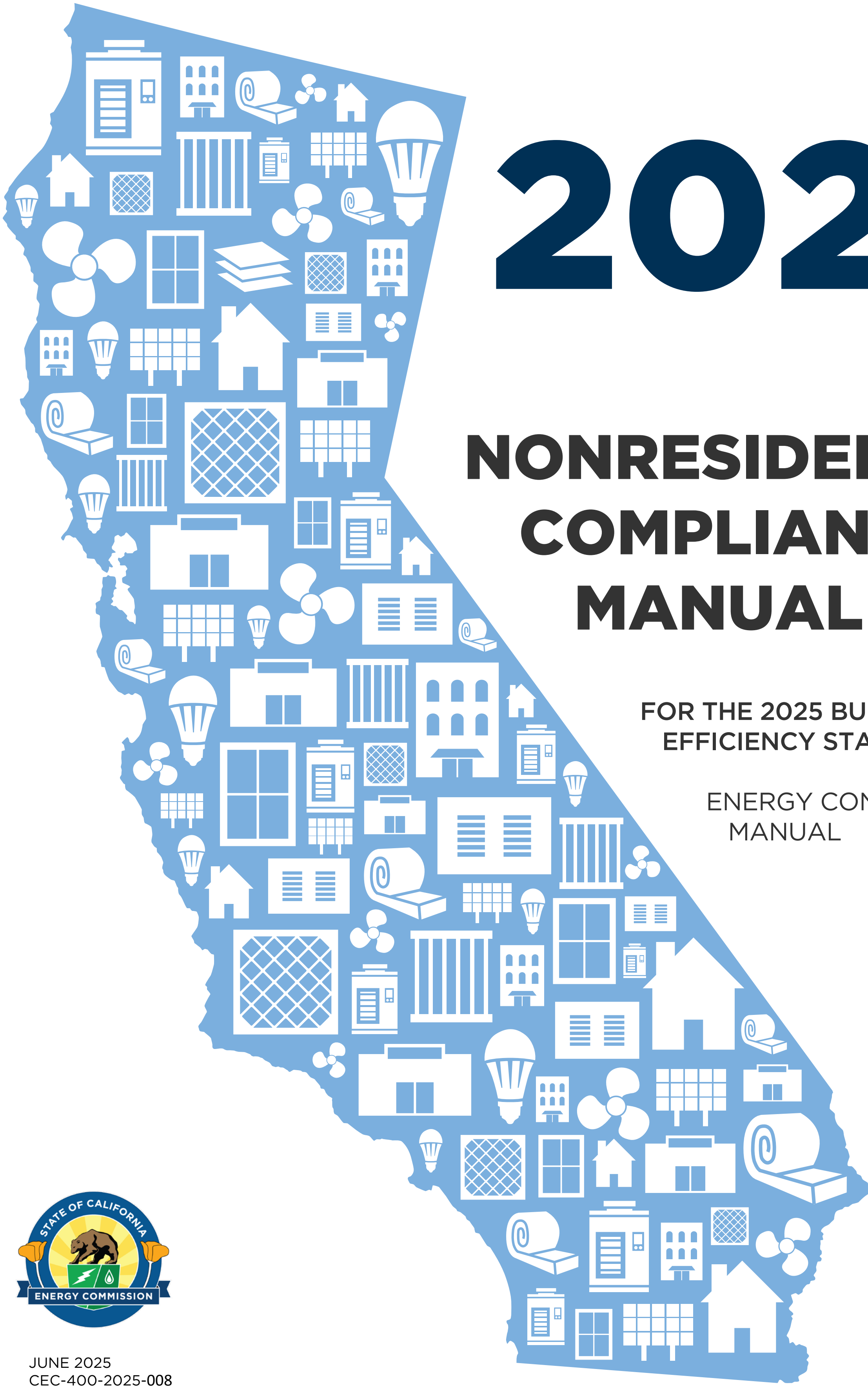

2025

NONRESIDENTIAL COMPLIANCE MANUAL

FOR THE 2025 BUILDING ENERGY EFFICIENCY STANDARDS

ENERGY CONSERVATION MANUAL

JUNE 2025
CEC-400-2025-008

CALIFORNIA ENERGY COMMISSION
Gavin Newsom, Governor

CALIFORNIA ENERGY COMMISSION

California Energy Commission

STAFF REPORT

2025 Nonresidential Compliance Manual

FOR THE 2025 BUILDING ENERGY EFFICIENCY STANDARDS

2025 Energy Code Conservation Manual

June 2025 | CEC-400-2025-008

Haile Bucaneg
Primary Author

Haile Bucaneg
Project Manager

Gypsy Achong
Branch Manager
BUILDING STANDARDS BRANCH

Will Vicent

Deputy Director

EFFICIENCY DIVISION

Michael J. Sokol
Director
EFFICIENCY DIVISION

Drew Bohan
Executive Director

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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 are 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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ABSTRACT

California's Building Energy Efficiency Standards were adopted by the California Energy Commission (CEC) 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 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; Title 24, Part 6; valuation; refrigeration; 2025 Building Energy Efficiency Standards; 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

This *2025 Nonresidential 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 California's Building Energy Efficiency Standards (Energy Code) for nonresidential buildings. The manual is a reference and instructional guide for anyone involved in the design and construction of energy-efficient nonresidential buildings.

Fourteen chapters make up the manual:

Chapter 1 introduces the Energy Code and discusses the application and scope of the standards for nonresidential buildings.

Chapter 2 analyzes the compliance and enforcement process, including design and preparation of compliance documentation through acceptance testing.

Chapter 3 details the building envelope.

Chapter 4 discusses heating, ventilation, and air-conditioning (HVAC) systems and water heating systems.

Chapter 5 discusses indoor lighting.

Chapter 6 discusses outdoor lighting.

Chapter 7 discusses sign lighting for indoor and outdoor applications.

Chapter 8 details electrical power distribution.

Chapter 9 examines photovoltaics, battery energy storage systems, and shared solar electric systems or community-shared battery system compliance options and solar-ready requirements for nonresidential buildings.

Chapter 10 details covered process requirements.

Chapter 11 is reserved, previously described multifamily building requirements.

Chapter 12 outlines to the performance approach for compliance.

Chapter 13 discusses commissioning requirements.

Chapter 14 discusses acceptance test requirements.

Related Documents

This compliance manual supplements four other related documents that are available from the California Energy Commission. These are:

- The *2025 Building Energy Efficiency Standards, Title 24, Part 6* (Energy Code). This compliance manual supplements, explains, and clarifies California's energy efficiency standards for buildings; it does not replace them. Readers should have a copy of the Energy Code to refer to while reading this manual, as well as a copy of the *2025 Reference Appendices*.

- 2025 Reference Appendices — The reference appendices have three main subsections: Reference Joint Appendices, Reference Residential Appendices, and Reference Nonresidential Appendices.
- The *2025 Reference Joint Appendices* contain information common to single-family residential, nonresidential, and multifamily buildings including, but not limited to, definitions, climate zone information, weather data, assembly properties, qualification requirements for high-efficacy light sources, compliance documentation registration procedures, qualification requirements for photovoltaic systems, and qualification requirements for battery storage systems.
- The *2025 Reference Residential Appendices* contain information for single-family residential and low-rise multifamily buildings. The Reference Residential Appendices contain Energy Code Compliance (ECC) field verification and diagnostic testing procedures for HVAC equipment, air distribution ducts, and quality insulation installation.
- The *2025 Reference Nonresidential Appendices* contain information for nonresidential and high-rise multifamily buildings. The Reference Nonresidential Appendices contain ECC field verification and diagnostic testing procedures for HVAC equipment and air distribution ducts, acceptance testing procedures, and luminaire power default values.
- *The 2025 Nonresidential and Multifamily Alternative Calculation Method Reference Manual* lays out the technical rules for implementing the 2025 performance compliance path in software programs.

Material from related documents is referenced but not repeated in this compliance manual. If you are using the electronic version of this compliance manual, there are hyperlinks throughout the manual that will take you directly to the document that is referenced.

The Technical Chapters

Please refer to Chapter 1.3 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Why California Needs the Energy Code

Please refer to Chapter 1.4 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Electricity Reliability and Demand

Please refer to Chapter 1.4.1 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Comfort

Please refer to Chapter 1.4.2 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Economics

Please refer to Chapter 1.4.3 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Environment

Please refer to Chapter 1.4.4 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Greenhouse Gas Emissions and Global Warming

Please refer to Chapter 1.4.5 of the *2022 Nonresidential and Multifamily Compliance Manual.*

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.

What's New for 2025

Envelope

- Reduced the prescriptive U-factor requirement equivalent to an additional R-2 continuous insulation for:
    - All roof/ceiling assemblies in all climate zones.
    - Metal building walls in all climate zones.
    - Wood-framed and other walls in all climate zones.
- Mass light walls in all climate zones.
    - Mass heavy walls in Climate Zones 1 and 11–16.
- Added a mandatory vestibule requirement at public entrances for buildings of Occupancy Types A, B, E, I, and M. Multiple exceptions are included.
- Added a mandatory area-weighted U-factor requirement for exterior vertical fenestration assemblies.
- Added a mandatory U-factor requirement for exterior vertical fenestration alterations.

Lighting

- Revision to the requirements for daylight responsive controls (Section 130.1[d])
- Improvements to code language in specifying requirements throughout for conciseness and clarity

Mechanical

- Updates to mandatory cooling tower controls requirements (Section 110.2(e))
- New mandatory pool heating source and sizing requirements (Section 110.4(c))
- New mandatory requirements limiting the temperature of supply hot water for hydronic space heating (Section 120.2(l))
- Revision to the prescriptive axial fan open circuit cooling tower fan efficiency requirements (Section 140.4(h))
- New prescriptive requirements for the use of ASHRAE Guideline 36 (Section 140.4(r))
- New prescriptive requirements for simultaneous mechanical heat recovery (Section 140.4(s))

Covered Processes

- Updated mandatory requirements for controlled environmental horticulture systems (Section 120.6(h)) for lighting efficiency
- New mandatory requirements for evaporator specific efficiencies for refrigeration (Section 120.6(b)). Updated efficiencies are in Table 120.6-A-2.
- New mandatory requirements for electric readiness for commercial kitchens (Section 120.6(k))
- New mandatory requirements for process pipe insulation for pipes that carry heated or chilled fluids used in process unrelated to space conditioning or water heating (Section 120.3(a)). Updated pipe insulation thickness requirements can be found in Tables 120.3-A1 and 120.3-A2.
- Updated prescriptive requirements for laboratory and factory exhaust systems (Section 140.9(c))

Mandatory Requirements and Compliance Approaches

Mandatory Requirements

Please refer to Chapter 1.6.1 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Prescriptive Approach

The prescriptive approach (composed of requirements described in Chapters 3, 4, 5, 6, 7, and 10) requires each component of the proposed building to meet a prescribed minimum efficiency. The approach offers little flexibility but is easy to use. If the design fails to meet even one requirement, then the system does not comply with the prescriptive approach. In this case, the performance approach provides more flexibility to the building designer for choosing alternative energy efficiency features.

- Building envelope. The prescriptive envelope requirements are the required thermal performance levels for each building component (walls, roofs, and floors). These requirements are described in Chapter 3. The only flexibility is if portions of an envelope component do not meet a requirement, a weighted average of the component can be used to demonstrate compliance. The stringency of the envelope requirements varies according to climate zone and occupancy type.
- Mechanical. The prescriptive mechanical requirements are described in Chapter 4. The prescriptive approach specifies equipment, features, and design procedures but does not mandate the installation of a particular HVAC system.
- Indoor lighting. The prescriptive lighting power requirements are determined by one of two methods: the complete building method or the area category method. These approaches are described in Chapter 5. The allowed lighting varies according to the requirements of the building occupancy or task requirements.
- Outdoor lighting. Outdoor lighting standards are described in Chapter 6, setting power limits for various applications such as parking lots, pedestrian areas, sales canopies, building entrances, building façades, and signs. The Energy Code also set minimum requirements for cutoff luminaires and controls. Detailed information on the outdoor lighting power allowance calculations is in Chapter 6.

Performance Approach

The performance approach (Chapter 12) allows greater flexibility than the prescriptive approach. It is based on an energy simulation model of the building.

The performance approach requires an approved computer compliance program that models a proposed building, determines the allowed energy budget, calculates the energy use of the building, and determines when it complies. Design options such as window orientation, shading, thermal mass, zonal control, and building configuration are all considered in the performance approach. In addition to flexibility, it helps find the most cost-effective solution for compliance.

The performance approach may be used for:

- Envelope or mechanical compliance alone.
- Envelope and mechanical compliance.
- Envelope and indoor lighting compliance.
- Envelope, mechanical, and indoor lighting compliance.

Indoor lighting compliance must be combined with envelope compliance. The performance approach does not apply to outdoor lighting, sign lighting, exempt process load, some covered process loads (for example, refrigerated warehouses), or solar-ready applications.

Long-term System Cost (LSC) and Hourly Source Energy (HSE) are the "currency" for the performance approach. LSC considers the systemwide benefits associated with the type of energy (electricity, gas, or propane) and the time when it is saved or used. The LSC method helps the state account for the long-term benefits of policies needed to meet its climate actions goals, such as 100 percent renewable and zero-carbon generation, proliferation of electric transportation, and drastic reductions in fossil fuel combustion occurring in buildings. Appendix JA3 of the Reference Appendices has more information on LSC. Like LSC, HSE considers the type of energy (electricity, gas, or propane) but is based on the amount of long-term depletable energy resources used to meet the energy demand of the building in each hour. HSE values are similar to the long-term hourly utility greenhouse gas emissions and an effective metric for encouraging building decarbonization.

See Chapter 12 if the performance approach will be used for additions and alterations.

Compliance Options

Please refer to Chapter 1.6.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Scope and Application

The Energy Code applies to nonresidential and residential buildings. This manual addresses the requirements for nonresidential buildings, including hotels and motels. The Single-Family Residential Compliance Manual discusses the requirements for single-family residential buildings. The Multifamily Compliance Manual discusses the requirements for low-rise and high-rise multifamily residential buildings.

Building Types Covered

The nonresidential standards apply to all California Building Code (CBC) occupancies of Groups A, B, E, F, H, I, L, M, S, and U. If buildings are directly or indirectly conditioned, they must meet all mechanical, envelope, indoor, and outdoor lighting requirements of the standards. Buildings that are not directly or indirectly conditioned must meet only the indoor and outdoor lighting requirements.

The standards also do not apply to buildings that fall outside the jurisdiction of the CBC, such as mobile structures. If outdoor lighting is associated with a Group L occupancy, it is exempt. If the outdoor lighting is part of any other occupancy groups listed, it must comply.

Historical Buildings

Please refer to Chapter 1.7.2 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Multifamily Buildings

The Multifamily Compliance Manual provides information for multifamily buildings.

Scope of Standard Requirements

Please refer to Chapter 1.7.4 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Speculative Buildings

Known Occupancy

Please refer to Chapter 1.7.5.1 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Unknown Occupancy

Please refer to Chapter 1.7.5.2 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Mixed- and Multiple-Use Buildings

Mixed Residential and Nonresidential Occupancies

Please refer to Chapter 1.7.6.1 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Multiple Nonresidential Occupancies

Please refer to Chapter 1.7.6.2 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Hotels and Motels

This chapter discusses the similarities and differences among the requirements for a hotel/motel and other nonresidential buildings.

Hotels or motels are unique in that the design incorporates a wide variety of occupancies and functions into one structure. The occupancies range from nonresidential occupancies to hotel/motel guest rooms. Design functions that affect guests range from the arrival experience created through the architectural features of the main lobby to the thermal comfort of the guest rooms. Other functions that designs must address include restaurants, kitchens, laundry, storage, assembly, outdoor lighting, and sign lighting. These structures can range from simple guest rooms with a small office to a structure encompassing a small city (Section 100.1 "HOTEL/MOTEL").

The 2025 Energy Code expanded on the definition of “Hotel/Motel” to include:

- A building of Occupancy Group R-1.
- Vacation timeshare properties and hotel or motel buildings of Occupancy Group R-2.

- The following types of Occupancy Group R-3:
    - Congregate residences for transient use.
    - Boarding houses of more than six guests.
    - Alcohol or drug abuse recovery homes of more than six guests.

Like other occupancies, compliance is submitted for the features covered in the permit application only. The nonresidential areas must meet the envelope, mechanical, indoor lighting, outdoor lighting, and sign lighting portions of the nonresidential Energy Code. The guest room portions of hotels/motels must meet the envelope, mechanical, and lighting provisions applicable only to hotel/motel guest rooms. Each portion of the building individually complies with the provisions applicable to that occupancy.

Since hotel/motels are treated as a mixture of occupancies covered by the Energy Code, the concepts at the beginning of each chapter apply to hotels/motels as they would any other nonresidential occupancy.

Mandatory Requirements

Please refer to Chapter 1.7.8.1 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Prescriptive Compliance

Please refer to Chapter 1.7.8.2 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Performance Compliance

Please refer to Chapter 1.7.8.3 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Live-Work Spaces

Live-work buildings combine residential and nonresidential uses within individual units. In general, the residential requirements apply since these buildings operate and are conditioned 24 hours per day. Lighting in designated workspaces is required to show compliance with the nonresidential lighting standards (Section 140.6).

Unconditioned Space

Please refer to Chapter 1.7.10 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Newly Conditioned Space

Please refer to Chapter 1.7.11 of the *2022 Nonresidential and Multifamily Compliance Manual.*

New Construction in Existing Buildings

Please refer to Chapter 1.7.12 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Alterations to Existing Conditioned Spaces

Please refer to Chapter 1.7.13 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Additions

Please refer to Chapter 1.7.14 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Change of Occupancy

Please refer to Chapter 1.7.15 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Repairs

Please refer to Chapter 1.7.16 of the *2022 Nonresidential and Multifamily Compliance Manual.*

About the Energy Code

History

Reference: Section 25402 of the Public Resources Code

The Legislature adopted the Warren-Alquist Act (the Act), which created the Energy Resources Conservation and Development Commission (California Energy Commission, or CEC) in 1975 to deal with energy-related issues and charged the CEC with adopting and maintaining energy efficiency standards for new buildings. The first standards were adopted in 1978 in the aftermath of the Organization of Petroleum Exporting Countries (OPEC) oil embargo of 1973.

The Act requires that the Energy Code be cost-effective "when taken in their entirety and amortized over the economic life of the structure."

The CEC is required to update the standards periodically. One hundred eighty (180) days after the approval of the standards, manuals must be published to support the Energy Code. The Energy Code (Part 6) goes into effect along with the other parts of the California Building Standards Code (Title 24) on the statutorily required triennial update cycle. The Act directs local building permit jurisdictions to not approve permits until the building satisfies the requirements of the standards.

The first-generation standards for nonresidential buildings took effect in 1978. Second-generation standards took effect for offices, and retail and wholesale stores, in 1984 and 1985, respectively.

The next major revision occurred in 1992 when the requirements were simplified and consolidated for all building types. Major changes were made to lighting, building envelope, fenestration, and HVAC and mechanical requirements. Structural changes made in 1992 led the way for national standards in other states.

The standards went through minor revisions in 1995. In 1998, lighting power limits were reduced significantly because electronic ballasts and T-8 lamps were cost-effective and becoming commonplace in nonresidential buildings.

The California electricity crisis of 2000 resulted in rolling blackouts throughout much of the state. This crisis produced escalating energy prices at the wholesale market and, in some areas, in the retail market. The Legislature responded with Assembly Bill 970 (Ducheny, Chapter 329, Statutes of 2000), which required the CEC to update the Energy Code through an emergency rulemaking. This rulemaking was achieved within the 120 days required by the Legislature. The 2001 Standards (or the AB 970 Standards) took effect in mid-2001. The 2001 Energy Code included requirements for high-performance windows throughout California, more stringent lighting requirements, and other changes.

The Public Resources Code was amended in 2002 through Senate Bill 5X (Machado, Chapter 852, Statutes of 2008) to expand the authority of the CEC to develop and maintain standards for outdoor lighting and signs. The Energy Code covered in this manual builds on the rich history of Nonresidential Energy Code in California and the leadership and direction provided by the California Legislature over the years.

The 2008 Energy Code was expanded to include refrigerated warehouses and steep-sloped roofs.

The 2013 Energy Code reflected many significant changes and expanded the scope. Some changes included fault detection and diagnostic devices, economizer damper leakage and assembly criteria, air handler fan control for HVAC systems, updates to the low-sloped cool roofs requirements for nonresidential buildings, and, for the first time, set minimum mandatory requirements for insulation in nonresidential buildings. Expanding the scope of the standards included newly regulated covered processes such as parking garage ventilation, process boiler systems, compressed air systems, commercial refrigeration, laboratory exhaust, data center (computer room) HVAC, and commercial kitchens.

The 2016 Energy Code was current with ASHRAE 90.1 national consensus standards. Changes were made to HVAC controls, indoor and outdoor lighting, advanced building control systems, and covered processes, including new requirements for elevators, escalators, and moving walkways.

The 2019 Energy Code updated the indoor and outdoor lighting requirements to assume the use of LED lighting, updated indoor air quality requirements, and expanded to include requirements for healthcare facilities for the first time.

The 2022 Energy Code included a number of lighting, HVAC, and covered process updates. Lighting power densities were updated based on light-emitting diode technologies, while lighting control requirements were further clarified. Economizer requirements and HVAC controls were expanded to further reduce energy associated with space conditioning. Additional covered process requirements for steam systems and compressed air systems were also included.

For a detailed list of the changes to the 2025 Energy Code, see What’s New for 2025.

Example 1-1

Question

Does a LEED-certified building still need to meet the 2025 Energy Code?

Answer

Yes.

California Climate Zones

Please refer to Chapter 1.8.2 of the *2022 Nonresidential and Multifamily Compliance Manual.*

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Figure 2-1: Idealized International Code Council Permitting Process for Building Permit Applications 1

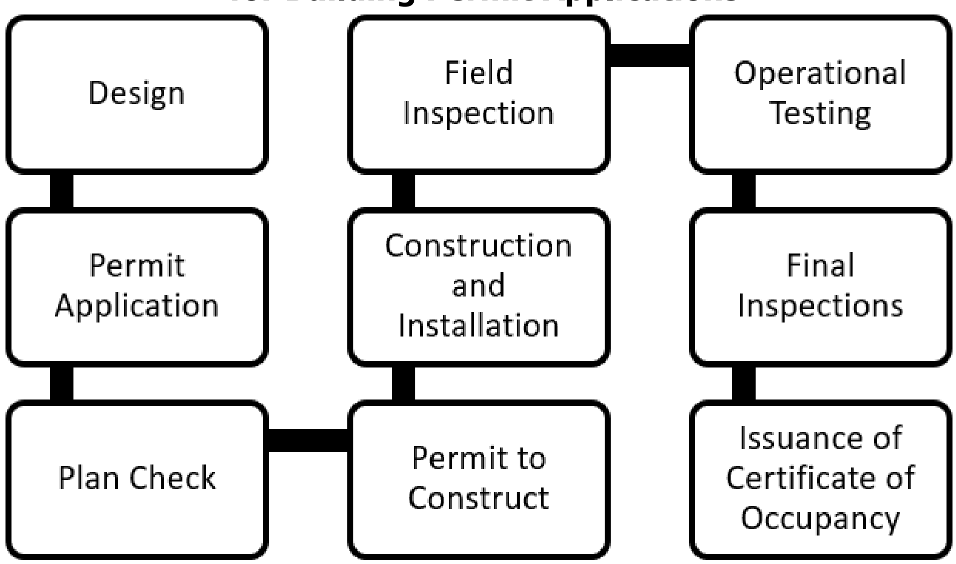
Compliance and Enforcement

Overview

The Building Energy Efficiency Standards (Energy Code) are written in Part 6 of Title 24 of the California Code of Regulations. All twelve parts of Title 24 comprise the California Building Standards Code, which is enforced by local authorities having jurisdiction (AHJ). Primary responsibility for compliance with the Energy Code rests with the builder and building owner. The builder or building owner must demonstrate compliance with the Energy Code to an enforcement agency. The California Energy Commission (CEC) does not directly enforce the Energy Code. Enforcement agencies have the primary responsibility to issue a building permit for newly constructed buildings or additions and alterations to existing buildings and enforcement of all parts of Title 24, including the Energy Code.

Most enforcement agencies are associated with a city or county government but can also include agencies such as the California Division of the State Architect (for public schools). This chapter (Chapter 2) of the Nonresidential Compliance Manual is intended to show how compliance and enforcement of the Energy Code are achieved in the typical building project permitting process. Most enforcement agencies follow some version of the permitting process recommended by the International Code Council (ICC). Figure 2.1-1 shows an idealized version of the ICC permitting process.

Figure 2-1: Idealized International Code Council Permitting Process for Building Permit Applications



Source: California Energy Commission staff

To assist the builder, building owner, and enforcement agency, the CEC created four categories of compliance documents used to demonstrate compliance with the Energy Code for nonresidential construction projects:

- Certificates of compliance (NRCC) are completed by the project proponent then submitted to the enforcement agency during the plan check phase.

- Certificates of installation (NRCI) are completed by the installing technician or contractor during construction then submitted to the enforcement agency during field inspections phase.
- Certificates of acceptance (NRCA) are completed by the technician (may be in-house or third-party) who checks compliance of the installation with the CEC's acceptance testing requirements then submitted to the enforcement agency during the final inspection phase and prior to the enforcement agency issuing the certificate of occupancy. For lighting controls and mechanical systems, the NRCA must be completed by a technician certified by a CEC-approved certification provider to perform the acceptance tests.
- Certificates of verification (NRCV) are required in some instances. They are completed by an independent, third-party agent certified by a CEC-approved Energy Code Compliance (ECC)-Rater on a residential data registry then submitted to the enforcement agency ahead of the final inspection phase and prior to the enforcement agency issuing the certificate of occupancy.

The certified technician responsible for the NRCAs are made available through the CEC's Acceptance Test Technician Certification Provider (ATTCP) program. Certified technicians are referred to as acceptance test technicians (ATTs) and are required to perform the NRCA acceptance tests for lighting controls and mechanical systems. Unlike ECC Raters, ATTs are not required to be independent, third-party agents from the builder. ATTs can (and often do) perform the installation work, as well as acceptance testing of the lighting controls or mechanical systems.

This chapter describes the overall compliance and enforcement process and responsibilities throughout the permitting process. The scope of the Nonresidential Compliance Manual includes newly constructed buildings, as well as addition and alterations to existing buildings. Building types covered in this manual include all of the following occupancy groups:

- Group A: Assembly. This occupancy is a used for gatherings such as civic, social, religious function, recreation, food and drink consumption, or waiting for transportation.
- Group B: Business. This occupancy is a used for functions such as an office or a professional or a service-type transaction.
- Group E: Educational. This occupancy is typically where six or more persons at any one time occupy a space for educational purposes through the twelfth grade.
- Group F: Factory and Industrial. This occupancy involves assembling, disassembling, fabricating, finishing, manufacturing, packaging, repair, and processing operations that would not be otherwise classified as a Group H or Group S occupancy.
- Group H: High Hazard. This occupancy includes manufacturing, processing, generation, or storage of materials that can constitute a physical or health hazard. Group H occupancies are classified into five high-hazard areas that identify the type of hazard for each group.
- Group I: Institutional, where care or supervision is provided to people who are or are not capable of self-preservation without physical assistance or in which people are detained for penal or correctional purposes or in which the liberty of the occupants is restricted.

- Group L: Laboratory, where hazardous materials are used for activities such as testing, analysis, instruction, research, or developmental activities. Group L includes occupancy space within a building or structure, which may include laboratory suites, multiple laboratories, offices, storage, equipment rooms, or similar support functions.
- Group M: Mercantile, involving the display and sale of merchandise, stocking of goods, and is accessible to the public.
- Group S: Storage. This occupancy involves a building that is used for storage purposes.
- Group U: Utility and Miscellaneous. This occupancy involves a building or structure that is used as an accessory or miscellaneous use not classified as any other specific occupancy.
- Hotel/Motels have six or more guest rooms or a lobby serving six or more guest rooms, where the guest rooms are intended or designed to be used, or which are used, rented, or hired out to be occupied, or which are occupied for sleeping purposes by guests, and all conditioned spaces within the same building envelope. Hotel/motel also includes all conditioned spaces that are (1) on the same property as the hotel/motel, (2) served by the same central heating, ventilation, and air-conditioning system as the hotel/motel, and (3) integrally related to the functioning of the hotel/motel as such, including, but not limited to, exhibition facilities, meeting and conference facilities, food service facilities, lobbies, and laundries. Hotel/motel also includes:
  - Group R-1. Sleeping units in this occupancy group are primarily transient in nature including vacation timeshare properties. This occupancy group is most often associated with hotels and motels.
  - Group R-2. Sleeping units or more than two dwelling units where the occupants are primarily permanent. For example: convents, dormitories, nontransient hotels, or vacation timeshare properties.
  - The following types of Group R-3:
    - Congregate residences for transient use
    - Boarding houses of more than six guests
    - Alcohol or drug abuse recovery homes of more than six guests.

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 NRCC 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 Energy Commission's website for additional information about the required information for manufacturers to certify products and for lists of certified products, https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment.

In nonresidential buildings, the following are examples of products that must be certified by the manufacturer:

- Air economizers (NA7)
- Airflow measurement apparatus — ventilation systems (NA2)
- Air-to-water heat pump systems
- Economizer fault detection and diagnostics (JA6)
- Intermittent mechanical ventilation systems
- Low-leakage air-handling unit (JA9)
- Occupant-controlled smart thermostats (JA5)
- Demand-responsive control receptacles and lighting
- Ducted variable-capacity heat pump
- Battery and energy storage systems (JA12)

Compliance Phases

Design Phase

Please refer to Chapter 2.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Building Commissioning

Section 10-103(a); Section 120.8

Building commissioning is a general industry term and a defined term (with associated regulations in Section 120.8) within the Energy Code. Originally, the term "commissioning" came from the shipbuilding industry, with the intent of that commissioning transferring to the concept of building commissioning. When a building is commissioned, it is intended to undergo a quality assurance process that begins during design and continues through construction, occupancy, and operations. Commissioning is intended to ensure that the newly constructed buildings perform initially as intended and that building staff is prepared to operate and maintain the systems and equipment to continue that performance.

The Energy Code defines "building commissioning" as a systematic quality assurance process that spans the entire design and construction process, including verifying and documenting that building systems and components are planned, designed, installed, tested, operated, and maintained to meet the owner's project requirements.

The CEC does not require certification to perform building commissioning for the Energy Code. Although a "commissioning agent" is not a defined term within the Energy Code, there are many professionals who are trained and certified by a variety of professional organizations to perform building commissioning. The CEC is aware of these certification programs but does not endorse them.

Title 24, Part 1, Section 10-103(a)1 does require that the person(s) reviewing and signing the commissioning compliance documents must be a licensed professional engineer or a licensed architect (as specified in the provisions of Division 3 of the Business and Professions Code). A licensed contractor that is representing services performed by or under the direct supervision of a licensed engineer or architect is also eligible to sign. The signatory is further restricted by Section 10-103(a)1 as follows:

- For buildings less than 10,000 square feet, this signatory may be the engineer or architect of record.
- For buildings greater than 10,000 square feet but less than 50,000 square feet, this signatory 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 (as defined by the Energy Code) serving more than 10,000 square feet, the signatory shall be a third-party engineer, architect, or contractor.

The square footage referenced in Section 10-103(a)1 refers to the total square footage of the project. This is an important distinction from the square footage used by the building commissioning triggers below.

Building commissioning (Section 120.8) applies to newly constructed nonresidential and hotel/motel buildings and is based on the square footage of the nonresidential spaces as opposed to the total square footage of these buildings. For example, the corridors, meeting rooms, lobbies, and other public spaces within a newly constructed hotel/motel or high-rise multifamily building count toward the nonresidential space, but the dwelling units themselves do not. Healthcare facilities are also not required to meet the Energy Code building commissioning requirements but must comply with Chapter 7, Safety Standards for Health Facilities of the California Administrative Code (Title 24, Part 1).

From Section 120.8, the explicit triggers for building commissioning are as follows:

- Newly constructed nonresidential buildings, including nonresidential spaces within hotel/motels and excluding healthcare facilities, are required to comply with applicable requirements of Section 120.8.
    - Such buildings with conditioned space of 10,000 square feet or more of nonresidential space are required to comply with the applicable requirements of Section 120.8(a) through Section 120.8(i).
    - Such buildings with conditioned space of less than 10,000 square feet must comply with only Section 120.8(d) and Section 120.8(e).
    - All building systems and components covered by Section 110.0, Section 120.0, Section 130.0, and Section 140.0 are required to be included in the scope of the commissioning process, excluding those related solely to covered processes.

Building commissioning requires the completion and documentation of the following items (Section 120.8(a) lists the coded sections within Section 120.8 that require compliance — Section 120.8(b) through Section 120.8(i)):

Section 120.8(b) Owner's or owner representative's project requirements (OPR)

- Required for projects with 10,000 square feet or more of conditioned nonresidential space.
    - OPR is the energy-related expectations and requirements of the building that are documented before the design phase of the project begins.
    - Compliance documentation: 2025-NRCC-CXR-E, Table G.

Section 120.8(c) Basis of design (BOD)

- Required for projects with 10,000 square feet or more of conditioned nonresidential space.
- BOD is a written explanation of how the design of the building systems and components meets the OPR and is completed at the design phase of the building project and updated as necessary during the design and construction phases. The BOD document at a minimum covers the following systems and components:
    - Heating, ventilation, air conditioning (HVAC) systems and controls
    - Indoor lighting system and controls
    - Water heating systems and controls
    - Any other building equipment or system listed in the OPR
    - Any building envelope component considered in the OPR
    - Compliance documentation: 2025-NRCC-CXR-E, Table H

Section 120.8(d) Design Phase Design Review.

- The design reviewer is the signatory of the Design Review Kickoff Certificate(s) of Compliance and Construction Document Design Review Checklist Certificate(s) of Compliance.
- Required for all projects with conditioned nonresidential space.
    - Design review kickoff. During the schematic design phase of the building project, the owner or owner's representative, design team, and design reviewer must meet to discuss the project scope, schedule, and ways that the design reviewer will coordinate with the project team.
    - Compliance documentation: 2025-NRCC-CXR-E, Table F
    - Construction documents design review. The Construction Document Design Review Checklist Certificate of Compliance lists the items checked by the design reviewer during the construction document review.
    - Compliance documentation: 2025-NRCC-CXR-E, Table I

Section 120.8(e) Commissioning measures shown in the construction documents

- Required for all projects with conditioned nonresidential space.
    - These documents are complete descriptions of all measures or requirements necessary for commissioning included in the construction documents (plans and specifications).
    - Compliance documentation: 2025-NRCC-CXR-E, Table I

Section 120.8(f) Commissioning plan

- Required for projects with 10,000 square feet or more of conditioned nonresidential space.
    - Prior to permit issuance, a commissioning plan is completed to document how the project will be commissioned and is started during the design phase of the building project.
    - Compliance documentation: 2025-NRCC-CXR-E, Table J

Section 120.8(g) Functional performance testing

- Required for projects with 10,000 square feet or more of conditioned nonresidential space.
    - Functional performance tests demonstrate the correct installation and operation of each component, system, and system-to-system interface in accordance with the acceptance test requirements in the Energy Code.
    - Compliance documentation: 2025-NRCC-CXR-E, Table K

Section 120.8(h) Documentation and training

- Required for projects with 10,000 square feet or more of conditioned nonresidential space.
- This is a systems manual and systems operations training to be provided prior to the owner or owner's representative post-construction.
    - Compliance documentation: 2025-NRCC-CXR-E, Table L

Section 120.8(i) Commissioning report

- Required for projects with 10,000 square feet or more of conditioned nonresidential space.
- This is a complete report of commissioning process activities undertaken through the design, construction, and reporting recommendations for post-construction phases of the building project and is provided to the owner or owner's representative.
    - Compliance documentation: 2025-NRCC-CXR-E, Table-M

The compliance document NRCC-CXR-E is the minimum that the Energy Code requires. Certified commissioning agents will typically provide far more support and organization to a construction project as a matter of their certification training and industry best practices. The CEC encourages but does not require a building commissioning process and documentation beyond the minimum requirements of the Energy Code Section 120.8.

Integrated Design

Please refer to Chapter 2.2.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Permit Application

Reference: Section 10-103(a), Section 10-103(a)2

Certificates of Compliance

Nonresidential certificates of compliance (NRCC) are required for newly constructed buildings, as well as additions and alterations to existing buildings. The design team (architects, engineers, designers, or other specialty contractors) is responsible for ensuring that the building designs comply with the California Building Standards Code, including the Energy Code. Once the design team has settled on a code-compliant design, it is required (Section 10-

103(a)1) to document the compliance with the Energy Code by completing and signing the NRCCs. Appendix A of this manual lists all the possible NRCCs that the design team may need to use.

These NRCCs were available from the CEC (via Energy Code Ace) for 2019 Energy Code compliance and were designed to be dynamic forms that would expand and contract as needed to describe the proposed project. The CEC adopted the Energy Code Ace Virtual Compliance Assistance (VCA) tool instead of the individual NRCCs for 2022 and 2025 Energy Code compliance.

The VCA tool uses an interrogatory method to determine which NRCCs are necessary for a specific project, completes the necessary NRCCs based on the information entered, and makes them ready for review and signature. The VCA can make recommendations only for projects that use the prescriptive path. (See Chapter 1 of the Nonresidential Compliance Manual) To complete the necessary NRCCs for projects using the performance path, the design team must use a CEC-approved compliance model. The CEC maintains a list of these approved compliance models on the 2025 Building Energy Efficiency Standards Approved Computer Compliance Programs website. The compliance model will create an NRCC-PRF-01 form with the necessary information for the design team to complete the required NRCCs.

Regardless of which compliance path or what compliance tool is used, the builder or building owner is solely responsible for selecting and completing the correct NRCCs and designing a code-compliant project. Once the design team has completed the required project design details, NRCCs, and any other documentation required by the enforcement agency, it can begin the permitting phase by submitting a complete application for a permit to construct to the enforcement agency.

All applicable NRCCs must be signed by a document author and a responsible person. While there are no requirements for the document author, the responsible person must be eligible under Division 3 of the Business and Professions Code to accept responsibility for the building design or system design identified on each NRCC (Section 10-103(a)1). For example, a technician may complete the NRCC-MCH-E, but only the engineer of record (that was on the design team) can review and sign as the responsible person. The responsible person can also act as the document author. Once reviewed and by the responsible person, each NRCC must be included with the permit application.

Commissioning Design Review

Please refer to Chapter 2.2.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Preparation and Incorporation Onto the Plans

Please refer to Chapter 2.2.3.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Plans and Specifications

Enforcement agencies are required to check submitted building plans to determine compliance with the California Building Code, including the Energy Code. Vague, missing, or incorrect information on the NRCCs may be identified by the plans examiner as requiring correction by the permit applicant. The permit applicant would then resubmit the revised building plans and specifications. When the permit applicant submits comprehensive, accurate, clearly defined building plans and specifications, the submission may help speed plan review. Because the enforcement agency bears responsibility for code enforcement, only it may pursue corrections to approved plans and compliance documents.

During plan review, the enforcement agency must verify that the building design details specified on the construction documents conform to the applicable energy code features information specified on the submitted NRCCs. This conformance is necessary since materials-purchasing personnel and building-construction craftsmen in the field may rely solely on a copy of the building plans and specifications for direction in performing their responsibilities.

Energy Plan Review

The enforcement agency is responsible for verifying that all required NRCCs have been submitted for plan review, are consistent with the submitted plans, and do not contain errors. When the compliance documents are produced by a CEC-approved compliance software application or the VCA, it is unlikely that there will be computational errors on the NRCCs. Some examples of how the plans examiner will verify that the energy efficiency features detailed on the NRCCs are consistent with the building plans include:

- Verifying the lighting fixtures and associated wattages, lighting controls, and so forth from NRCC-LTI-E are consistent with the electrical plans in a lighting schedule, lighting fixture legend for the floor plan, and so forth.
- Verifying the window and skylight U-factor and SHGC values from NRCC-ENV-E are consistent with the structural/architecture plans in a window/skylight schedule, window/skylight legend for the floor plan, and so forth.
- Verifying the wall, floor, and roof/ceiling insulation R-values from the NRCC-ENV-E are consistent with the structural/architecture plans in a framing plan, structural details, and so forth.
- Verifying the HVAC equipment SEER, EER, AFUE, and other efficiency values from the NRCC-MCH-E are consistent with the mechanical plans in an equipment schedule.

The enforcement agency should clearly articulate to the builder/designer the acceptable methods of specifying energy features on the building plans for approval.

Permit to Construct

Reference: Section 10-103(d)1

After the plans examiner has reviewed and approved the building plans, specifications, and NRCCs for the project, the enforcement agency may issue a building permit at the builder's request. Issuance of the building permit is the first significant milestone in the compliance and enforcement process. The building permit is the green light for the contractor to begin work. In many cases, building permits are issued in phases. Sometimes, there is a permit for site work and grading that precedes the permit for actual construction. In large office or institutional buildings, the permit may be issued in phases, such as site preparation or structural steel.

Construction and Installation

Reference: Section 10-103(a)3

Certificates of Installation

As construction begins and progresses, the installing contractor, general contractor, specialty contractor, or other qualified person is required to complete the nonresidential certificates of installation (NRCI) for each category of the energy efficiency features being installed. The NRCIs show that the installed and constructed building features match the features described in the NRCC and the comply with Energy Code.

NRCIs are required to be completed and submitted to demonstrate compliant installation of regulated energy efficiency features such as windows and skylights, water heaters, plumbing, HVAC ducts and equipment, lighting fixtures and controls, and building envelope insulation. The licensed contractor responsible for the building construction or the installation of a regulated energy efficiency feature must ensure the work is done in accordance with the approved building plans, specifications, and NRCC for the project. The installing contractor (and document author) must sign the NRCI.

The responsible persons must also sign the NRCI and are expected to verify that the installed features, materials, components, or manufactured devices for which they are responsible conform to the building plans, specifications, and NRCC approved by the enforcement agency for the project. A copy of the completed, signed, and dated NRCI must be posted at the building site for review by the enforcement agency before the final project inspection.

If construction of any regulated portion of the project will be impossible to inspect once subsequent construction is completed, the enforcement agency may require the NRCI to be posted upon completion of that feature/portion of the project and before completion of any subsequent construction.

A listing of NRCI documents is provided in Appendix A. A copy of the NRCIs must be included with the documentation the builder provides to the building owner at occupancy as specified in Section 10-103(b). The NRCIs are available through the VCA tool and the NRCIs are linked to the NRCCs. The NRCI identifies each energy efficiency feature that the contractor must install and provides a check box (if that exact feature is installed). If the feature is changed out for another feature, the NRCI provides data entry fields for the new feature and will automatically indicate if the change needs to be approved by the enforcement agency.

Change Orders

A "change order” is an industry term for a formal amendment to a construction contract that changes the contractor's scope of work. Not all changes to a construction project result in a formal change order. In many instances, the project owner can change the scope of work without a formal agreement. Most change orders modify the work, materials, or time to complete the work. For there to be a valid change order, the owner and contractor must both agree on all terms. Change orders exist because construction plans, although very detailed, cannot possibly anticipate every nuance or issue that may arise on a construction project. Some change orders will affect the plans approved by the enforcement agency and will require a separate approval. For example, changing the finish on an interior wall is unlikely to affect the approved plans, but adding or removing a window will.

For the energy efficiency features recorded on the approved NRCCs, generally any change that reduces the energy efficiency will require a new NRCC to be completed, signed, submitted (to the enforcement agency), and approved. These actions may also result in a special inspection by the enforcement agency. For example, switching to more efficient lighting will not likely result in a change order that is required to be approved, but changing which lights are daylighting-controlled will.

To help track what change orders should result in an enforcement agency approval, the CEC requires that the installing contractor complete the NRCIs using the VCA tool or paper forms from the CEC website. If the enforcement agency approval is required for the change order, the responsible person must update and resubmit the affected NRCC or both to the enforcement agency.

It is the responsibility of the builder and building owner to determine if a change order needs to be approved by the enforcement agency. Additionally, many enforcement agencies have a stricter policy when it comes to change orders and want them all submitted for review and possible approval regardless of the scope of the change.

Operational Testing

Reference: Section 10-103(a)4; Section 10-103.1; Section 10-103.2

Operational testing is part of the competency of workmanship that any installing contractor will perform to verify that their own work is up to industry standards and complies with the project design and California Building Standards Code (including the Energy Code). Formal operational testing is typically referred to as *acceptance testing* or *acceptance criteria verification*. The Energy Code requires specific acceptance testing (performed by the installing contractor) for lighting controls, HVAC controls, air distribution ducts, envelope features, and special purpose equipment, referred to as *covered processes*. 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 controls and mechanical systems are required by 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 classrooms 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 NRCAs (Nonresidential Certificates of Acceptance) 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 keeps a link to all ATTCP at its ATTCP website, https://www.energy.ca.gov/programs-and-topics/programs/acceptance-test-technician-certification-provider-program/acceptance. Appendix A lists the Energy Code required NRCAs and indicates which are to be completed by ATTs through the ATTCP program. For more information of the ATTCP program, see Chapter 14 of the Nonresidential Compliance Manual.

Final Inspection by the Enforcement Agency and Issuance of the Certificate of Occupancy

Please refer to Chapter 2.2.9 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Certificate of Occupancy

Please refer to Chapter 2.2.10 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Occupancy – Compliance, Operating, and Maintenance Information

Reference: Section 10-103(b)

At the occupancy phase, the general contractor or design team or both are required to provide the owner with copies of the energy compliance documents, including NRCCs, NRCIs, NRCAs, and NRCVs. Documents for the construction/installation, operating, maintenance, ventilation information and instructions for operating and maintaining the features of the building efficiently are also included.

Compliance Documentation

Compliance documentation includes the documents, reports, and other information that are submitted to the enforcement agency with an application for a building permit. Compliance documentation also includes documentation completed by the installing contractor, engineer/architect of record, owner's agent, or certified technician to verify that certain systems and equipment have been correctly installed and commissioned.

Each portion of the applicable compliance documentation must be completed and/or submitted during:

- The building permit phase (NRCCs).
- The construction phase (NRCIs).
- The acceptance testing (NRCAs).
- The final inspection phase (all compliance documents include building commissioning documents).

All submitted compliance documentation is required to be compiled by the builder or general contractor. A copy of the compliance documentation is required to be provided to the building owner so that the end user has information describing the energy features installed in the building.

Roles and Responsibilities

Please refer to Chapter 2.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Designer

Please refer to Chapter 2.4.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Documentation Author

Please refer to Chapter 2.4.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Builder or General Contractor

The term *builder* refers to the general contractor responsible for construction. During construction, the builder usually hires specialty subcontractors to provide specific services, such as installing insulation and designing and installing HVAC systems. The builder must ensure that the certificate(s) of installation is submitted to the enforcement agency by the person(s) responsible for construction/installation of regulated features, materials, components, or manufactured devices.

The builder may sign the NRCIs (as the responsible person) on behalf of the specialty subcontractors they hire, but generally, preparation and signature responsibility reside with the specialty subcontractor who provided the installation services. The NRCIs identify the installed features, materials, components, or manufactured devices detailed in the building plans and the NRCCs. A copy of each NRCI is required to be posted at the building site for review by the enforcement agency in conjunction with requests for final inspection.

At final inspection, the builder is required to leave all applicable completed and signed compliance documents for the building owner at occupancy in the building. Such information must, at a minimum, include information indicated on the following documents: NRCCs, NRCIs, NRCAs, NRCVs. These documents may be in paper or electronic format and must conform to the applicable requirements of Section 10-103(a).

Specialty Subcontractors

Please refer to Chapter 2.4.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Enforcement Agency

Reference: Section 10-103(a); Section 10-103(b); Section 10-103(d)

The enforcement agency is the local authority that issues building permits, verifies compliance with applicable codes and standards, and issues the final certificate of occupancy. The enforcement agency performs several key roles in the compliance and enforcement process.

- Plan check: The enforcement agency performs the plan review of the permit application, NRCCs, and building plans and specifications. During plan review, the NRCCs are compared to the plans and specifications for the building design to confirm that the building is specified consistently in all the submitted documents. If the building design features shown on the NRCCs do not conform to the specifications shown on the designer's submitted plans and specifications for the building, the submitted documents must be revised to make the design specification consistent in all documents. Thus, if the features on the NRCCs are consistent with the features given in the plans and specifications for the building design and indicates that the building complies, then the enforcement agency may issue a building permit.
- Construction inspection: During building construction, the enforcement agency should make several visits to the construction site to verify that the building is being constructed in accordance with the approved plans and specifications and Energy Code compliance documentation, including supportive documentation. At each site visit, the enforcement

agency should review any applicable NRCIs that have been posted or made available with the building permit(s). The enforcement agency should confirm that:

  - The energy efficiency features installed in the building are consistent with the requirements given in the plans and specifications for the building approved during plan review.
  - The installed features are described accurately on the NRCIs.
  - All applicable sections of the NRCIs have been signed by the responsible licensed person(s).

The enforcement agency does not issue final certificate of occupancy until it has received all applicable NRCIs.

- Final approval: The enforcement agency may approve the building at the final inspection phase if the enforcement agency field inspector determines that:
  - The building conforms to the requirements of the building plans and specifications.
  - The building meets the requirements of all other applicable codes and standards.

For buildings that have used an energy efficiency compliance feature that requires an NRCI, the enforcement agency shall not issue the final certificate of occupancy until it has received an NRCI that meets the requirements of Section 10-103(a) and has been completed and signed by the builder or subcontractor for each compliance feature. The builder must ultimately take responsibility to ensure that all required energy compliance documentation has been completed and posted at the job site or submitted to the enforcement agency in conjunction with any of the enforcement agency's required inspections.

However, the enforcement agency, in accordance with Section 10-103(d), must examine all required copies of NRCIs and NRCAs made available for the required inspections. It must confirm that these documents have been properly prepared and are consistent with the plans, specifications, and NRCCs approved by the enforcement agency for the building at plan review.

Corroboration of information provided for the owner at occupancy

At final inspection, the enforcement agency shall require the builder to leave energy compliance, operating, maintenance, and ventilation information documentation in the building (for the building owner at occupancy) as specified by Section 10-103(b). The information may be provided in a paper or electronic format.

Compliance information includes:

- Certificates of compliance.
- Certificates of installation.
- Certificates of acceptance.

- Certificates of verification

These documents are copies of the documentation submitted to or approved by the enforcement agency, and the copies must conform to the applicable requirements of Section 10-103(a).

Operating information includes instructions on how to operate or maintain the energy features, materials, components, and mechanical devices of the building correctly and efficiently. Such information shall be provided in paper or electronic format and contain all information specified in Section 10-103(b).

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

Maintenance information is provided for all features, materials, components, and manufactured devices that require routine maintenance for efficient operation. Required routine maintenance actions are clearly stated and incorporated on a readily accessible label. The label may be limited to identifying, by title or publication number or both, the operation and maintenance manual for that particular model and type of feature, material, component, or manufactured device.

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

Ventilation information for nonresidential and hotel motel buildings includes a description of the quantities of outdoor and recirculated air that the ventilation systems are designed to provide to each area. The ventilation information is provided to the building owner. If the building or tenant spaces are not individually owned and operated, or are centrally operated, the ventilation information is provided to the person(s) responsible for operating the equipment.

For buildings or tenant spaces that are not individually owned and operated, or are centrally operated, such information is provided to the person(s) responsible for operating and maintaining the feature, material, component, or mechanical ventilation device installed in the building.

Permit Applicant

Please refer to Chapter 2.4.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Plans Examiner

Please refer to Chapter 2.4.7 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Field Inspector

The field inspector is responsible for:

- Verifying that the building or system is constructed according to the plans.
- Checking off appropriate items on the summary document at each relevant inspection.

- Verifying that all the required compliance documentation (NRCIs and NRCAs are completed, dated, and signed).

The NRCCs may be used by the building permit applicant, the plans examiner, and the field inspector. This way, the permit application can call the plans examiner's attention to the relevant drawing sheets and other information, and the plans examiner can call the field inspector's attention to items that may require special attention in the field. The compliance documents and worksheets encourage communications and coordination within each discipline.

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Building Envelope

Overview

Please refer to Chapter 3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

What's New for 2025

The 2025 Energy Code include several important changes to the building envelope component requirements as described below:

- Reduced the prescriptive U-factor requirement equivalent to an additional R-2 continuous insulation for:
    - All roof/ceiling assemblies in all climate zones.
    - Metal building walls in all climate zones.
    - Wood-framed and other walls in all climate zones.
- Mass light walls in all climate zones
- Mass heavy walls in Climate Zones 1 and 11–16. Added a mandatory vestibule requirement at public entrances for buildings of Occupancy Types A, B, E, I and M. Multiple exceptions are included.
- Added a mandatory area-weighted U-factor requirement for exterior vertical fenestration assemblies.
- Added a mandatory U-factor requirement for exterior vertical fenestration alterations.

Opaque Envelope Assembly

This section addresses the requirements for thermal control of the opaque portion of the building shell or envelope.

Opaque Envelope Definitions

Please refer to Chapter 3.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Thermal Properties of Opaque Envelope Components

Please refer to Chapter 3.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

General Envelope Requirements

Please refer to Chapter 3.2.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Requirements

Infiltration and Air Leakage

Reference: Section 110.7

All joints and other openings in the building envelope that are potential sources of air leakage must be caulked, gasketed, weather stripped, 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.

Certification of Insulation Materials

Reference: Section 110.8(a)

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 Electronic and Appliance Repair, Home Furnishing and Thermal Insulation. Builders and enforcement agencies shall use the Department of Consumer Affairs *Directory of Certified Insulation Materials* to verify certification of the insulating material. 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, at (916) 999-2041 or by email: HomeProducts@dca.ca.gov.

Urea Formaldehyde Foam Insulation

Reference: Section 110.8(b)

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

If foam insulation is used that has urea formaldehyde, it must be installed on the exterior side of the wall (not in the cavity of framed walls), and a continuous 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.

Flame Spread Index and Smoke Development Index of Insulation

Reference: 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.

Mandatory Requirements for Building Envelopes

Reference: Section 120.7

Nonresidential and hotels/motel buildings must meet mandatory U-factor requirements for opaque portions of the building and fenestration portions of the building that separate conditioned spaces from unconditioned spaces or ambient air.

See the sections in Section 120.7 on roof, walls, doors, floors, and windows.

An exception is specified that exempts buildings designed as data centers with high, constant server loads from the mandatory insulation requirements. To qualify for this exception, the building should have a design computer room process load of 750 kW or greater.

Vestibules

Reference: Section 120.7(e)

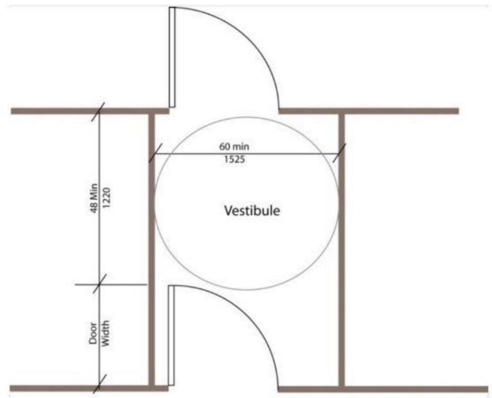
Public entrances in buildings of Occupancy Types A, B, E, I, and M must include an enclosed vestibule. A public entrance is defined in Title 24, Part 2, as an entrance that is not a service entrance or a restricted entrance. Vestibules are two doors or sets of doors between inside and outside that reduce air infiltration into the building as most times, when one door is open the other is still closed. See Figure 3- 1: Vestibule at Public Entrance. The use of vestibules leads to energy savings and improved indoor air quality in many climates.

- All doors opening into and out of the vestibule shall be equipped with self-closing devices.
- Vestibules shall be designed so that in passing through the vestibule, it is not necessary for the interior and exterior doors to open at the same time.
- Where a heating and cooling system is provided for the vestibule, it shall be thermostatically controlled to operate within a range of 60°F and 85°F and be automatically shut off when the outdoor air temperature is greater than 45°F.

Vestibules are not required for the following:

- Doors not intended to be used by the public, such as doors to mechanical or electrical equipment rooms, or intended solely for employee use
- Doors opening directly from a sleeping unit or dwelling unit
- Doors that open directly from a space less than 3,000 square feet in area
- Revolving doors installed where a public entrance to a newly constructed building is required
- Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors
- Doors that have an air curtain with a velocity of not less than 6.56 feet per second at the floor that have been tested in accordance with ANSI/AMCA 220 and installed in accordance with the manufacturer's instructions. Manual or automatic controls shall be provided that operate the air curtain with the opening and closing of the door
- Public entrances in buildings that are located in Climate Zones 2–13, where the building is less than four stories above grade and less than 10,000 square feet in of gross conditioned floor area
- Buildings with building plans that have been submitted to the local planning department before the effective date of the *2025 Building Energy Efficiency Standards,* where compliance with the vestibules requirements of Section 120.7(e) would require a resubmittal for approval

Figure 3-1: Vestibule at Public Entrance



Source: California Statewide CASE Team

Air Barrier

Prescriptive Requirements for Air Barriers

Reference: Section 140.3(a)9, Table 140.3-B

The 2025 Energy Code requires that the air barrier is clearly detailed on construction documents and that acceptable air barrier materials are used. Verification may be carried out by blower door testing. This measurement procedure is described in Nonresidential Appendix NA5.

Construction documents shall include details, notes, or specifications to clearly identify air barrier boundaries, interconnections, penetrations, and associated square foot calculations for all sides of the air barrier. See Figure 3-2: Sample Detail Indicating Strategy of Maintaining Air Barrier Continuity at Duct Penetration of a Concrete Wall, for example.

Table 140.3-B of the Energy Code specifies material requirements for air barriers in nonresidential buildings. Air barrier requirements apply to nonresidential buildings, but not relocatable public school buildings, and cannot be traded off in the performance approach. These requirements reduce the overall building air leakage rate. The reduction in air leakage can be met with a continuous air barrier that seals all joints and openings in the building envelope and is composed of one of the following:

- Materials having a maximum air permeance of 0.004 cfm/ft² (Table 3-1: Materials Deemed to Comply as Air Barrier).
- Assemblies of materials and components having an average air leakage not exceeding 0.04 cfm/ft².

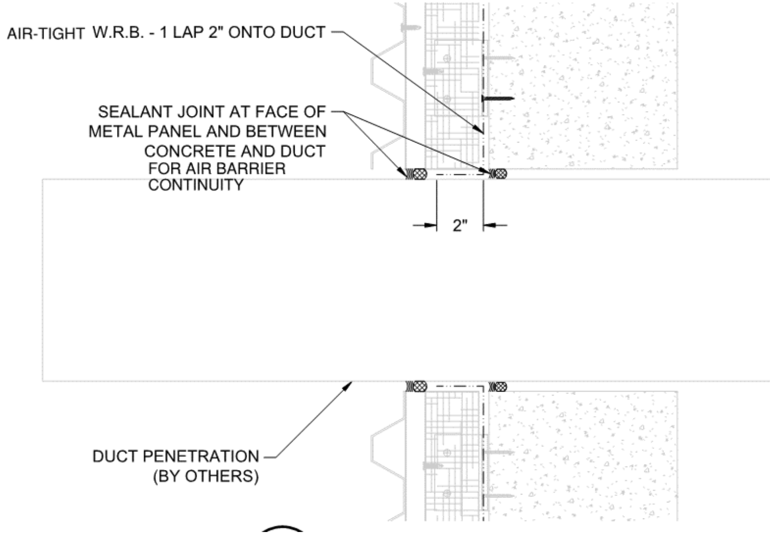
The air leakage requirements stipulated in Section 140.3 may be verified by demonstrating that the whole-building air leakage of 0.4 cfm/ft² is not exceeded.

Table 3-1: Materials Deemed to Comply as Air Barrier

MATERIALS AND THICKNESS
Plywood – min. 3/8 inches thickness
Oriented strand board – min. 3/8 inches thickness
Extruded polystyrene insulation board – min. ½ inches thickness
Foil-back polyisocyanurate insulation board – min. ½ inches thickness
Closed- cell spray foam with a minimum density of 2.0 pcf and a min. 1½2.0 inches thickness
Open cell spray foam with a density no less than 0.4 pcf and no greater than 1.5 pcf, and a min. 5½ inches thickness
Exterior or interior gypsum board min. ½ inches thickness
Cement board – min. ½ inches thickness
Built-up roofing membrane
Modified bituminous roof membrane
Fully adhered single-ply roof membrane
A Portland cement or Portland sand parge, or a gypsum plaster, each with min. 5/8 inches thickness
Cast-in-place concrete, or precast concrete
Fully grouted concrete block masonry
Sheet steel or sheet aluminum

Source: California Energy Commission

Figure 3-2: Sample Detail Indicating Strategy of Maintaining Air Barrier Continuity at Duct Penetration of a Concrete Wall



Source: California Statewide CASE Team

Roofing Products and Insulation

The U-factor criteria for roofs depend on the class of construction. U-factors used for compliance must be selected from Reference Appendices, Joint Appendix JA4. Alternatively, the assembly calculator that is incorporated into California Building Energy Code Compliance (CBECC) software can be used to determine U-factors for assemblies or components not listed in JA4 or both.

Mandatory Requirements for Roofing Products and Insulation

Roof/Ceiling Insulation

Reference: Section 120.7(a)

Metal building: Weighted average U-factor of U-0.098 (R-19 screw down roof, no thermal blocks. See JA4 Tables for additional configurations).

Wood-framed and others: Weighted average U-factor of U-0.075 (2x4 rafter, R-19 insulation. See JA4 Tables for additional configurations).

Insulation Placement on Roof/Ceilings

Reference Section 120.7(a)3

Insulation installed on top of suspended (T-bar) ceilings with removable ceiling panels may not be used to comply with the Energy Code unless the installation meets the criteria described in the *Exception* to Section 120.7(a)3 below. Insulation may be installed in this location for other purposes such as for sound control, but it will have no value in terms of meeting roof/ceiling insulation requirements of the Energy Code.

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

When insulation is installed at the roof in nonresidential buildings, the space between the ceiling and the roof is considered either directly or indirectly conditioned space. Therefore, this space must not include fixed vents or openings to the outdoors or to unconditioned spaces. This space is not considered an attic for complying with California Building Code (CBC) attic ventilation requirements. Vents that do not penetrate the roof deck and that are designed for wind resistance for roof membranes are acceptable.

Exception to Section 120.7(a)3: When there are conditioned spaces with a combined floor area no greater than 2,000 square feet in an otherwise unconditioned building, and when the average height of the space between the ceiling and the roof over these spaces is greater than 12 feet, insulation placed in direct contact with a suspended ceiling with removable ceiling panels shall be an acceptable method of reducing heat loss from a conditioned space and shall be accounted for in heat loss calculations.

Wet Insulation Systems

Reference 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 before choosing the table column in Reference Joint Appendix JA4 for determining assembly U-factor. See the footnotes in JA4 for Tables 4.2.1 through 4.2.7.

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

Reference: Section 10-113, Section 110.8(i)

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 and thermal emittance of the roofing product must be tested and certified according to CRRC procedures. The aged solar reflectance and thermal emittance properties are rated and listed by the Cool Roof Rating Council, https://www.coolroofs.org/. When a CRRC rating is not obtained for the roofing products, the Energy Code default values for solar reflectance and thermal emittance must be used.

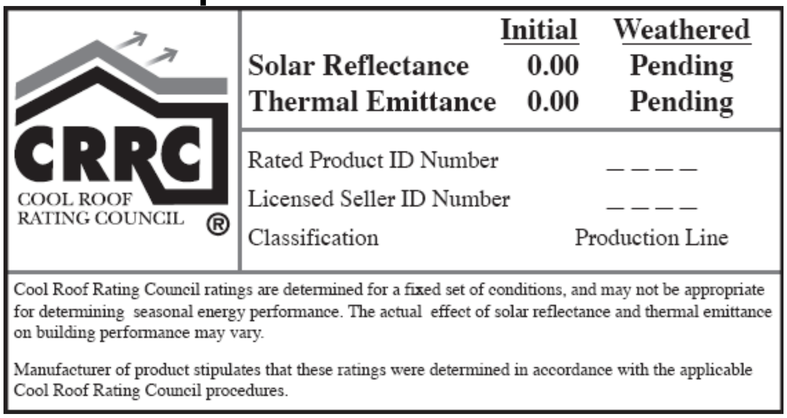
Rating and Labeling

Reference: Section 10-113

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

Figure 3-3: Sample CRRC Product Label and Information



Source: Cool Roof Rating Council

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

Reference: Section 110.8(i)1-3

Both solar reflectance and thermal emittance are measured from 0 to 1; the higher the value, the "cooler" the roof. There are numerous roofing materials in a wide range of colors that have 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 quickly (upward and out of the building) than roof surfaces with low-emitting properties.

Solar reflectance (SR): There are three measurements of solar reflectance:

- Initial solar reflectance
- Three-year aged solar reflectance
- Accelerated aged solar reflectance

All requirements of the Energy Code are based on the three-year aged solar reflectance. 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.

$$AAAAAAAA\ RRAARRRRAARRRRRRRRRRAA_{cccccccccccccccccc} = [0.2 + \beta\beta \times (rr_{iiiiiicciiccc} - 0.2)]$$

Where,

- rinitial = 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 thermal emittance, 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 aged solar reflectance and thermal emittance values must be used for compliance:

- For asphalt shingles, 0.08/0.75
- 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 of a surface 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 thermal emittance of the desired roofing material. The calculator can be found at [Solar Reflective Index (SRI) Calculation Worksheet.]() The SRI worksheet can calculate the aged solar reflectance of the roofing product if it is not available. The thermal emittance value can be either the initial or the three-year aged value. By using the SRI calculator, a cool roof may comply with a lower emittance, as long as the aged solar reflectance is higher and vice versa. The CRRC aged SRI values can be used to show compliance. However, when the aged SRI value is not available from the CRRC, then use the CEC SRI calculation worksheet.

Field-Applied Liquid Coatings

Reference: Section 110.8(i)4, Table 110.8-C

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 thermal emittance 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.[1] 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.

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,[2] 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.

Prescriptive Requirements for Roofing Products and Insulation

Thermal Emittance and Aged Solar Reflectance

Reference: Section 140.3(a)1A, Table 140.3-B, Table 140.3-C, Table 140.3-D

The prescriptive requirements call for roofing products to meet the aged solar reflectance and thermal emittance in low-sloped and steep-sloped roof applications for nonresidential buildings. A qualifying roofing product under the prescriptive approach for a nonresidential building must have an aged solar reflectance and thermal emittance greater than or equal to the values indicated in Tables 140.3-B of the Energy Code.

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

---

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

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

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

2 A. This guide is intended for the evaluation of clear and pigmented coatings designed for use on rigid or semi rigid plastic substrates. Coated film and sheeting are not covered by this guide.

B. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Exceptions to the minimum prescriptive requirements for aged solar reflectance and thermal emittance include the following:

- Roof area covered by building-integrated photovoltaic panels and building-integrated solar thermal panels is not required to meet the cool roof requirements. 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 façades.
- If the roof construction has a thermal mass like gravel, concrete pavers, stone, or other materials with a weight of at least 25 lb/ft² over the roof membrane, then it is exempt from the above requirements for solar reflectance and thermal emittance.
- Wood-framed roofs in Climate Zones 3 and 5 with a U-factor of 0.034 are exempt from the low-sloped cool roof requirement.

Where the aged reflectance of a low-sloped nonresidential roof is less than the prescribed requirement, insulation tradeoffs are available. By increasing the insulation level of a roof, a roofing product with a lower reflectance than the prescriptive requirements can be used to meet the cool roof requirements. The appropriate U-factor can be determined from Table 3-2: Roof/Ceiling Insulation Tradeoff for Aged Solar Reflectance for nonresidential buildings based on roof type, climate zone and aged reflectance of at least 0.25.

Table 3-2: Roof/Ceiling Insulation Tradeoff for Aged Solar Reflectance

Aged Solar Reflectance	Metal Building Climate Zone 1-16 U-factor	Wood-Framed and Other Climate Zone 6, 7, and 8 U-factor	Wood Framed and Other All Other Climate Zones U-factor
0.62-0.56	0.038	0.039	0.029
0.55-0.46	0.035	0.036	0.028
0.45-0.36	0.033	0.033	0.027
0.35-0.25	0.031	0.032	0.026

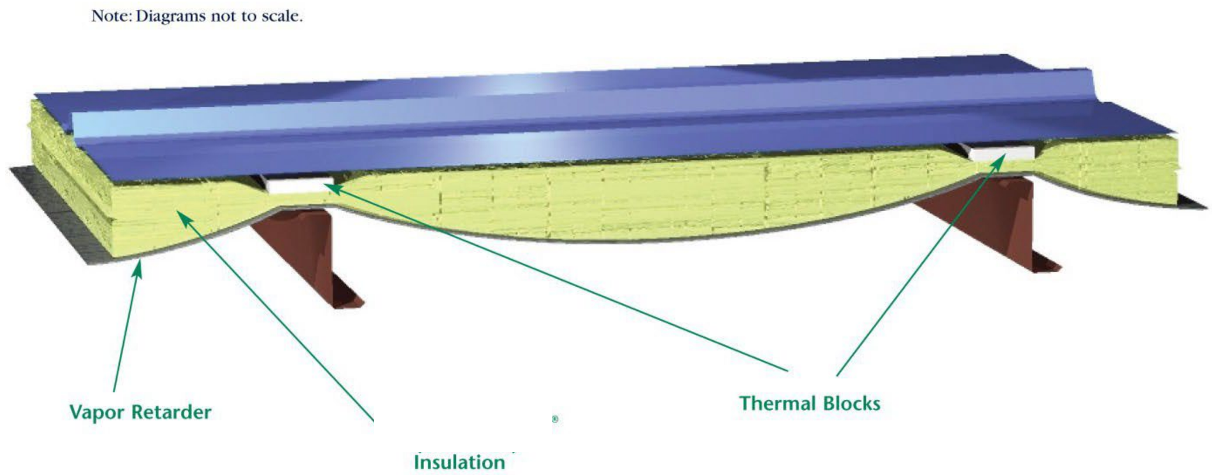
Source: Energy Code, Table 140.3

Reference: Section 140.3(a)1B, Table 140.3-B, Table 140.3-C, Table 140.3-D

Under the prescriptive requirements, roofs or ceilings must have an assembly U-factor equal to or lower than the U-factor criterion for nonresidential buildings. The U-factor values for exterior roofs and ceilings from Reference Appendices, Joint Appendix JA4 must be used to determine compliance with the maximum assembly U-factor requirements. Alternatively, the assembly calculator that is incorporated into the approved energy modeling software can be used to determine U-factors for assemblies or components not listed in JA4 tables or both.

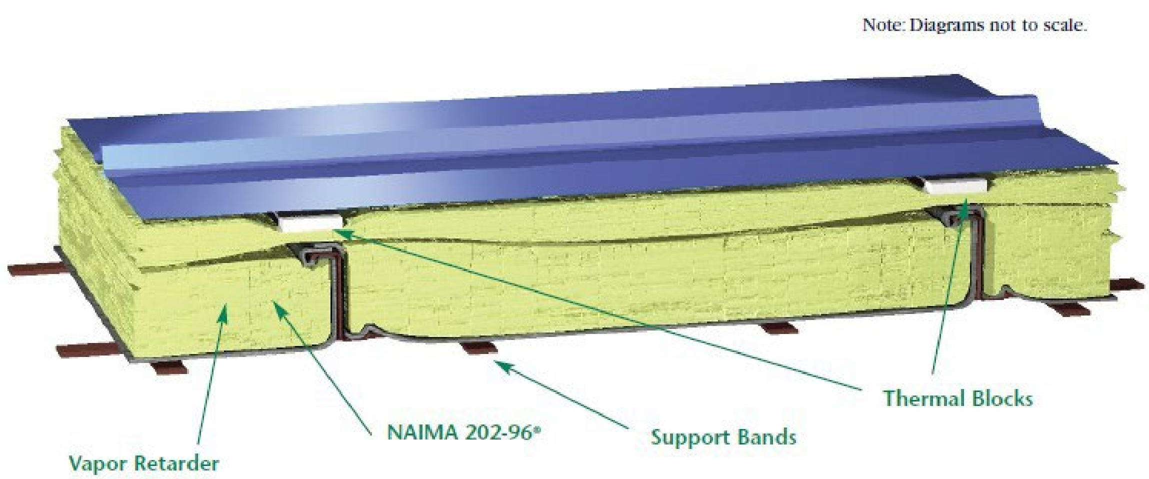
The prescriptive requirement for metal building roofs requires the entire cavity be filled with insulation. A common technique for standing seam metal roofs is to drape a layer of insulation over the purlins, using thermal blocks where the insulation is compressed at the supports (See Figure 3-4: Standing Seam Metal Building Roof with Single Insulation Layer). Either approach on insulation may be used in the performance approach. However, there are significant benefits to using the “filled cavity” approach, as shown in Figure 3-5: Filled Cavity Insulation for Metal Building Roofs.

Figure 3-4: Standing Seam Metal Building Roof with Single Insulation Layer



Source: North American Insulation Manufacturers Association (NAIMA)

Figure 3-5: Filled Cavity Insulation for Metal Building Roofs



Source: North American Insulation Manufacturers Association (NAIMA)

A rigid polyisocyanurate ("polyiso") thermal block with a minimum R-value of R-3.5 should be installed at the supports (a 1-inch-thick thermal block is recommended). The first rated R-value of the insulation is for faced insulation installed between the purlins. The second rated R-value of insulation represents unfaced insulation installed above the first layer, perpendicular to the purlins and compressed when the metal roof panels are attached. A supporting structure retains the bottom of the first layer at the prescribed depth required for the full thickness of insulation.

The bottom layer of insulation should completely fill the space between the purlins, and the support bands should be installed tightly to prevent the insulation from sagging.

The configuration in Figure 3-5: Filled Cavity Insulation for Metal Building Roofs shown with two layers, one of R-19 and one of R-10 insulation, corresponds to the prescriptive requirement of U-0.038. Other insulation combinations exceeding the minimum requirement are readily achievable. See the JA4 Tables for additional configurations.

Performance Approach

Reference: Section 10-113, Section 140.1, Table 140.3

Compliance options for roofing products and insulation. See Performance Approach and Chapter 12 for more on the performance approach.

Example 3-1

Question:

According to the provisions of the Energy Code, are cool roofs mandatory for nonresidential buildings?

Answer:

No. Cool roofs are not mandatory. The prescriptive compliance requirements depend on the climate zone, building type, and roof slope. Compliance with aged solar reflectance and thermal emittance, or SRI, is required per the Energy Code, Tables 140.3-B, C, and D. In the performance approach, reflectance, and emittance values less than the minimum prescriptive requirements may be used; however, any deficit that results from this choice must be made up by improving other energy efficiency features in the building, which include envelope, space-conditioning system, and lighting systems. Some local jurisdictions may have additional cool-roof requirements.

Example 3-2

Question:

Must all roofing materials used in California, whether cool roof or not, be certified by the Cool Roof Rating Council (CRRC) and labeled accordingly?

Answer:

Yes, when altering your roof, such as a new reroof or replacement of 50 percent or 2,000ft^2, whichever is less, either the prescriptive envelope component approach or the performance approach can be used for compliance. In these cases, the roof must be certified and labeled by the CRRC for nonresidential roofs. If you are using the performance approach to receive compliance credit, you can either obtain a CRRC certification **or** use a default solar reflectance of 0.10 and thermal emittance of 0.75. Using default values instead of CRRC certificates may result in a significant energy penalty that must be made up by increasing energy efficiency in other building features. The default solar reflectance for asphalt shingles is 0.08.

However, in the case of a roof repair, such as for a leak, the roofing product does not need to be a cool roof nor certified by the CRRC.

Example 3-3

Question:

Can I use aged solar reflectance and thermal emittance data generated by any nationally recognized and well-respected laboratory in lieu of CRRC ratings? Can in-house testing by the manufacturer be used to qualify my product?

Answer:

No. Only CRRC ratings from the product directory list can be used to establish cool-roof product qualification for standards compliance. The CRRC process requires use of a CRRC-accredited laboratory (under most circumstances, an "Accredited Independent Testing Laboratory (AITL) defined by the CRRC program). Any testing laboratory can become an AITL by following the CRRC accreditation process and satisfying the requirements. The roster of CRRC-accredited laboratories is posted on the CRRC website (http://www.coolroofs.org).

Example 3-4

Question:

Can the reflectance and emittance requirements of ENERGY STAR® cool roofs be substituted for standards requirements?

Answer

No. Only roofing products that are listed by the CRRC in its Rated Product Directory can be used to comply with the standards. The CRRC is the only organization that has met the criteria set in Section 10-113.

Example 3-5

Question:

Can I claim to have a cool roof, or can I get anything higher than a default reflectance, if my roof does not meet the field-applied coating performance requirements of the Energy Code?

Answer:

No, you cannot claim to have a cool roof, and you cannot claim higher energy credits if your roof does not meet the coating performance requirements of the Energy Code for field-applied coatings.

Example 3-6

Question:

How does a product get CRRC cool roof certification?

Answer:

Any party wishing to have a product or products certified by CRRC should contact the CRRC toll-free (866) 465-2523 from inside the United States or (510) 482-4420, ext. 215, or email info@coolroofs.org. In addition, the CRRC publishes the procedures in the *CRRC-1 Program Manual*, available for free on http://www.coolroofs.org or by calling the CRRC. Working with CRRC staff is strongly recommended.

Example 3-7

Question:

Do alterations to the roof of an unconditioned building trigger cool-roof requirements?

Answer:

No, alterations to the roof of an unconditioned building do not trigger cool-roof requirements. In general, the lighting requirements are the only requirements applicable for newly constructed and altered unconditioned buildings; these requirements include Section 140.3(c), the skylight requirements. Building envelope (other than skylight requirements) and space-conditioning requirements do not apply to unconditioned buildings.

Example 3-8

Question:

What happens if I have a low-sloped roof on most of my buildings and steep-sloped roof on another portion of the roof? Do I have to meet the two different sets of rules in Section 140.3(a)1Ai and ii?

Answer:

Yes, your building would have to meet both the low-sloped requirement and the steep-sloped roof requirements for the respective areas.

Example 3-9

Question:

I am installing a green/garden roof (roofs whose surface is composed of soil and plants) on top of an office building. Although green/garden roofs are not cool roofs by the reflectance properties, will they be allowed under the Energy Code?

Answer:

Yes, the California Energy Commission considers a green/garden roof as a roof with thermal mass on it.

Under Exception 4 to Section 140.3(a)1Ai, if a garden roof has a dry unit weight of 25 lb/ft^2, then the garden roof is equivalent to a cool roof.

Example 3-10

Question:

When installing a new roof with building-integrated photovoltaic panels, is the entire roofing exempt from the Energy Code requirements in Section 140.3(a)1A?

Answer:

No. Only the active photovoltaic area of the roof is exempt from these requirements. The nonactive sections of the roofing product must comply with the Energy Code and be rated by the CRRC.

Exterior Walls

The U-factor criteria for walls depend on the class of construction. U-factors used for compliance must be selected from Reference Appendices, Joint Appendix JA4. Alternatively, the assembly calculator that is incorporated into California Building Energy Code Compliance (CBECC) software can be used to determine U-factors for assemblies or components not listed in JA4 or both.

There are five common classes of wall constructions: wood-framed, metal-framed, metal building walls, light mass, and heavy mass (Figure 3-7). 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 2025 California Building Code, Type IV 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 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. 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: These 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.

Note**:** 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.

- Furred walls: These walls are a specialty wall component, commonly applied to a mass wall type. See Figure 3-6: Brick Wall With Furring Details. The Reference Appendices, Joint Appendix JA4, Table 4.3.5, 4.3.6, or other masonry tables list alternative walls. Additional continuous insulation layers are selected from JA4 Table 4.3.13 and calculated using either Equation 4-1 or 4-4 from JA4. The effective R-value of the furred component depends upon the framing thickness, type, and insulation level.

Figure 3-6: Brick Wall With Furring Details

Source: California Energy Commission

- Spandrel panels and curtain walls: These wall types consist of metalized, opaque, or semitranslucent glass panels often hung outside structural framing to create exterior wall elements around fenestration and between floors. See Reference Appendices, Joint Appendix JA4, Table 4.3.8, for U-factor data.

For some climate zones, mass walls and metal-framed walls require continuous insulation to meet the prescriptive U-factor requirements. When this is the case, the effect of the continuous insulation is estimated by Equation 4-1 in Reference Appendices, Joint Appendix JA4.

$$UU_{pppppppp} = \frac{1}{UU_{ccppcc,AA}} + \; RR_{ccppiicc,iiiiiicccc}$$

Framed or block walls can also have insulation installed between interior or exterior furring strips. The effective continuous R-value of the furring/insulation layer is shown in Table 4.3.13 of Reference Appendix JA4.

Example 3-11

Question:

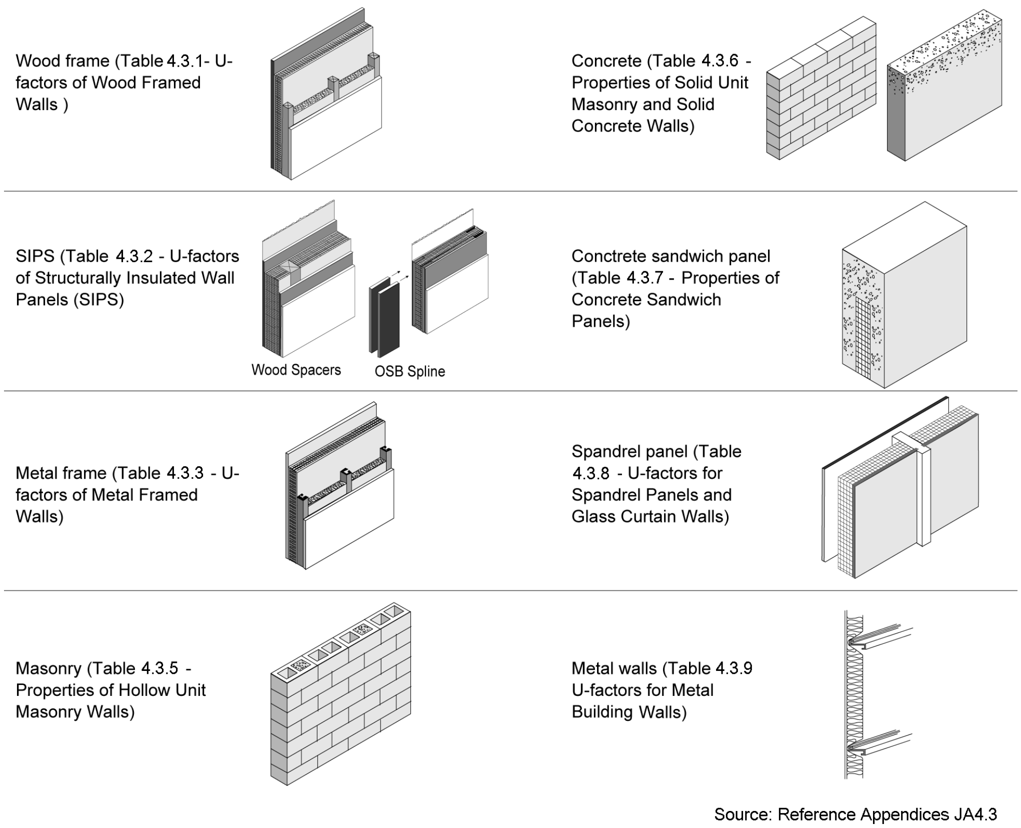
An 8-inch (20 cm) medium-weight concrete block wall with uninsulated cores has a layer of 1-inch- (25 mm) thick exterior polystyrene continuous insulation with an R-value of R-5. What is the U-factor for this assembly?

Answer:

From Reference Appendices, Joint Appendix JA4, Table 4.3.5, the U-factor for the block wall is 0.53. From Equation 4-1, the U-factor is calculated as:

U= 1 / [(1/0.53) + 5] = 0.145

Figure 3-7: Classes of Wall Construction



Source: Reference Appendix JA4.3

Mandatory Requirements for Wall Insulation

Reference: Section 110.8, Section 120.7(b)

In addition to the mandatory requirements in Section 110.8 for all buildings, nonresidential hotels and motels must also meet the requirements in Section 120.7.

The opaque portions of walls that separate conditioned spaces from unconditioned spaces or ambient air shall meet these applicable requirements.

- Metal building: Weighted average U-factor of U-0.113 (single layer of R-13 batt insulation. See JA4 Tables for additional configurations).
- Metal-framed: Weighted average U-factor of U-0.151 (R-8 continuous insulation, or R-13 batt insulation between studs and 1/2" of continuous rigid insulation of R-2. See JA4 Tables for additional configurations). It may be possible to meet the area-weighted average U-factor without continuous insulation if the appropriate siding materials are used.
- Light-mass walls: 6 inches or greater hollow core concrete masonry unit having a U-factor not exceeding 0.440 (partially grouted with insulated cells).
- Heavy-mass walls: 8 inches or greater hollow core concrete masonry unit having a U-factor not exceeding 0.690 (solid grout concrete, normal weight, 125 lb/ft^3).

- Wood-framed and others: Weighted average U-factor of U-0.110 (R-11 batt insulation. See JA4 Tables for additional configurations).
- Spandrel panels and curtain wall: Weighted average U-factor of U-0.280.

Exception to Section 120.7: Buildings designed as data centers with high, constant server loads are exempt from the mandatory minimum requirements. To qualify for this exception, it should have a design computer room process load of 750 kW or greater.

Prescriptive Requirements for Wall Insulation

Reference: Section 140.3(a)2, Table 140.3-B, Table 140.3-C, Table 140.3-D

Under the prescriptive requirements, exterior walls must have an assembly U-factor equal to or lower than the U-factor criterion for nonresidential buildings in Tables 140.3-B, C, or D.

The U-factor for exterior walls from Reference Appendices, Joint Appendix JA4, must be used to determine compliance with the assembly U-factor requirements. The Energy Code does not allow using the R-value of the cavity or continuous insulation alone to demonstrate compliance with the insulation values of Reference Appendices, Joint Appendix JA4; only U-factors may be used to demonstrate compliance.

For metal-framed walls with insulation between the framing sections, continuous insulation may need to be added to meet the U-factor requirements of the Energy Code. For light mass walls, insulation is required in all climate zones. For heavy mass walls, insulation is not required for buildings in Climate Zones 2–10 but is required for other climate zones.

Demising Walls

Mandatory Insulation for Demising Walls

Please refer to Chapter 3.2.10.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Exterior Doors

Exterior doors are operable openings in the building envelope, including swinging and roll-up doors, fire doors, pet doors, and access hatches with less than 25 percent glazed area. When an exterior door has 25 percent or more glazed area, it is considered fenestration.

Mandatory Requirements for Exterior Doors

Please refer to Chapter 3.2.11.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Requirements for Exterior Doors

Reference: Section 140.3(a)7, Table 140.3-B, Table 140.3-C, Table 140.3-D

The Energy Code defines prescriptive requirements for exterior doors in Tables 140.3-B and 140.3-C. For swinging doors, the maximum U-factor is 0.70, and for nonswinging doors, the maximum allowed U-factor is 1.45 in Climate Zones 2 through 15 and 0.50 in Climate Zones 1 and 16. Refer to the Energy Code, Tables 140.3-B, 140.3-C, and 140.3-D, for exterior door U-factor requirements. 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.

The swinging door requirement corresponds to uninsulated double-layer metal swinging doors. The 1.45 swinging door U-factor requirement corresponds to insulated single-layer metal doors or uninsulated single-layer metal roll-up doors and fire-rated doors. The 0.50 U-factor requirement for Climate Zones 1 and 16 corresponds to wood doors with a minimum nominal thickness of 1¾ inches. For more information, consult Reference Appendices, Joint Appendix JA4, Table 4.5.1.

When glazing area is 25 percent or more of the entire door area, it is then defined as a fenestration product in the Energy Code, and the entire door area is modeled as a fenestration unit. If the glazing area is less than 25 percent of the door area, the glazing must be modeled as the glass area plus two inches in each direction of the opaque door surface (to account for a frame). However, exterior doors are part of the gross exterior wall area and must be considered when calculating the window-to-wall ratio.

Floors

Please refer to Chapter 3.2.12 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Requirements for Floors

Please refer to Chapter 3.2.12.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Requirements for Floors

Please refer to Chapter 3.2.12.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Fenestration (Window/Skylight/Glazed Door)

Please refer to Chapter 3.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Fenestration Definitions

Please refer to Chapter 3.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Fenestration Categories

Please refer to Chapter 3.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additional Fenestration Definitions

Please refer to Chapter 3.3.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Requirements for Fenestration Certification and Labeling

Please refer to Chapter 3.3.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Certification and Labeling

Reference: Section 10-111, Section 10-112, Section 110.6. Reference Nonresidential Appendices NA6

The Administrative Regulations Section 10-111 and Section 110.6 require that fenestration products have labels that list the U-factor, solar heat gain coefficient (SHGC), visible transmittance (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 3-8: NFRC Manufactured Label), which is not to be removed before inspection by the enforcement agency. The manufacturer rates and labels its fenestrations products for U-factor, SHGC, and VT.

The manufacturer can choose to have the fenestration product rated and labeled in accordance with the National Fenestration Rating Council (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 3-8: NFRC Manufactured Label

Source: NFRC

Default Temporary Label

Fenestration product manufacturers can choose to use default performance values for U-factors in Table 110.6-A and SHGC in Table 110.6-B. For fenestration products requiring a VT value, assume a value of 1.0 as specified in the Reference Appendices, Nonresidential Appendix NA6. The manufacturer must attach a temporary label to each window (Figure 3-9: Sample Default Temporary Label), and manufacturer specification sheets or cut sheets must be included with compliance documentation. An NRCC-ENV-E will be required to document the thermal performance if no default temporary labels are attached to the window units.

There is no exact format for the default temporary label. It must be clearly visible and large enough to be clearly visible from 4 feet for the enforcement agency field inspector to read easily. It must include all information required by the regulations. The minimum suggested label size is 4 inches x 4 inches, and the label must have the following words at the bottom of the label:

"Product meets the air infiltration requirements of Section 110.6(a)1, U-factor criteria of Section 110.6(a)2, SHGC criteria of Section 110.6(a)3, and VT criteria of Section 110.6(a)4 of the 2025 California Building Energy Efficiency Standards for Residential and Nonresidential Buildings."

If the product claims the default U-factor for a thermal-break product, the manufacturer must certify that the thermal-break criteria upon which the default value is based are met by placing a check in the check box:

- Air space 7/16 inch or greater
- For skylights, the label must indicate the product was rated with a built-in curb
- Meets thermal-break default criteria

Figure 3-9: Sample Default Temporary Label
2025 California Energy Commission Default Label

XYZ Manufacturing Co.

Key Features:	o Doors	o Double-Pane
	o Skylight	o Glass Block
Frame Type	**Product Type:**	**Product Glazing Type:**
o Metal	o Operable	o Clear
o Non-Metal	o Fixed	o Tinted
o Metal, Thermal Break	o Greenhouse/Garden Window	o Single-Pane
o Air space 7/16 in. or greater o With built-in curb o Meets Thermal-Break Default Criteria	----------	To calculate VT see NA6
California Energy Commission Default U-factor =	**California Energy Commission** Default SHGC =	**California Energy Commission** Calculated VT =

Source: California Energy Commission

Product meets the air infiltration requirements of Section 110.6(a)1, U-factor criteria of Section 110.6(a)2, SHGC criteria of Section 110.6(a)3, and VT criteria of Section 110.6(a)4 of the *2025 California Building Energy Efficiency Standards for Residential and Nonresidential Buildings*.

For the visible transmittance (VT) of diffusing skylights that is not covered by NFRC 200 or NFRC 203, a test report should be included using the ASTM E972 method.

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 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:

- Design energy-efficient windows, curtain wall systems, and skylights for high-performance building projects.
- Determine whether a product meets the specifications for a project and local/state building energy codes.
- 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 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 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.

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:

- The CMA’s online tool has the ability to output a file with values for use in building energy analysis software programs.
- The program can export detailed information for angular-dependent SHGC and VT values, seamlessly transferring the data to the analytical software.

- A 2010 study[3] 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 default calculation methods of the Energy Codes.
- The 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 because of more accurate fenestration performances and potential energy benefits from above-code utility incentives. Details are available at www.NFRC.org.

Figure 3-10: 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: NFRC

3 Study conducted by the Heschong Mahone Group for NFRC, "Compared to alternative fenestration rating values detailed in California's Title 24, using CMA provides a maximum increase of 11.7 percent in energy compliance margins. This means that compared to other available options, CMA provides the most accurate values on window energy and visible performance."

Figure 3-11: 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:

CPD ID	Total Area	Name	Framing Ref	Glazing Ref	Spacer Ref	CERTIFIED Performance Rating at NFRC Model Size		
						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: NFRC

Fenestration Certificate NRCC-ENV-E

For nonrated products where no default label certificates are placed on the fenestration product, use the NRCC-ENV-E to document thermal performances of each fenestration product that results in a different U-factor, SHGC, and VT. One certificate will suffice when all the windows are the same.

The NRCC-ENV-E should indicate the total amount of non-NFRC-rated fenestration products throughout the project. The locations and orientations where fenestration products are being installed should be indicated on the drawings and in a fenestration schedule that lists all fenestration products.

The NRCC-ENV-E should clearly identify the appropriate table or equation that is used to determine the default U-factor and SHGC and, if applicable, the center of glass, $SHGC_C$, used in calculating the $SHGC_{fen}$. Manufacturer's documentation of these product characteristics that list the center-of-glass values must also be attached to the NRCC-ENV-E and located at the job site for verification.

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.

- For site-built skylight fenestration 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 a NFRC label certificate from either approach listed below:
    - 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
- For new, altered and replacement site-built skylight fenestration totaling less than 200 ft^2 the glazing contractor or specifier must comply with one of the following:
    - A 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:

- Architects or engineers or both design the basic glazing system by specifying the components, the geometry of the components, and, sometimes, the assembly method.
- An extrusion manufacturer provides the mullions and frames that support the glazing and is responsible for thermal breaks.
- 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.
- 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.
- 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.
- 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 before 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 Reference Nonresidential Appendix NA6.

Field-Fabricated Fenestration and Field-Fabricated Exterior Door

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 NRCC-ENV-E with the default values is required. Field-fabricated fenestration and field-fabricated exterior doors may be installed only if the documentation has demonstrated compliance with the Energy Code.

For field-fabricated fenestration, the U-factor and SHGC default values can be found in Table 110.6-A and Table 110.6-B, respectively, below. Values are determined by frame type, fenestration type, and glazing composition.

Exterior doors with glazing for 25 percent or more of the door area are treated as fenestration products and must meet all requirements and ratings associated with fenestration. When a door has glazing of less than 25 percent the door area, the portion of the door with fenestration must be treated as part of the envelope and the fenestration independent of the remainder of the door area.

The field inspector is responsible for ensuring field-fabricated fenestration meets the specific U-factor, SHGC, and VT, as listed on the NRCC-ENV-E. Thermal break values do not apply to field-fabricated fenestration products.

Vertical Fenestration (Windows and Doors)

Mandatory Requirements for Vertical Fenestration

Reference: Section 120.7(d)

Exterior vertical fenestration assemblies in new construction are required to have a maximum area-weighted average U-factor no greater than 0.47. This requirement must be met even when complying using the performance approach. The U-factors essentially require thermally broken metal frames or better (wood, metal clad wood, or plastic frames) and double glazing with either low-emissivity coating or a low-conductivity gas fill (argon or krypton). Since the requirement is an area-weighted U-factor, one can offset higher U-factor windows with more efficient lower U-factor windows.

Prescriptive Requirements for Vertical Fenestration

Reference: Section 140.3(a)5

There are four aspects of the envelope component approach for windows:

- Maximum total area plus west-facing
- Maximum U-factor
- Maximum relative solar heat gain coefficient (RSHGC)

- Minimum visible transmittance (VT)

Conditioned greenhouses are excepted from the requirements of Section 140.3(a)5 and must meet the requirements of Section 120.6(h)3B.

Window Area

Reference: Section 140.3(a)5.A.

In the prescriptive approach, the total window area may not exceed 40 percent of the gross wall area (encompassing total conditioned space) for the building. Likewise, the west-facing window area may not exceed 40 percent of the west gross wall area (encompassing total conditioned space for the building). This maximum area requirement will affect those buildings with very large glass areas, such as high-rise offices, automobile showrooms, or airport terminals.

The maximum area may be determined by multiplying the length of the display perimeter by 6 feet in height and use the larger of the product of that multiplication or 40 percent of gross exterior wall area.

Display perimeter is the length of an exterior wall in a Group B; Group F, Division 1; or Group M occupancy that immediately abuts a public sidewalk, measured at the sidewalk level for each story that abuts a public sidewalk. This generally refers to retail display windows, although other occupancies such as offices can also have a display perimeter. Public sidewalks are accessible to the public (no obstructions, limits to access, or intervening nonpublic spaces). Demising walls are not counted as part of the display perimeter.

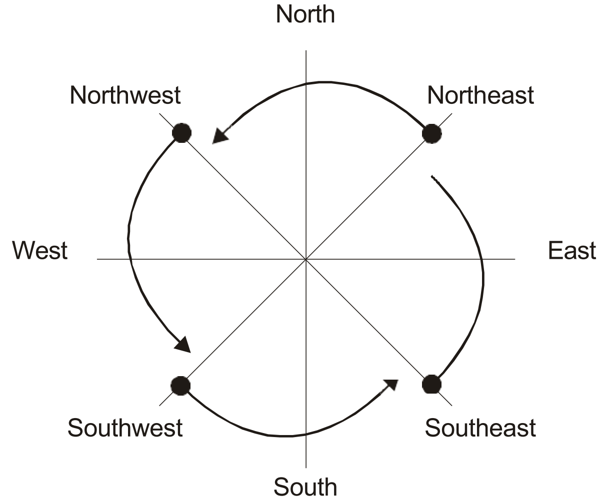
Glazing in a demising wall does not count toward the total building allowance. There is no limit to the amount of glazing allowed in demising walls, but it must meet the prescriptive U-factor requirements for the climate zone.

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 3-12: 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 3-12: Four Surface Orientations



Source: California Energy Commission

Window U-Factor

Reference: Section 140.3(a)5B, Table 140.3-B, Table 140.3-C

Fenestration products must meet the prescriptively required maximum U-factor criteria in Tables 140.3-B and 140.3-C of the Energy Code for each climate zone. Most NFRC-rated multiglazed windows with a low-e coating and a thermally broken frame will comply with the U-factor criterion. See NFRC's Certified Product Directory database at https://nfrc.org/ or use Equation NA6-1 found in Reference Appendices Nonresidential Appendix NA6. Note that NA6 calculations are applicable for skylights.

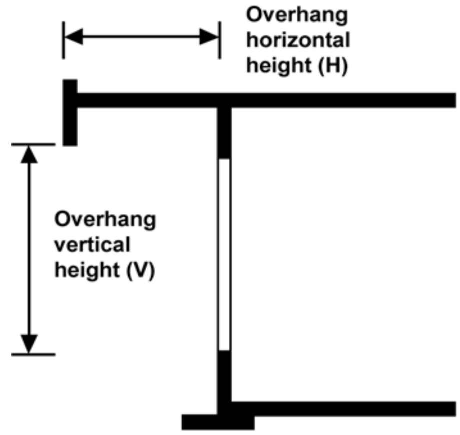
SHGC and Shading Factor

Reference: Section 140.3(a)5C

Relative solar heat gain (RSHGC) allows for an external shading correction. It is calculated by multiplying the SHGC of the fenestration product by a shading factor (SHF). If shading does not exist, then the shading factor is 1.0. Relative solar heat gain is applicable only when using the prescriptive compliance approach. Tables 140.3-B and 140.3-C specify the maximum area-weighted average RSHGC, excluding the effects of interior shading.

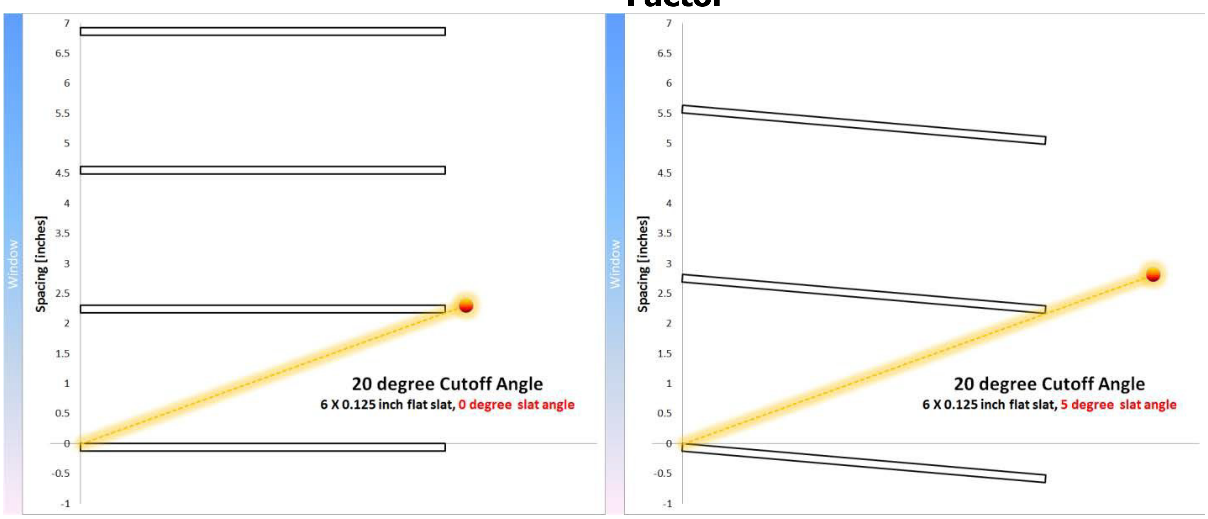
Shading factors depend upon the projection factor (PF) from Equation 140.3-C, which is the ratio of the projection (P) and the spacing (s). These dimensions are measured from the vertical and horizontal planes passing through the bottom edge of the window glazing for overhangs or the slat below for horizontal slats, as shown in Figure 3-13: Overhang Dimensions and Figure 3-14: 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)5Cii), 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 3-13: Overhang Dimensions



Source: California Energy Commission

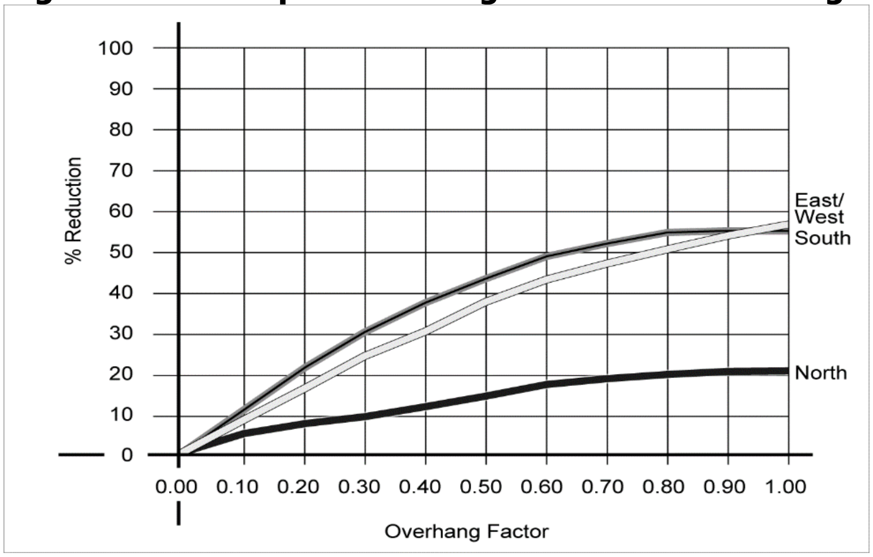
Figure 3-14: Exterior Horizontal Slat – Cutoff Angle, Tilt Angle, and Projection Factor



Source: California Energy Commission

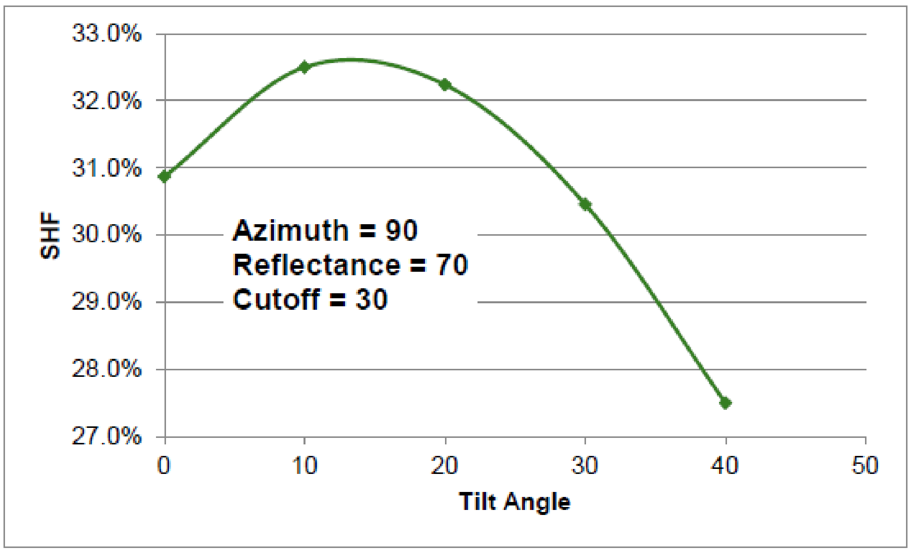
Figure 3-15: Graph of Shading Factors for Overhangs and Figure 3-16: Graph of Shading Factors for Horizontal Slats illustrate the benefits of shading factors of the various projection factors as a function of azimuth (orientation) for overhangs and as a function of tilt angle for horizontal slats. The 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 toward a southerly direction and also increase as overhangs or slats project more (i.e., have a higher projection factor).

Figure 3- 15: Graph of Shading Factors for Overhangs



Source: California Energy Commission

Figure 3-16: Graph of Shading Factors for Horizontal Slats



Source: California Energy Commission

Example 3--12

Question:

A window facing due east has glass with a solar heat gain coefficient of 0.71. It has a fixed overhanging eave that extends 3 feet out from the plane of the glass (P = 3) and is 6 feet above the bottom of the glass (s = 6). The overhang extends more than 3 feet beyond each side of the glass, and the top of the window is less than 2 feet vertically below the overhang. What is the RSHGC for this window?

Answer:

First, calculate the projection factor as P/s. This value is 3 / 6 = 0.50. Next, calculate the shading factor using the 90 degrees azimuth of the window. This value is 0.60. Finally, multiply it by the solar heat gain coefficient to obtain the RSHGC: 0.62 x 0.71 = 0.44.

Visible Light Transmittance (VT)

Reference: Section 140.3(a)5D

The prescriptive requirements of Tables 140.3-B and 140.3-C of the Energy Code prescribe specific VT values for all climate zones and glass types. The visible light transmittance is used in the performance method in the calculation of the interior illumination levels and lighting energy savings due to daylight controls. The performance method is discussed in more detail in Chapter 5.

Fenestration 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. The strategy of using high VT glazing in the upper part of a window allows daylight to enter the space through the high VT glazing, making a better daylighting design.

The Energy Code also allows a slight variance if the window-to-wall ratio (WWR) is greater than 40 percent. For this case, assume 0.40 for the WWR in the equation below, or the glazing can comply with the prescriptive requirements if the area-weighted average VT meets the following minimum requirement:

$VT \geq 0.11 / WWR$ $VVVV \geq \frac{0.11}{WWWWWW}$

Where,

- VT = the visible transmittance of the framed window
- WWR = the gross window-to-wall ratio

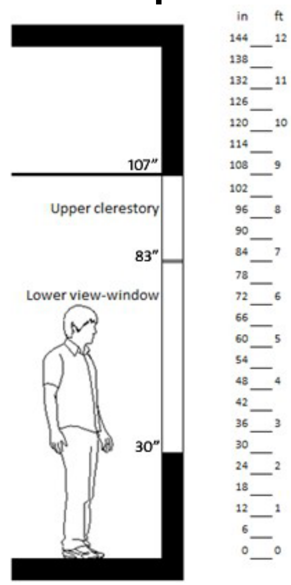
The average VT requirements apply separately to chromatic (dynamic or color-changing) glazing and nonchromatic glazing. For chromatic glazing, higher ranges of VT can be used to meet the prescriptive requirements. All glazing that is not chromatic must separately meet the area-weighted VT prescriptive requirements.

Example 3-13

Question:

A space has a gross window-to-wall ratio of 30 percent and has a fixed window with a sill height of 2’6” (30”) and a head height of 8’11” (107”), which runs 10’ wide (120”). The window has a break at 6’11” (83”) such that the upper portion or clerestory portion of the window is 2’ (24”) tall and can have a glazing different from that in the lower portion (view window). Can a designer use 0.30 VT glazing in the view window?

Figure 3-17: Example Window/Wall



Source: California Energy Commission

Answer:

Use the formula VT ≥ 0.11 / WWR, to determines the minimum area weighted average VT for this space,

VT ≥ 0.11 / 0.3 = 0.367. The area weighted minimum VT we need for this window is 0.367.

(View window Area x View window VT) + (Clerestory Area x Clerestory VT) / Total Window Area = 0.367

In this case:

Clerestory area = 24" height x 120" width = 2,880 sq.in

View window area = (83" - 30") height x 120" width = 6,360 sq.in.

Using a 0.30 VT glazing in the view window then View window VT = 0.30

Total window area = (107" - 30") height x 120" width = 9,240 sq.in.

Solve the equation for Clerestory VT: Clerestory VT = 0.515

(6360 x 0.367) + (2880 x VT_{CL})/9240

To use a 0.3 VT glazing in the view window, the designer must use a 0.515 VT window in the clerestory.

Example 3-14

Question:

A designer is using a U-factor of 0.57 for compliance with a curtain wall system. The glazing system uses two lites of 1/4-in (6mm) glass with a low-e = 0.1 coating on the second surface. The air gap is 1/2 inch (12 mm). A standard metal frame is proposed for the curtain wall system. Is 0.57 a reasonable U-factor for compliance, and can it reasonably be achieved by the glazing contractor through the NFRC process for site-built fenestration?

Answer:

No. If this is a newly constructed building and there is no NFRC rating, then the default U-factor must be used for this glazing combination from Table 110.6-A of the Energy Code. In this example, the U-factor would be 0.71.

However, if this is part of an alteration, then the design U-factor may be calculated using the default U-factor equation (Equation NA6-1) in the Reference Appendices, Nonresidential Appendix, NA6. Assuming a center of glass U-factor of 0.32, then the calculated U-factor would be 0.59.

Compliance Options

Please refer to Chapter 3.3.9 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Skylights

Please refer to Chapter 3.3.10 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Requirements for Skylights

Please refer to Chapter 3.3.10.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Requirements for Skylights

Please refer to Chapter 3.3.10.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Ignoring Partitions and Shelves

Please refer to Chapter 3.3.10.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Glazing Material and Diffusers

Please refer to Chapter 3.3.10.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Daylighting Design Power Adjustment Factors (PAFs)

Please refer to Chapter 3.3.11 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Clerestory Fenestration

Please refer to Chapter 3.3.11.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Interior and Exterior Horizontal Slats

Please refer to Chapter 3.3.11.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Interior and Exterior Light Shelves

Please refer to Chapter 3.3.11.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Relocatable Public School Buildings

Please refer to Chapter 3.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Performance Approach

Reference: Section 140.1

Under the performance approach, energy use of the building is modeled by compliance software approved by the Energy Commission. The compliance software simulates the long-term system cost (LSC) 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 lighting design — 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.

This section presents some basic details on the modeling of building envelope components. The following modeling capabilities are required by all approved nonresidential compliance software. These modeling features affect the thermal loads seen by the HVAC system model. More information may be found in the *ACM Reference Manual* and the CBECC User Guide.

Compliance Modeling

Mass Characteristics

Please refer to Chapter 3.5.1.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Opaque Surfaces

Please refer to Chapter 3.5.1.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Fenestration

Please refer to Chapter 3.5.1.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Overhangs and Vertical Shading Fins

Please refer to Chapter 3.5.1.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Slab-on-Grade Floors and Basement Floors

Please refer to Chapter 3.5.1.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions and Alterations

Please refer to Chapter 3.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Requirements

Additions

All additions must meet the applicable mandatory requirements from the following Energy Code sections:

- Section 110.6 — Mandatory Requirements for Fenestration Products and Exterior Doors
- Section 110.7 — Mandatory Requirements to Limit Air Leakage

- Section 110.8 — Mandatory Requirements for Insulation, Roofing Products and Radiant Barriers
- Section 120.7 — Mandatory Requirements for Building Envelopes

Alterations

Please refer to Chapter 3.6.1.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Requirements

Please refer to Chapter 3.6.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions

Please refer to Chapter 3.6.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Alterations

Reference: Section 141.0(b)2

In general, any alteration to an existing building that involves changes to a portion of the building envelope triggers the Energy Code. The prescriptive requirements for alterations to building envelopes are in Section 141.0(b)2A and B of the Energy Code.

The altered components of the envelope shall meet the applicable mandatory requirements of Section 110.6, Section 110.7, and Section 110.8.

Fenestration

When fenestration is altered that does not increase the fenestration area, it shall meet the requirements of Table 141.0-A of the Energy Code based on climate zone.

When more than 50 square feet of new vertical fenestration area is added to an alteration, it shall meet the requirements of Section 120.7(d), Section 140.3(a), and Tables 140.3-B, C, or D of the Energy Code. Compliance with Section 140.3(a) is not required when the fenestration is temporarily removed and then reinstalled.

In cases where fenestration is replaced or added, the following mandatory requirements apply:

- If more than 150 ft^2 of fenestration area is replaced throughout the entire building, the Energy Code requires that the maximum U-factor of the replaced units shall not exceed U-0.58. The SHGC, RSHGC, or VT requirements need not be met.
- If more than 50 ft^2 of fenestration is added through, the Energy Code requires that the added fenestration meet Section 120.7(d).

The following prescriptive requirements are also applicable:

- If less than 150 ft^2 of fenestration area is replaced throughout the entire building, then the Energy Code requires that only the U-factor requirements in Tables 140.3-B, C, or D are met. The SHGC, RSHGC, or VT requirements need not be met.
- The same requirements and exceptions apply if 50 ft^2 or less of fenestration (or skylight) area is added. A typical example of this may be changing a door from a solid door to a glass door.

Example 3-15

Question:

The envelope and space conditioning system of an office building with 120,000 square feet of conditioned floor area is being altered. The building has 24,000 square feet of vertical fenestration. Which of the following scenarios does the NFRC label certificate requirement apply to?

- Existing glazing remains in place during the alteration.
- Existing glazing is removed, stored during the alteration period, and then reinstalled (glazing is not altered in any way).
- Existing glazing is removed and replaced with new site-built glazing with the same dimensions and performance specifications.

Answer:

NFRC label certificate requirements do not apply to Scenarios 1 and 2 but do apply to Scenario 3.

- Requirement does not apply because the glazing remains unchanged and in place.
- Exception to Section 110.6(a) applies to fenestration products removed and reinstalled as part of a building alteration or addition.
- NFRC label certificate applies in this case as 24,000 ft^2 of new fenestration is being installed.

Walls and Floors

All nonresidential building alterations involving exterior walls, demising walls, external floors, or soffits must either comply as a component with the requirements in Tables 140.3-B, C, or D in the Energy Code, or by approved compliance software following the rules of the *ACM Reference Manual* that demonstrates that the overall LSC use of the altered building complies with the Energy Code.

Air Barrier

If 25 percent or more of the building envelope wall area is altered, it needs to meet the air barrier design and material requirements for newly constructed buildings. See Air Barrier for detailed guidance on the air barrier requirements for newly constructed buildings and how to perform the blower door testing.

If a blower door test is performed and the air leakage rate exceeds 0.4 cfm/ft2, a visual inspection and diagnostic evaluation must be completed in accordance with Nonresidential Appendix, NA5.7 to find the sources of excessive leakage. The leaks shall then be sealed. An additional report identifying the corrective actions taken to seal air leaks should be submitted to the building owner and code official. Retesting is not needed.

Additions that do not have a completely separate air barrier from the existing building — there is not wall separating the two — shall be temporarily partitioned to conduct the air leakage test if the pressurization test is chosen to comply with the requirements of 140.3(a)9C.

Roofs

Existing roofs being replaced, recovered, or recoated for nonresidential and hotels/motels 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, nonprocess 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, nonprocess areas.

The California Building Code (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.

Roof Insulation

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 Table 141.0-C 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.

The amount of insulation required varies by climate zone and building type. The requirements are given in terms of a continuous layer of insulation (usually installed on top of the roof deck) or an overall roof U-factor based on the default tables and calculation method in Reference Appendices, Joint Appendix JA4. The U-factor method provides more flexibility, as insulation can be added continuously on top of the roof deck, below the roof deck between roof joists, or a combination of insulation above and below the roof deck.

For roof alterations, when roofs are replaced or recovered and meet the roofing products requirements in Section 141.0(b)2Bi or ii, the altered area must be insulated to levels specified in the Energy Code, Table 141.0-C. For nonresidential buildings, this level is:

- R-17 or R-23 (depending on climate zone) with the use of continuous insulation; or
- U-0.047 or U-0.037 (depending on climate zone) if the insulation is a combination of above deck continuous insulation and cavity insulation. Under the U-factor option, at least R-10 of continuous insulation must be installed above the roof deck.

Exceptions to Section 141.0(b)2Bii:

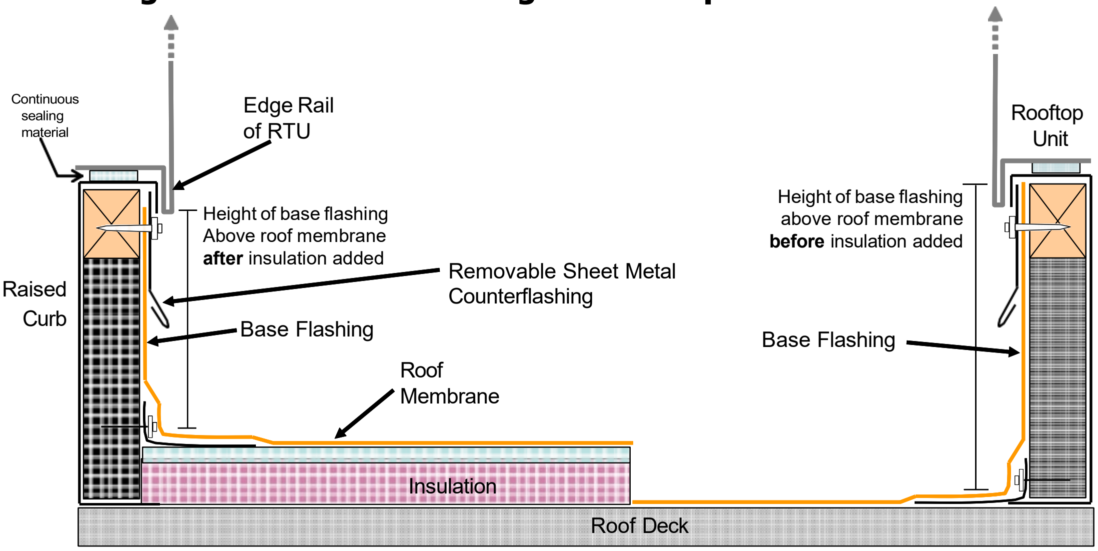
- Roof recovers with new R-10 insulation added above deck do not need to be insulated to the level specified in Table 141.0-C.
- When mechanical equipment located on the roof will not be disconnected and lifted as part of the roof replacement, insulation added may be the greater of R-10 or the maximum 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 Table 141.0-C 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 Table 141.0-C.

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 3-18: 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 orientation 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 underinsulated 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 3-18: Base Flashing on Rooftop Unit Curb Detail



Source: California Energy Commission

Roof Products

Reference: Section 141.0(b)2B

Thermal Emittance and Aged Solar Reflectance Prescriptive Requirements are described here.

For nonresidential buildings, the prescriptive requirements for roofing products are:

- Low-sloped roofs in Climate Zones 1 through 16 have a required minimum aged solar reflectance of 0.63 and a minimum thermal emittance of 0.75, or a minimum SRI of 75.
- Steep-sloped roofs in Climate Zones 1 and 3 have a minimum aged solar reflectance of 0.20 and a minimum thermal emittance of 0.75, or a minimum SRI of 16. Climate Zones 2 and 4 through 16 have a minimum aged solar reflectance of 0.25 and a minimum emittance of 0.80, or a minimum SRI of 23.

Exception for nonresidential buildings: an aged solar reflectance less than 0.63 is allowed, provided that additional insulation is installed.

For hotel and motel buildings, the prescriptive requirements for roofing products are the following:

- Low-sloped roofs in Climate Zones 9, 10, 11, 13, 14 and 15 have a required minimum aged solar reflectance of 0.55 and a minimum thermal emittance of 0.75, or a minimum SRI of 64.
- Steep-sloped roofs in Climate Zones 2 through 15 have a required minimum aged solar reflectance of 0.20 and a minimum thermal emittance of 0.75, or a minimum SRI of 16.

Exceptions for hotel and motel buildings:

- For roof areas covered by building integrated photovoltaic panels and building integrated solar thermal panels, roofing products are not required to meet the minimum requirements for solar reflectance, thermal emittance, or SRI.

- For low-sloped roof constructions that have thermal mass over the roof membrane with a weight of at least 25 lb/ft², roofing products are not required to meet the minimum requirements for solar reflectance, thermal emittance, or SRI.

U-factors measure the thermal performance of the entire roof assembly, both above and below the roof deck. Utilizing U-factors provides flexibility. Trade-offs can be made by installing additional insulation continuously above the roof deck, between the joists below the roof deck, or a combination of both approaches. Table 141.0-B shows the overall roof U-factors trade-off requirements by climate zones.

Table 141.0-B of the Energy Code not only takes into account of the amount of insulation necessary to compensate for using a noncompliant roofing product, but it also accounts for the minimum insulation requirements that apply to roof alterations generally.

Example 3-16

Question:

What are the Energy Code requirements for cool roofs when reroofing a low-sloped roof on an unconditioned warehouse containing conditioned office space?

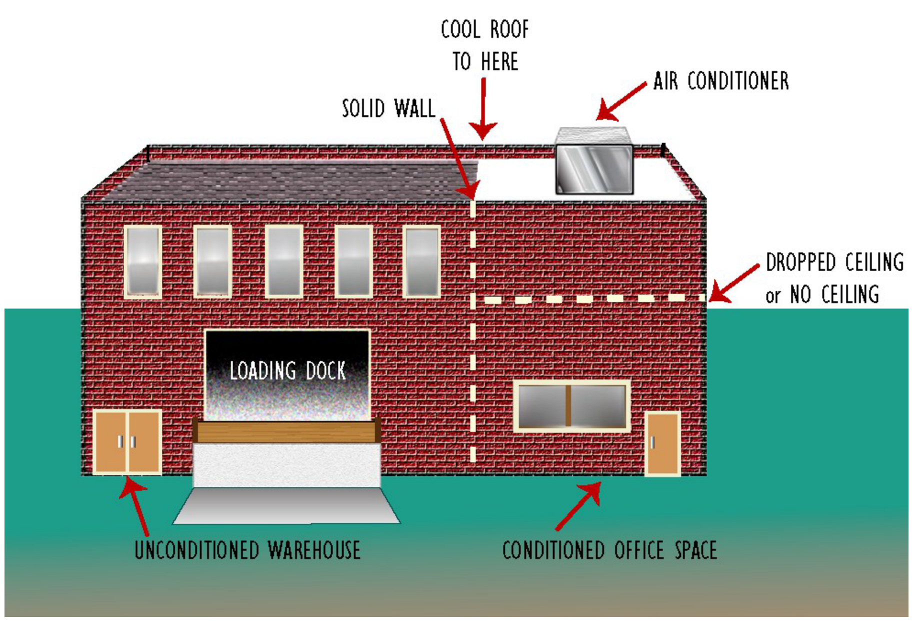
Answer:

Scenario 1.

There is either directly or indirectly conditioned space under the roof. The cool roof requirements apply to just the portion(s) of the warehouse roof over the conditioned space(s). The rest of the roof (over unconditioned warehouse space) is not required to be a cool roof.

The walls of the conditioned space go all the way up to the underside of the warehouse.

Figure 3-19: Example Warehouse Scenario 1

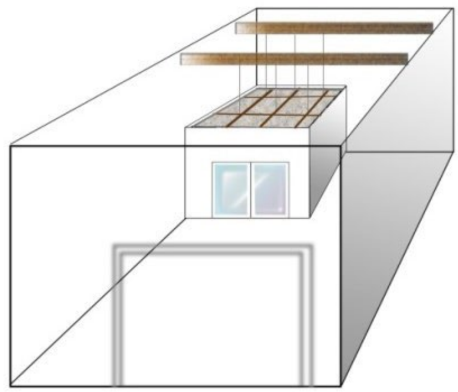


Source: California Statewide CASE Team

Scenario 2.

The walls of the conditioned space do not reach all the way to the warehouse roof. The roof requirements do not apply because the space directly below the roof is unconditioned and communicates with the rest of the unconditioned portion of the warehouse.

Figure 3-20: Example Warehouse Scenario 2



Source: California Statewide CASE Team

Example 3--17

Question:

I have a barrel roof on nonresidential conditioned building that needs to be reroofed. Must I follow the Energy Code roofing product requirement?

Answer:

Yes, the roof would need to meet the aged solar reflectance and thermal emittance for a steep-sloped roof. Although a barrel roof has both low-sloped and steep-sloped roofing areas, the continuous gradual slope change allows the steep-sloped section of the roof to be seen from ground level. Barrel roofs only need to meet the steep-sloped requirement for the entire roof area.

Figure 3-21: Example Barrel Roof Building

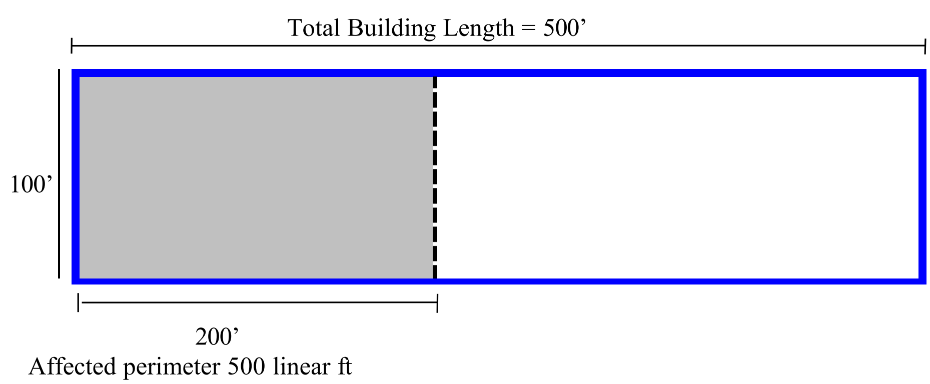
Source: California Statewide CASE Team

Example 3--18

Question 1:

Forty percent of the low-sloped roof on a 500 ft by 100 ft retail building in Concord, California (CZ12), is being reroofed. The roofing is removed down to the roof deck, and there is no insulation. Must insulation be added before reroofing?

Figure 3-22: Example Building With Partial Low-Slope Roof



Source: California Statewide CASE Team

Answer 1:

Yes, Section 141.0(b)2B requires when either 50 percent (or more) of the roof area or 2,000 ft² (whichever is less) is reroofed down to the roof deck or recover boards, that insulation be installed if the roof has less than the insulation in Energy Code, Table 141.0-C. Though the reroofing covers only 40 percent of the roof area, the requirements still apply because the 20,000 ft² of replacement roof area is greater than the threshold area of 2,000 ft². The roof does not have any insulation and, therefore, is required to add insulation. As per Energy Code, Table 141.0-C Insulation Requirements for Roof Alterations, for nonresidential buildings in

Climate Zone 12, the requirement for insulation is either R-23 continuous insulation (e.g., 4-inches of polyisocyanurate (polyiso) rated at R-5.7/inch) or an effective roof U-factor of 0.037 Btu/h•ft²•°F with at least R-10 continuous insulation installed above deck.

Question 2:

If the building is in San Francisco, would the insulation requirements be different on the building?

Answer 2:

No. San Francisco (as shown in Reference Appendices, Joint Appendix JA2) is in Climate Zone 3. Per Table 141.0-C from Section 141.0(b)2B, the insulation requirement for roof alterations for nonresidential buildings in Climate Zone 3 is R-23 or a U-factor of 0.037 with at least R-10 continuous insulation installed above deck.

Example 3--19

Question 1:

A nonresidential building is having 5,000 ft² of roofing replaced in Richmond (Climate Zone 3). During roofing replacement, the roof deck will be exposed. This building has a rooftop air conditioner that is sitting on an 8-inch-high curb above the roof membrane level. The roof is uninsulated. If the rooftop air-conditioner unit is not disconnected and not lifted off the curb during reroofing, is adding insulation required? If so, how much?

Answer 1:

Yes, the only time insulation is not required to be added is if the roof already meets the insulation requirements in Energy Code, Table 141.0-C. However, the exception to Section 141.0(b)2Bii allows for less insulation to be installed if the space-conditioning equipment is not disconnected and lifted during reroofing. In this case, the requirements for adding insulation are limited to the greater of R-10 (for example, 1.75 inches of polyisocyanurate insulation rated at R-5.7/inch) 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. Ask the roofing manufacturer what the lowest curb height is that they will provide a warranty for. If it is 6.25 inches or lower (8-inch curb height – 1.75 inches of polyiso), install the maximum amount of insulation to remain in accordance with the manufacturer's instructions. If it is higher than 6.25 inches and therefore it is not possible to install R-10 or greater, the space conditioning must be disconnected and lifted, the curb must be replaced or a curb extension added, and the full insulation required by Energy Code, Table 141.0-C must be added, in this case R-23 or U-0.037 with at least R-10 above deck.

Question 2:

What if the rooftop air conditioner is lifted temporarily during reroofing to remove and replace the roofing membrane? How much is added insulation is required?

Answer 2:

The insulation required by Energy Code, Table 141.0-C must be added — in this case R-23 or U-0.037 with at least R-10 above deck.

When the rooftop unit is lifted as part of the reroofing project, the incremental cost of replacing the curb or adding a curb extension is reduced; therefore, the exception does not apply.

Thus, to maintain the 8-inch base flashing height, one can replace the curb or add a curb extension before reinstalling the rooftop unit. Alternatively, one can ask for a roofing manufacturer's variance to the warranty from the typical minimum required 8 inches base flashing height above the roof membrane to the reduced amount after the roof insulation is installed. The specific risk of roof leakage at a given site has to be considered carefully before reducing the base flashing height. An alternative method of compliance that does not affect base flashing heights is to add insulation below the roof deck to the overall U-factor levels given in Table 141.0-C of Section 141.0(b)2B.

Example 3-20

Question:

A nonresidential building is having 5,000 ft² of roofing replaced. During roofing replacement, the roof deck will be exposed. This building has several unit skylights that are sitting on an 8–inch-high (20 cm) curb above the roof membrane level. The roof is uninsulated. Is added insulation required?

Answer:

Yes, insulation is required. There are no exceptions for skylights. Removing a unit skylight and increasing the associated curb height is substantially less effort than that for space-conditioning equipment.

Example 3-21

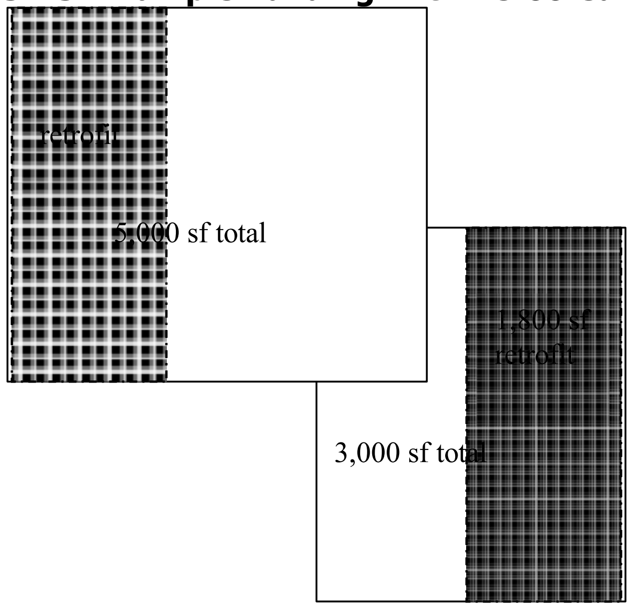
Question 1:

A building has low-sloped roofs at two elevations. One roof is 18 feet above grade and has a total area of 5,000 ft²; the other roof is 15 feet above grade and has a total area of 3,000 ft². Both roofs are uninsulated and are above conditioned space. If 1,800 ft² of the 3,000 ft² roof is being reroofed and the roof deck is exposed, is that portion of the roof required to be insulated and be a cool roof (high reflectance and emittance)?

Answer 1:

Yes, the reroofed section of the roof must be insulated and have a cool roof. Section 141.0(b)2B requires insulation and cool roofs for low-sloped roof alterations if the alteration is greater than 2,000 ft² or greater than 50 percent of the roof area. Since 1,800 ft² is 60 percent of 3,000 ft², the cool roof and insulation requirements apply.

Figure 3-23: Example Building With Reroofed Section



Source: California Statewide CASE Team

Question 2:

If the 1,800 ft² of roofing being replaced was on the 5,000 ft² uninsulated roof, would the portion of the roof replaced be required to be a cool roof and have insulation installed?

Answer 2:

No. The 1,800 ft² retrofit is 36 percent of the 5,000 ft² roof. Thus, the 1,800 ft² retrofit is less than 50 percent of the roof area and is less than 2,000 ft²; thus, it is not required to comply with the insulation and cool roof requirements in Section 141.0(b)2B.

Example 3-22

A 10,000 ft² building in Climate Zone 10 with an uninsulated roof above conditioned space is having roofing removed so that the roof deck is exposed. There are two rooftop units on this section of the roof that is being altered. One rooftop unit has a curb with a 9-inch base flashing, and the other has a modern curb with a 14-inch base flashing. Consider the following three scenarios:

Question 1: The rooftop unit with the 9-inch base flashing is disconnected and lifted during reroofing. However, the rooftop unit on the curb with the 14-inch (36 cm) base flashing is not lifted. In this situation, is the insulation added 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 on the unit with the lower curb to remain in accordance with the manufacturer's instructions?

Answer 1:

No. The unit with the 9-inch base flashing was disconnected and lifted and thus does not qualify for the exception to Section 141.0(b)2Bii. There is plenty of room to meet the insulation requirements in Energy Code Table 141.0-C in any climate zone without impacting the unlifted rooftop unit with a 14-inch curb.

Question 2:

The rooftop unit with the 9-inch base flashing is not disconnected and lifted during reroofing. In this situation, does an exception apply for the amount of insulation that must be added?

Answer 2:

Yes. The unit with the 9-inch (23 cm) base flashing was not disconnected and lifted and thus qualifies for the Exception 2 to Section 141.0(b)2Bii. This should be handled in the same way as Example 3-22, Question 1, above.

Question 3:

In Question 2, does this reduced amount of required insulation apply only to the area immediately surrounding the unlifted unit or to the entire roof?

Answer 3:

The reduced amount of insulation applies to the entire roof. However, if a building has multiple roofs, the limitation would apply only to any roof with a rooftop unit that was not disconnected and lifted and that has a low curb.

Example 3-23

Question:

In reroofing, is existing roofing that is a rock or gravel surface equivalent to a gravel roof over an existing cap sheet, and therefore qualify for the exceptions in 140.3(a)Ai?

Answer:

No, the two roofs are not equivalent. Rock or gravel roofs do not perform the same as gravel roofs over an existing cap sheet. Therefore, the gravel roof over existing cap sheet may not qualify for the exception.

Example 3-24

Question:

If I am doing a reroof, would Exceptions 1 through 4 to Section 140.3(a)1Ai apply to reroofing and roof alterations?

Answer:

Yes, these exceptions apply to reroofing and alterations, and the roofs that meet one or more of these exceptions are exempt from the cool-roof requirements.

Example 3-25

Question:

What happens if I have a low-sloped roof on most of the building but steep-sloped on another portion of the roof? Do I have to meet two sets of rules in Section 141.0(b)2Bi and ii?

Answer:

Yes, the low-sloped portion of the roof must comply with the requirements for low-sloped roofs, while the steep-sloped portion of the roof must comply with the requirements for steep-sloped roofs. These requirements are climate zone-based.

Example 3-26

Question:

A low-sloped nonresidential building in Santa Rosa needs to be reroofed. It has a wood-framed rafter roof. The rafters are 2x4's spaced 16 inches on center. The owner wants to install a roofing product with an aged reflectance of 0.60, which is less than the prescriptive standard of 0.63. Can I install additional insulation to make up for the shortfall in reflectance?

Answer:

Yes.

To make an insulation/reflectance trade-off under the prescriptive approach, use Table 141.0-B. Look up in the table the maximum roof/ceiling insulation U-factor for the aged solar reflectance of the roofing product and the climate zone in which the building is located. In this case, the roofing product has an aged reflectance of 0.60, and Santa Rosa is in Climate Zone 2, so the appropriate U-factor is found in row 1, column 2 of the table. It is 0.052. Consult Section 4.2 (Roofs and Ceilings) of Reference Appendices, Joint Appendix JA4 to find the U-factor table for the type of roof in question. Reference Appendices, Joint Appendix JA4 can be accessed on the Energy Commission's [website](https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency) at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency.

The appropriate table in this case is Table 4.2.2, U-Factors of Wood Framed Rafter Roofs. Locate the section of the table that pertains to 2x4 rafters spaced 16 inches on center. There are several U-factors in this area of the table that are equal to or less than 0.052. A combination of R-11 cavity insulation and R-8 continuous insulation, for example, has a U-factor of 0.050. Similarly, a combination of R-13 cavity insulation and R-6 continuous insulation has a U-factor of 0.052. Any U-factor that is equal to or less than 0.052 represents a combination of above- and below-deck insulation that complies with the requirements for the proposed trade-off.

Example 3-27

Question:

Is a full roof recoat exempt from the Energy Code insulation requirements in Section 141.0(b)2Bii?

Answer:

Yes. If a roof has an existing coating, the application of a top coating for renewal or maintenance (roof recoat) is exempt from the low-sloped roof insulation requirements of Section 141.0(b)2Bii. However, when a roof recoat layer is part of a roof recover as defined in Section 100.1, it is required to meet the insulation requirements of Section 141.0(b)2Bii.

Example 3-28

Question:

There are several exceptions to the minimum insulation requirements for roof alterations. Can these be used to limit the insulation required to make a trade-off under Table 141.0-B?

Answer:

No. The exceptions to Section 141.0(b)2Biii do not apply to trade-off situations. They apply only when a compliant roofing product is being installed and no trade-off is involved.

Performance Requirements

Additions

Please refer to Chapter 3.6.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Alterations

Please refer to Chapter 3.6.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

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Mechanical Systems

Overview

The objective of the Energy Code for mechanical systems is to reduce energy consumption while maintaining occupant comfort by:

- Maximizing equipment efficiency at design conditions and during part load operation
- Minimizing distribution losses of heating and cooling systems
- Optimizing system control to minimize unnecessary operation and simultaneous use of heating and cooling energy

An important goal of the Energy Code is also to ensure that indoor air quality is adequate for occupant comfort and health. The 2025 Energy Code incorporates requirements for outdoor air ventilation that must be met during normally occupied hours.

This chapter summarizes the requirements for space conditioning, ventilation, and service water heating systems for non-process loads in nonresidential buildings. Chapter 10 covers process loads in nonresidential buildings and spaces.

Acceptance requirements apply to all covered systems regardless of whether the prescriptive or performance compliance approach is used.

Chapter 12 details the mandated acceptance test requirements, which are summarized at the end of each section.

What's New for 2025

- New prescriptive requirements for single zone space conditioning system types for alterations
- New prescriptive requirements for multizone space conditioning systems in some building types and climate zones for new construction
- Changes to prescriptive requirements for HVAC system controls
- New prescriptive efficiency requirements for axial fan, open-circuit cooling towers
- Updates to cooling tower controls requirements
- New prescriptive requirements for simultaneous mechanical heat recovery
- New mandatory requirement for a 130°F limit to hot water supply temperatures for space conditioning hydronic systems

HVAC Energy Use

Please refer to Chapter 4.1.2 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Prescriptive and Performance Compliance Approaches

Please refer to Chapter 4.1.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Compliance Approach

Please refer to Chapter 4.1.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Performance Compliance Approach

The performance compliance approach, Section 140.1, allows the designer to trade off energy use between different building systems. This approach provides greater design flexibility but requires extra effort and a computer simulation of the building. The design must meet or exceed all mandatory requirements.

Performance approach trade-offs can be applied to the following disciplines: mechanical, lighting, envelope, and covered processes. The performance approach requires creating an energy model using approved Energy Commission compliance software for the proposed design that reflects the feature of the proposed building. The software will automatically create a standard design model based on the features of the proposed design which meets mandatory and prescriptive requirements (per the Alternative Calculation Method Reference Manual). The compliance software will compare the energy use of the two designs.

The proposed design complies with the Energy Code if it results in lower long-term system cost (LSC) energy use than the standard design.

The performance approach may only be used to model the performance of mechanical systems that are covered under the building permit application (see Performance Approach for more detail).

Equipment Requirements

Please refer to Chapter 4.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Requirements

Mechanical equipment must be certified by the manufacturer as complying with the mandatory requirements in the following sections:

- Section 110.0 - General and Certification Requirements for Systems and Equipment
- Section 110.1 - Mandatory Requirements for Appliances.
- Section 110.2 - Mandatory Requirements for Space-Conditioning Equipment
    - Efficiency
    - Gas- and Oil-Fired Furnace Standby Loss Controls
    - Low Leakage Air-Handling Units
- Section 110.3 - Mandatory Requirements for Service Water-Heating Systems and Equipment
    - Certification by Manufacturers
    - Efficiency
- Section 110.4 - Mandatory Requirements for Pool and Spa Systems and Equipment
    - Certification by Manufacturers
- Section 110.5 - Natural Gas Central Furnaces, Cooking Equipment, Pool and Spa Heaters, and Fireplaces: Pilot Lights Prohibited
- Section 110.12 – Mandatory Requirements for Demand Management

Mechanical equipment must be specified and installed in accordance with sections:

- Section 110.2 - Mandatory Requirements for Space-Conditioning Equipment
    - Controls for Heat Pumps with Supplementary Heaters

    - Thermostats
    - Open and Closed-Circuit Cooling Towers (blowdown control)
- Section 110.3 - Mandatory Requirements for Service Water-Heating Systems and Equipment
- Section 110.4 - Mandatory Requirements for Pool and Spa Systems and Equipment
    - Installation
    - Heating Source Sizing
    - Controls for Heat Pump Pool Heaters with Supplementary Heating
- Section 110.12 – Mandatory Requirements for Demand Management
- Section 120.1 - Requirements for Ventilation and Indoor Air Quality
- Section 120.2 - Required Controls for Space-Conditioning Systems (see HVAC System Control Requirements)
    - Zonal thermostatic controls
    - Occupant Controlled Smart Thermostats (OCST)
    - Dampers for air supply and exhaust equipment
    - Isolation area devices
    - Economizer Fault Detection and Diagnostics
    - Direct Digital Controls (DDC)
    - Optimum Start/Stop Controls
    - HVAC Hot Water Temperature
- Section 120.3 - Requirements for Pipe Insulation
- Section 120.4 - Requirements for Air Distribution System Ducts and Plenums
- Section 120.5 - Required Nonresidential Mechanical System Acceptance
- Section 120.8 - Commissioning
- Section 120.9 – Commercial Boilers
- Section 120.10 – Fan Energy Index

Space-Conditioning Equipment Efficiency

Reference: Section 110.2(a)

All space conditioning equipment installed in a nonresidential building, subject to these regulations, must be certified as meeting certain minimum efficiency and control requirements. These requirements are contained in Section 110.2 and vary based on the type and capacity of the equipment.

Where more than one efficiency standard or test method is listed, the requirements of both shall apply. For example, air-cooled air conditioners have an EER requirement for full-load operation and an IEER for part-load operation. The air conditioner must have both a rated EER and IEER equal to or higher than the minimum standard specified in the Energy Code at the specified Air-Conditioning, Heating, and Refrigeration Institute (AHRI) standard rating conditions. Where equipment serves more than one function, it must comply with the efficiency standards applicable to each function.

When there is a requirement for equipment rated at its "maximum rated capacity" or "minimum rated capacity," the proper capacity shall be maintained by the controls during steady state operation. For example, a boiler with high/low firing must meet the efficiency requirements when operating at both its maximum capacity and minimum capacity.

Three exceptions exist to the listed minimum efficiency for specific equipment.

Exception 1 applies to water-cooled centrifugal water-chilling packages not designed for operation at ANSI/AHRI Standard 550/590 test conditions, which are:

- 44 degrees Fahrenheit (F) leaving chilled water temperature
- 85 degrees F entering condenser water temperature
- Three gallons per minute per ton condenser water flow

Packages not designed to operate at these conditions must have maximum adjusted full load and NPLV ratings, which can be calculated in kW/ton, using the following equations.

$$FFFFFFF\ LLLLLLL\ RRLLRRRRRRRR_{mmmmmm,mmaaaa} = \frac{(FFFFFFF\ LLLLLLL\ RRLLRRRRRRRR)}{KK_{mmaaaa}}$$

$$NNNNLLNN\ RRLLRRRRRRRR_{mmmmmm,mmaaaa} = \frac{(IINNLLNN\ RRLLRRRRRRRR)}{KK_{mmaaaa}}$$

The values for the Full Load and IPLV ratings are found in Table 110.2-D **..** KK_{mmaaaa} is the product of AA and BB, as in the following equation.

$$KK_{mmaaaa} = AA \times BB$$

AA is calculated by entering the value for $LLIIFFLL$ into the fourth level polynomial:

$$AA = (1.4592 \times 10^{-7})(LLIIFFLL^4) - (3.46496 \times 10^{-5})(LLIIFFLL^3) + (3.14196 \times 10^{-3})(LLIIFFLL^2) - (0.147199)(LLIIFFLL) + 3.9302$$

$LLIIFFLL$ is calculated using the following equation.

$$LLIIFFLL = LLLLRRLLLLRRLL - LLLLRRLLLLLLLL$$

Where,

- $LLLLRRLLLLRRLL$ = Full-load leaving condenser fluid temperature (°F)
- $LLLLRRLLLLLLLL$ = Full-load leaving evaporator fluid temperature (°F)

BB is found using the following equation.

$$BB = (0.0015)(LLLLRRLLLLLLLL) + 0.934$$

Where,

- $LLLLRRLLLLLLLL$ = Full-load leaving evaporator fluid temperature (°F)

The maximum adjusted full-load and NPLV rating values are only applicable for centrifugal chillers meeting all of the following full-load design ranges:

- Minimum leaving evaporator fluid temperature: 36 degrees F
- Maximum leaving condenser fluid temperature: 115 degrees F
- LIFT greater than or equal to 20 degrees F and less than or equal to 80 degrees F

Centrifugal chillers designed to operate outside of these ranges are not covered by this exception and therefore have no minimum efficiency requirements.

Exception 2 is for positive displacement (air-cooled and water-cooled) chillers with a leaving evaporator fluid temperature higher than 32 degrees F. This equipment shall comply with Table 110.2-D in the Energy Code when tested or certified with water at standard rating conditions, per the referenced test procedure.

Exception 3 is for equipment primarily serving refrigerated warehouses or commercial refrigeration systems. These systems must comply with the efficiency requirements of Energy Code Section 120.6(a) or (b). For more information, see Chapter 10.

Equipment Not Covered by the Appliance Efficiency Regulations

Please refer to Chapter 4.2.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Controls for Heat Pumps with Supplementary Heaters

Reference: Section 110.2(b)

The Energy Code discourages the use of supplementary heating when the primary heating source has sufficient capacity to meet the load. Heat pumps may contain electric resistance heat strips or a gas fired furnace which serves as a supplementary heating source. If this type of system is used, then controls must be put in place to prevent the use of the supplementary heating when the heating load can be satisfied with the heat pump alone. The controls must set a cut-on temperature for heat pump heating higher than the cut-on temperature for supplementary heating. The cut-off temperature for heat pump heating must also be set higher than the cut-off temperature for supplementary heating. Consideration for cut-on temperatures in relation to cut-off temperatures should also be made to ensure that equipment provides heating when the space is occupied and to avoid sudden switching between heat pump and supplementary heating.

Exceptions exist for these control requirements if one of the following applies:

- During defrost.
- During transient periods such as start-ups and following room thermostat setpoint advances (or another control mechanism designed to preclude unnecessary operation).
- The heat pump is a room air-conditioner heat pump.

Thermostats

Please refer to Chapter 4.2.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Furnace Standby Loss Controls

Please refer to Chapter 4.2.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Open- and Closed-Circuit Cooling Towers

Reference: Section 110.2(e)

All open and closed-circuit cooling towers with rated capacity of 150 tons or greater must have a control system that maximizes the achievable cycles of concentration based on the local water quality conditions. The controls system must be conductivity based and 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. Controls performance shall be verified by an acceptance test per NA 7.5.18.

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 makeup water valve failure. The alarm system must send an audible signal or an alert through an energy management control system (EMCS). The functionality of this alarm system shall be verified per NA 7.5.18.

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 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, the designer must use the equations documented in Section 110.2(e)2 to calculate the maximum achievable cycles of concentration based on local water quality conditions (which are reported annually by the local utility), and the parameters identified in Table 110.2-A-1. The target maximum achievable cycles of concentration must be cataloged in the mechanical compliance documentation (NRCC-MCH-E) and reviewed and approved by the Professional Engineer (P.E.) of record.

Cooling towers shall not allow blowdown until one or more of the recirculating water parameters listed in Table 110.2-A-1 reaches the maximum values specified.

Pilot Lights

Please refer to Chapter 4.2.8 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Commercial Boilers

Reference: Section 120.9, Section 140.4(k)8, Section 140.5

A commercial boiler is a type of boiler with a capacity (rated maximum input) of 300,000 Btu/h or more and serving a space heating or water heating load in a commercial building.

There are two types of commercial packaged boilers:

- Boilers designed to operate with a nonpositive vent static pressure, sometimes referred to as natural draft or atmospheric boilers; and
  - Forced draft boilers, which rely on a fan to provide the appropriate amount of air into the combustion chamber.

Combustion air positive shut-off

Combustion air positive shut-off 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. Natural draft boilers receive the most benefit from combustion air positive shut-off 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.

Combustion air positive shut-off shall be provided on all newly installed commercial boilers as follows:

- All natural draft 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 non-positive vent static pressure
- All natural draft and forced-draft 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).

Combustion air fan motor requirements

Electricity savings are available from efficient part-load operation achieved by decreasing combustion air fan speed as the boiler firing rate decreases.

Combustion air fan motors of 10 horsepower or more in newly installed boilers must:

- Be driven by a variable speed drive; or
- Include controls that limit fan motor demand to no more than 30 percent of total design wattage, at 50 percent of design air volume.

Stack-gas oxygen concentration requirements

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.

Newly installed boilers with an input capacity of 5 MMBtu/h (5,000,000 Btu/h) and greater shall maintain stack-gas oxygen concentrations at less than or equal to 5 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 measured flue gas oxygen concentration. Use of a common gas and combustion air control linkage or jack shaft is prohibited. Boilers with steady state full-load thermal efficiency of 90 percent or higher are not subject to this requirement.

There are two control systems to meet stack-gas oxygen requirements:

- Parallel positioning combustion
- Oxygen trim

Parallel positioning combustion control

A parallel positioning combustion control system optimizes the combustion excess air based on the firing rate of the boiler to improve the combustion efficiency of the boiler. These systems allow excess air to remain relatively low throughout a burner's firing range. Maintaining low excess air levels at all firing rates provides significant fuel and cost savings while still maintaining a safe margin of excess air to insure complete combustion. These systems include individual servo motors 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

Oxygen trim control

Oxygen trim control systems measure the flue gas oxygen concentration to optimize combustion efficiency, and can provide higher levels of efficiency than parallel positioning combustion control systems based only on firing rate, as oxygen trim control can also account for the relative humidity of the combustion air. This control strategy relies on parallel positioning hardware and software as the basis but goes 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.

High capacity space heating gas boiler systems

Gas-fired hot water boiler systems with capacity between 1 and 10 million Btu/h, installed in newly constructed commercial buildings, shall have a capacity-weighted average thermal efficiency of 90 percent. In order to achieve a thermal efficiency at or over 90 percent, all or some of the boilers must have condensing capability. Condensing boilers condense moisture out of flue gas, recovering latent heat from water vapor. These boilers include a means of collecting and draining this condensate from its heat exchanger. Boilers within the same building but on separate loops are not considered to be a part of the same system. Weighted thermal efficiencies are calculated based off the input each boiler provides to the total system capacity.

Boiler systems in Climate Zones 7, 8, and 15 are not subject to this requirement.

Additionally, gas boilers with input capacity of less than 300,000 Btu/h are subject to the efficiency standards listed in Section 110.2 and shall not be included in the calculation of total system input or efficiency.

Additional requirements for the hot water distribution systems served by these boilers help optimize condensing capabilities.

- First, space heating coils and heat exchangers must be sized so that under design conditions the return temperature of the hot water to the boilers is 120°F or less. Condensing operation requires a sufficient difference in temperatures between the inlet and outlet water.
- Second, hot water space heating systems are designed so that under all conditions the return water entering the boiler(s) must be 120°F or less, or flow rates for supply hot water that recirculates directly into the return system must be no greater than 20 percent of the design flow of the operating boiler. This flow rate requirement increases the likelihood that the boiler system will operate in the condensing range by increasing the amount of time the heating medium, water, contacts the heat exchanger.

There are three exceptions to this condensing requirement:

- Space heating boilers where 25 percent of the annual space heating capacity is provided by on-site renewable energy (wind, photovoltaics , solar thermal) or site-recovered energy (heat recovery chiller, condenser desuperheater, refrigeration heat recovery, etc.).
    - Space heating boilers installed in individual dwelling units.

- Systems where 50 percent of more of the design heating load is served using perimeter convective heating, radiant ceiling panels, or both.

Example 4-1

Question:

If I have the following 4 boilers, how do I calculate weighted average thermal efficiency? Boiler 1 with capacity 500,000 Btu/h; Boiler 2 with capacity 600,000 Btu/h and serving an individual dwelling unit; Boiler 3 with capacity 250,000 Btu/h; Boiler 4 with capacity 750,000 Btu/h. Boiler 1 has thermal efficiency (TE) of 90%, Boiler 2 has a TE of 87%, Boiler 3 has a TE of 95%, and Boiler 4 has a TE of 95%.

Answer:

Since Boiler 2 serves an individual dwelling unit, it is not included in the weighted efficiency calculation. Similarly, since Boiler 3 has a capacity below 300,000 Btu/h, it is not included either. To calculate the weighted average thermal efficiency of Boilers 1 and 4, multiply both boilers' thermal efficiency by their capacity, add the two values together, and divide by the combined capacity. So, multiply 90% TE and 500,000 Btu/h and multiply 95% TE and 750,000 Btu/h. Add these two products together and divide by 1,250,000 Btu/h. The result is a weighted thermal efficiency of 93%.

Fan Energy Index

Please refer to Chapter 4.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Ventilation and Indoor Air Quality Requirements

Reference: Section 120.1

All of the ventilation and indoor air quality requirements are mandatory measures. Some measures require acceptance testing, which is addressed in Chapter 13.

Within a building, all space that is normally used by humans must be continuously ventilated (with outdoor air) during occupied hours, using either natural or mechanical ventilation as specified in Section 120.1(c). Ventilation requirements for healthcare facilities shall conform to the requirements in Chapter 4 of the California Mechanical Code.

"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:

- A closet, provided it is not normally occupied
- 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.

"Continuously ventilated during occupied hours" implies that minimum ventilation must be provided throughout the entire occupied period. Variable air volume (VAV) systems must provide the code-required ventilation over the full range of operating supply airflow.

Therefore, some means of dynamically controlling the minimum ventilation air must be provided.

Air Filtration

Reference: Section 120.1(c)1

Indoor air quality of occupied spaces may be degraded 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. 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 of said technology, removal of fine particulate contaminants by use of filtration is reasonable and achievable.

Air filter efficiency

The Energy Code requires that filters have a particle removal efficiency equal to or greater than the minimum efficiency reporting value (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 0.3-1.0 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.

Mechanical system types requiring air filtration

The following system types are required to provide air filtration:

- Mechanical space-conditioning (heating or cooling) systems that utilize forced air ducts greater than 10 feet in length to supply air to an occupied space. The total is determined by summing the lengths of all the supply and return ducts for the forced air system.

Mechanical supply-only ventilation systems and makeup air systems that provide outside air to an occupied space.

- The supply side of mechanical balanced ventilation systems, including heat recovery ventilators and energy recovery ventilators that provide outside air to an occupied space.

Note that for heat recovery ventilators and energy recovery ventilators, the filters may be downstream of a system thermal conditioning component, provided there is ancillary filtration upstream of the system's thermal conditioning component.

Air Filter Requirements

Space conditioning systems and ventilation systems in nonresidential and hotel/motel occupancies may use either of the two following compliance approaches:

- Install a filter grille or accessible filter rack sized by the system designer to accommodate a minimum nominal 2-inch depth filter and install the appropriate filter.
- Install a filter grille or accessible filter rack that accommodates a minimum nominal 1-inch depth filter and install the appropriate filter. The filter/grille must be sized for a face velocity of less than or equal to 150 ft per minute. The installed filter must be labeled to indicate that the pressure drop across the filter at the design airflow rate is less than or equal to 0.1-inch w.c. (25 PA).

To calculate the air filter face area in sq ft, use the following equation:

$$AA_{ffmmffff} = \frac{QQ_{ffffffffffff}}{NN_{ffmmffff}}$$

Since air filters are sold using nominal sizes in terms of inches, convert the face area to sq in by multiplying the face area (sq ft) by a conversion factor of 144 sq inch/sq ft.

Field verification and diagnostic testing of system airflow in accordance with the procedures in NA1 (Energy Code Compliance (ECC)-Verification) is not required for nonresidential and hotel/motel occupancies.

Energy Code Factors that Affect Air Filter Pressure Drop

Please refer to Chapter 4.4.1.1.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Filter Access and Filter Grille Sticker – Design Airflow and Pressure Drop

Please refer to Chapter 4.4.1.1.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Air Filter Selection

Please refer to Chapter 4.4.1.1.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Natural Ventilation Requirements

Reference: Section 120.1(c)2

The 2019 Energy Code changed the specifications for spaces that are to be naturally ventilated by adopting ASHRAE 62.1. Under these new 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 that complies with Section 120.1(c)3, except when: (1) the space has openings to the outdoors that are permanently open or has controls that prevent the opening from being closed during periods of expected occupancy; (2) or is not served by a space-conditioning system. This requirement for mechanical ventilation back-up to a naturally ventilated space protects the occupants during times or events when the outdoor air quality is not adequate for ventilation without filtration 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 zone, only the floor area within two times the ceiling height from the opening is permitted to be naturally ventilated. For zones with openings on two opposite sides of the zone, only the floor areas within five times the ceiling height from the openings are permitted to be naturally ventilated. For zones with operable openings on two adjacent sides of the zone (two sides of a corner), only the floor areas along a line drawn between the outside edges of the two openings that are the farthest apart meet the requirement. Floor areas not along these lines connecting the windows must meet the one side or two opposite side opening calculation to be permitted to be naturally ventilated. The ceiling height for all of these cases is the minimum ceiling height, except 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. This is achieved through window contact switches or another type of relay switch that interlocks the operable opening with the mechanical ventilation system. (Section 140.4(n))

Mechanical Ventilation

Reference: Section 120.1(c)3, Table 120.1-A

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 (see Direct Air Transfer for updates to transfer air classification). The required minimum ventilation airflow rate at the space can be provided by an equal quantity of supply or transfer air. At the air-handling unit, the minimum outside airflow rate 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 VAV and constant volume units. The design minimum outside airflow rate can be no less than the calculated minimum outside airflow rate.

In summary:

- Ventilation compliance at the space is satisfied by providing supply and/or transfer air.
- Ventilation compliance at the air handling system level is satisfied by providing, at minimum, the outdoor air that represents the sum of the ventilation requirements of all the spaces that it serves.

For each space requiring mechanical ventilation, the ventilation rate (V_z) must be the larger of either:

- The net occupiable floor area (A_z) of the space multiplied by the area-based outdoor air rate (R_a) from Table 120.1-A. This provides dilution for the building-borne contaminants like off-gassing of paints and carpets; or
  - The outdoor airflow per person (R_p) multiplied by the expected number of occupants (P_z). R_p shall be 15 cubic feet per minute per person. The expected number of occupants for each space (P_z) shall be the number specified by the building designer or the default occupancy density in Table 120.1-A times the net occupiable floor area of the space, whichever is greater. For spaces with fixed seating (such as a theater or auditorium), the expected number of occupants for each space (P_z) shall be the number of fixed seats or as determined by the California Building Code.

As previously stated, each ventilation system must provide outdoor ventilation air as follows:

1. For a ventilation system serving a single space, the required system outdoor airflow rate is equal to the design outdoor ventilation rate of the space.
2. For a ventilation system serving multiple spaces, the required outdoor air quantity delivered by the system must not be less than the sum of the required outdoor ventilation rate to each space. The Energy Code does not require that each space actually receive its exact calculated outdoor air quantity. Instead, the supply air to any given space may be any combination of recirculated air, outdoor air, or air transferred directly from other spaces, provided:
   i. The total amount of outdoor air delivered by the ventilation system(s) to all spaces is at least as large as the sum of the space design quantities.
   ii. Each space always receives supply airflow, including recirculated air and/or transfer air, no less than the calculated outdoor ventilation rate.
   iii. When using transfer air, none of the spaces from which air is transferred has any unusual sources of contaminants.

Example 4-2: Ventilation for a Two-Room Building

Question:

Consider a building with two spaces, each having an area of 1,000 sq ft. One space is used for general administrative functions, and the other is used as a classroom. It is estimated that the office will contain seven people, and the classroom will contain 50 people (fixed seating). What are the required outdoor ventilation rates?

Answer:

- For the office area, the design outdoor ventilation airflow rate is the larger of:
  - 7 people x 15 cfm/person = 105 cfm; or
  - 1,000 ft² x 0.15 cfm/ft² = 150 cfm
  - For this space, the design ventilation rate is 150 cfm.
- For the classroom, the design outdoor ventilation air is the larger of:
  - 50 people x 15 cfm/person = 750 cfm; or
  - 1,000 ft² x 0.15 cfm/ft² = 150 cfm
  - For this space the design ventilation rate is 750 cfm.

Assume the total supply air necessary to satisfy cooling loads is 1,000 cfm for the office and 1,500 cfm for the classroom. If each space is served by a separate system, then the required outdoor ventilation rate of each system is 150 cfm and 750 cfm, respectively. This corresponds to an outside air fraction of 15 percent in the office HVAC unit, and 50 percent in the classroom unit.

If both spaces are served by a central system, then the total supply will be (1,000 + 1,500) cfm = 2500 cfm. The required outdoor ventilation rate is (150 + 750) = 900 cfm total. The actual outdoor air ventilation rate for each space is:

- Office outside air = 900 cfm x (1,000 cfm / 2,500 cfm) = 360 cfm
- Classroom outside air = 900 cfm x (1,500 cfm / 2,500 cfm) = 540 cfm

While this simplistic analysis suggests that the actual outside air cfm to the classroom is less than design (540 cfm vs. 750 cfm), the analysis does not take credit for the dilution effect of the air recirculated from the office. The office is over-ventilated (360 cfm vs. 150 cfm) so the concentration of pollutants in the office return air is low enough that it can be used, along with the 540 cfm of outdoor air, to dilute pollutants in the classroom. The Energy Code allows this design provided that the system always delivers at least 750 cfm to the classroom (including transfer or recirculated air), and that any transfer air is free of unusual contaminants.

Exhaust Ventilation

Reference: Section 120.1(c)4, Table 120.1-A, Table 120.1-B

The exhaust ventilation requirements are aligned with ASHRAE 62.1 and require certain occupancy categories to be exhausted to the outdoors, as listed in Table 120.1-A. Exhaust flow rates must meet or exceed the minimum rates specified in Table 120.1-B. 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.

Air Classification and Recirculation Limitations

Reference: Section 120.1(g), Table 120.1-A, Table 120.1-B, Table 120.1-C

Air from difference occupancy categories are assigned an air class numberthat determines limits on transferring or recirculating that air. This air classification system offers designers clear guidance on what air can and cannot be used for transfer, makeup, or recirculation air. In the past, the Energy Code allowed air transfer as long as the air did not have "unusual sources of indoor air contaminants," which resulted in arbitrary enforcement of this rule. Now, all spaces listed in Table 120.1-A are assigned an air class and specific direction is given for each class in alignment with ASHRAE 62.1.

Class 1: This class consists of air with low contaminant concentration, low sensory-irritation intensity or inoffensive odor, and is suitable for recirculation or transfer to any space. Some examples include classrooms, lecture halls, and lobbies.

Class 2: This class consists of air with moderate contaminant concentration and mild sensory-irritation intensity or mildly offensive odors. Class 2 air is suitable for recirculation or transfer to any space with Class 2 or Class 3 air that is utilized for the same or similar purpose and involves the same or similar pollutant sources. Class 2 air may be transferred to toilet rooms and to any Class 4 air occupancies. Class 2 air is not suitable for recirculation or transfer to dissimilar spaces with Class 2 or Class 3 air. It is also not suitable in spaces with Class 1 air, unless the Class 1 space uses an energy recovery device. In this case, recirculation from leakage, carryover, or transfer from the exhaust side of the energy recovery device is permitted. The amount of Class 2 air allowed to be transferred or recirculated shall not exceed 10 percent of the outdoor air intake flow.

Thus, HVAC systems serving spaces with Class 2 air shall not share the same air handler as spaces with Class 1 air. Some examples of Class 2 spaces include warehouses, restaurants, and auto repair rooms.

Class 3: This class consists of air with significant contaminant concentration and significant sensory-irritation intensity or offensive odor. Recirculation of Class 3 air is only permitted within the space of origin. It is not suitable for recirculation or transfer to any other spaces. However, when a space uses an energy recovery device, then recirculation from leakage carryover or transfer from the exhaust side of the energy recovery device is permitted. In this case the amount of Class 3 air allowed to be transferred or recirculated shall not exceed 5 percent of the outdoor air intake flow. HVAC systems serving spaces with Class 3 air shall not share the same air handler serving spaces with Class 1 or Class 2 air. Some examples of Class 3 spaces include general manufacturing (excludes heavy industrial and processes using chemicals) and janitor closets.

Class 4: This class consist of air with highly objectionable fumes or gases or with potentially dangerous particles, bioaerosols, or gases at concentrations high enough to be considered harmful. Class 4 air is not suitable for recirculation or transfer within the space of origin or to any other space. No leakage of Class 4 air from energy recovery devices is allowed. Some examples of Class 4 spaces include spray paint booths and chemical storage rooms.

In addition to Table 120.1-A and Table 120.1-B, the Energy Code also includes air classifications for specific airstreams and sources as detailed in Table 120.1-C. In the event that Table 120.1-A, Table 120.1-B, and Table 120.1-C do not list the space or location, the air classification of the most similar space listed in terms of occupant activities or building construction shall be used.

For ancillary spaces that are designated as Class 1 air but support a Class 2 air space, re-designation of these ancillary spaces to Class 2 areas is allowed. For example, a bank lobby is designated as Class 1 while bank vaults or safety deposit areas are designated at Class 2. The ancillary space to the bank safety deposit area can be re-designated to Class 2 from Class 1.

Direct Air Transfer

Please refer to Chapter 4.4.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Distribution of Outdoor Air to Zonal Units

Reference: Section 120.1(e)

When a return plenum is used to distribute outside air to a zonal heating or cooling unit, the outside air supply must be connected either:

- Within 5 ft. of the unit; or
- Within 15 ft. of the unit, with the air directed substantially toward the unit, and with a discharge velocity of at least 500 ft per minute.

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.

Ventilation System Operation and Controls

Outdoor Ventilation Air and VAV Systems

Reference: Section 120.1(d)

Except for systems employing Energy Commission-certified DCV devices or space occupancy sensors, the Energy Code requires that the minimum rate of outdoor air calculated per Section 120.1(c)3 be provided to each space *at all times* when the space is normally occupied according to Section 120.1(d)1. For spaces served by VAV systems, the minimum supply setting of each VAV box should be no less than the design outdoor ventilation rate calculated for the space, unless transfer air is used. If transfer air is used, the minimum box position, plus the transfer air, must meet the minimum ventilation rate.

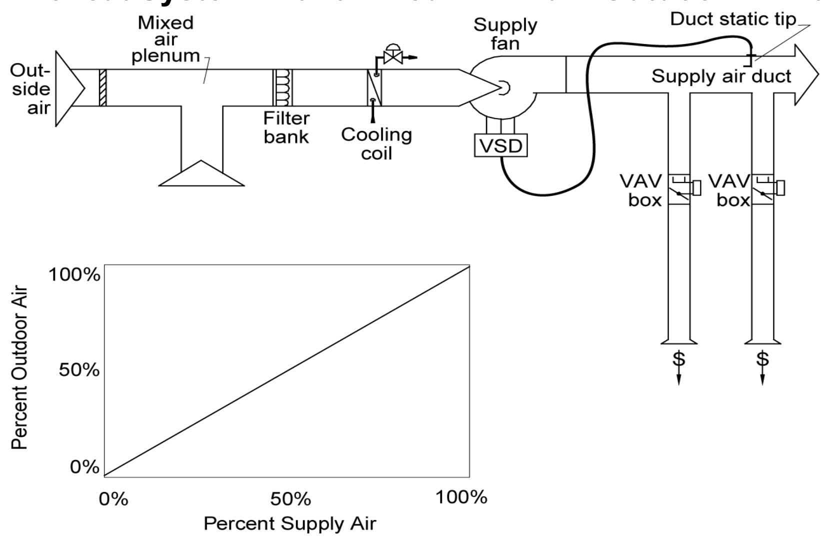
The design outdoor ventilation rate at the system level must always be maintained when the space is occupied, even when the fan has modulated to its minimum capacity per Section 120.1(d)1. Acceptance Requirements describes mandated acceptance test requirements for outside air ventilation in VAV air handling systems where the minimum outside air will be measured at full flow with all boxes at minimum position.

Figure 4- 1: VAV Reheat System with a Fixed Minimum Outdoor Air Damper Setpoint shows a typical VAV system. In standard practice, the testing and balancing contractor sets the minimum position setting for the outdoor air damper during construction. It is set under the conditions of design airflow for the system and remains in the same position throughout the full range of system operation, which does not meet code. As the system airflow drops, so will the pressure in the mixed air plenum. A fixed position on the minimum outdoor air damper will produce a varying outdoor airflow. Figure 4- 1: VAV Reheat System with a Fixed Minimum Outdoor Air Damper Setpoint shows this effect will be approximately linear (in other words, outdoor air airflow will drop directly in proportion to the supply airflow).

The following paragraphs present several methods used to dynamically control the minimum outdoor air in VAV systems.

Care should be taken to reduce the amount of outdoor air provided when the system is operating during the weekend or after hours with only a fraction of the zones active. Section 120.2(g) requires provision of "isolation zones" of 25,000 sq. ft. or less, which can be accomplished by having the VAV boxes return to fully closed when their associated zone is in unoccupied mode. When a space or group of spaces is returned to occupied mode (e.g., through off-hour scheduling or a janitor's override), only the boxes serving those zones need to be active. During this period when not all the zones are occupied, the ventilation air can be reduced to the required ventilation air of just those zones that are active. If all zones are of the same occupancy type (e.g., private offices), simply assign a floor area to each isolation zone and prorate the minimum ventilation area by the ratio of the sum of the floor areas presently active divided by the sum of all the floor areas served by the HVAC system.

Figure 4-1: VAV Reheat System with a Fixed Minimum Outdoor Air Damper Setpoint



Source: California Energy Commission

Fixed Minimum Damper Setpoint

This method does not comply with the Energy Code. The airflow at a fixed minimum damper position will vary with the pressure in the mixed air plenum. It is explicitly prohibited in Section 120.1(f)2.

Dual Minimum Setpoint Design

This method complies with the Energy Code. An inexpensive enhancement to the fixed damper setpoint design is the dual minimum setpoint design, commonly used on some packaged AC units. The minimum damper position is set proportionally based on fan speed or airflow between a setpoint determined when the fan is at full speed (or airflow) and minimum speed (or airflow). This method complies with the Energy Code but is not accurate over the entire range of airflow rates or when wind or stack effect pressure fluctuates. With DDC, this design has a relatively low cost.

Energy Balance Method

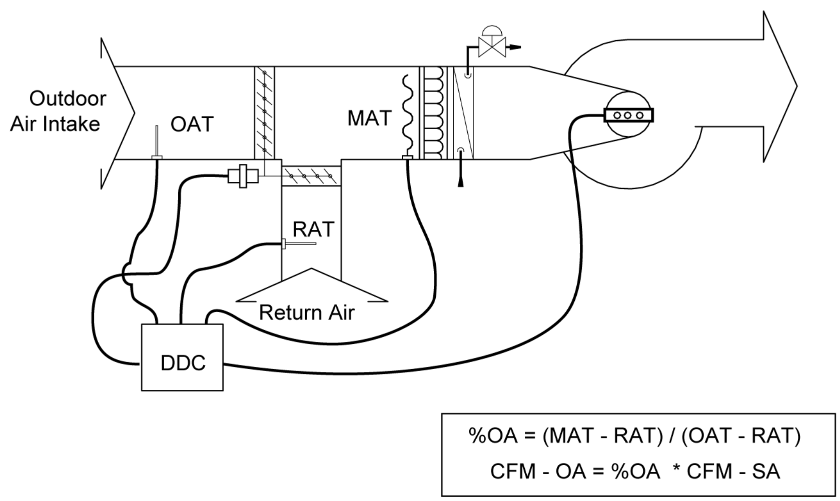
The energy balance method uses temperature sensors located outside, as well as in the return and mixed air plenums to determine the percentage of outdoor air in the supply air stream.

The outdoor airflow is then calculated using the equations shown in Figure 4- 2: Energy Balance Method of Controlling Minimum Outdoor Air. This method requires an airflow monitoring station on the supply fan.

While technically feasible, it may be difficult to meet the outside air acceptance requirements with this approach because:

- It is difficult to accurately measure the mixed air temperature, which is critical to the success of this strategy. Even with an averaging type of bulb, most mixing plenums have some stratification or horizontal separation between the outside and mixed airstreams.[1]
- Even with the best installation, high accuracy sensors, and field calibration of the sensors, the equation for percent outdoor air will become inaccurate as the return air temperature approaches the outdoor air temperature. When they are equal, this equation predicts an infinite percentage of outdoor air.
- The airflow monitoring station is likely to be inaccurate at low supply airflows.
- The denominator of the calculation amplifies sensor inaccuracy as the return air temperature approaches the outdoor air temperature.

Figure 4-2: Energy Balance Method of Controlling Minimum Outdoor Air



Source: California Energy Commission

Return Fan Tracking

This method is also technically feasible but will likely not meet the acceptance requirements because the cumulative error of the two airflow measurements can be large, particularly at low supply/return airflow rates. It only works theoretically when the minimum outdoor air rate equals the rate of air required to maintain building pressurization (the difference between supply air and return air rates). Return fan tracking (Figure 4- 3: Return Fan Tracking) uses airflow monitoring stations on both the supply and return fans. The theory behind this is that the difference between the supply and return fans should be made up by outdoor air and

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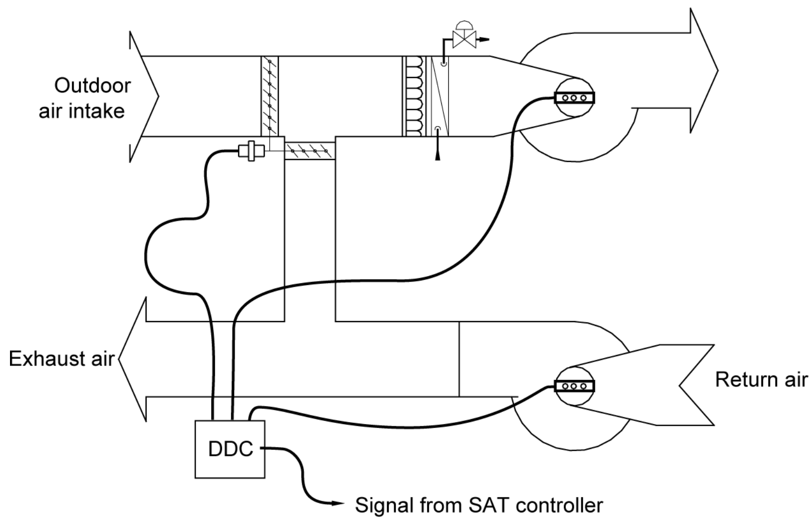
[1] This was the subject of ASHRAE Research Project 1045-RP, "Verifying Mixed Air Damper Temperature and Air Mixing Characteristics." Unless the return is over the outdoor air there are significant problems with stratification or airstream separation in mixing plenums.

controlling the flow of return air forces more ventilation into the building. Several problems occur with this method:

- The relative accuracy of airflow monitoring stations is poor, particularly at low airflows
- The high cost of airflow monitoring stations
- Building pressurization problems unless the ventilation air is equal to the desired building exfiltration plus the building exhaust

ASHRAE research has also demonstrated that in some cases this arrangement can cause outdoor air to be drawn into the system through the exhaust dampers due to negative pressures at the return fan discharge.

Figure 4-3: Return Fan Tracking

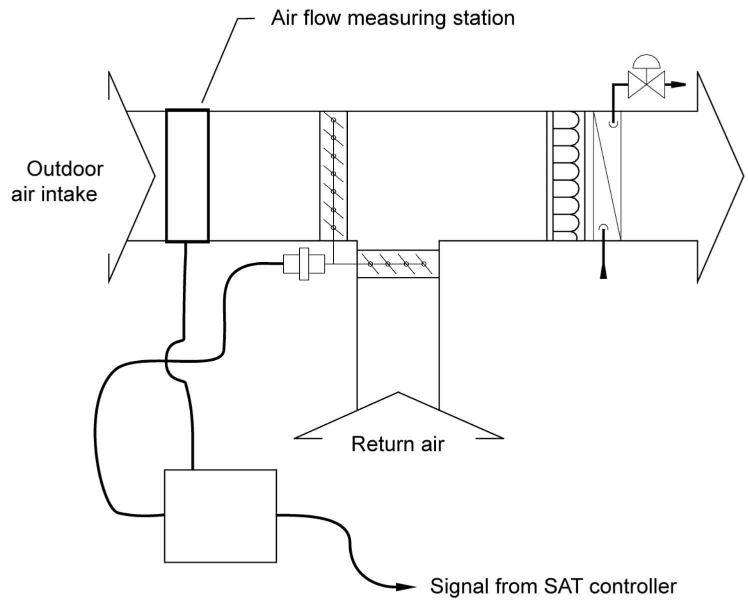


Source: California Energy Commission

Airflow Measurement of the Entire Outdoor Air Inlet

This method is technically feasible but will likely not meet the acceptance requirements, depending on the airflow measurement technology. Most airflow sensors will not be accurate within a 5 to 15 percent turndown (the normal commercial ventilation range). Controlling the outdoor air damper by direct measurement with an airflow monitoring station (Figure 4- 4: Airflow Measurement of 100 Percent Outdoor Air) can be an unreliable method. Its success relies on the turndown accuracy of the airflow monitoring station. Depending on the loads in a building, the ventilation airflow can be between 5 and 15 percent of the design airflow. If the outdoor airflow sensor is sized for the design flow for the airside economizer, this method has to have an airflow monitoring station that can turn down to the minimum ventilation flow (between 5 and 15 percent). Of the different types available, only a hot-wire anemometer array is likely to have this low-flow accuracy while traditional pitot arrays will not. One advantage of this approach is that it provides outdoor airflow readings under all operating conditions, not just when on minimum outdoor air. For highest accuracy, provide a damper and outdoor air sensor for the minimum ventilation air that is separate from the economizer outdoor air intake.

Figure 4-4: Airflow Measurement of 100 Percent Outdoor Air

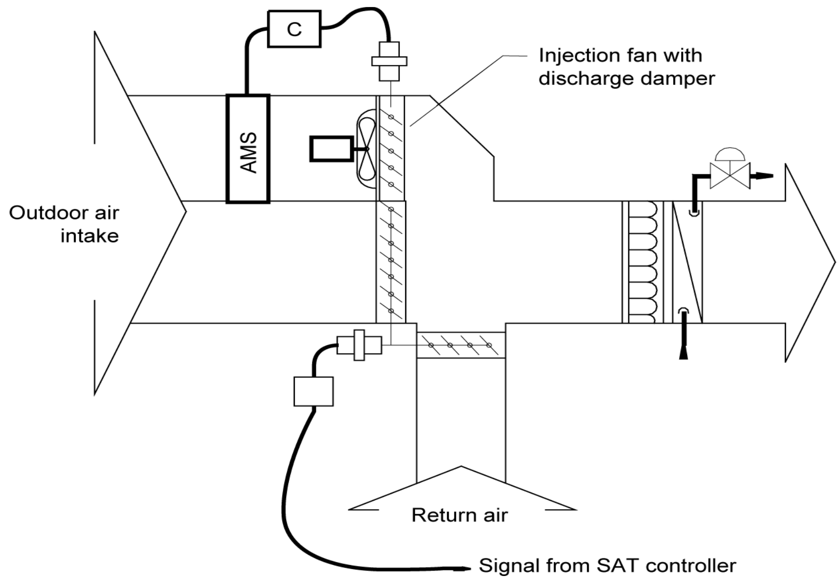


Source: California Energy Commission

Injection Fan Method

This method complies with the Energy Code, but it is expensive and may require additional space. An airflow sensor and damper are required since fan airflow rate will vary, as mixed air plenum pressure varies. The injection fan method (Figure 4- 5: Injection Fan with Dedicated Minimum Outdoor Air Damper) uses a separate outdoor air inlet and fan sized for the minimum ventilation airflow. This inlet contains an airflow monitoring station and a fan with capacity control (e.g., discharge damper; variable frequency drives [VFD]), which is modulated as required to achieve the desired ventilation rate. The discharge damper is required to shut off the intake when the air handling unit (AHU) is off and also to prevent excess outdoor air intake when the mixed air plenum is significantly negative under peak conditions. The fan is operating against a negative differential pressure and thus cannot stop flow just by slowing or stopping the fan. Though effective, the cost of this method is high and often requires additional space for the injection fan assembly.

Figure 4-5: Injection Fan with Dedicated Minimum Outdoor Air Damper



Source: California Energy Commission

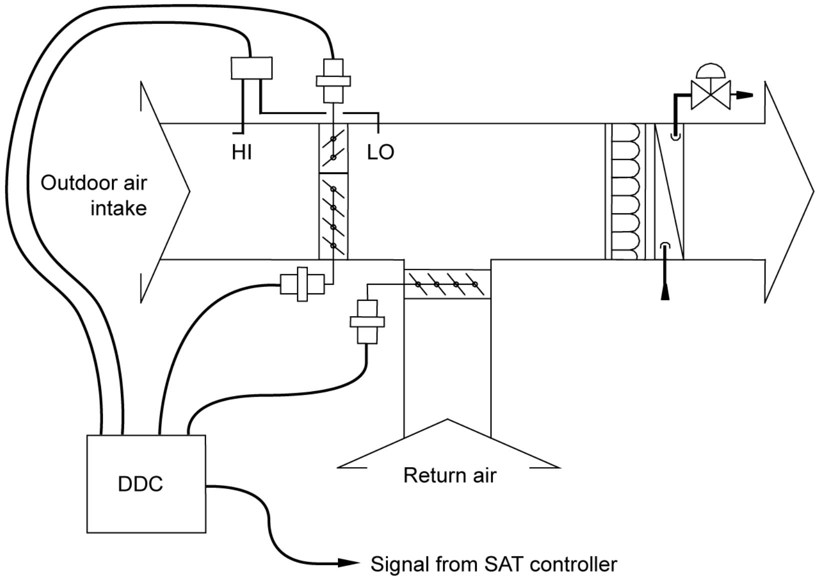
Dedicated Minimum Ventilation Damper with Pressure Control

This approach is low cost and takes little space. It can be accurate if the differential setpoint corresponding to the minimum outdoor air rate is properly set in the field. An inexpensive but effective design uses a minimum ventilation damper with differential pressure control (Figure 4- 6: Minimum Outdoor Air Damper with Pressure Control). In this method, the economizer damper is broken into two pieces: a small two position damper controlled for minimum ventilation air and a larger, modulating, maximum outdoor air damper that is used in economizer mode. A differential pressure transducer is placed across the minimum outdoor air damper. During start-up, the air balancer opens the minimum outside air (OA) damper and return air damper, closes the economizer OA damper, runs the supply fan at design airflow, measures the OA airflow, and adjusts the minimum OA damper position until the OA airflow equals the design minimum OA airflow. The linkages on the minimum OA damper are then adjusted so that the current position is the "full open" actuator position. At this point the design pressure (DP) across the minimum OA damper is measured. This value becomes the DP setpoint. The principle used here is that airflow is constant across a fixed orifice (the open damper) at fixed DP.

As the supply fan modulates when the economizer is off, the return air damper is controlled to maintain the DP setpoint across the minimum ventilation damper.

The main downside of this method is the complexity of controls and the potential problems determining the DP setpoint in the field. It is often difficult to measure the outdoor air rate due to turbulence and space constraints.

Figure 4-6: Minimum Outdoor Air Damper with Pressure Control



Source: California Energy Commission

Example 4-3: Minimum VAV cfm

Question:

If the minimum required ventilation rate for a space is 150 cfm, what is the minimum allowed airflow for its VAV box when the percentage of outdoor air in the supply air is 20 percent?

Answer:

The minimum allowed airflow may be as low as 150 cfm provided that enough outdoor air is supplied to all spaces combined to meet the requirements of Section 120.1(c)3 for each space individually.

Pre-Occupancy Purge

Reference: Section 120.1(d)2

Since many indoor air pollutants are out gassed from the building materials and furnishings, the Energy Code requires that buildings having a scheduled operation be purged before occupancy per Section 120.1(d)2. Immediately prior to occupancy, outdoor ventilation must be provided in an amount equal to the lesser of:

- The minimum required ventilation rate for 1 hour; or
- Three complete air changes.

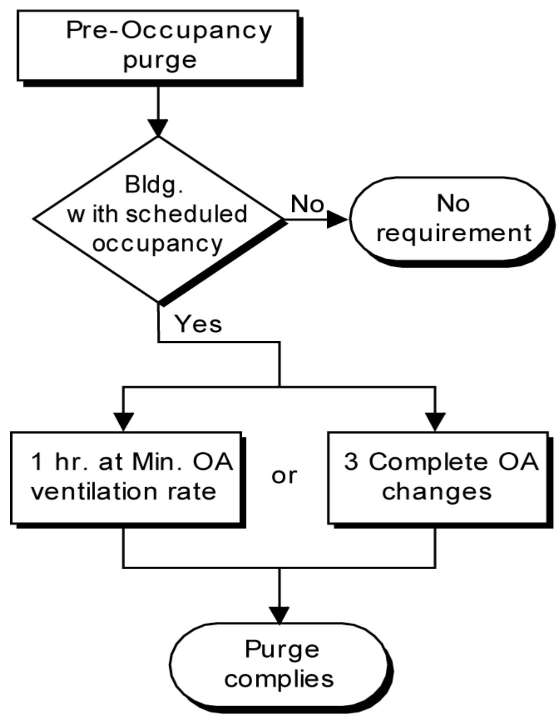
Either criterion can be used to comply with the Energy Code. Three complete air changes mean an amount of ventilation air equal to three times the volume of the occupied space. This air may be introduced at any rate provided for and allowed by the system, so that the actual purge period may be less than an hour.

A pre-occupancy purge is not required for buildings or spaces that are not occupied on a scheduled basis, such as storage rooms. Also, a purge 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 4-7: Pre-Occupancy Purge Flowchart



Source: California Energy Commission

Example 4-4: Purge Period

Question:

What is the length of time required to purge a space 10 ft high with an outdoor ventilation rate of 1.5 cfm/sq ft?

Answer:

For three air changes, each sq ft of space must be provided with:

OA volume = 3 x 10 = 30 cf/ft^2

At a rate of 1.5 cfm/sq ft, the time required is:

Time = 30 cf/ft^2 / 1.5 cfm/ft^2 = 20 minutes

Example 4-5: Purge with Natural Ventilation

Question:

In a building with natural ventilation, do the windows need to be left open all night to accomplish a building purge?

Answer:

No. A building purge is required only for buildings with mechanical ventilation systems.

Example 4-6: Purge with Occupancy Timer

Question:

How is a purge accomplished in a building without a regularly scheduled occupancy, whose system operation is controlled by an occupancy sensor?

Answer:

This building is most likely 24/7 accessible and a purge requirement would not apply for this building. The occupancy sensors and manual timers can only be used to control ventilation systems in buildings that are intermittently occupied without a predictable schedule.

Demand Controlled Ventilation

Reference: Section 120.1(d)3 and 4

Demand controlled ventilation systems reduce the amount of ventilation supply air in response to a measured level of carbon dioxide (CO_2) in the breathing zone. The Energy Code only permits CO_2 sensors 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). The purpose of CO_2 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 CO_2. 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 CO_2 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.

The Energy Code requires the use of DCV systems for spaces. Those that have a design occupancy of 40 sq. ft./person or smaller (for areas without fixed seating where the design density for egress purposes is 40 sq. ft./person or smaller), and has at least one of the following:

- An air economizer
- Modulating outside air control
- Design outdoor airflow rate greater than 3,000 cfm

Exceptions to this requirement:

- The space exhaust is greater than the required ventilation rate minus 0.2 cfm/ft². This 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.
- DCV devices are not allowed in 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, areas designated for unvented food service preparation, daycare, sickroom, science lab, barber shop, or beauty and nail salons.

  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.
- Spaces with an area of less than 150 sq. ft., or a design occupancy of less than 10 people, per Section 120.1(c)3 (Table 120.1-A).

  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.

Although not required, the Energy Code permits design professionals to apply DCV on any intermittently occupied spaces served by either single-zone or multiple-zone equipment. Section 120.1(c)3 requires a minimum of 15 cfm of outdoor air per person multiplied by the expected number of occupants. However, it must be noted that these are minimum ventilation levels, and the designers may specify higher ventilation levels if there are health related concerns that warrant higher ventilation rates.

CO_2 based DCV is based on several studies (Berg-Munch et al. 1986, Cain et al. 1983, Fanger 1983 and 1988, Iwashita et al. 1990, Rasmussen et al. 1985) which concluded that about 15 cfm of outdoor air ventilation per person will control human body odor such that roughly 80 percent of unadapted persons (visitors) will find the odor to be at an acceptable level. As activity level increases and bioeffluents increase, the rate of outdoor air required to provide acceptable air quality increases proportionally, resulting in the same differential CO2 concentration.

A CO_2 sensor only tracks indoor contaminants that are generated by occupants themselves and, to a lesser extent, their activities. It will not track other pollutants, particularly volatile organic compounds that off-gas from furnishings and building materials. Hence, where permitted or required by the Energy Code, DCV systems cannot reduce the outdoor air ventilation rate below the lowest rate listed in Table 120.1-A (typically 0.15 cfm/ft²) during normally occupied times, as per Mechanical Ventilation.

DCV systems save energy if the occupancy varies significantly over time. Hence, they are most cost effective when applied to densely occupied spaces like auditoriums, conference rooms, lounges, or theaters. Because DCV systems must maintain the lowest ventilation rate listed in Table 120.1-A, they will not be applicable to sparsely occupied buildings such as offices where the floor rate always exceeds the minimum rate required by the occupants (See Table 120.1-A).

Where DCV is employed, the controls must meet all of the following requirements:

- Sensors must be provided in each room served by the system that has a design occupancy of 40 sq. ft. per person or less, with no less than one sensor per 10,000 sq. ft. of floor space. When a zone or a space is served by more than one sensor, signals from any sensor indicating that CO_2 is near or at the setpoint 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.
- The CO_2 sensors must be located in the breathing zone (between three and six ft. above the floor or at the anticipated height of the occupant's head). Sensors in return air ducts are not allowed since they can result in under-ventilation due to CO_2 measurement error caused by short-circuiting of supply air into return grilles and leakage of outdoor air (or return air from other spaces) into return air ducts.
- The ventilation must be maintained that will result in a concentration of CO_2 at or below 600 ppm above the ambient level. The ambient levels 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 CO_2 concentration, the resulting DCV CO_2 setpoint 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 CO_2 is a commonly recognized guideline value and referenced in earlier versions of ASHRAE Standard 62.1.) 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. ASHRAE Guideline 36-2021, High-Performance Sequences of Operation for HVAC Systems, contains separate sequences of operation for complying with Title 24 and ASHRAE 90.1-2019.
- Regardless of the CO_2 sensor's reading, the system is not required to provide more than the minimum ventilation rate required by Section 120.1(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 no less than R_a x A_z per Mechanical Ventilation for each space with a CO_2 sensor plus the greater of either the exhaust air rate or the rate required by other spaces served by the system, as listed in Table 120.1-A. This is a low limit setting that must be implemented in the controls.
- The CO_2 sensors must be factory-certified to have an accuracy within plus or minus 75 ppm at 600 and 1000 ppm concentration when measured at sea level and 25 degree Celsius (77 degrees F), factory calibrated or calibrated at start-up, and certified by the manufacturer to require calibration no more frequently than once every five years. 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.

- When a sensor failure is detected, the system must provide a signal to reset the system to provide the minimum quantity of outside air levels required by Section 120.1(c)3 to the zone(s) serviced by the sensor at all times that the zone is occupied. This requirement ensures that the space is adequately ventilated in case a sensor malfunctions. A sensor that provides a high CO_2 signal on sensor failure will comply with this requirement.
- For systems that are equipped with DDC to the zone level, the CO_2 sensor(s) reading for each zone must be displayed continuously and recorded. The 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 systems performance.

Occupied Standby Zone Controls

Reference: Section 120.1(d)5, Section 120.2(e)3

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 130.1(c). 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 in Table 120.1-A (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 120.1(d)5 and Section 120.2(e)3 when a space meets both the following conditions.

- Section 130.1(c)5 and 6 specify that occupant sensing, as opposed to time-switch, is required to implement shutoff controls.
- Table 120.1-A specifies that ventilation air in the space is allowed to be reduced to zero when the space is in occupied standby mode.
- The zone and ventilation system is not served by pneumatic controls.

Table 4- 1: Occupancy Categories Qualifying for Occupied Standby Control Requirements lists all the occupancy categories that meet both conditions above and thus are required to install occupied standby controls if the ventilation zone is serving only qualifying spaces. Note that the "Corridors" category is duplicated from the general category and offices are duplicated from the office category to other building types for clarity.

Table 4-1: Occupancy Categories Qualifying for Occupied Standby Control Requirements

Occupancy Category
Offices
Multiuse assembly less than 1,000 sqft
Classrooms
Corridors
Conference Rooms
Restrooms
General

Occupancy Category
Guest rooms in hotel/motel

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. 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 systems using DOAS units, please see the special note at the end of this section.

Where occupied-standby zone controls are employed (whether mandated or not) the controls must meet all of the following requirements:

- Sensors must meet the requirements of Section 110.9(b)4 and shall have suitable coverage to detect occupants in the entire space.
- Sensors that are used for lighting can be used for ventilation if the ventilation system is controlled directly from the occupant sensor and is not subject to daylighting control or other manual overrides.
- If a space conditioning system(s) serves several enclosed spaces, each space shall have its own occupant sensor and all sensors must indicate lack of occupancy before the zone airflow is cut off.
- The occupant sensor override of ventilation shall be disabled during preoccupancy purge (i.e., the terminal unit and central ventilation shall be active regardless of occupant status). Preoccupancy purge occurs during times that are scheduled to be unoccupied and the HVAC system is scheduled off and thus does not overlap with occupied standby periods.
- Single zone systems when "floating" between a call for heating or cooling will be shut off. For multizone systems, when a zone enters occupied standby and sets its zone airflow to zero, the system outside airflow shall be reduced to account for the reduced need for outside air. ASHRAE Guideline 36-2021, *High-Performance Sequences of Operation for HVAC Systems,* provides operating sequences that include the specific instructions for resetting air handler outside air amounts in response to a zone being placed in occupied standby while complying with the Title 24, Part 6 minimum outside air flowrates for the other zones.

The following three requirements allow a time delay up to 25 minutes (20 minutes sensor time delay + 5 minute occupied standby time delay) after no occupant activity is detected in all lighting zones served by the space conditioning zone and before the ventilation to the rooms is shut off.

The HVAC system must have the ability to modulate ventilation to each space conditioning zone that must comply with occupied standby mode.

The space conditioning zones and the lighting zones are not required to match controls operation. The illustration below (Figure 4- 8: Control Sequence Diagram of Occupied Standby Control of HVAC Thermal Zone Serving Two Lighting Zones (LZ1 and LZ2) Pre-Occupancy

Purge Flowchart) provides an example of the sequence of events for two lighting zones (LZ1 and LZ2) served by one HVAC zone and how occupant-sensing lighting controls relate to the HVAC ventilation controls. If an HVAC zone serves multiple lighting zones, then all lighting zones must be vacant for the HVAC zone to go into occupied standby. If a large lighting zone serves several small HVAC zones within the lighting zone, then all HVAC zones will go into occupied standby when the lighting zone is unoccupied.

- Occupant sensing controls shall indicate that a space or lighting zone is vacant in 20 minutes or less after no occupant activity is detected by any occupant sensors covering the space.
- When all the lighting zones served by the same space conditioning zone are vacant as indicated by the occupant sensing controls, the space conditioning zone enters occupied-standby mode.
- Once a space conditioning zone enters occupied-standby mode, in 5 minutes or less, thermostatic setpoints are reset and mechanical ventilation to the zone shall be shut off until any room served by the space conditioning zone becomes occupied or until ventilation is needed to provide space heating or conditioning. Temperature setback can be achieved either by:
    - 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
    - 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.

What is ASHRAE Guideline 36?

ASHRAE Guideline 36, *High-Performance Sequences of Operation for HVAC Systems*, provides peer-reviewed sequences of operation for HVAC systems, written in a format that can be readily implemented by building controls manufacturers and control system contractors. It is continuously updated by a large committee of engineers, manufacturers, scientists, and contractors following the rigorous ASHRAE public review process. These sequences are intended to maximize energy efficiency while maintaining good indoor air quality and comfort. The sequences have been configured and tested to provide control stability and real-time fault detection and diagnostics. Specifying Guideline 36 control sequences reduces risk of Energy Management Control System programming errors and provides a common set of terms and sequences to facilitate communication between specifiers, contractors, and operators.

Example 4-7

Question:

If an HVAC zone is designed to serve an office space, conference room, and corridor, does this configuration require occupied standby capabilities to shut off ventilation?

Answer:

Yes.

Offices Spaces and Corridors all require occupancy sensing controls under Section 130.1(c) **AND** are occupancy categories that can have their ventilation air reduced to zero when the space is in occupied-standby mode.

- Small offices (250 square feet or less) require occupant sensing controls under 130.1(c)5.
- Large offices (250 square feet or greater) require occupant sensing controls under 130.1(c)6.
- Conference rooms of any size require occupant sensing controls under 130.1(c)5.
- Office Corridors require occupant sensing controls under sections 130.1(c)6.

Corridors which provide that ventilation are subject to occupied-standby mode under Table 120.1-A, as are office spaces (as indicated by the note "F" Column).

Example 4-8

Question:

If an HVAC zone is designed to serve both an office space and classrooms does this configuration require occupied standby capabilities to shut off ventilation?

Answer:

No, for Pre-K and K-12 classrooms.

Yes, for most Higher Education and commercial training classrooms.

As noted in the previous example, the occupied standby mode requirements are triggered if the space is subject to have occupant sensing controls under 130.1(c) **AND** are occupancy categories that can have their ventilation air reduced to zero when the space is in occupied-standby mode under Table 120.1-A. While all classrooms are required occupant sensing controls under Section 130.1(c)5, only certain types of classrooms can reduce ventilation flow to zero when the space is in occupied-standby mode.

In the case of classrooms, pre-K and K-12 educational facilities and some specialized classrooms such as art classrooms do not require occupied standby while those intended for college, community college, business lectures, or classrooms do require them. Note that the space types listed under other building types "Offices" and "General" would still apply to Educational Facilities, as result offices and corridors in educational buildings which both are required to have occupancy sensing and are allowed to set ventilation to 0 during occupied standby would also be required to have occupied standby controls if all the spaces in a thermal zone qualify for occupied standby.

Example 4-9

Question 1:

For thermal zones required to have occupant sensor ventilation controls, are these spaces allowed to set the ventilation rate to 0 during the preoccupancy ventilation purge period if there are no occupants sensed in the thermal zone?

Answer 1:

No. Preoccupancy controls (Section 120.1(d)), ventilate the building "during the 1-hour period immediately before the building is normally occupied." Occupant sensor control devices

(Section 120.1(d)5E), in contrast operate “When the zone is scheduled to be occupied and occupant sensing controls in all rooms and areas served by the zone indicate the spaces are unoccupied, ” To be doubly clear, Section 120.1(d)5D says, “One hour prior to normal scheduled occupancy, occupant sensor ventilation control shall allow pre-occupancy purge as described in Section 120.1(d)2. See Figure 4- 8: Control Sequence Diagram of Occupied Standby Control of HVAC Thermal Zone Serving Two Lighting Zones (LZ1 and LZ2) Pre-Occupancy Purge Flowchart even though both spaces are vacant, and lights are out in these spaces, the space is being ventilated during the pre-occupancy purge period. This pre-occupancy purge period ventilated the space prior to the day’s scheduled occupancy dilute site generated pollutants that have built up over night.

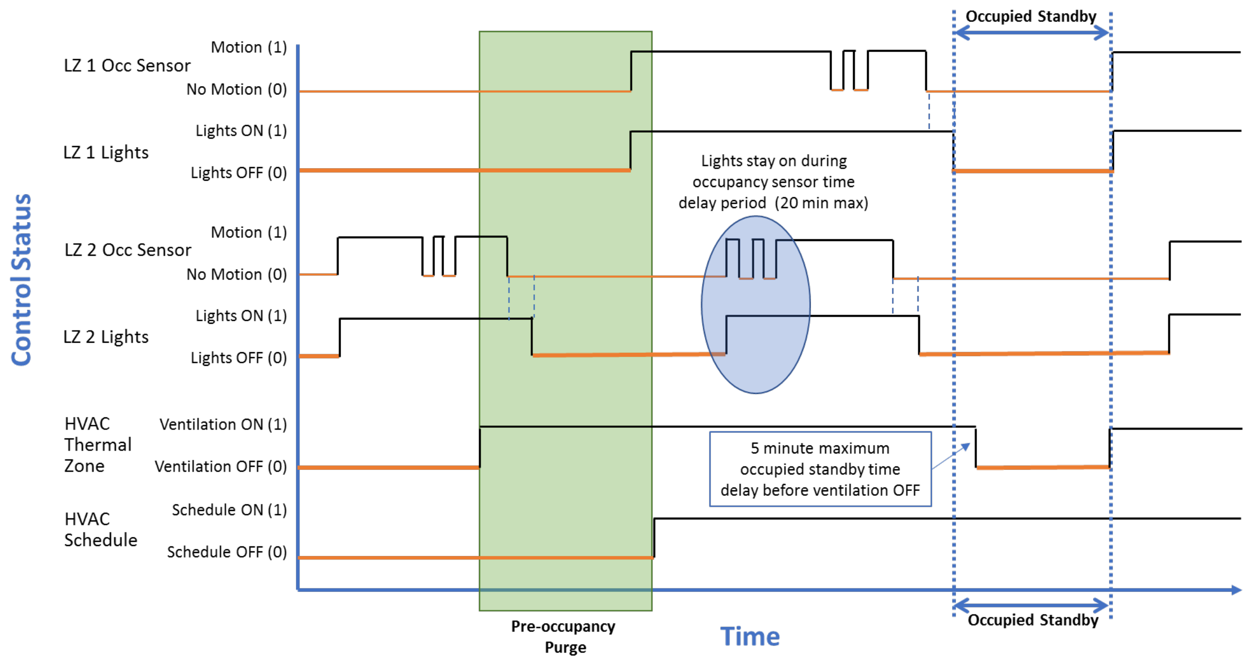
Question 2:

For a thermal zone required to have occupant sensor ventilation controls, what is the range of time delays allowed between all occupancy sensors in the zones sensing vacancy and the control shutting off ventilation air to the zone?

Answer 2:

Between 0 and 25 minutes. For the control with the shortest time delay, one could directly receive the output of the occupancy sensors and place the system in occupied standby mode whenever all the sensors do not receive a signal indicating occupancy. However, this control would have a lot of false vacancy signals as the occupant sensors are not able to detect movement continuously in occupied spaces and would be cycling the system back and forth between occupied standby and occupied. There are some HVAC designers that directly take the occupant sensor signal without the time delay built into the occupancy sensor and the program the system shut off ventilation air after a 5-minute time delay. It is also acceptable to take the lighting occupant sensor control signal that includes the lighting system time delay which is allowed to be set to as long as 20 minutes. This approach is used when the HVAC control system is taking the on/off signal from an extra set of dry contracts on the lighting occupant sensor. The HVAC system designer is allowed to take this lighting system signal which included the lighting control time delay and add on an extra 5-minute time delay before resetting the system setpoints and shutting off the ventilation air to zero.

Figure 4-8: Control Sequence Diagram of Occupied Standby Control of HVAC Thermal Zone Serving Two Lighting Zones (LZ1 and LZ2) Pre-Occupancy Purge Flowchart



Source: California Energy Commission

Special Note for Dedicated Outdoor Air Systems (DOAS)

HVAC zones utilizing DOAS units must still adhere to occupied standby control requirements.

Fan Cycling

Reference: Section 120.1(d)1

While Section 120.1(d)1 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:

- 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.
- The HVAC system shall be operated continuously during working hours except:
  - During scheduled maintenance and emergency repairs.
  - During periods not exceeding a total of 90 hours per calendar year when a serving electric utility by contractual arrangement requests its customers to decrease electrical power demand, or
  - During periods for which the employer can demonstrate that the quantity of outdoor air supplied by nonmechanical means meets the outdoor air supply rate. The employer must have available a record of calculations and/or measurements

substantiating that the required outdoor air supply rate is satisfied by infiltration and/or by a nonmechanically driven outdoor air supply system.

- When a space has entered occupied standby mode as permitted by Section 120.2(e)3.

Title 8 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." The required ventilation rates are thus not required whenever the zones are unoccupied. This section affirms that ventilation fans may be turned off during unoccupied periods. 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 hour's 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.

Exceptions A, B, and C to Title 8 Section 5142(a)(2) all refer to a complete system shutdown where the required ventilation is not maintained.

Example 4-10

Question:

Does a single zone air-handling unit serving a 2,000 sq. ft. auditorium with fixed seating for 240 people require DCV?

Answer:

Since the space has an occupant load factor of 8.3 sq. ft. per person (2,000 sq. ft. per 240 people), it meets the 40 sq. ft./person or less requirement triggering demand control ventilation if it has at least one of the following:

- Air economizer
- Modulating outside air control
- -Design outdoor airflow greater than 3,000 cfm

A single CO_2 sensor could be used for this space provided it is certified by the manufacturer to cover 2,000 sq. ft. of space. The sensor must be placed directly in the space.

Example 4-11

Question

If two separate units are used to condition the auditorium in the previous example, is DCV required?

Answer

Yes, for each system that meets the criteria above.

Example 4-12

Question

Does the 2,000 sq ft auditorium in the previous examples require both DCV per Section 4.3.9. and occupied-standby zone controls per Section 4.3.10?

Answer

No, only DCV is required because occupied-standby zone controls are only required for spaces such as offices 250 sq ft or less, multipurpose rooms 1,000 sq ft or less, classrooms, conference rooms, or restrooms.

Example 4-13

Question

If a central AHU supplies five zones of office space (with a design occupant density of 100 sq ft per person and two zones with conference rooms (with a design occupant density of 35 sq ft per person) is it required to have demand-controlled ventilation and if so, on which zones?

Answer

If the AHU has DDC controls to the zone and an airside economizer it is required to have DCV controls in both of the conference room zones.

The minimum OSA will be set for 0.15 cfm/ft² times the total area of all seven zones (the office and conference room zones) and the maximum required OSA does not need to exceed the sum of 0.15 cfm/ft² for the five office zones plus 15 cfm per person for the two conference rooms.

Variable Air Volume (VAV) Changeover Systems

Please refer to Chapter 4.4.12.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Adjustment of Ventilation Rate

Please refer to Chapter 4.4.13 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Acceptance Requirements

Please refer to Chapter 4.4.14 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Ventilation Airflow

Please refer to Chapter 4.4.14.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Ventilation System Time Controls and Preoccupancy Purge

Please refer to Chapter 4.4.14.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Demand-Controlled Ventilation System

Please refer to Chapter 4.4.14.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Pipe and Duct Distribution Systems

Mandatory Measures

Requirements for Pipe Insulation

Reference: Section 120.3, Table 120.3-A-1, Table 120.3-A-2

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.

Table 120.3-A-1 and Table 120.3-A-2 of the Energy Code 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. Piping within fan coil units and within other heating or cooling equipment should be insulated based on the pipe diameter and the required value in the table.

Piping that does not require insulation includes the following:

- Factory installed piping within space-conditioning equipment certified under Section 110.1 or Section 110.2, see Equipment Requirements. Nationally recognized certification programs that are accepted by the Energy Commission for certifying efficiencies of appliances and equipment are considered to meet the requirements for this exception.
- Piping that conveys fluid with a design operating temperature range between 60 degrees F and 105 degrees F, such as cooling tower piping or piping in water loop heat pump systems.
- Where the heat gain or heat loss, to or from piping without insulation, will not increase building source energy use. For example, this requirement does not apply to piping connecting fin-tube radiators within the same space, nor to liquid piping in a split system air conditioning unit. This exception does not apply to piping in solar systems. Solar systems

typically have backup devices that will operate more frequently if piping losses are not minimized.

- 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 assure that no contact is made with the metal framing.

Conductivities and thicknesses listed in Table 120.3-A-1 and Table 120.3-A-2 are typical for fiberglass and foam. When insulating materials are used that have conductivities different from those listed here for the applicable fluid range, such as calcium silicate, the equation below for insulation thickness may be used to calculate the required insulation thickness.

When a pipe carries cold fluids, condensation of water vapor within the insulation material may impair the effectiveness of the insulation, particularly for applications in very humid environments or for fluid temperatures below 40 degrees F. Examples include refrigerant suction piping and low-temperature thermal energy storage (TES) systems. In these cases, manufacturers should be consulted, and consideration given to low permeability vapor barriers, or closed-cell foams.

The Energy Code also requires that pipe insulation be protected from damage by moisture, UV and physical abrasion including but not limited to the following:

- Insulation exposed to weather shall be installed with a cover suitable for outdoor service. The cover shall be water retardant and provides shielding from solar radiation that can cause degradation of the material. Insulation must be protected by an external covering unless the insulation has been approved for exterior use using a recognized federal test procedure. Adhesive tape shall not be used as protection for insulation exposed to weather.
- Insulation covering chilled water piping and refrigerant suction piping located outside the conditioned space shall have a Class I or Class II vapor retarder. All penetrations and joints of which shall be sealed.
- Pipe insulation buried below grade must have a waterproof, uncrushable casing or sleeve. The Energy Code does not define "uncrushability" as any material can be crushed, given enough pressure, and thus it is left to the professional judgement of the designer.

If the conductivity of the proposed insulation does not fall into the conductivity range listed in Table 120.3-A-1 and Table 120.3 -A-2, the minimum thickness must be adjusted using the following equation for insulation thickness:

$$LL = NNRR \times [(1 + \frac{RR}{NNRR})^{\frac{KK}{kk}} - 1]$$

Where,

- LL = Minimum insulation thickness for material with conductivity K, inches.
- $NNRR$ = Pipe actual outside radius, inches.
- RR = Insulation thickness, inches (Table 120.3-A-1 and Table 120.3-A-2 for conductivity k).
- KK = Conductivity of alternate material at the mean rating temperature indicated in Table 120.3-A-1 and Table 120.3-A-2 for the applicable fluid temperature range, in Btu-in./(h-ft^2 -°F).

- kk = The lower value of the conductivity range listed in Table 120.3-A-1 and Table 120.3-A-2 for the applicable fluid temperature, Btu-in/(h-ft^2 -°F).

Example 4-14

Question

What is the required thickness for calcium silicate insulation on a four-inch diameter pipe carrying a 300-degree F fluid?

Answer

From Table 120.3-A-1 and Table 120.3-A-2, using data for 300-degree F fluid:

- PR = 2"
- **t = 4.5"** (from the table for a 4-inch pipe with 300-degree F fluid)
- **K = 0.40 (Btu-in.)/(h-ft^2-°F)** (from calcium silicate insulation manufacturer's conductivity data at 200-degree F)
- **k = 0.29 (Btu-in.)/(h-ft^2-°F)** (the lower value of the range for conductivity for 300-degree F fluid)

$T = PR[(1 + t/PR)^{K/k} – 1]$

T = 2[(1 + 4.5/2)(0.40/0.29)– 1]

T = 8.2 inches

When insulation is not available in the exact thickness calculated, the installed thickness should be the next larger available size.

Requirements for Air Distribution System Ducts and Plenums

Reference: Section 120.4

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

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.

Healthcare facilities are not subject to Section 120.4 and shall comply with the applicable requirements of the California Mechanical Code.

Installation and Insulation

Reference: Section 120.4(a)

Portions of supply-air and return-air ducts or ductwork conveying heated or cooled air shall be insulated to a minimum installed level of R-8 when installed:

- Outdoors
- In a space between the roof and an insulated ceiling
- In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces
- In an unconditioned crawlspace
- In other unconditioned spaces

Portions of supply-air ducts ductwork that are not in one of the above spaces shall be insulated to a minimum installed level of R-4.2 or be exposed in a directly conditioned space. For example, supply-air ducts that are inside the thermal envelope but concealed from view (such as ducts in a chase or above a hard or T-bar ceiling) are required to be insulated with at least R-4.2. However, if the ducts are exposed to directly conditioned space (i.e. ducts are visible to the occupants), then no insulation would be required.

Requirements of the California Mechanical Code

- Mechanically fasten connections between metal ducts and the inner core of flexible ducts.
- Joint and seal openings with mastic, tape, aerosol sealant or other duct closure system that meets the applicable requirements of UL 181, UL 181A, UL 181B or UL 723 (aerosol sealant).

All joints must be made airtight by use of mastic, tape, aerosol sealant, or other duct-closure system that meets the applicable requirements of UL 181, UL 181A, UL 181B, or UL 723. Duct systems shall not use cloth-back, rubber adhesive duct tape regardless of UL designation, unless it is installed in combination with mastic and clamps.

When mastic or tape is used to seal openings greater than 1/4 inch, a combination of mastic and mesh or mastic and tape must be used.

The Energy Commission has approved two cloth-backed duct tapes with special butyl or synthetic adhesives rather than rubber adhesive to seal flex duct to fittings. These tapes are:

- Polyken 558CA or Nashua 558CA, manufactured by Berry Plastics, Tapes and Coatings Division; and
- Shurtape PC 858CA, manufactured by Shurtape Technologies, Inc.

These tapes passed Lawrence Berkeley National Laboratory tests comparable to those that cloth-back rubber-adhesive duct tapes failed (the Lawrence Berkeley National Laboratory test procedure has been adopted by the American Society of Testing and Materials as ASTM E2342-03). These tapes are allowed to be used to seal flex ducts to fittings without 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. On their backing, these tapes have the phrase "CEC Approved," and 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 box explains how to install the tape on duct core to fittings and a statement that the tape cannot be used to seal fitting to plenum and junction box joints.

Factory-Fabricated Duct Systems

Reference: Section 120.4(b)1

Factory-fabricated duct systems must meet the following requirements:

- 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 UL181. UL181 testing may be performed by UL laboratories or a laboratory approved by the Executive Director.
- Pressure-sensitive tapes, heat-activated tapes, and mastics used in the manufacture of rigid fiberglass ducts comply with UL 181 and UL181A.
- Pressure-sensitive tapes and mastics used with flexible ducts comply with UL181 and UL181B.
- All 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.

Duct located in occupied space and exposed to view is not required to meet Seal Class A.

Field-Fabricated Duct Systems

Reference: Section 120.4(b)2

Field-fabricated duct systems must meet the following requirements:

- Factory-made rigid fiberglass and flexible ducts for field-fabricated duct systems comply with UL 181. Pressure-sensitive tapes, mastics, aerosol sealants or other closure systems shall meet applicable requirements of UL 181, UL 181A and UL 181B.
- Mastic Sealants and Mesh:
    - Sealants comply with the applicable requirements of UL 181, UL 181A, and UL 181B, and shall be non-toxic and water resistant.
    - Sealants for interior applications shall pass ASTM C 731(extrudability after aging) and D 2202 (slump test on vertical surfaces), incorporated herein by reference.
    - Sealants for exterior applications shall pass ASTM C 731, C 732 (artificial weathering test) and D 2202, incorporated herein by reference.
    - Sealants and meshes shall be rated for exterior use.
- Pressure-sensitive tapes shall comply with the applicable requirements of UL 181, UL 181A and UL 181B.
- Drawbands used with flexible duct shall:
    - Be either stainless-steel worm-drive hose clamps or UV-resistant nylon duct ties.
    - Have a minimum tensile strength rating of 150 lbs.
    - Be tightened as recommended by the manufacturer with an adjustable tensioning tool.
- Aerosol-Sealant Closures:
    - Aerosol sealants meet applicable requirements of UL 723 and must be applied according to manufacturer specifications.

- Tapes or mastics used in combination with aerosol sealing shall meet the requirements of this section.

- All 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.

Ductwork located in occupied space and exposed to view is not required to meet Seal Class A.

Duct Insulation R-Values

Reference: Section 120.4(c), Section 120.4(d), Section 120.4(e)

Since 2001, the Energy Code has included the following requirements for the labeling, measurement, and rating of duct insulation:

- Insulation R-values shall be based on the insulation only and not include air-films or the R-values of other components of the duct system.
- Insulation R-values shall be tested C-values at 75 degrees F mean temperature at the installed thickness, in accordance with ASTM C 518 or ASTM C 177.
- The installed thickness of duct insulation for purpose of compliance shall be the nominal thickness for duct board, duct liner, factory made flexible air ducts and factory-made rigid ducts. 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.
- The installed thickness of duct insulation for purpose of compliance shall be 75 percent of its nominal thickness for duct wrap.
- Insulated flexible air ducts must bear labels no further than three feet apart that state the installed R-value (as determined per the requirements of the Energy Code).

A typical duct wrap, nominal 1-1/2 inches and 0.75 pound per cubic foot will have an installed rating of R-4.2 with 25 percent compression.

Protection of Duct Insulation

Reference: Section 120.4(f)

The Energy Code requires that exposed duct insulation be protected from damage by moisture, UV and physical abrasion including 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. Insulation must be protected by an external covering unless the insulation has been approved for exterior use using a recognized federal test procedure.
- 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.

Example 4-15

Question:

What are the sealing requirements in a VAV system having a static pressure setpoint of 1.25 inches water gauge and a plenum return? What are the sealing requirements for exposed ductwork in a utility closet?

Answer:

All duct work located within the return plenum must be sealed in accordance with the Seal Class A: all joints, seams, and penetrations must be sealed. A utility closet is not occupied space and therefore exposed ductwork in a utility closet must also be sealed in accordance with Seal Class A. Pressure-sensitive tape heat-seal tape and mastic may be used, if it meets the applicable requirement of UL 181, 181A, 181B, to seal joints and seams which are mechanically fastened per the California Mechanical Code.

Duct Sealing and Leakage Testing.

Reference: Section 120.4(g)

Since 2001, the Energy Code has included prescriptive duct leakage testing for ducts that are part of small single zone systems with portions of the ductwork either outdoors or in uninsulated or vented ceiling spaces. The 2019 California Mechanical Code (CMC) introduced mandatory requirements to seal and test all nonresidential air distribution systems. The prescriptive requirements for duct leakage in the Energy Code were therefore made mandatory and all systems that do not meet the criteria for testing according to the Energy Code are required to meet the requirements in the CMC.

New or replacement duct systems that meet the criteria below shall be sealed to a leakage rate not to exceed 6 percent of the nominal air handler airflow rate as confirmed through ECC acceptance testing, in accordance with Reference Nonresidential Appendix NA7.5.3.

- The duct system does not serve a healthcare facility.
- The duct system provides conditioned air to an occupiable space for a constant volume, single zone, space-conditioning system.
- The space conditioning system serves less than 5,000 square feet of conditioned floor area.
- The combined surface area of the ducts located outdoors or in unconditioned space is more than 25 percent of the total surface area of the entire duct system.

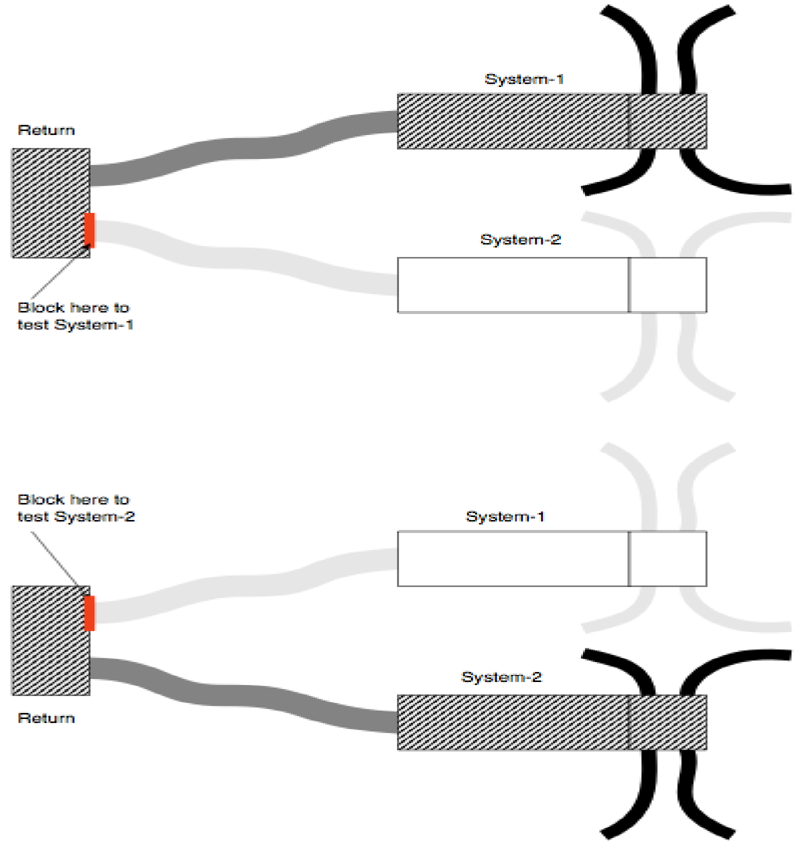
New or replacement duct systems that do not meet the criteria above shall instead meet the duct leakage testing requirements of CMC Section 603.10.1.

Alterations to an existing space conditioning system may trigger the duct sealing requirement. For more information, see Requirements for Alterations.

Duct Leakage Testing for Multiple Duct Systems with Common Return Ducts

If there are two or more duct systems in a building that are tied together at a common return duct, then each duct system should be tested separately, including the shared portion of the return duct system which should be included in each system test. Under this scenario, the portions of the second duct system that is not being tested must be completely isolated from the portions of the ducts that are being tested, so the leakage from the second duct system does not affect the leakage rate from the side that is being tested. The diagram below represents the systems that are attached to a shared return boot or remote return plenum. In this case, the point in the return system that needs to be blocked off is readily accessible through the return grille. The “duct leakage averaging” method where both systems are tested together (as though it is one large system) and the results divided by the combined tonnage to get the target leakage may not be used as it allows a duct system with more the 6 percent leakage to pass if the combined system's leakage is 6 percent or less.

Figure 4-9: Example of Two Duct Systems with a Common Return



Source: California Energy Commission

Example 4-16

Question:

A new 20-ton single zone system with new ductwork serving an auditorium is being installed. Approximately half of its ductwork is on the roof. Does it need to be leak tested in accordance with NA7.5.3 or the California Mechanical Code?

Answer:

It likely needs to be tested to the CMC Section 603.10.1. Although this system meets the criteria of being single zone and having more than 25 percent of the duct surface area on the roof, the unit probably serves more than 5,000 sq ft of space. Most 15- and 20-ton units will serve spaces that are significantly larger than 5,000 sq ft. If the space is 5,000 sq ft or less the ducts do need to be leak tested per Section 120.4(g)1 and NA7.5.3.

Example 4-17

Question:

A new 5-ton single zone system with new ductwork serving a 2,000 sq ft office is being installed. The unit is a down discharge configuration and the roof has insulation over the deck. Does the ductwork need to be leak tested in accordance with NA7.5.3 or the California Mechanical Code?

Answer:

It likely needs to be tested according to the CMC Section 603.10.1. Although this system meets the criteria of being single zone and serving less than 5,000 sq ft of space, it does not have 25 percent of its duct area outdoors or in unconditioned space. With the insulation on the roof and not on the ceiling, the plenum area likely meets the criteria of indirectly conditioned.

Acceptance Requirements

The Energy Code has acceptance requirements where duct sealing and leakage testing is required by Section 120.5(a)3.

These tests are described in the Chapter 13, Acceptance Requirements, and the Reference Nonresidential Appendix NA7.

HVAC System Control Requirements

Mandatory Measures

This section covers controls that are mandatory for all system types, including:

- Heat pump controls for the auxiliary heaters
- Zone thermostatic control including special requirements for hotel/motel guest rooms and perimeter systems
- Shut-off and setback/setup controls
- Infiltration control
- Off-hours space isolation
- A new mandatory requirement for hot water supply temperature (HWST)
- Economizer fault detection and diagnostics (FDD)
- Control equipment certification
- Direct digital controls (DDC)
- Optimum start/stop controls.

Zone Thermostatic Controls

Reference: Section 120.2(a), (b), and (c)

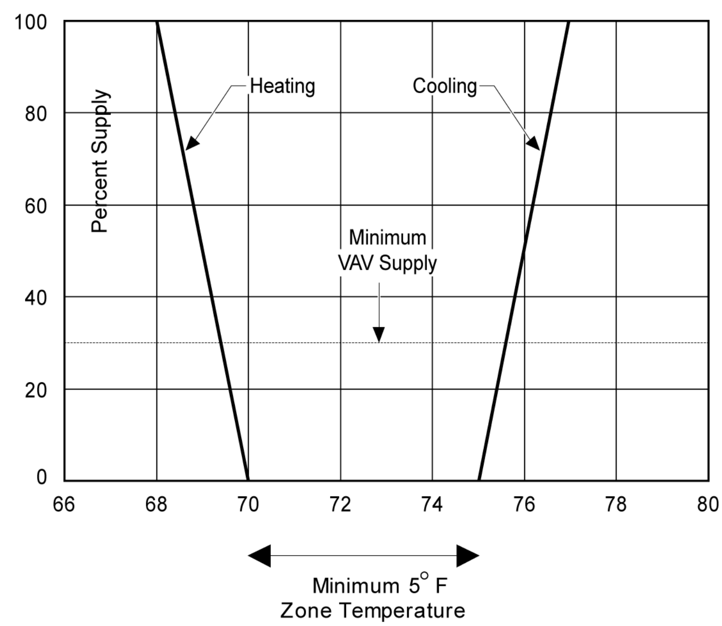
Thermostatic controls must be provided for each space-conditioning zone or dwelling unit to control the supply of heating and cooling energy within that zone. The controls must have the following characteristics:

- When used to control **heating**, the thermostatic control must be adjustable down to 55 degrees F or lower.
- When used to control **cooling**, the thermostatic control must be adjustable up to 85 degrees F or higher.

- When used to control both **heating and cooling**, the thermostatic control must be adjustable from 55 degrees F to 85 degrees F and also provide a temperature range or **dead band** of at least 5 degrees F. When the space temperature is within the dead band, heating and cooling energy must be shut off or reduced to a minimum. A dead band is not required if the thermostat requires a manual changeover between the heating and cooling modes Exception to Section 120.2(b)3.
- For all single-zone air conditioners and heat pumps, all thermostats shall have setback capabilities with a minimum of four separate setpoints per 24-hour period. Also, the thermostat must comply with the occupant controlled smart thermostat requirements in Section 110.12(a), which is capable of responding to demand response signals in the event of grid congestion and shortages during high electrical demand periods.
- Systems equipped with DDC to the zone level, rather than zone thermostats, must be equipped with automatic demand shed controls that provide demand shedding, as described later in Automatic Demand Shed Controls.

The setpoint may be adjustable either locally or remotely, by continuous adjustment or by selection of sensors.

Figure 4-10: Proportional Control Zone Thermostat



Source: California Energy Commission

Supplemental perimeter heating or cooling systems are sometimes used to augment a space-conditioning system serving both interior and perimeter zones. This is allowed provided controls are incorporated to prevent the two systems from conflicting with each other. If that were the case, then the Energy Code requires that:

- The perimeter system must be designed solely to offset envelope heat losses or gains.
- The perimeter system must have at least one thermostatic control for each building orientation of 50 ft or more.
- The perimeter system is controlled by at least one thermostat located in one of the zones served by the system.

The intent is that all major exposures are controlled by their own thermostat, and that the thermostat is located within the conditioned perimeter zone. Other temperature controls, such as outdoor temperature reset or solar compensated outdoor reset, do not meet these requirements of the Energy Code.

Thermostats with adjustable setpoints and deadband capability are not required for zones that must have constant temperatures to prevent the degradation of materials, an exempt process, plants, or animals (Exception 1 to Section 120.2(b)4). Included in this category are manufacturing facilities, hospital patient rooms, museums, and computer rooms. Chapter 13 describes mandated acceptance test requirements for thermostat control for packaged HVAC systems.

Example 4-18

Question

Can an energy management system be used to control the space temperatures?

Answer

Yes, provided the space temperature setpoints can be adjusted, either locally or remotely. This section sets requirements for "thermostatic controls" which need not be a single device like a thermostat; the control system can be a broader system like a DDC system. Some DDC systems employ a single cooling setpoint and a fixed or adjustable deadband. These systems comply if the deadband is adjustable or fixed at 5 degrees F or greater.

Hotel/Motel Guest Room Thermostats

Please refer to Chapter 4.6.1.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Heat Pump Controls

Please refer to Chapter 4.6.1.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Shut Off and Temperature Setup/Setback

Reference: Section 120.2(e)1, Section 120.2(e)2, Section 120.2(e)3

For specific occupancies and conditions, each space-conditioning system must be provided with controls that comply with the following requirements:

- The control can automatically shut off the equipment during unoccupied hours and shall have one of the following:
    - An automatic time switch device with the same characteristics that lighting devices must have, as described in Chapter 5, and a manual override accessible to the occupants that allows the system to operate up to four hours. The manual override can be included as a part of the control device, or as a separate override control.
    - An occupancy sensor. Since a building ventilation purge is required prior to normal occupancy, an occupancy sensor may be used to control the availability of heating and cooling but should not be used to control the outdoor ventilation system.

    - A four-hour timer that can be manually operated to start the system. As with occupancy sensors, the same restrictions apply to controlling outdoor air ventilation systems.

Exception to Section 120.2(e)1: The mechanical system serving retail stores and associated malls, restaurants, grocery stores, churches, or theaters equipped with seven-day programmable timers do not have to comply with the above requirements.

- When shut down, the controls shall automatically restart the system to maintain:
    - A setback heating thermostat setpoint if the system provides mechanical heating. *Exception:* Thermostat setback controls are not required in nonresidential buildings in areas where the winter median of extremes outdoor air temperature is greater than 32 degrees F.
    - A setup cooling thermostat setpoint if the system provides mechanical cooling. *Exception:* Thermostat setup controls are not required in nonresidential buildings in areas where the summer design dry bulb 0.5 percent temperature is less than 100 degrees F.
- Occupant-sensing zone controls:

Space conditioning systems serving rooms that are required to have occupant sensing controls to satisfy the lighting control requirements of Section 130.1(c) and where Table 120.1-A of the Energy Code identifies the room or space is eligible to reduce the ventilation air to zero, shall incorporate this control strategy known as occupied standby mode. Occupancy sensors are required to report the room status as vacant if all sensors within that room do not detect activity for 20 minutes (building designers are allowed to set a shorter time threshold to define vacancy).

A space conditioning zone shall enter occupied standby mode when occupant sensing controls indicate that all the lighting zones within the zone are vacant for five minutes or less. After entering occupied standby mode, the cooling setpoint shall be increased by at least 2 degrees F and the heating setpoint shall be decreased by at least 2 degrees F, or for a multiple zone system with DDC to the zone level the cooling setpoint shall be increased by at least 0.5 degrees F and the heating setpoint shall be decreased by at least 0.5 degrees F. All airflow to the zone shall be shut off when in occupied standby mode. If the temperature in the zone drifts outside the deadband, then the full space conditioning system will turn on to satisfy the load in that zone.

This occupancy control must not prevent outside air ventilation of the space when the pre-occupancy ventilation purge cycle is required by Section 120.1(d)2. Pre-occupancy purge ventilates the space prior to scheduled occupancy each day to dilute and exhaust contaminants that have built up inside the building over night while the HVAC systems were off. Typically, the space is unoccupied during these periods and the occupancy control must not disable this scheduled ventilation cycle.

- Exceptions for automatic shutoff, setback and setup, and occupant sensor setback:
    - *Exception to A, B, and C:* It can be demonstrated to the satisfaction of the enforcement agency that the system serves an area that must operate continuously.

- *Exception to A, B, and C:* Systems that have a full load demand of 2 kW or less, or 6,826 Btu/h, if they have a readily accessible manual shut off switch. Included is the energy consumed within all associated space-conditioning systems including compressors, as well as the energy consumed by any boilers or chillers that are part of the system.
- *Exception to A and B:* Systems serve hotel/motel guest rooms, if they have a readily accessible manual shut-off switch.

- Hotel/motel guest room controls:

Reference: Section 120.2(e)4

Hotel/motel guest rooms shall have captive card key controls, occupancy sensing controls, or automatic controls such that within 30 minutes of a guest leaving the room, setpoints are set-up of at least +5 degrees F (+3 degrees Celsius) in cooling mode and set-down of at least -5 degrees F (-3 degrees Celsius) in heating mode.

Example 4-19

Question:

Can occupancy sensors be used in an office to shut off the VAV boxes during periods when the spaces are unoccupied?

Answer:

Yes, only if the ventilation is provided through operable openings. With a mechanical ventilation design the occupancy sensor could be used to reduce the VAV box airflow to the minimum allowed for ventilation. It should not shut the airflow off completely; ventilation must be supplied to each space at all times when the space is usually occupied.

Example 4-20

Question:

Must a 48,000 sq ft building with 35 fan coil units have 35-time switches?

Answer:

No. More than one space-conditioning system may be grouped on a single time switch, subject to the area limitations required by the isolation requirements (see Isolation). In this case, the building would need two isolation zones, each no larger than 25,000 sq ft, and each having its own time switch.

Example 4-21

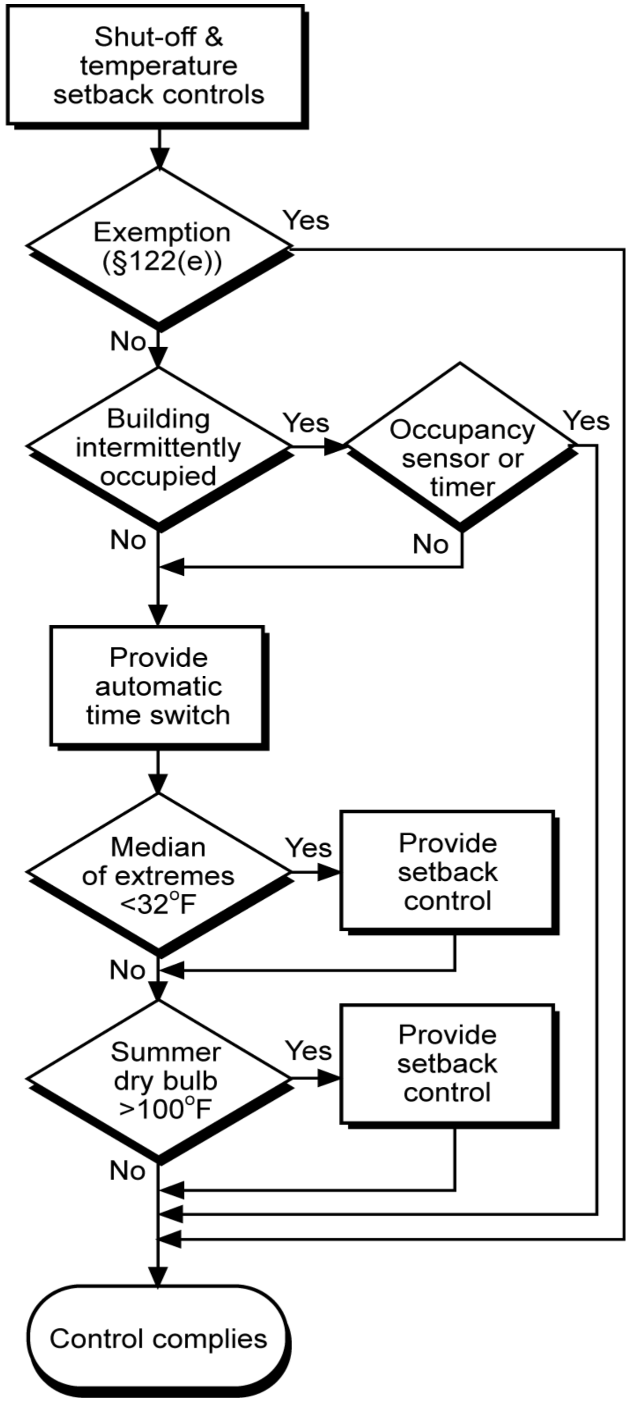
Question:

Can a thermostat with setpoints determined by sensors (such as a bi-metal sensor encased in a bulb) be used to accomplish a night setback?

Answer:

Yes. The thermostat must have two heating sensors, one each for the occupied and unoccupied temperatures. The controls must allow the setback sensor to override the system shutdown.

Figure 4-11: **Shut-Off and Setback Controls Flowchart**



Source: California Energy Commission

These provisions are required by the Energy Code to reduce the likelihood that shut-off controls will be circumvented to cause equipment to operate continuously during unoccupied hours.

Example 4-22

Question:

If a building has a system comprised of 30 fan coil units, each with a 300-watt fan, a 500,000 Btu/h boiler, and a 30-ton chiller, can an automatic time switch be used to control only the boiler and chiller (fan coils operate continuously)?

Answer:

No. The 2 kW criterion applies to the system as a whole and is not applied to each component independently. While each fan coil only draws 300 W, they are served by a boiler and chiller that draw much more. The consumption for the system is well in excess of 2 kW.

Assuming the units serve a total area of less than 25,000 sq ft (see Isolation), one-time switch may control the entire system.

Infiltration Control

Reference: Section 120.2(f)

Outdoor air supply and exhaust equipment must incorporate dampers that automatically close when fans shut down.

Fans shut down when ventilation or conditioned air is not necessary for the building, which only occurs when a normally scheduled unoccupied period begins (such as overnight or a weekend for office buildings) or when occupancy sensors are used for ventilation control. The dampers may either be motorized, or of the gravity type. However, only motorized dampers that remain closed when the fan turns on would be capable of accomplishing the best practice below.

Best Practice

Though the Energy Code only specifies fan shut down, as a best practice outside air dampers should also remain completely closed during the unoccupied periods, even when the fan turns on to provide setback heating or cooling. However, to avoid instances of insufficient ventilation, or sick building syndrome, the designer should specify that the outside air dampers open and provide ventilation if:

- The unoccupied period is a one-hour pre-occupancy purge ventilation, as per Section 120.1(c)2.
- The damper is enabled by an occupant sensor in the building as per Section 120.1(c)5, indicating that there are occupants that demand ventilation air.
- The damper is enabled by an override signal as per Section 120.2(e)1, which includes an occupancy sensor and an automatic time switch control device or manually operated four-hour timer.

Exception 1: Equipment that serves an area that must operate continuously.

Exception 2: Damper control required on gravity ventilators or other non-electrical equipment, provided that readily accessible manual controls are incorporated.

Exceptions 3 and 4: Damper control is not required at combustion air intakes and shaft vents or where prohibited by other provisions of law. If the designer elects to install dampers or shaft vents to help control stack-induced infiltration, the damper should be motorized and controlled to open in the event of a fire in accordance with applicable fire codes.

Isolation Area Controls

Reference: Section 120.2(g)

Large space-conditioning systems serving multiple zones may waste considerable quantities of energy by conditioning all zones when only a few are occupied. Typically, this occurs during evenings or weekends when less people are working. When the total area served by a system exceeds 25,000 sq ft, the Energy Code requires that the system be designed, installed, and controlled with area isolation devices to minimize energy consumption during these times. The requirements are:

- The building shall be divided into isolation areas, the area of each not exceeding 25,000 sq ft. An isolation area may consist of one or more zones.
- An isolation area cannot include spaces on different floors.
- Each isolation area shall be provided with isolation devices such as valves or dampers that allow the supply of heating or cooling to be setback or shut off independently of other isolation areas.
- Each isolation area shall be controlled with an automatic time switch, occupancy sensor, or manual timer. The requirements for these shut-off devices are the same as described previously in Shut Off and Temperature Setup/Setback. As discussed previously for occupancy sensors, a building purge must be incorporated into the control sequences for normally occupied spaces, so occupancy sensors and manual timers are best limited to use in those areas that are intermittently occupied.

Any zones requiring continuous operation do not have to be included in an isolation area.

Example 4-23

Question

How many isolation zones does a 55,000 sq ft building require?

Answer

At least three. Each isolation zone may not exceed 25,000 sq ft.

Isolation of Zonal Systems

Small zonal type systems such as water loop heat pumps or fan coils may be grouped on automatic time-switch devices, with control interlocks that start the central plant equipment whenever any isolation area is occupied. The isolation requirements apply to equipment supplying heating and cooling only; central ventilation systems serving zonal type systems do not require these devices.

Isolation of Central Air Systems

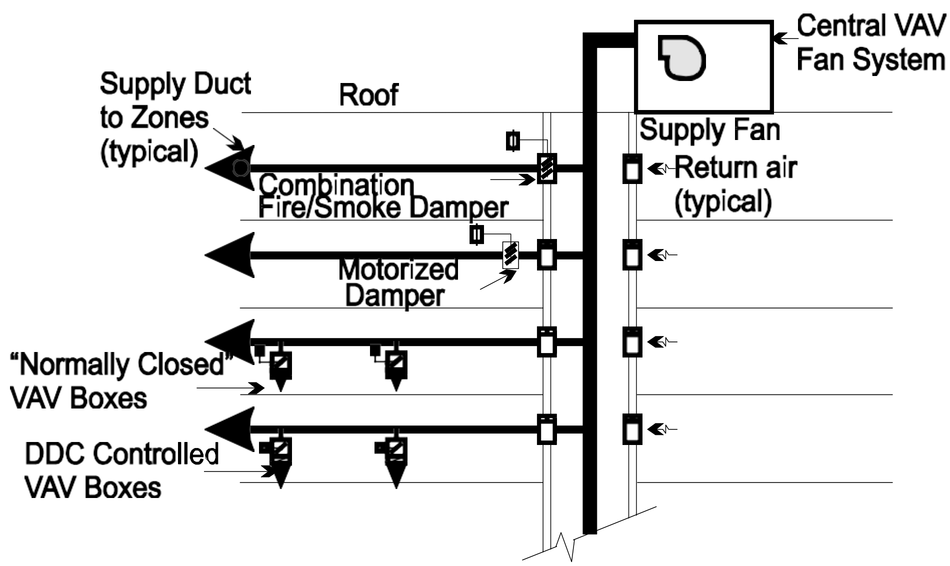
Figure 4-12 below depicts four methods of area isolation with a central VAV system:

- On the lowest floor, programmable DDC boxes can be switched on a separate time schedule for each zone or blocks of zones. When unoccupied, the boxes can be programmed to have zero minimum volume setpoints and unoccupied setback/setup setpoints. This form of isolation can be used for sections of a single floor distribution system.
- On the second floor, normally closed pneumatic or electric VAV boxes are used to isolate zones or groups of zones. In this scheme the control source (pneumatic air or control power) for each group is switched on a separate control signal from an individual time

schedule. Again, this form of isolation can be used for sections of a single floor distribution system.

- On the third floor, isolation is achieved by inserting a single motorized damper on the trunk of the distribution ductwork. With the code requirement for fire/smoke dampers (see next numbered item) this method is somewhat obsolete. When applied, this method can only control a single trunk duct. Care must be taken to integrate the motorized damper controls into the fire/life safety system.
- On the top floor, a combination fire smoke damper is controlled to provide the isolation. This control can only be used on a single trunk duct. Fire/smoke dampers required by code can be used for isolation at virtually no cost, provided that they are wired so that the fire life-safety controls take precedence over off-hour controls (local fire officials generally allow this dual usage of smoke dampers since it increases the likelihood that the dampers will be in good working order in the event of a fire). No isolation devices are required on the return.

Figure 4-12: Isolation Methods for a Central VAV System



Source: California Energy Commission

Example 4-24

Question

Does each isolation area require a ventilation purge?

Answer

Yes. Consider each isolation area as if it were a separate air-handling system, each with its own time schedule, setback, and setup control.

Turndown of Central Equipment

Where isolation areas are provided, it is critical that the designer plans the central systems (fans, pumps, boilers, and chillers) to have sufficient stages of capacity or turndown controls to operate stably, as required to serve the smallest isolation area on the system. Failure to do so may cause fans to operate in surge, excessive equipment cycling and loss of temperature control. Acceptable schemes include:

- Application of demand-based supply pressure reset for VAV fan systems. This will generally keep variable speed driven fans out of surge and can provide 10:1 turndown.
- Use of pony chillers (an additional small chiller to be used at partial load conditions) or unevenly split capacities in chilled water plants. This may already be required to serve 24/7 loads.
- Unevenly split boiler plants.

Automatic Demand Shed Controls

Please refer to Chapter 4.6.1.7 of the 2022 Nonresidential and Multifamily Compliance Manual.

Economizer Fault Detection and Diagnostics

Reference: Section 120.2(i)

Economizer Fault Detection and Diagnostics (FDD) is a mandatory requirement for all newly installed air handlers with a mechanical cooling capacity greater than 33,000 Btu/hr and an air economizer.

The FDD system can be either a stand-alone unit or integrated. A stand-alone FDD unit is added onto the air handler, while an integrated FDD system is included in the air handler system controller or is part of the DDC system.

Where required, the FDD system shall meet each of the following requirements:

- Temperature sensors shall be permanently installed to monitor system operation of outside air, supply air, and return air.
- Temperature sensors shall have an accuracy of ±2 degrees F over the range of 40 degrees F to 80 degrees F.
- The controller shall have the capability of displaying the value of each sensor.
- The controller shall provide system status by indicating the following conditions:
    - Free cooling available.
    - Economizer enabled.
    - Compressor enabled. For systems that don’t have compressors, indicating “mechanical cooling enabled” also complies.
    - Heating enabled if the system is capable of heating.
    - Mixed air low limit cycle active.
- The unit controller shall allow manual initiation of each operating mode so that the operation of cooling systems, economizers, fans, and heating system can be independently tested and verified.
- Faults shall be reported using one of the following options:
    - An EMCS that is regularly monitored by facility personnel
    - Displayed locally on one or more zone thermostats or a device within five feet of a zone thermostat, clearly visible, at eye level and meet the following requirements:

        - On the thermostat, device, or an adjacent written sign, there must be instructions displayed for how to contact the appropriate building personnel or an HVAC technician to service the fault.
        - In buildings with multiple tenants, the fault notification shall either be within property management offices or in a common space accessible by the property or building manager.
    - Reported to a fault management application that automatically provides notification of the fault to a remote HVAC service provider. This allows the service provider to coordinate with an HVAC technician to service the fault.
- The FDD system shall have the minimum capability of detecting the following faults:
    - Air temperature sensor failure/fault. This failure mode is a malfunctioning air temperature sensor, such as the outside air, discharge air, or return air. This could include loss of calibration, complete failure (either through damage to the sensor or its wiring) or failure due to disconnected wiring.
    - Not economizing when programmed to do so. In this case, the economizer should be enabled yet is not providing free cooling. This leads to an unnecessary increase in mechanical cooling energy. For example, if the economizer high limit setpoint is too low (55˚F), or the economizer is stuck in the closed position.
    - Economizing when not programmed to do so. This is the opposite malfunction from the previous problem. In this case, conditions are such that the economizer should be at minimum ventilation position but instead is open beyond the correct position. This leads to an unnecessary increase in heating and cooling energy. For example, if the economizer high limit setpoint is too high (82˚F), or the economizer is stuck in the open position.
    - Damper not modulating. This issue represents a stuck, disconnected, or otherwise inoperable damper that does not modulate. It is a combination of the previous two faults: not economizing when programmed to do so and economizing unnecessarily.
    - Excess outdoor air. This failure occurs when the economizer provides an excessive level of ventilation, usually much higher than is needed for design minimum ventilation. It causes an energy penalty during periods when the economizer should not be enabled (during cooling mode when outdoor conditions are higher than the economizer high limit setpoint). During heating mode, excess outdoor air will increase heating energy.
- The FDD system shall be certified to the Energy Commission, by the manufacturer of the FDD system, to meet the requirements one through seven, above. The manufacturer submittal package is available in Joint Appendices JA6.3, Economizer Fault Detection and Diagnostics Certification Submittal Requirements.

For air handlers controlled by DDC (including packaged systems), FDD sequences of operations must be developed to adhere with the requirements of Section 120.2(i)1 through 7. FDD systems controlled by DDC are not required to be certified to the Energy Commission, but manufacturers, controls suppliers, or other market actors can choose to apply for certification. For DDC based FDD systems, a new acceptance test has been developed to test the sequences of operations in the field to verify that they in-fact comply with the required faults of Section 120.2(i).

ASHRAE Guideline 36-2021 is a good reference for developing sequences of operations specifically for the faults listed in 120.2(i). The purpose of Guideline 36 is to provide uniform sequences of operation for heating, ventilating, and air-conditioning (HVAC) systems that are intended to maximize HVAC system energy efficiency and performance, provide control stability, and allow for real-time fault detection and diagnostics. To properly adhere to Guideline 36, all sequences of operations design elements in Sections 5.16.14 and/or 5.18.13 of that guideline must be implemented, including defining operating states, the use of an alarm delay, and the installation of an averaging mixed air temperature sensor. If a designer uses Guideline 36 to detect the required economizer faults in Title 24, Section 120.2(i), the sequences of operations should include Guideline 36 Fault Conditions numbers #2, 3, and 5 through 13, at a minimum. Other Title 24 FDD requirements in Section 120.2(i) and acceptance tests would not be met by including these fault conditions into sequences of operations and must be met through other means.

Direct Digital Controls

Reference: Section 120.2(j)

The requirement for DDC will mostly impact smaller buildings, since it is already common practice to install DDC in medium and large buildings; primarily due to the size and complexity of HVAC systems of medium and large buildings, which DDC is well suited to operate. Small buildings in the past did not require DDC and therefore could not take advantage of basic energy savings strategies.

DDC systems facilitate energy saving measures through monitoring and regulating the HVAC systems and optimizing their efficient operation. With most buildings requiring DDC, the following energy saving measures will be triggered if DDC is applied to the zone level:

- DCV (mandatory) - Demand Controlled Ventilation
- Automatic Demand Shed Controls (mandatory) - Automatic Demand Shed Controls
- Optimum Start/Stop Controls (mandatory) - Optimum Start/Stop Controls
- Setpoint Reset Controls for VAV systems (prescriptive) - Variable Air Volume (VAV) Supply Fan Controls

For further explanation, see the appropriate compliance manual sections for the measures listed above.

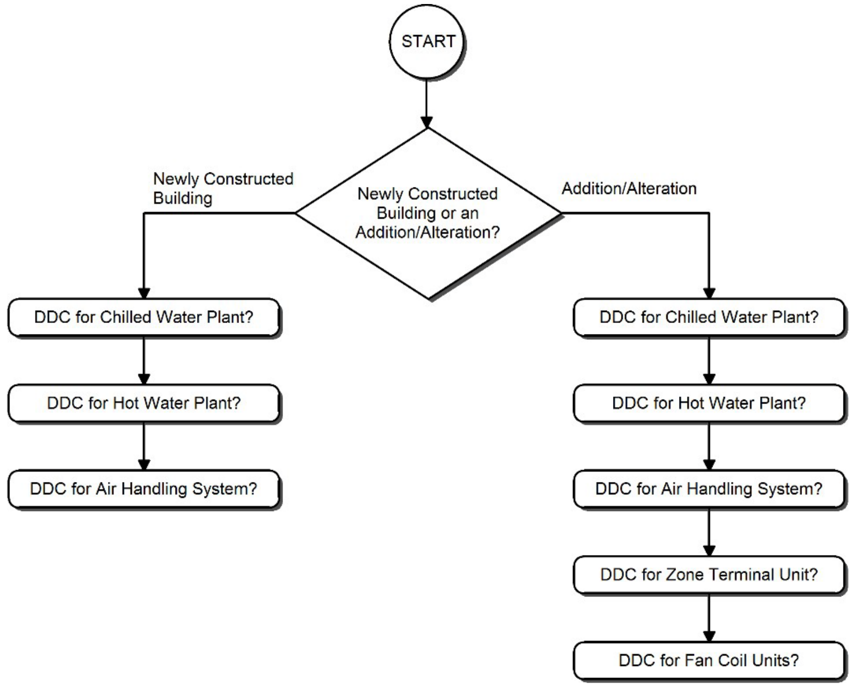
The Energy Code mandates DDC for only certain building applications with minimum qualifications or equipment capacities, as specified in Table 120.2-A of the Energy Code.

Buildings that do not meet the specified minimum qualifications are not required to install DDC.

Follow the flowchart in Figure 4-13: Building Status Flowchart to determine if a DDC system is required for newly constructed buildings, additions, or alterations. The Building Status Flowchart will indicate which equipment flowchart (Figure 4-14: Chilled Water Plant Flowchart through Figure 4-18: Fan Coil Units Flowchart) should be used for each type of HVAC equipment that will be installed in the building.

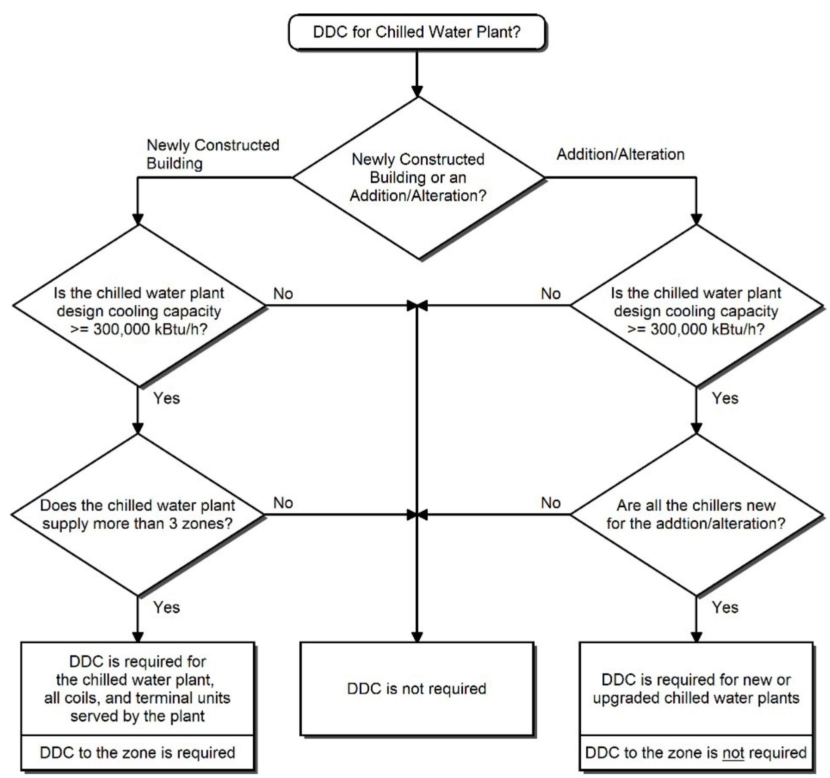
The flowcharts will indicate whether DDC is required for the building, how it should be applied to the equipment and whether it is required to be installed at the zone level.

Figure 4-13: Building Status Flowchart



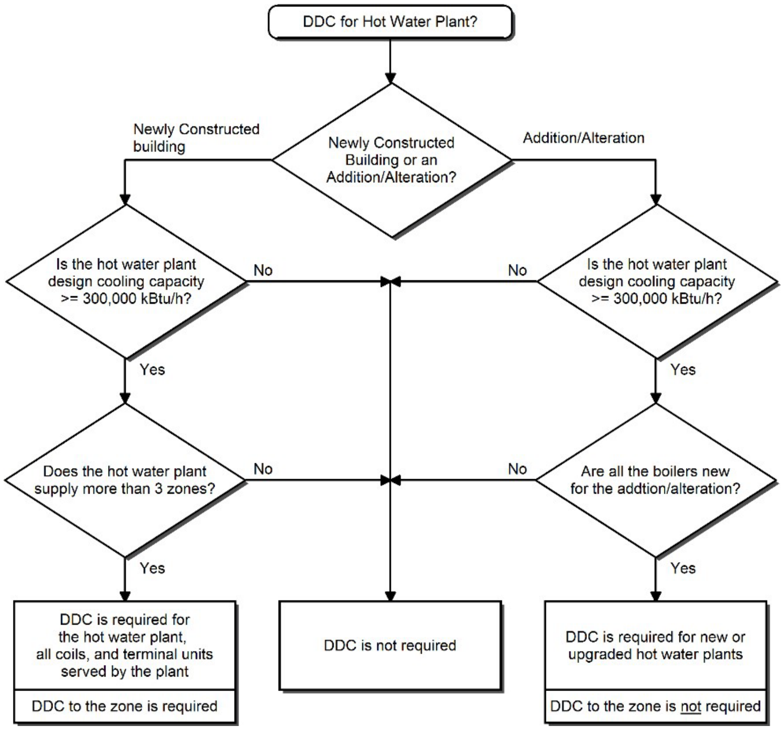
Source: California Energy Commission

Figure 4-14: Chilled Water Plant Flowchart



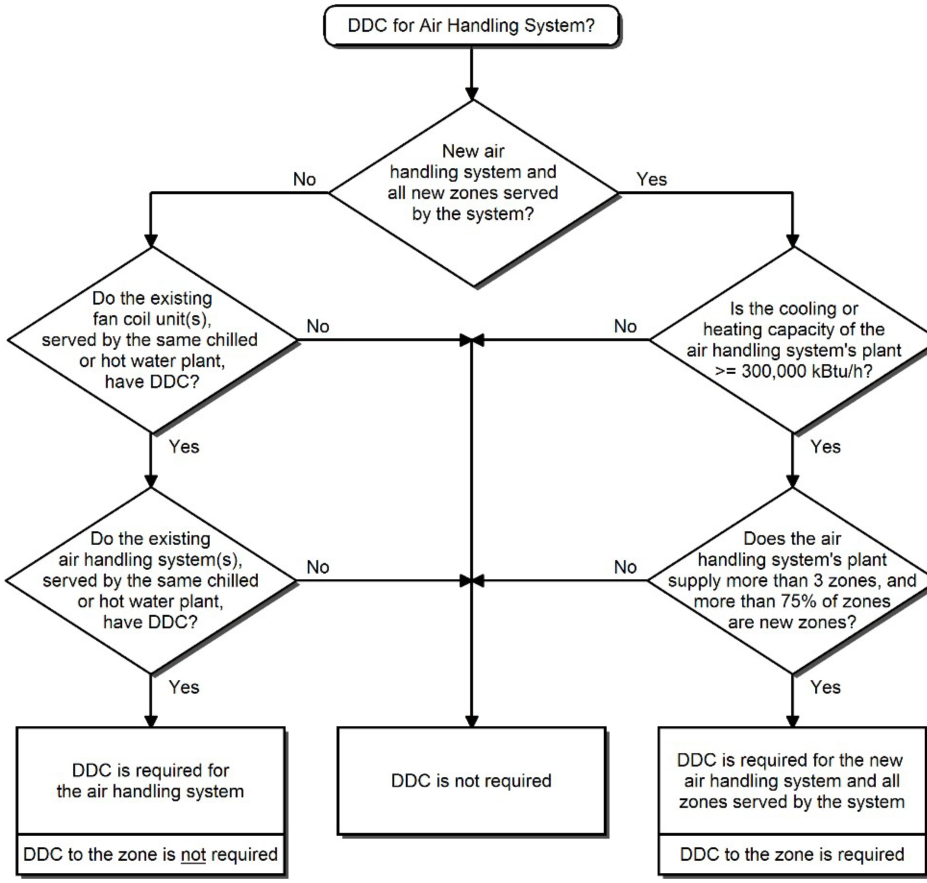
Source: California Energy Commission

Figure 4-15: **Hot Water Plant Flowchart**



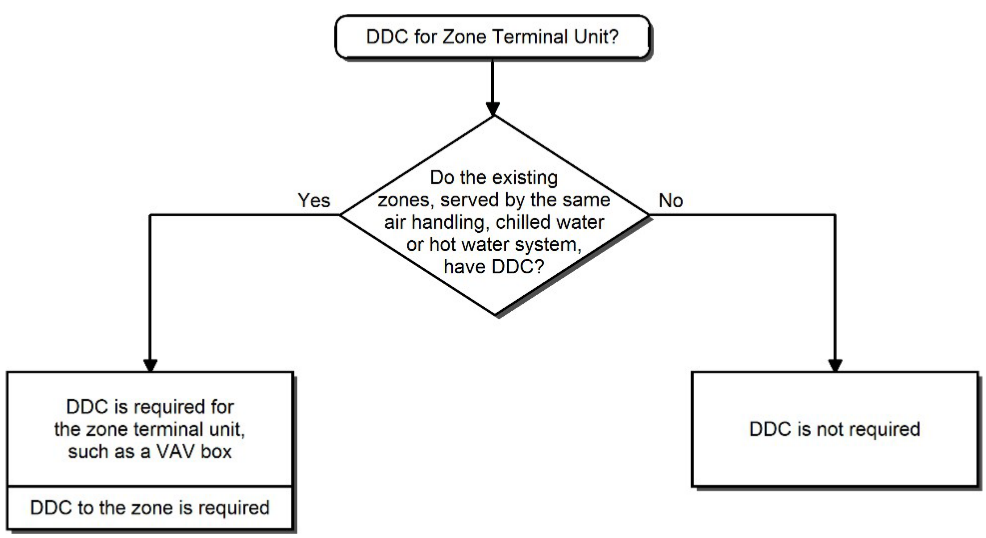
Source: California Energy Commission

Figure 4-16: **Air Handling System Flowchart**



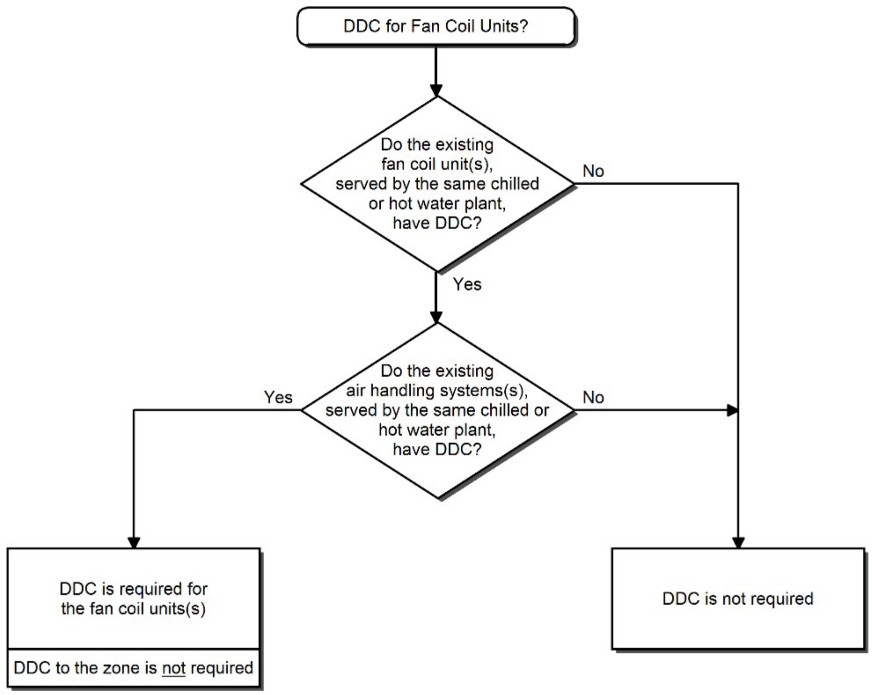
Source: California Energy Commission

Figure 4-17: Zone Terminal Unit Flowchart



Source: California Energy Commission

Figure 4-18: Fan Coil Units Flowchart



Source: California Energy Commission

For additions or alterations to buildings, zones that are not part of the addition or alteration are not required to be retrofitted with DDC to the zone. Pre-existing DDC systems in buildings are not required to be retrofitted so DDC is to the zone.

Example 4-25

Question:

If a newly constructed building has an HVAC system comprised of an air handling system, serving four zones and a chilled water plant with a design cooling capacity of 250,000 Btu/h, is DDC required?

Answer:

No. Although the HVAC system is serving more than three zones, the chilled water plant does not meet the minimum design cooling capacity of 300,000 Btu/h (300 kBtu/h). A DDC system would be required if the design cooling capacity was 300,000 Btu/h or larger.

Example 4-26

Question:

If an addition to a building requires a new VAV box, is DDC required?

Answer:

Maybe. The answer is dependent upon whether there is already a DDC system for the zones served by the same air handling, chilled water, or hot water system. Essentially this is to ensure that if a DDC system is already installed, then it must be continued throughout the building, including the addition.

Example 4-27

Question:

If a building's chilled water plant is upgraded with new chillers that have a design capacity of 500 kBtu/h and serves three zones, is DDC required?

Answer:

Yes. The criterion that triggers the DDC requirement is that the plant upgrade is installing **new** chillers with a cooling capacity greater than 300 kBtu/h. In this case, the number of zones is irrelevant for determining if DDC is required.

The Energy Code now requires the mandated DDC system to have the following capabilities to ensure the full energy saving benefits of DDC:

- Monitor zone and system demand for fan pressure, pump pressure, heating, and cooling
- Transfer zone and system demand information from zones to air distribution system controllers and from air distribution systems to heating and cooling plant controllers
- Automatically detect those zones and systems that may be excessively driving the reset logic and generate an alarm, or other indication, to the system operator
- Readily allow operator removal of zone(s) from the reset algorithm
- Trend and graphically display input and output points for new buildings
- Reset setpoints in non-critical zones, signal from a centralized contact or software point

Optimum Start/Stop Controls

Reference: Section 120.2(k)

Optimum start/stop controls are an energy saving technique where the HVAC system determines the optimum time to turn on or turn off the HVAC system. This ensures that the space reaches the appropriate temperature during occupied hours only, without wasting energy to condition the space during unoccupied hours. It applies to heating and cooling.

Optimum start controls are designed to automatically adjust the start time of a space conditioning system each day. The purpose of these controls is to bring the space temperature to the desired occupied temperature levels at the beginning of scheduled occupancy. The controls take in to account the space temperature, outside ambient temperature, occupied temperature, amount of time prior to scheduled occupancy, and if present, the floor temperatures of mass radiant floor slab systems.

Optimum stop controls are designed to automatically adjust the stop time of a space conditioning system each day with the intent of letting the space temperature coast to the unoccupied temperature levels after the end of scheduled occupancy. The controls shall take in to account the space temperature, outside ambient temperature, unoccupied temperature, and the amount of time prior to scheduled occupancy.

Systems that must operate continuously are not subject to these requirements.

Hot Water Supply Temperature

Reference: Section 120.2(l)

Hydronic space heating systems shall be designed for a hot water supply temperature (HWST) no greater than 130°F. This applies to new construction, additions, and alterations, all building types, and in all climate zones.

Historically, higher temperatures than 130°F were used, but a maximum HWST of 130°F is compatible with existing systems. This measure allows a gradual transition as noncondensing boilers are replaced in additions and alterations with condensing boilers or air-to-water heat pumps (AWHPs). This measure requires only incremental system adjustments, like potentially upsized piping and more powerful pumps, and will ensure future buildings in California are optimized for lower hot water supply and return temperatures, enhancing efficiency without sacrificing occupant comfort.

Example 4-28

Question

Does the new measure ban the use of noncondensing boilers?

Answer

No. The measure does not ban noncondensing boilers as long as there is a secondary loop that will comply with the 130°F maximum HWST limit.

Example 4-29

Question

If we are doing an alteration that includes new zoning while having a non-condensing boiler that must operate at 180°F, can the additional piping be designed for 180°F?

Answer

No. While the existing plant may need to run at 180°F to serve existing zones, the new piping must be upsized to handle the lower hot water supply temperature of 130°F. The noncondensing boiler can keep operating at 180°F, but when it gets replaced, it will likely be with a unit (such as an AWHP or condensing boiler) that would benefit from the 130°F requirement.

Prescriptive Requirements

There are two sections describing the prescriptive requirements for space conditioning systems:

- HVAC equipment requirements includes sizing, equipment selection and type, calculations, fan systems, electric resistance heating, heat rejection systems, minimum chiller efficiency, limitation of air-cooled chillers, exhaust system transfer air, dedicated outdoor air systems, exhaust heat recovery, and mechanical heat recovery covering Sections 140.4(a), (b), (c), (g), (h), (i), (j), (o), (p), (q) and (s).
- Space conditioning control requirements includes space conditioning zone controls, economizers, variable air volume supply fan controls, supply air temperature reset controls, heat rejection fan controls, window/door switches for mechanical system shutoff, and DDC controller logic covering Sections 140.4(c), (d), (e), (f), (h), (m), (n) and (r).

Note: Section 140.4(l) is reserved.

Space Conditioning Zone Controls

Reference: Section 140.4(d)

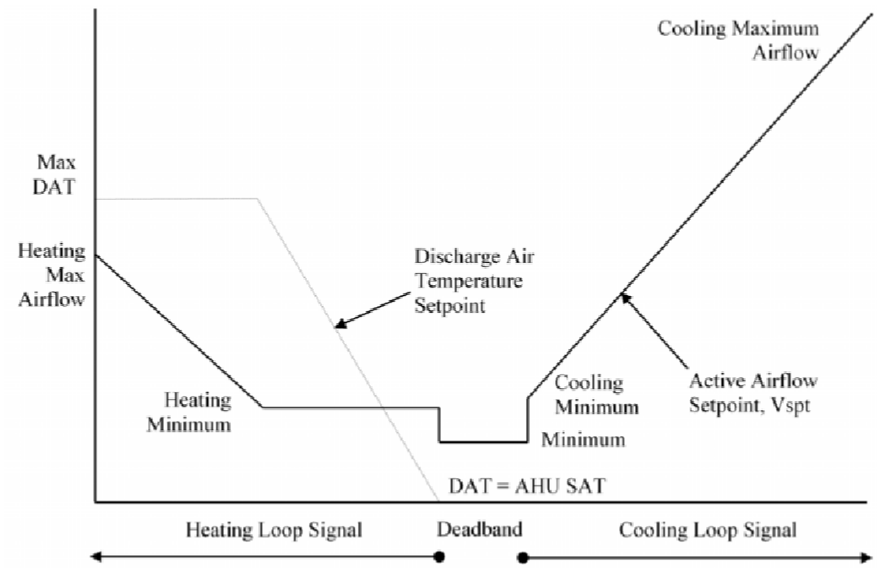
Each space-conditioning zone shall have controls designed in accordance with either of the following sets of requirements:

- Each space-conditioning zone shall have controls that prevent:
  - Reheating of air that has been previously cooled by mechanical cooling equipment or an economizer.
  - Recooling of air that has been previously heated. This does not apply to air returned from heated spaces.
  - 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.
- Zones served by VAV systems that are designed and controlled to reduce the volume of reheated, recooled, or mixed air to a minimum are allowed only if the controls meet all of the following requirements:
  - For each zone with DDC:
    - 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 Mechanical Ventilation.
    - The volume of primary air in the deadband shall not exceed the design zone outdoor airflow rate, per Mechanical Ventilation.
    - The first stage of heating consists of modulating the zone supply air temperature setpoint up to a maximum setpoint no higher than 95 degrees 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.
    - Control sequences of operation for reheat zones shall be in accordance with ASHRAE Guideline 36.
  - 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 Mechanical Ventilation.

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 4-19: 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 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 degrees F) as a first stage of heating then, if more heat is required, it increases airflow rate up to a "heating" maximum airflow setpoint, which is the same value as what traditional control logic uses as the minimum airflow setpoint. 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 also very useful for diagnosing control and heating system problems.

Figure 4-19: Dual-Maximum VAV Box Control Diagram with Minimum Flow in Deadband



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:

- Special pressurization relationships or cross contamination control needs (laboratories are an example of spaces that might fall in this category)
- Site-recovered or site-solar energy providing at least 75 percent of the energy for reheating, or providing warm air in mixing systems
- Specific humidity requirements to satisfy non-covered process loads (computer rooms are explicitly not covered by this exception)
- Zones with a peak supply air quantity of 300 cfm or less
- Systems with healthcare facilities

Example 4-30

Question:

What are the limitations on VAV box minimum airflow setpoint for a 1,000 sq ft office having a design supply of 1,100 cfm and eight people?

Answer:

For a zone with pneumatic thermostats, the minimum cfm cannot exceed the larger of:

- 1,100 cfm x 30 percent = 330 cfm; or
- the minimum ventilation rate: which is the larger of:
    - 1,000 ft² x 0.15 cfm/ft² = 150 cfm; and
    - 8 people x 15 cfm/person = 120 cfm

Thus, the minimum airflow setpoint can be no larger than 330 cfm.

For a zone with DDC to the zone, the minimum cfm in the deadband cannot exceed the minimum ventilation rate. which is the larger of:

- 1,000 ft² x 0.15 cfm/ft² = 150 cfm; and
- 8 people x 15 cfm/person = 120 cfm

Thus, the minimum airflow setpoint in the dead band can be no larger than 150 cfm. And this can rise to 1100 cfm X 50 percent or 550 cfm at peak heating.

For either control system, based on ventilation requirements, the lowest minimum airflow setpoint must be at least 150 cfm, or transfer air must be provided in this amount.

Economizers

Reference: Section 140.4(e)

Airside economizers are required on air handler systems with a mechanical cooling capacity greater than 33,000 Btu/h (2.75 tons) and must be fully integrated (capable of modulating outside air and return air dampers to supply all the design supply air as outside air, even when additional mechanical cooling is required to meet the remainder of the cooling load). Under certain conditions an applicable economizer exception can be taken.

Waterside economizers are required for chilled-water systems without a fan or that induce airflow (such as chilled beams) based on the total chilled water system capacity and climate zone as described under Table 140.4-E. Additionally, waterside economizers must be capable of providing 100 percent of the expected system cooling load at an outside air temperature of 50 degrees F dry-bulb and 45 degrees F wet-bulb and below.

A schematic of an air-side economizer is depicted below in Figure 4-20: Air-Side Economizer Schematic. All air-side economizers have modulating dampers on the return and outdoor air streams.

Best Practice:

To provide 100 percent of the design supply air, designers will need to specify an economizer with a nominal capacity sufficient to deliver the design air flow rate when the economizer's outdoor air damper is in the fully open position, and the return air damper is completely closed.

An appropriately sized economizer can also be estimated by determining the face velocity passing through the economizer, using the design airflow and the area of the economizer damper/duct opening.

The design airflow (cfm) should be available from the mechanical drawings or air handler cutsheet. The minimum area (sq ft) through which air is flowing from the outside to the fan can be measured in the field, or it can be found on the economizer damper cutsheet if the economizer damper is the smallest area. Dividing the design airflow by the smallest area will give the velocity of the air in ft per min.

Appropriately sized economizers that can supply 100 percent of the supply airflow without large pressure drops typically have face velocities of less than 2,000 ft per min.

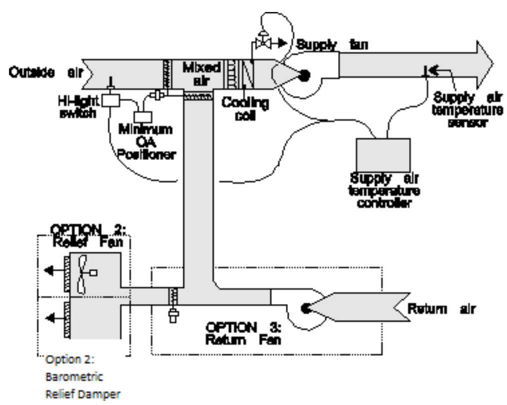
To maintain acceptable building pressure, systems with an airside economizer must have provisions to relieve or exhaust air from the building. In Figure 4-20: Air-Side Economizer Schematic, three common forms of building pressure control are depicted:

- Option 1: barometric relief
- Option 2: a relief fan generally controlled by building static pressure
- Option 3: a return fan often controlled by tracking the supply

On first call for cooling the outdoor air damper is modulated from minimum position to 100 percent open while the return air damper remains 100 percent open. As additional cooling is required, the outdoor air damper remains 100 percent open while the return air damper is modulated from 100 percent open to 0 percent open (fully-closed, 100 percent outdoor air). As more cooling is required, the outdoor air damper remains at 100 percent open and the return air damper remains at 0 percent open as the cooling coil is sequenced on. Slightly different approaches may apply depending on whether relief or return fans are involved and what minimum outdoor air control strategy applies.

Graphics of water-side economizers are presented in Water Economizers at the end of this chapter.

Figure 4-20: Air-Side Economizer Schematic



Source: California Energy Commission

Economizers are not required where:

Reference: Exceptions to Section 140.4(e)1

- Outside air filtration and treatment for the reduction of unusual outdoor contaminants make compliance unfeasible.
- Increased overall building TDV energy use results. This may occur where economizers adversely impact other systems, such as humidification, dehumidification, or supermarket refrigeration systems.
- Systems serving hotel/motel guest rooms.
- Cooling systems have the cooling efficiency that meets or exceeds the cooling efficiency improvement requirements in Table 140.4-F (typically used for VRF systems).
- Fan systems primarily serving computer room(s). See Section 140.9(a) for computer room economizer requirements.
- Systems utilizing dedicated outside air systems (DOAS) for ventilation capable of providing at least 0.3 cfm/sf and exhaust air heat recovery can take an economizer exception for their independent space-cooling air handlers (typically VRF or WSHP), if those systems are less than 54,000 Btu/h (4.5 tons).
- Where the use of an air economizer in controlled environment horticulture spaces will affect carbon dioxide enrichment systems.
- Systems complying with sections 140.4(a)3Ai or 140.4(a)3Aii.

If an economizer is required, it must be:

Reference: Section 140.4(e)2

- 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. With these systems, the operation of the economizer to pre-cool the air entering the cold deck also precools the air entering the hot deck and thereby increases the heating energy. *Exception:* when at least 75 percent of the annual heating is provided by site-recovered or site-solar energy.
- 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.
- Designed and equipped with a device capable of turning off the economizer under various conditions, see Air-side economizer high limit switches.
- If controlled by a DDC system, configured with control sequences of operation in accordance with ASHRAE Guideline 36.

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 requirement that DDC controllers be configured with ASHRAE Guideline 36 control sequences will avoid challenges with legacy control logic while ensuring effective implementation of the following key features:

- Pressure drop through air handling equipment will be minimized, as the economizer and return air dampers are sequenced such that they will not simultaneously restrict airflow.
- Economizer outdoor air and return air dampers are controlled to ensure that the supply air temperature control scheme does not yield an outdoor air flowrate that is less than the minimum outdoor airflow setpoint, as could occur in cold weather as the incoming outdoor air drives the supply air temperature down.
- Control loop conflicts, i.e., "fighting," between the economizer dampers and the cooling/heating coils is avoided. This conflict-avoidance prevents simultaneous heating and cooling and ensures that the economizer is maximized before enabling mechanical cooling.
- Building pressure is controlled to ensure that the building does not become over-pressurized.

Refer to the *Advanced Building Automation System Best Practices Guide*, referenced in DDC Controller Logic Using ASHRAE Guideline 36, for guidance with the selection and installation of building pressure sensors and economizer temperature sensors.

Refer to ASHRAE Guideline 16, *Selecting Outdoor, Return, and Relief Dampers for Air-Side Economizer Systems,* for guidance with the selection and sizing of economizer control dampers.

Refer to DDC Controller Logic Using ASHRAE Guideline 36 for additional guidance regarding the specification and implementation of ASHRAE Guideline 36 control sequences.

Air-side economizer high limit switches:

Reference: Section 140.4(e)2C

If an economizer is required by Section 140.4(e)1 and an air economizer is used to meet the requirement, the air side economizer is required to have high-limit shut-off controls that comply with Table 140.4-G.

- The first column identifies the high limit control category. There are three categories allowed in this prescriptive requirement: fixed dry bulb; differential dry bulb; and fixed enthalpy plus fixed dry bulb.
- The second column represents the California climate zone. "All" indicates that this control type complies in every California climate.
- The third and fourth columns present the high-limit control setpoints required.

The Energy Code eliminated the use of fixed enthalpy, differential enthalpy, and electronic enthalpy controls. 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. However, the performance model will show a penalty due to the inaccuracy of the enthalpy sensors.

Air Economizer Construction

Reference: Section 140.4(e)2E

If an economizer is required by Section 140.4(e)1, and an air economizer is used to meet the requirement, then the air economizer, and all air dampers shall have the following features:

- A five-year factory warranty for the economizer assembly.
- Certification by the manufacturer that equipment has been tested and is able to open and close against the rated airflow and pressure of the system for at least 60,000 damper opening and closing cycles. Required equipment includes, but is not limited to, outdoor air dampers, return air dampers, drive linkages and actuators.
- Economizer outside air and return air dampers shall have a maximum leakage rate of 10 cfm/sq ft at 250 Pascals (1.0 in. w.g) when tested in accordance with AMCA Standard 500-D. The leakage rates for the outside and return dampers shall be certified to the Energy Commission in accordance with Section 110.0.
- If the high-limit control uses either a fixed dry-bulb, or fixed enthalpy plus fixed dry-bulb control, the control shall have an adjustable setpoint.
- Economizer sensors shall be calibrated within the following accuracies:
    - Dry bulb (db) and wet bulb (wb) temperatures accurate to plus or minus 2 degrees F over the range of 40 degrees F to 80 degrees F.
    - Enthalpy accurate to plus or minus 3 Btu/lb over the range of 20 Btu/lb to 36 Btu/lb.
    - Relative humidity (RH) accurate to plus or minus 5 percent over the range of 20 percent to 80 percent
- Data from sensors used for control of the economizer shall be plotted on a sensor performance curve.
- 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.
- Relief air systems shall be capable of providing 100 percent outside air without over-pressurizing the building.

Compressor unloading:

Reference: Section 140.4(e)2F

Systems that include an air economizer must comply with the following requirements:

- 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 degrees F.
- 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.
- DX units not within the scope of number two (above), shall comply with the requirements in Table 140.4-H, and 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.

Chapter 14 of this manual describes mandated acceptance test requirements for economizers.

If the economizer is factory-calibrated the economizer acceptance test is not required at installation. A calibration certificate of economizer control sensors (outdoor air temperature, return air temperature, etc.) must be submitted to the local code enforcement agency in the permit application.

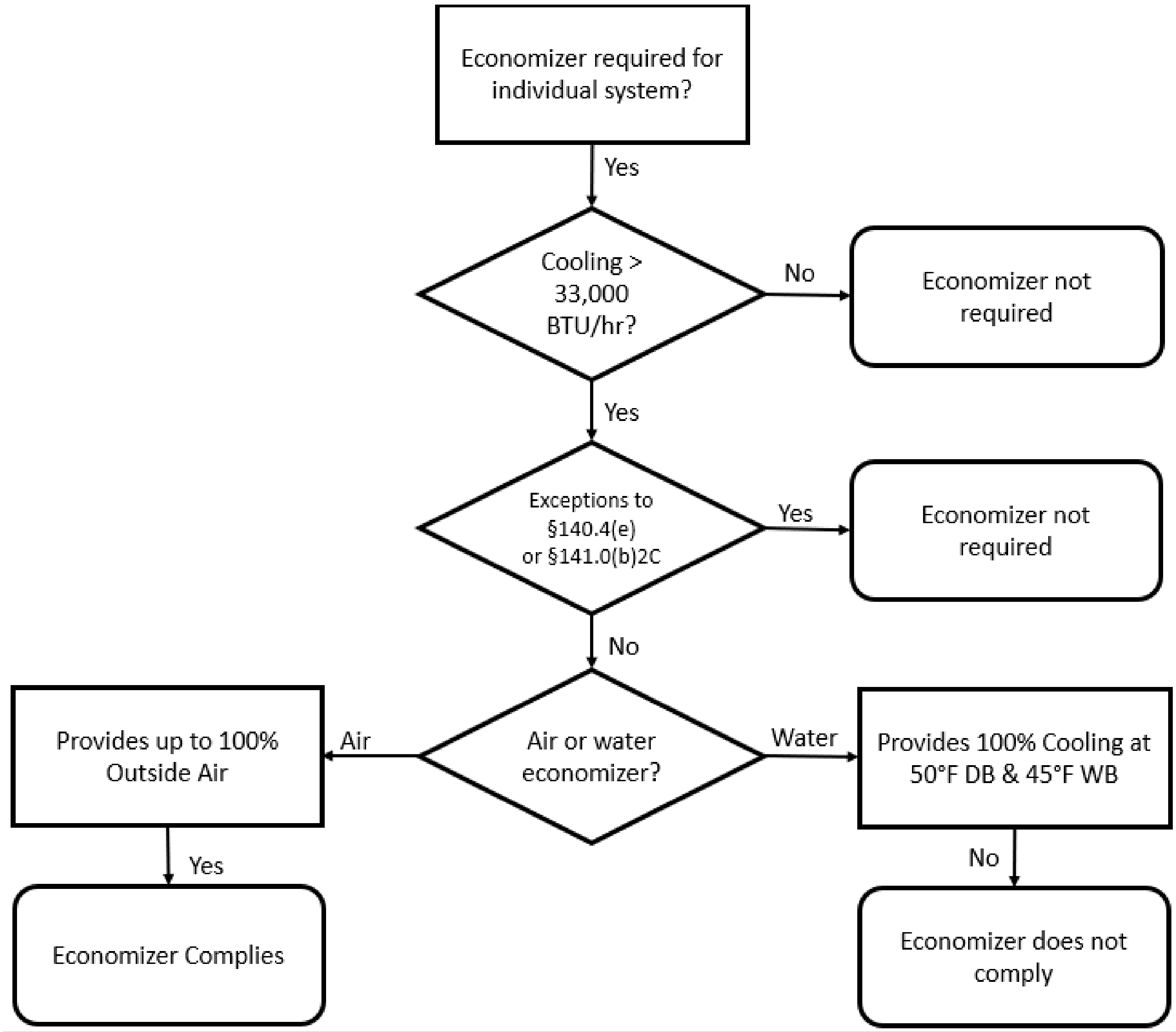
Water Economizer Specific Requirements

Reference: Section 140.4(e)3

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.

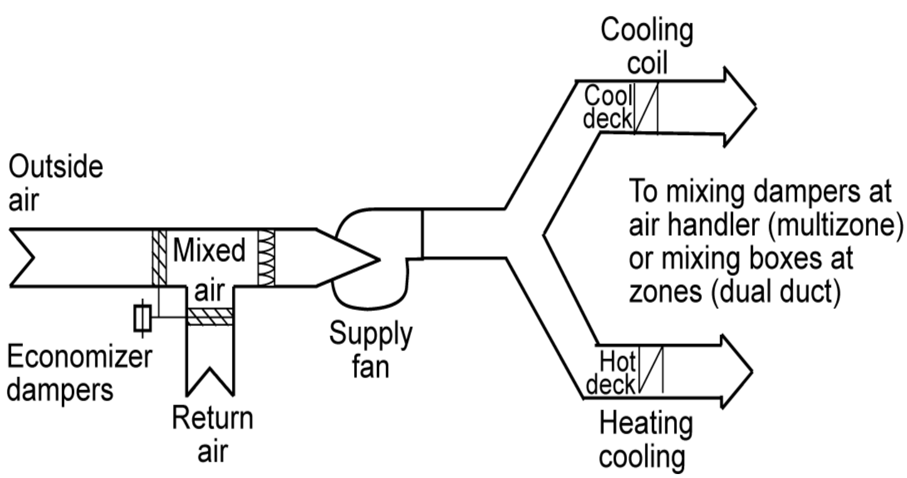
Water economizer systems must also be integrated with the mechanical cooling system so that they are capable of providing partial cooling--even when additional mechanical cooling is required to meet the remainder of the cooling load. This includes controls that do not false load the mechanical cooling 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.

Figure 4-21: Economizer Flowchart



Source: California Energy Commission

Figure 4-22: Single-Fan Dual-Duct System



Source: California Energy Commission

Example 4-31

Question:

If the design conditions are 94 degrees F db/82 degrees F wb can the design cooling loads be used to size a water-side economizer?

Answer:

No. The design cooling load calculations must be rerun with the outdoor air temperature set to 50 degrees F db/45 degrees F wb. The specified tower, as well as cooling coils and other devices, must be checked to determine if it has adequate capacity at this lower load and wet-bulb condition.

Example 4-32

Question:

Will a strainer cycle water-side economizer meet the prescriptive economizer requirements?

Answer:

No. It cannot be integrated to cool simultaneously with the chillers.

Example 4-33

Question:

Does a 12-ton packaged AC unit in climate zone 10 need an economizer?

Answer:

Yes. In addition, the economizer must be equipped with a fault detection and diagnostic system. However, the requirement for an economizer can be waived if the AC unit's efficiency is is at least 30% more efficient than the minimum cooling efficiency requirement. Refer to Table 140.4-F.

Variable Air Volume (VAV) Supply Fan Controls

Reference: Section 140.4(c), Section 140.4(m)

The VAV requirements for supply fans are as follows:

- Single zone systems (where the fans are controlled directly by the space thermostat) shall have a minimum of two stages of fan speed with no more than 66 percent speed when operating on stage one while drawing no more than 40 percent full fan power when running at 66 percent speed.
- All systems with air-side economizers to satisfy Economizers are required to have a minimum of 2 speeds of fan control during economizer operation.
- Multiple zone systems shall limit the fan motor demand to no more than 30 percent of design wattage at 50 percent design air volume.

Variable speed drives can be used to meet any of these three requirements.

VAV fan systems that do not have DDC to the zone level are required to have the static pressure sensor located in a position such that the control setpoint is less than or equal to 1/3 of the design static pressure of the fan. For systems without static pressure reset, the further the sensor is from the fan the more energy will be saved. For systems with multiple duct branches in the distribution separate sensors in each branch must be provided to control the fan and to satisfy the sensor with the greatest demand. When locating sensors, care should be taken to have at least one sensor between the fan and all operable dampers (e.g., at the bottom of a supply shaft riser before the floor fire/smoke damper) to prevent loss of fan static pressure control.

For systems with DDC to the zone level the sensor(s) may be anywhere in the distribution system and the duct static pressure setpoint must be reset utilizing control sequences of operation in accordance with ASHRAE Guideline 36. Guideline 36 applies a zone level demand-based trim and respond algorithm. For example, each zone will generate "requests" for increased static pressure as the damper approaches its full-open position. The AHU controller will respond by increasing its duct static pressure setpoint as requests are generated. Once the number of requests has reduced sufficiently (based on setpoint parameters), the AHU controller will trim its duct static pressure setpoint downward to reduce fan power.

Reset of supply pressure by demand not only saves energy but it also protects fans from operation in surge at low loads. Chapter 13, Acceptance Requirements, describes mandated acceptance test requirements for VAV system fan control.

The requirement that systems with zone level DDC controls utilize Guideline 36 control sequences ensures effective implementation of the following key features:

- System response (i.e., static pressure setpoint adjustments) can be tuned to ensure that critical zones are not starved of airflow and nuisance zones may be deprioritized by adjusting the zone level "Importance Multiplier."
- Rogue zones are automatically tracked and clearly identified. "Rogue zones" are zones that continuously drive the reset strategy in the direction of increased energy use. Automatic rogue zone detection offers an effective mechanism to diagnose and remedy an ineffective reset strategy, both during and post-implementation. Early rogue zone tracking can help to identify problems such as undersized VAV terminals, which presents the opportunity to remedy these problems before the owner takes occupancy.
- SAT setpoint and static pressure setpoint will be reset independently, using entirely separate loops. Both reset strategies react to zone demand, but each uses a distinct type of request. Note that zones requesting additional static pressure do not necessarily need colder air, and vice versa. For example, a zone that is in heating status may be starved for air as the heating airflow setpoint increases, hence it will generate static pressure requests without generating cold air requests. Alternatively, a zone that is located relatively close to the AHU may experience a climbing space temperature during a period of high cooling demand, despite having no issues achieving its design supply airflow rate. In this case, the zone controller will generate cold air requests without generating static pressure requests.

Refer to the *Advanced Building Automation System Best Practices Guide*, referenced in DDC Controller Logic Using ASHRAE Guideline 36, for additional guidance and information regarding trim and respond reset strategies.

Refer to DDC Controller Logic Using ASHRAE Guideline 36 for additional guidance regarding the specification and implementation of ASHRAE Guideline 36 control sequences.

Fan power consumption for laboratory exhaust systems must meet requirements in Section 140.9(c).

Supply Air Temperature Reset Control

Reference: Section 140.4(f)

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. The controls must also be configured with control sequences of operation in accordance with ASHRAE Guideline 36.

For example, if the design supply temperature is 55 degrees F and the design room temperature is 75 degrees F, then the difference is 20 degrees F, of which 25 percent is 5 degrees F. Therefore, the controls must be capable of resetting the supply temperature from 55 degrees F to 60 degrees 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.

Control sequences of operation for supply air temperature (SAT) setpoint reset shall be in accordance with ASHRAE Guideline 36. Guideline 36 applies a two-factor SAT reset based on both zone level demand and outside air temperature (OAT), as follows:

- The demand-based SAT reset strategy utilizes a trim and respond algorithm. For example, each zone will generate "requests" for colder air as the zone controller approaches full-cooling operation, as indicated by the controller's cooling control loop approaching an output of 100 percent. For a VAV controller, a cooling control loop output that is approaching 100 percent typically correlates to an airflow setpoint that is approaching the design maximum cooling airflow. Each zone will generate additional requests for colder air as the zone temperature drifts further above the active cooling setpoint. The AHU controller will respond by reducing its SAT setpoint as requests are generated. Once the number of requests has reduced sufficiently (based on setpoint parameters), the AHU controller will trim its SAT setpoint in the direction of lower energy use.
- The OAT-based SAT reset strategy imposes an upper setpoint limit that is linearly-scaled with OAT (see Figure 4- 23: Energy Efficient Supply Air Temperature Reset Control for VAV Systems).
  For example, consider a single-duct VAV system that is configured with:
    - Maximum Cooling SAT Setpoint = 65 degrees F
    - Minimum Cooling SAT Setpoint = 55 degrees F
    - OAT Maximum Threshold = 70 degrees F
    - OAT Minimum Threshold = 60 degrees F

  In this case, the AHU controller will limit the SAT setpoint as follows:
    - If OAT < 60 degrees F, SAT may be reset to a maximum of 65 degrees as dictated by the zone level trim and respond logic.

  - If OAT > 60 degrees F and < 70 degrees F, SAT may be reset to a maximum that is linearly-scaled between 65 degrees F and 55 degrees F as a function of OAT, and as dictated by the zone level trim and respond logic.
  - If OAT > 70 degrees F, SAT is limited to 55 degrees F regardless of the zone level trim and respond logic.

  The OAT thresholds shown here offer a starting point but should be manipulated for the specific application. For instance, a building that has a relatively low envelope load (i.e. low window-to-wall ratio, low exterior-to-interior space area ratio) or a building that has inherently high air change rates may achieve greater energy performance by raising the OAT thresholds such that SAT reset is extended further into the cooling season.

The two-factor Guideline 36 SAT reset strategy is intended to conserve fan energy as the outside air temperature rises and the building cooling demand increases. The requirement that systems with zone level DDC controls utilize Guideline 36 control sequences ensures effective implementation through many key features. See Variable Air Volume (VAV) Supply Fan Controls for related discussion about setpoint reset strategies.

SAT reset is required for VAV reheat systems even if they have variable-speed drive (VSD) fan controls and static pressure setpoint reset logic.

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.

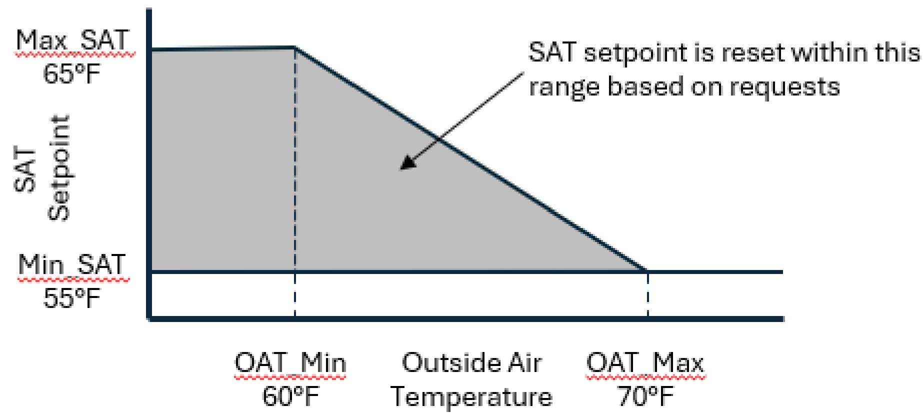
Refer to the *Advanced Building Automation System Best Practices Guide*, referenced in DDC Controller Logic Using ASHRAE Guideline 36, for additional guidance and information regarding trim and respond reset strategies.

Refer to DDC Controller Logic Using ASHRAE Guideline 36 for additional guidance regarding the specification and implementation of ASHRAE Guideline 36 control sequences.

Supply-air temperature reset is not required when:

- The zone(s) must have specific humidity levels required to meet exempt process needs. Computer rooms cannot use this exception.
- Where it can be demonstrated (to the satisfaction of the enforcement agency) that supply air reset would increase overall building energy use.
- The space-conditioning zone has controls that prevent reheating and recooling and simultaneously provide heating and cooling to the same zone.
- Systems serving healthcare facilities.

Figure 4-23: Energy Efficient Supply Air Temperature Reset Control for VAV Systems



Source: California Energy Commission

Heat Rejection Fan Control

Reference: Section 140.4(h)

When the fans on open cooling towers, closed-circuit fluid coolers, air-cooled condensers, and evaporative condensers are powered by a fan motor of 7.5 hp or larger, the system must be capable of operating at two-thirds speed, or less. In addition, the system must have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature or pressure of the heat rejection device. Fan speed controls are not subject to these requirements when:

- Fans are powered by motors smaller than 7.5 hp.
- Heat rejection devices are included as an integral part of the equipment listed in Section 110.2(a).
- Condenser fans are serving multiple refrigerant circuits or flooded condensers.
- Up to one third of the fans on a condenser or tower with multiple fans have lead fans that comply with the speed control requirement.

Example 4-34

Question

A chilled water plant has a three-cell tower with 10 hp motors on each cell. Are speed controls required?

Answer

Yes. At minimum the designer must provide 2-speed motors, pony motors or variable speed drives on two of the three fans for this tower.

Hydronic System Measures

Reference: Section 140.4(k)

Hydronic Variable Flow Systems

Reference: Section 140.4(k)1

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 require 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:

- Systems that include no more than three control valves.
- 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.

The primary loop on a primary/secondary or primary/secondary/tertiary system could be designed for constant flow even if the secondary or tertiary loop serves more than three control valves. This is allowed because the primary loop does not directly serve any coil control valves. However, the secondary and tertiary loops of these systems must be designed for variable flow if they have four or more control valves.

The flow limitations are provided for primary-only variable flow chilled-water systems where a minimum flow is typically required to keep a chiller on-line. In these systems minimum flow can be provided with either a bypass with a control valve or some three-way valves to ensure minimum flow at all times. The system with a bypass valve is more efficient as it only provides bypass when absolutely required to keep the plant online.

For hot water systems, application of slant-tube or bent tube boilers will provide the greatest flow turndown. Typically, copper fin tube boilers require a higher minimum flow.

Example 4-35

Question

A plant is trying to meet the variable flow requirements of Section 140.4(k). Must each individual pump meet these requirements for the plant to comply with the Energy Code?

Answer

No. Individual pumps do not need to meet the variable flow requirements of this section. As long as the entire plant meets the variable flow requirements, the plant is in compliance. For example, the larger pumps may be equipped with variable frequency drives, or the pumps can be staged in a way that can meet these requirements.

Isolation for Chillers and Boilers

Reference: Section 140.4(k)2 and 3

Plants with multiple chillers or boilers are required to provide either isolation valves or dedicated pumps. In addition, they must check valves to ensure that flow will only go through the chillers or boilers that are staged on. Chillers that are piped-in series for the purpose of increased temperature differential shall be considered as one chiller.

Chilled and Hot Water Reset

Reference: Section 140.4(k)4

Similar to the requirements for supply air temperature reset, chilled and hot water systems that have a design capacity greater than 500,000 Btu/h are required to provide controls to reset the hot or cold-water temperature setpoints as a function of building loads or the outdoor air temperature. This reset can be achieved either using a direct indication of demand (usually cooling or heating valve position) or an indirect indication of demand (typically outdoor air temperature). On systems with DDC controls reset using valve position is recommended.

Exceptions for this requirement:

- Hydronic systems that are designed for variable flow complying with Section 140.4(k)1
- Systems serving healthcare facilities

Isolation Valves for Water-Loop Heat Pump Systems

Reference: Section 140.4(k)5

Water-circulation systems serving water-cooled air conditioner and hydronic heat pump systems with a design circulation pump brake horsepower greater than five bhp are required to be provided with 2-way isolation valves that close whenever the compressor is off. These systems are also required to be provided with the variable speed drives and pressure controls described in the following section.

Although not required on central tenant condenser water systems (for water-cooled AC units and HPs) it is beneficial to provide the 2-way isolation valves on these systems as well. In addition to providing pump energy savings, these two-way valves can double as head-pressure control valves allowing aggressive condenser water to reset for energy savings in chilled water plants that are also cooled by the towers.

Variable-Speed Drive for Pumps Serving Variable-Flow Systems

Reference: Section 140.4(k)6

Pumps on variable flow systems that have a design circulation pump brake horsepower greater than 5 bhp are required to have variable-speed drives. Alternatively, they may have a different control that will result in pump motor demand of no more than 30 percent of design wattage, at 50 percent of design water flow.

Pressure Sensor Location and Setpoint:

- For systems without direct-digital control of individual coils reporting to the central control panel, differential pressure must be measured at the most remote heat exchanger or the heat exchanger requiring the most pressure. This includes chilled-water systems, condenser water systems serving water-cooled air conditioning loads and water-loop heat pump systems.
- For systems with direct digital control of individual coils with a central control panel, the static pressure setpoint must be reset based on the valve requiring the most pressure and the setpoint shall be no less than 80 percent open. The pressure sensor(s) may be mounted anywhere.

Exceptions are provided for hot-water systems and condenser water systems that only serve water-cooled chillers. The hot water systems are not subject to these requirements because the heat from the added energy of the pump riding the curve provides a beneficial heat that reduces the boiler use. This diminishes the benefit from the reduced pumping energy.

Hydronic Heat Pump (WLHP) Controls

Reference: Section 140.4(k)7

Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection and heat addition must have controls that are capable of providing a heat pump water supply temperature dead band of at least 20 degrees F between initiation of heat rejection and heat addition by the central devices. Exceptions are provided 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, dead bands of less than 20 degrees F shall be allowed.

Window/Door Switches for Mechanical System Shutoff

Reference: Section 140.4(n)

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 setpoint to 55 degrees 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 setpoint to 90 degrees F unless the outside air temperature is less than the space temperature, in which case the cooling setpoint 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 Mechanical Ventilation 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 still subject to 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.

Exceptions to this requirement:

- Interlocks are not required on doors with automatic closing devices
- Any space without a thermostatic control
- Healthcare facilities

Alterations to existing buildings are not subject to this requirement. Additions to existing buildings only have to comply if the operable opening(s) and associated zone are new.

DDC Controller Logic Using ASHRAE Guideline 36

Reference: Section 140.4(r)

HVAC systems with DDC controllers shall use controller logic originating from a programming library based on sequences of operation from ASHRAE Guideline 36 in accordance with the following:

- Requirement applies to all controllers that are capable of being programmed in the field; and
- Requirement applies to the entirety or all applicable portions of equipment control for configurations included in the programming library; and
- The programming library shall be certified to the Energy Commission as meeting the requirements of Reference Joint Appendix JA18.
  Note: Non-programmable (configurable-only) controllers for zone terminal units shall follow applicable ASHRAE Guideline 36 zone sequences referenced in JA18 Table 18.3-1 but are not subject to certification requirements.

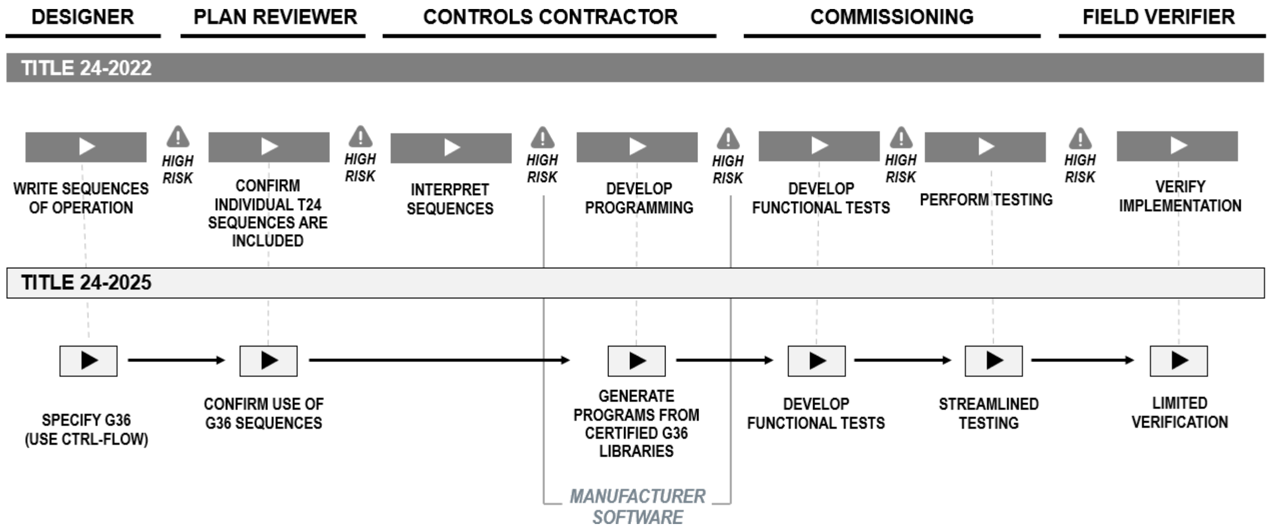
There are two exceptions to these requirements:

Exception 1: Logic from the certified programming library modified to suit application-specific operation that are not included in Guideline 36 sequences.

Exception 2: Systems serving healthcare facilities.

Figure 4-24: Industry delivery process for control logic for Title 24-2022 and Title 24-2025, depicts the process from designer to field verifier under the 2022 Energy Code (dark bars) and under the 2025 Energy Code (light bars). The new process references ASHRAE Guideline 36, which provides standardized, high-performance sequence logic for the control of select HVAC systems and equipment. The 2022 Energy Code has multiple steps that are manual and customized per project and is highly dependent on the expertise of individual engineers, controls technicians, and commissioning providers. Under the 2025 Energy Code, with the introduction of references to Guideline 36, designers specify sequences based on Guideline 36 and controls contractors follow the guideline using programming from certified programming libraries. A common workflow may be a BAS manufacturer that develops a Guideline 36 programming library, certifies it with the Energy Commission according to Reference Joint Appendix JA18, and then makes the library available to its installers. For applicable projects, the installers start with logic from the Guideline 36 programming libraries and then adapt and supplement the logic as needed to meet site specific needs. The 2025 Energy Code process reduces effort and improves quality over the 2022 Energy Code product delivery chain.

Figure 4- 24: Industry delivery process for control logic for Title 24-2022 and Title 24-2025



Source: California Statewide CASE Team

Guideline 36 consists of several parts to be used by the controls designer (with Parts 1 and 2 covering the purpose and scope of the guideline, respectively):

- Part 3: Setpoints, Design and Field Determined describes the setpoints and other parameters that must be specified by the design engineer, or determined during construction by the testing, adjusting, and balancing (TAB) or controls contractor.
- Part 4: List of Hardwired Points includes points lists for all system types addressed by the Guideline.
- Part 5: Sequences of Operations contains the control logic itself, organized by the type of equipment.
- Informative Appendix A has control diagrams that correspond to a subset of the Part 4 points lists.

Parts 3, 4, and 5 of the Guideline are intended to be edited and issued together as part of a specification under Division 23 or Division 25 and are formatted accordingly.

The requirements in Section 140.4(r) apply to controller logic that is used in field-programmable controllers. It does not apply to packaged controls that come integrated with some mechanical equipment, such as DX rooftop units (RTU).

Non-programmable (configurable) zone controllers are a special case addressed by Exception to Section 140.4(r)3. This exception expands applicability of this section to configurable-only zone controllers so that they are required to follow applicable Guideline 36 zone sequences. Because the configurable controllers do not have field-programmable logic, they are not subject to the certification requirements in JA18.

Guideline 36 provides high performance sequences of operation for many common HVAC system types but there may be some system types and unique circumstances that are not directly supported. Section 140.4(r) requires the use of a certified programming library for applications that are supported by Guideline 36. That may mean that a particular project has a mix of programming that originates from a certified programming library and custom programming that does not. The certified programming library requirements in JA18 do not include chilled water and hot water plants, so although these types of equipment are supported by Guideline 36, the requirement for the use of logic from certified programming libraries does not apply.

Example 4-36

Question:

A project will include packaged DX rooftop units (RTU). The packaged unit includes factory-built controls that control the fans, dampers, and compressors. The packaged unit controls are technically programmable but are fully programmed at the factory and not intended to be programmed in the field. Does the controller logic need to come from a programming library certified according to JA18?

Answer:

No, the controller logic provided with the packaged unit would not be subject to JA18. Often there is a DDC system that controls the zone-level equipment (e.g., VAV boxes) and communicates with a packaged DX RTU controller. In that situation, projects following the prescriptive compliance approach would be required to follow Section 140.4(r) for applicable portions of Guideline 36, including dual maximum VAV logic, supply air temperature setpoint reset, and duct static pressure setpoint reset. The setpoint reset logic in the DDC system would communicate setpoints to the packaged controller, and the packaged controller would be responsible for modulating dampers, compressor staging, and fan speed control to meet those setpoints with its own internal logic. In this case, the actual SAT control logic within the packaged controls would not be subject to this requirement because it is not field-programmed and because Guideline 36 does not directly address the control of DX cooling coils.

Compliance and Certification

The programming library shall be certified to the Energy Commission. The submittal package is available in Joint Appendices JA18, Guideline 36 Programming Library Certification. A controls manufacturer, controls contractor, or other controls company may certify their Guideline 36 programming library to the Energy Commission.

For an individual job, the controls designer must specify sequences of operation based on Guideline 36 where applicable and must indicate it on the construction documents (drawings and specifications) and relevant NRCC forms (specifically forms MCH-E and PRF-01-E). The plans examiner must review the construction documents and NRCC forms and verify that where Guideline 36 is applicable, that it is referenced. The installer must start controls programs from a certified Guideline 36 programming library and must make this certification information available to the building inspector. The inspector must verify that the installer used a certified Guideline 36 programming library where applicable.

Guideline 36 is intended to be specified by editing the control sequences in the Guideline to only include applicable sections. Guideline 36 is available as an editable document to facilitate this approach. The *Advanced Building Automation System Best Practices Guide,* at https://tayloreng.egnyte.com/dl/phXTDfFQb8/2022-06-

13_BAS_Best_Practices_Guide_v1.0.pdf, provides additional support and guidance on applying Guideline 36 to project-specific needs.

Portions of the native Guideline 36 control sequences must be tailored for the project. For example, the intended building pressure relief strategy for a Multiple-Zone VAV Air Handling Unit (AHU) will require some designer input. If the AHU includes a return fan, then the designer must determine whether the return fan and relief damper will be controlled based on a Direct Building Pressure control strategy or an Airflow Tracking strategy. The setpoints for either strategy must also be communicated.

Where Guideline 36 sequences are not required by Title 24, the designer may still decide to implement available Guideline 36 sequences, or they may elect to specify another control sequence that is specific to the application. For systems, equipment, and components where Guideline 36 sequences have not been published, the designer must specify an application-specific sequence. Where control sequences are specified that do not originate from Guideline 36, or where deviations are made from native Guideline 36 text, it is recommended that the alternate and/or deviated sequence language is clearly differentiated from the native Guideline 36 text to ensure scope clarification and avoid ambiguity during project delivery, such as through the use of different font colors.

Applications that require modification of native Guideline 36 sequences will also require modifications from Guideline 36 Certified Programming Libraries. Installing contractors, during programming, will start out with the Certified Programming Libraries and will modify or add additional logic as required to meet the specified sequence of operation. Modifications from the Certified Programming Libraries should only be made where needed to comply with the specified sequence.

Example 4-37

Question:

A project will include a Multiple-Zone VAV AHU that will incorporate an integral steam humidifier. The current publication of Guideline 36 does not include any sequence logic for humidification. How do I ensure that this project is compliant with this code requirement?

Answer:

It is recommended that the base AHU control sequence is created by editing the Guideline directly. In this case, any sections that do not apply to the project will be deleted such that only the applicable sections remain. Note that there are tools and resources available to support this first step. As mentioned prior, Guideline 36 is available as an editable document that can be used as a starting point. Alternatively, base control sequences for some system components can be generated using a free tool called "ctrl-flow" (see references that follow). The current version of ctrl-flow has the capability to generate draft control sequences for VAV terminals and Multiple-Zone VAV AHUs such that only the applicable sections of Guideline 36 remain.

Each base control sequence should be edited for the project-specific application. The control sequence for the steam humidifier should be added to the native Guideline 36 AHU sequence. It is recommended that the steam humidifier control sequence be clearly differentiated such that it stands out from the surrounding native Guideline 36 AHU sequence. For example, the steam humidifier sequence language should reside in a dedicated paragraph, and the text should be modified to appear differently from the native Guideline 36 text. One possible method is to assign the steam humidifier text an alternate font with a heavier weight and a different font color.

From here, the installing contractor should be positioned to clearly identify the project-specific sequence language that will not otherwise be available from the Guideline 36 Certified Programming Libraries. The contractor may then apply the base AHU sequence based on what is available from the Certified Programming Libraries, before implementing the additional programming that's necessary to incorporate the steam humidifier control sequence.

Acceptance Requirements

Please refer to Chapter 4.6.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

HVAC Equipment Requirements

Mandatory Requirements

Water-Conservation Measures for Cooling Towers

Reference: Section 110.2(e)

There are mandatory requirements (Section 110.2(e)) for the efficient use of water in the operation of open (direct) and closed (indirect) cooling towers. The building standard applies to the new construction and retrofit of commercial, industrial, and institutional cooling towers with a rated capacity of 150 tons or greater. For these towers all of the following are required:

- The towers shall be equipped with conductivity controls to manage cycles of concentration based on local water quality conditions. The controls shall automate system bleed and chemical feed (if applicable) based on conductivity. Conductivity controllers shall be installed in accordance with manufacturer's specifications.
- Design documents have to document target maximum achievable cycles of concentration based on local water supply as reported by the local water supplier using the equations documented in Section 110.2(e)2. The calculations shall determine maximum cycles based on the parameters identified in Table 110.2-A-1. Building owner shall document maximum cycles of concentration on the mechanical compliance form which shall be reviewed and signed by the Professional Engineer (P.E.) of Record.
- Cooling towers shall not allow blowdown until one or more of the parameters in Table 110.2-A-1 reaches the maximum value specified.
- The towers shall be equipped with a flow meter with an analog output for flow. This can be connected to the water treatment control system using either a hardwired connection or gateway.
- The towers shall be equipped with an overflow alarm to prevent overflow of the sump in case of makeup water valve failure. This requires either a water level sensor or a moisture detector in the overflow drain. The alarm contact should be connected to the building Energy Management Control System to initiate an alarm to alert the operators.
- The towers shall be equipped with drift eliminators that achieve a maximum rated drift of 0.002 percent of the circulated water volume for counter-flow towers and 0.005 percent for crossflow towers.
- Conductivity controls and overflow alarm shall be verified according to NA 7.5.18.

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 is best controlled 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. Good practice involves maintaining the levels below those listed in Table 110.2-A-1.

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.

Additionally, the pH in new cooling towers using galvanized metal should be maintained at less than or equal to 8.3 until metal is passivated, which occurs after three-six months of operation.

To meet compliance, the design documents must document the target maximum achievable cycles of concentration and install conductivity controls that prevent blowdown from occurring until one or more of the parameters in Table 110.2-A-1 reaches the maximum value specified. These values are available from the local water supplier in the most recent annual Consumer Confidence Report or Water Quality Report. These reports are generally posted on the water supplier’s website, or by contacting the local water supplier by telephone. Many water districts have multiple sources of water which often are changed seasonally. For example, many water districts use a reservoir in the winter and spring then switch to well water in the summer and fall. Each supply will typically have different characteristics; the water treatment and control cycles of concentration should be seasonally shifted as well.

After entering the required water quality data, the user must also enter skin temperature; the default value of 110 degrees F is acceptable. The resulting cycles of concentration are considered by the Energy Commission to be the Achievable Cycles of Concentration and must be recorded on the mechanical compliance document (NRCC-MCH-06-E), to which a copy of the Consumer Confidence Report or Water Quality Report must be attached. The professional engineer of record must sign the compliance document (NRCC-MCH-06-E) attesting to the calculated maximum cycles of concentration.

Example 4-38

Question:

Where is the data for makeup water quality?

Answer:

Water agencies are required to make their annual water quality data available to the public. Water quality data is generally organized into an annual Consumer Confidence Report or Water Quality Report, which can often be found posted on the water agency’s website by searching for the key words “water quality”. Since many water districts have more than one water supply ask for a report for each source.

Example 4-39

Question:

What if all, or some, of the water quality data is not provided in the Consumer Confidence Report or Water Quality Report?

Answer:

Some data may be available by calling the local water agency’s Water Quality Division. For example, agencies are not required to test for and report alkalinity. However, they often do test for it and will provide data over the phone or in an email. Also check with water treatment firms that are doing business in the area. They often have test data that they will share. Finally, it is possible to hire a water treatment firm to take samples of the water to test.

Sizing and Equipment Selection

Reference: Section 140.4(a)1

The Energy Code requires mechanical heating and cooling equipment (including electric heaters and boilers) serving common use areas in multifamily buildings, hotel/motel buildings, and nonresidential buildings other than healthcare facilities 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.

Mechanical heating and mechanical cooling equipment serving healthcare facilities shall be sized to meet the design heating and cooling loads of the building or facility being served. 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:

- It can be demonstrated (to the satisfaction of the enforcing agency) that oversizing will not increase building source energy use

- 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
- 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.

Single Zone Space Conditioning System Type

Reference: Section 140.4(a)2

For prescriptive compliance, the Energy Code requires single zone space-conditioning systems with direct expansion cooling with rated cooling capacity 240,000 Btu/hr or less serving the following spaces to meet the following requirements.

- Retail and Grocery Building Spaces in climate zones 2 through 15. The space-conditioning system shall be a heat pump.
- Retail and Grocery Building Spaces in climate zones 1 and 16 with cooling capacity less than 65,000 Btu/hr. The space-conditioning system shall be an air conditioner with furnace.
- Retail and Grocery Building Spaces in climate zones 1 and 16 with cooling capacity 65,000 Btu/hr or greater. The-space conditioning system shall be a dual-fuel heat pump.
- School Building Spaces. For climate zones 2 – 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.
- Office, Financial Institution, and Library Building Spaces in climate zones 1 – 15. The space-conditioning system shall be a heat pump.
- Office, Financial Institution, and Library Building Spaces in climate zone 16 with cooling capacity less than 65,000 Btu/hr. The space-conditioning system shall be an air conditioner with furnace.
- Office, Financial Institution, and Library Building Spaces in climate zone 16 with cooling capacity 65,000 Btu/hr or greater. The space-conditioning system shall be a dual-fuel heat pump.
- Office Spaces in Warehouses. The space-conditioning system shall be a heat pump in all climate zones.

For performance compliance, the prescriptive requirements in Section 140.4(a)2 set the standard design space conditioning budget. Under the performance compliance approach the building can comply using any supported space conditioning system type as long as it meets the standard design source energy and LSC budgets for the building.

Multi-Zone Space Conditioning System Type

Reference: Section 140.4(a)3

For prescriptive compliance, the Energy Code requires multi-zone space-conditioning system types in some office buildings and school buildings not covered by Section 140.4(a)2 to include certain characteristics and system types, as described below.

There are two exceptions to these requirements. The first exception is for school buildings and office buildings greater than 150,000 square feet or greater than five habitable stories. The second exception is for school buildings in climate zones 6 and 7.

Allowable System Types

Applicable office buildings and school buildings with multi-zone space-conditioning systems shall use one of the following four HVAC system types:

- Variable refrigerant flow (VRF) heat pump with a dedicated outdoor air system (DOAS) providing ventilation to all zones served by the VRF system. The VRF system must include a refrigerant heat recovery loop. Additional requirements for the indoor fans and DOAS are outlined in Additional Indoor Fan Requirements and Additional DOAS Requirements, respectively.
- Four-pipe fan coil (FPFC) terminal units with heating supplied by an air-to-water heat pump (AWHP) with DOAS providing ventilation to all zones served by the FPFC terminal units. Additional requirements for the AWHP, indoor fans, and DOAS are outlined in Additional AWHP Requirements, Additional Indoor Fan Requirements, and Additional DOAS Requirements, respectively.
- A variable air volume (VAV) system with heating supplied by an AWHP that meets the requirements of Additional AWHP Requirements. Additional restrictions and requirements for school buildings and office buildings are described below.
    - For office buildings:
        - In climate zones 1 – 6 and 16, parallel fan-powered boxes shall be used to meet 100% of the perimeter zone terminal unit heating capacity. In climate zones 7 – 15, parallel fan-powered boxes shall be used to meet 25% of the perimeter zone terminal unit heating capacity. Parallel fan-powered boxes must meet the requirements in Additional Parallel Fan-Powered Box Requirements.
        - In climate zones 1, 3, and 5, the system shall include a heat recovery ventilation system that complies with Exhaust Air Heat Recovery (EAHR) Requirements.
        - In climate zones 3 and 5, the ventilation system's fan power allowance shall be 15% lower than the value specified by Fan Power Consumption.
    - For school buildings:
        - This system type is only allowed in climate zones 2, 4, and 8 through 16.
        - All perimeter zone terminal units shall be parallel fan-powered boxes that comply with Additional Parallel Fan-Powered Box Requirements.
        - In climate zones 2, 4, and 11 – 16, the system shall include a heat recovery ventilation system that complies with Exhaust Air Heat Recovery (EAHR) Requirements.
        - In climate zone 2:
            - The ventilation system's fan power allowance shall be 15% lower than the value specified by Fan Power Consumption.

    - The design leaving water temperature of the heating loop shall be no greater than 120 °F.
- A dual fan dual duct system (DFDD) with hot and cold decks served by separate fan systems. Additionally, when Economizers are required, economizers shall be located on the cold deck. The hot deck shall supply 100% return air, except when outdoor air is needed to supplement the cold deck to maintain the design minimum outdoor air flow rate. The heating source for the hot deck shall be a heat pump. All control sequences related to the DFDD system (both the central and terminal units) shall comply with ASHRAE Guideline 36.

In addition to the four options listed above, other systems that demonstrate equal or greater energy efficiency performance can comply prescriptively if approved by the Executive Director.

This requirement only applies to systems within the buildings, not necessarily the entire building. For example, if a given office includes a combination of single zone space-conditioning systems with a rated cooling capacity of 240 kBtu/hr (20 tons) or less and a multi-zone space-conditioning system, then only the multi-zone system must meet these requirements. The single zone system must meet the requirements as described in Single Zone Space Conditioning System Type.

Additional AWHP Requirements

The AWHP must meet the following requirements:

- The AWHP must meet the minimum efficiency requirements listed in Equipment Efficiency.
- If chilled water produced by an AWHP is used for space-cooling, then the heat recovery system shall comply with the Mechanical Heat Recovery Requirements.
- Supplemental heating shall be provided by an electric resistance (ER) boiler with a capacity that does not exceed 50% of the design hot water loop capacity. As a supplemental boiler, it should be configured such that it never activates unless the AWHP cannot satisfy the building's hot water demand on its own.

Additional Indoor Fan Requirements

The indoor fans must meet the following requirements:

- The fan shall have a maximum fan power of 0.35 W/cfm at design airflow
- Shall have no less than three speeds
- Shall turn off when there is no demand for heating or cooling in the space
- At 66 percent air flow the power draw shall be no more than 51 percent of the fan power at full fan speed
- At 33 percent air flow the power draw shall be no more than 12 percent of the fan power at full fan speed

Additional DOAS Requirements

The DOAS system must meet the following requirements:

- The DOAS system must comply with the prescriptive DOAS requirements located in Dedicated Outdoor Air System (DOAS).
- The DOAS system must include a heat recovery system that meets the Exhaust Air Heat Recovery (EAHR) Requirements.

- The maximum fan power consumption shall not exceed 0.77 W/cfm at design airflow.
- DOAS units that provide active heating and cooling shall meet one of the following requirements:
    - Heating coils served by the AWHP system and cooling coils served by a chilled water loop.
    - Heating and cooling provided by a heat pump without an electric resistance heating element.

Additional Parallel Fan-Powered Box Requirements

Parallel fan-powered boxes used to comply with the third option in Allowable System Types shall meet the following requirements:

- The system shall use only recirculated air from the zone or plenum when in heating mode.
- Fans shall cycle on only when there is a demand for heating.
- The maximum fan power shall not be greater than 0.3 W/cfm at design airflow.
- Terminal units providing ventilation air shall be set to no greater than the minimum ventilation rate when the zone is in deadband or in heating mode.

Load Calculations

Reference: Section 140.4(b)

For the purposes of sizing HVAC equipment, the designer shall use all of the following criteria for load calculations:

- 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. When submitting load calculations of this type, the designer must accompany the load calculations with a written affidavit certifying that the method used 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.
    - For systems serving healthcare facilities, the method in the California Mechanical Code shall be used.
- Indoor design conditions of temperature and relative humidity for general comfort applications are not explicitly defined. Designers are allowed to use any temperature conditions within the “comfort envelope” defined by ANSI/ASHRAE 55-1992 or the 2017 ASHRAE Handbook, Fundamentals Volume. Winter humidification or summer dehumidification is not required.
    - For systems serving healthcare facilities, the method in Section 320.0 of the California Mechanical Code shall be used.
- 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 from the ASHRAE Handbook, Equipment Volume, Applications Volume and Fundamentals Volume, for the following design conditions:

    - Heating design temperatures shall be no lower than 99.0 percent Heating Dry Bulb or 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.

  For systems serving healthcare facilities, the method in Section 320.0 of the California Mechanical Code shall be used.
- Outdoor air ventilation loads must be calculated using the ventilation rates required in Ventilation and Indoor Air Quality Requirements.
- 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.
- Lighting heating and cooling loads shall be based on actual design lighting levels or power densities consistent with Chapter 5.
- Sensible and latent gains from people must be based on the expected occupant density of the building and occupant activities as determined under Ventilation and Indoor Air Quality Requirements. If ventilation requirements are based on a cfm/person basis, then loads from people must be based on the same number of people used to calculate ventilation requirements. Sensible and latent gains must be selected for the expected activities as listed in 2017 ASHRAE Handbook, Fundamentals Volume, Chapter 18.
- Loads caused by a process shall be based on actual information on the intended use of the building.
- Miscellaneous equipment loads include 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
- Internal heat gains may be ignored for heating load calculations.
- A safety factor of up to 10 percent may be applied to design loads to account for unexpected loads or changes in space usage.
- 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 in Item 11.

- 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).

Example 4-40

Question:

Do the sizing requirements restrict the size of duct work, coils, filter banks, etc. in a built-up system?

Answer:

No. The intent of the Energy Code is to limit the size of equipment, which if oversized will consume more energy on an annual basis. Coils with larger face areas will usually have lower pressure drops than otherwise and may also allow the chilled water temperature to be higher, both of which may result in a decrease in energy usage. Larger filter banks will also usually save energy. Larger duct work will have lower static pressure losses, which may save energy, depending on the duct's location, length, and degree of insulation.

Oversizing fans, on the other hand, may or may not improve energy performance. An oversized airfoil fan with inlet vanes will not usually save energy, as the part-load characteristics of this device are poor. But the same fan with a variable frequency drive may save energy. Controls are also an important part of any system design.

The relationship between various energy consuming components may be complex and is left to the designer's professional judgment. When components are oversized, it must be demonstrated to the satisfaction of the enforcement agency that energy usage will not increase.

Fan Power Consumption

Reference: Section 140.4(c)

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. 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 1kW total criteria apply to:

- All supply and return fans within the space-conditioning system that operate at peak load conditions.
- 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.
- 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.

- 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.

Fans not directly associated with moving conditioned air to or from the space-conditioning system, or fans associated with a process within the building.

Meeting the fan power limit is accomplished in two parts. First, the designer calculates the allowable fan input power for their fan systems (Fan kWbudget). Second, the designer calculates the actual electrical input power (Fan kWdesign, system) values of the fans in the system by summing up the Fan kWdesign 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:

- The type of fan system (described below)
- 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
- 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 140.4-A, Table 140.4-B, etc.) apply to the fan system when calculating Fan kWbudget.
- 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 140.4-A) and exhaust/return/relief/transfer fan power allowance table (e.g., Table 140.4-B) at the fan system design airflow. Examples include:
    - A rooftop unit with a single fan that both supplies air to the space and recirculates air.
    - An air handler with a supply and return fan in the same cabinet.
    - 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 140.4-A) at the fan system design supply airflow. Examples include:
    - An air handler with only a supply fan where the return fan is not in the same cabinet.

   - The supply fan of an ERV, even if there is an exhaust fan in the same cabinet.
   - 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 140.4-B) 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 140.4-B) 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 the 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 kWbudget 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.

$$FFNNAA_{mmaaaa} = \frac{QQ_{ffccmmcc}}{QQ_{ssssss}} \times FFNNAA_{ffccmmcc}$$

Where,

- FPA_{adj} = The corrected 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 the applicable table (e.g., Table 140.4-A or Table 140.4-B)

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 140.4-C to the resulting Fan kWbudget value.

Fan electrical input power (Fan kWdesign) 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 kWdesign 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.

- Use the default values for Fan kWdesign (Table 140.4-D in the standard) 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.
- 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.
- 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.
- 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 kWbudget) and their fan system's input electrical power at design conditions (Fan kWdesign, system), the two values are compared against each other to determine if the fan system complies.

$$FFLLRR\ kkkk_{aaffssffdddd,sssssffffmm} \leq FFLLRR\ kkkk_{bbbbaaddffff}$$

If the above inequality is valid, then the fan system complies with the fan power budget.

Selected Fan Power Budget Allowance

Please refer to Chapter 4.7.2.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Fractional HVAC Motors for Fans

Reference: Section 140.4(c)3

HVAC fan motors that are one hp or less 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 the National Electric Manufacturers Association (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.

This requirement can be met with either electronically commutated motors or brushless direct current (DC) motors. These motors have higher efficiency than permanent split capacitor

(PSC) motors and inherently have speed control that can be used for VAV operation or balancing.

This requirement includes fan-powered terminal units, fan-coil units, exhaust fans, transfer fans, and supply fans. There are three exceptions to this requirement:

- Motors in fan-coil units and terminal units that operate only when providing heating to the space served. This includes parallel style fan-powered VAV boxes and heating only fan-coils.
- Motors that are part of space conditioning equipment certified under Section 110.1 or Section 110.2. This includes supply fans, condenser fans, ventilation fans for boilers, and other fans that are part of equipment that is rated as a whole.
- Motors that are part of space conditioning serving healthcare facilities.

Electric-Resistance Heating

Reference: Section 140.4(g), Section 141.0

The Energy Code strongly discourages the use of electric-resistance space heat. Electric-resistance space heat is not allowed in the prescriptive approach except where:

- Site-recovered or site-solar energy provides at least 60 percent of the annual heating energy requirements.
- A heat pump is supplemented by an electric-resistance heating system, and the heating capacity of the heat pump is more than 75 percent of the design heating load at the design outdoor temperature (determined in accordance with the Energy Code).
- 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.
- The total capacity of all electric-resistance heating systems serving the building, excluding those that supplement a heat pump, is no more than 3 kW.
- An electric-resistance heating system serves an entire building that:
  - Is not a hotel/motel building.
  - Has a conditioned floor area no greater than 5,000 sq ft.
  - Has no mechanical cooling.
  - Is in an area where natural gas is not currently available and an extension of a natural gas system is impractical, as determined by the natural gas utility.
- The existing mechanical systems use electric reheat (when adding VAV boxes) added capacity cannot exceed 20 percent of the existing installed electric capacity, under any one permit application in an alteration.
- The existing VAV system with electric reheat is being expanded, the added capacity cannot exceed 50 percent of the existing installed electric reheat capacity under any one permit in an addition.
- Heating systems serve as emergency backup to gas heating equipment.
- Supplemental electric resistance heating systems complying with the prescriptive requirement for multi-zone space-conditioning system types.

The Energy Code allows a small amount of electric-resistance heat to be used for local space heating or reheating (provided reheat is in accordance with these regulations).

Example 4-40

Question:

If a heat pump is used to condition a building having a design heating load of 100,000 Btu/h at 35 degrees F, what are the sizing requirements for the compressor and heating coils?

Answer:

The compressor must be sized to provide at least 75 percent of the heating load at the design heating conditions, or 75,000 Btu/h at 35 degrees F. The Energy Code does not address the size of the resistance heating coils. Normally, they will be sized based on heating requirements during defrost.

Cooling Tower Flow Turndown

Reference: Section 140.4(h)2

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.

In a large plant at low load operation, not all the cells are typically run at once. This is allowed in the Energy Code.

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. This typically only costs $100 to $150 per tower cell. As low-flow nozzles can eliminate the need for a tower isolation control point, this option provides energy savings at a reduced first cost.

Example 4-41

Question:

If a large central plant has five equally sized chillers and five equally sized cooling tower cells do all of the cooling tower cells need to operate when only one chiller is on-line?

Answer:

No. You would probably only run three cells with one chiller. The cooling tower cells must be designed to run at 33 percent of their nominal design flow. With two to five chillers running, you would run all of the cells of the cooling tower. With only one chiller running you would run three cells. In each case, you would need to keep the tower flow above the minimum that it was designed for.

Centrifugal Fan Limitation

Reference: Section 140.4(h)3

Open cooling towers with a combined rated capacity of 900 gpm and greater are prohibited from using centrifugal fans. The 95-degree F condenser water return, 85-degree F condenser water supply and 75-degree 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. There are a couple of exceptions to this requirement:

- Cooling towers that are ducted (inlet or discharge) or have an external sound trap that requires external static pressure capability.
- Cooling towers that meet the energy efficiency requirement for propeller fan towers in Table 110.2-E.

Centrifugal fans may be used on closed circuit fluid coolers.

As with all prescriptive requirements centrifugal fan cooling towers may be used when complying with the performance method. The budget building will be modeled using propeller towers.

Cooling Tower Efficiency

Reference: Section 140.4(h)5

For prescriptive compliance, axial fan open-circuit cooling towers with a combined rated capacity of 900 gpm or greater must achieve a rated efficiency between 42.1-80 gpm/hp depending on the climate zone - climate zones 1 and 16 are 42.1 GPM/HP; climate zones 3, 11, and 14 are 60 GPM/HP; Climate Zones 2, 4, 5, and 12 are 70 GPM/HP; and Climate Zones 6, - 10, 13 and 15 are 80 GPM/HP. This efficiency is rated at 95-degree F condenser water return; 85-degree F condenser water supply; and 75-degree F outdoor wet-bulb temperature. These conditions are specified in the Cooling Technology Institute's (CTI) standards, CTI ATC-105 and CTI STD-201 RS. These test conditions are used for code compliance purposes and do not have to align with the conditions a designer may want to use for selecting a given cooling tower for a given project. There is one exception to this requirement:

- Cooling towers that are installed as a replacement to an existing chilled water plant if the tower is located on an existing roof or inside an existing building.

Axial-fan open-circuit cooling towers with a capacity of 900 gpm or larger and less than 60 gpm/hp may be used when complying with the performance method if the towers comply with the mandatory minimum efficiency rating of 42.1 gpm/hp as listed in Table 110.2-E.

Chiller Efficiency

Reference: Section 140.4(i)

In Table 110.2-D, there are two sets 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.

There are a number of exceptions to this requirement:

- Chillers with an electrical service of greater than 600 volts. The cost of a VSD is much higher on medium voltage service.
- Chillers attached to a heat recovery system with a design heat recovery capacity greater than 40 percent of the chiller's design cooling capacity. Heat recovery typically requires operation at higher lifts and compressor speeds.
- Chillers used to charge thermal energy storage systems with a charging temperature of less than 40 degrees F. This performance again requires a high lift operation for chillers.
- In a building with more than three chillers only three of the chillers are required to meet the Path B efficiencies.

Limitation on Air Cooled Chillers

Reference: Section 140.4(j), Section 141.0

New central cooling 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.

In the studies provided to support this requirement, air cooled chillers always provided a higher life cycle cost than water-cooled chillers even accounting for the water and chemical treatment costs.

Exceptions to this requirement:

- Where the water quality at the building site fails to meet manufacturer's specifications for the use of water-cooled chillers. 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.
- Chillers that are used to charge a thermal energy storage system with a design temperature of less than 40 degrees F. 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.
- Systems serving healthcare facilities.

Exhaust System Transfer Air

Reference: Section 140.4(o)

The Energy Code 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: (1) the supply flow required for space heating or space cooling, (2) the required ventilation rate, or (3) 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 by in Section 120.1.

There are a few exceptions to this requirement:

- Biosafety laboratories classified Level 3 or higher

- Vivarium spaces
- Spaces that are required by applicable codes and standards to be maintained at positive pressure relative to adjacent spaces. For spaces taking this exception, any transferable air that is not directly transferred shall be made available to the associated air-handling unit and shall be used whenever economizer or other options do not save more energy.
- Spaces where the demand for transfer air may exceed the available transfer airflow rate and where the spaces have a required negative pressure relationship. For spaces taking this exception, any transferable air that is not directly transferred shall be made available to the associated air-handling unit and shall be used whenever economizer or other options do not save more energy.
- Healthcare facilities

A compliant example would be a space with a restroom with 300 cfm of exhaust. The makeup air would consist of 60 cfm of supply air and 240 cfm of transfer air from an adjacent ceiling return air plenum. The amount of air required for the space is 60 cfm for heating and cooling and the rest of the makeup air is transferred from the return air plenum.

A non-compliant example would be if the same space had a constant air volume box with reheat supplying all of the makeup air. The reheat would be needed to prevent the space from being overcooled. Since there is transfer air available in the adjacent plenum, the maximum allowed supply air would be only what’s required for space heating or cooling, which would be 60 cfm.

Dedicated Outdoor Air System (DOAS)

Reference: Section 140.4(p)

Systems specifying DOAS units must comply with the following requirements to ensure a compliant system:

- DOAS fan efficiency: If the DOAS unit fan power is less than 1 kW, then the fan efficiency of that fan must be less than or equal to 1.0 watt per cubic foot per minute. If the fan power is greater than or equal to 1 kW, it is subject to the fan power budgets requirements under Section 140.4(c).
- DOAS complying with requirements under Section 140.4(a)3E are not subject to this requirementReducing terminal unit fan power: in order to ensure that adequate ventilation air can be provided to the space without severely impacting the ability of independent terminal unit fans to shut off when not needed, the following scenarios are compliant:
    - Ventilation air provided by the DOAS unit must be provided directly to the space
    - Ventilation air is provided to the outlet of the terminal heating or cooling coils (such as a VRF).
    - A system using active-chilled beam systems
    - Sensible-only cooling terminal units with pressure independent variable airflow devices that limit DOAS supply air to the greater of latent load or minimum ventilation requirements.
    - Any configuration where the downstream terminal fans use no greater than 0.12 watts per cubic foot per minute.

- Airflow Balance: supply and exhaust fans for the DOAS shall have a minimum of three speeds for system balancing
- Limiting reheat: if a DOAS utilizes mechanical cooling, then the DOAS ventilation air shall not use supply air above 60°F when the majority of zones require cooling.

Under certain climate zones and air handler design scenarios, DOAS units may also require Exhaust Air Heat Recovery requirements under section 140.4(q).

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Exhaust Air Heat Recovery (EAHR)

Reference: Section140.4(q)

HVAC systems (including DOAS) must comply with 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 140.4-J or Table 140.4-K or where required by Section 140.4(a)3.

These requirements are also triggered if a decoupled DOAS system is utilizing Exhaust Air Heat Recovery instead of meeting economizer requirements for the independent space-conditioning indoor units using the DOAS-Economizer exception (Exception 6 to 140.4(e)).

- The HVAC System must utilize an exhaust air heat recovery device with an energy recovery ratio of 60 percent or an enthalpy recovery ratio of 50 percent for both heating and cooling (note: climate zone 1 only needs to comply with heating requirements and climate zone 15 only needs to comply with cooling requirements).
- The HVAC System must utilize energy recovery or bypass controls to disable exhaust air heat recovery and directly economizer with ventilation air. Economizing with ventilation air is dependent on the outside air temperature as described in Table 140.4-G of the Energy Code. Where energy transfer cannot be stopped, a bypass shall be included which prevents the airflow rate of either the outdoor air or exhaust air through the energy recovery exchanger from exceeding 10 percent of the full design airflow rate.

Reference: Exceptions to Section 140.4(q)

- Laboratory and factory exhaust systems (those meeting Section 140.9c)
- Systems designed to condition to 60 degrees F or less
- Systems within heating-dominated Climate Zone 16 (only) where 60% of heating energy is recovered on site.
- Systems where the usable[2] exhaust air is too distributed to utilize for heat recovery (systems where a quantity of less than 75 percent of the outdoor airflow rate can be gathered within 20 linear feet).
- Systems with low operating hours (20 hours or less per week)

Example 4-42

[2] (1) Unusable exhaust air includes air used for another energy recovery system; (2) air not allowed for energy recovery under the CMC; (3) Class 4 air as specified under Section 120.1(g)

Question:

If a building has some areas that need continuous operation (24 hours per day & 7 days a week) and some which has lower hours, which table of Exhaust Air Heat Recovery requirements do you need to follow?

Answer:

These requirements are system-based and **not** building-based. If any part of an air handling system serves an area that need to operate 24/7, they will need to comply with the requirements under the greater than 8,000 hours per year table or else take a relevant exception.

Mechanical Heat Recovery

Reference: Section 140.4(s)

This requirement exists to ensure heat recovery occurs for sites with a meaningful amount of simultaneous cooling and heating loads. The code language is geared toward detecting whether the site's cooling and heating loads are likely to be overlapping or not. The benefit of a heat recovery system is that instead of concurrently rejecting waste heat from the cooling system and separately generating heat with a boiler or air to water heat pump, the waste heat from the cooling system provides the heating energy. However, this is only beneficial to the site when both end uses are present simultaneously.

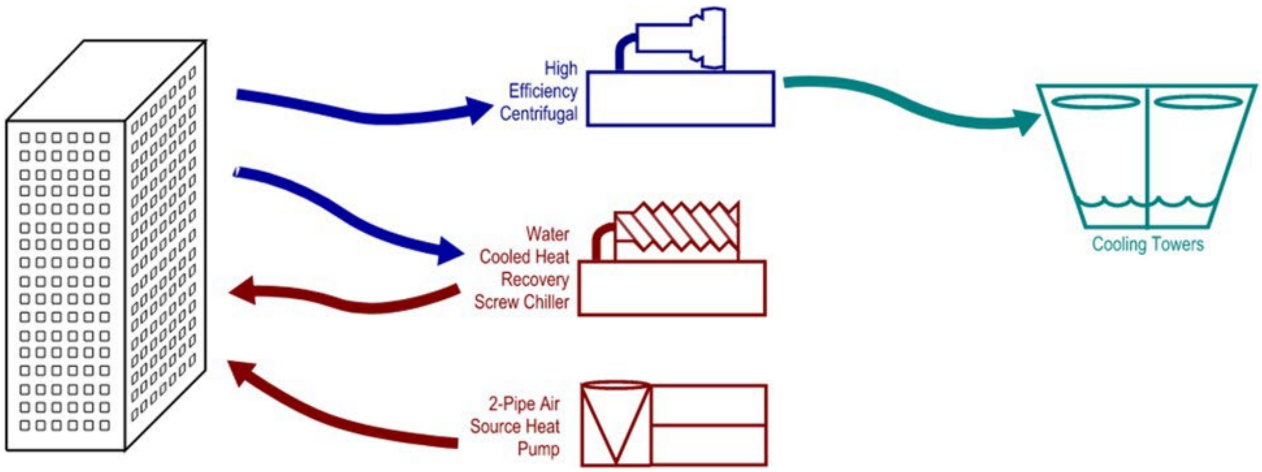
Typical building types that are expected to be triggered by this requirement include hospitals, mixed-use buildings that include functions such as commercial kitchens or laundromats, offices with data centers, or any medium to large sized building with a process cooling or heating load.

Laboratory buildings with exhaust air heat recovery systems meeting Section 140.9(c)6 and buildings in climate zone 15 with service water heating design capacity less than 600 kBtu/h are not subject to the simultaneous mechanical heat recovery requirement.

The purpose of the formulas in 140.4(s)1Ai and 140.4(s)1Aii is to estimate the approximate coincident cooling and heating loads for the building without having to run a full year hourly energy model for the building. Since this is a prescriptive code requirement, it cannot be assumed that a whole building energy model is being conducted. Simultaneous cooling and heating loads are more likely to occur during mild weather conditions or when the building contains a process cooling or heating load. This is what drives the 10% multiplier next to CLL in the first equation and HCAP in the second one. This adjusts the design capacities to a more appropriate estimated value for mild weather conditions (e.g., temperatures in the 50s or 60s Fahrenheit). The distinction between "low density" cooling and "high density" cooling in the first equation is intended to estimate the component to the cooling load that is likely present during mild or colder ambient conditions, e.g., for a data center. In the second equation, the service hot water (i.e., the aspect with the potential for significant process loads) aspect is similarly broken out from the ambient temperature-driven space heating loads. It is expected that sites with larger process heating loads will maintain those loads into higher ambient temperatures, when significant cooling loads occur.

Section 140.4(s)B describes the equipment capable of meeting this requirement for mechanical heat recovery. The most common unit is expected to be a 4-pipe heat recovery chiller or water-to-water heat pump (WWHP) whose evaporator is connected to the chilled water loop and condenser is connected to the hot water loop (see Figure 4-25: Pipe Heat Recovery Chiller (configured to reject heat from the CHW to HW loop)).

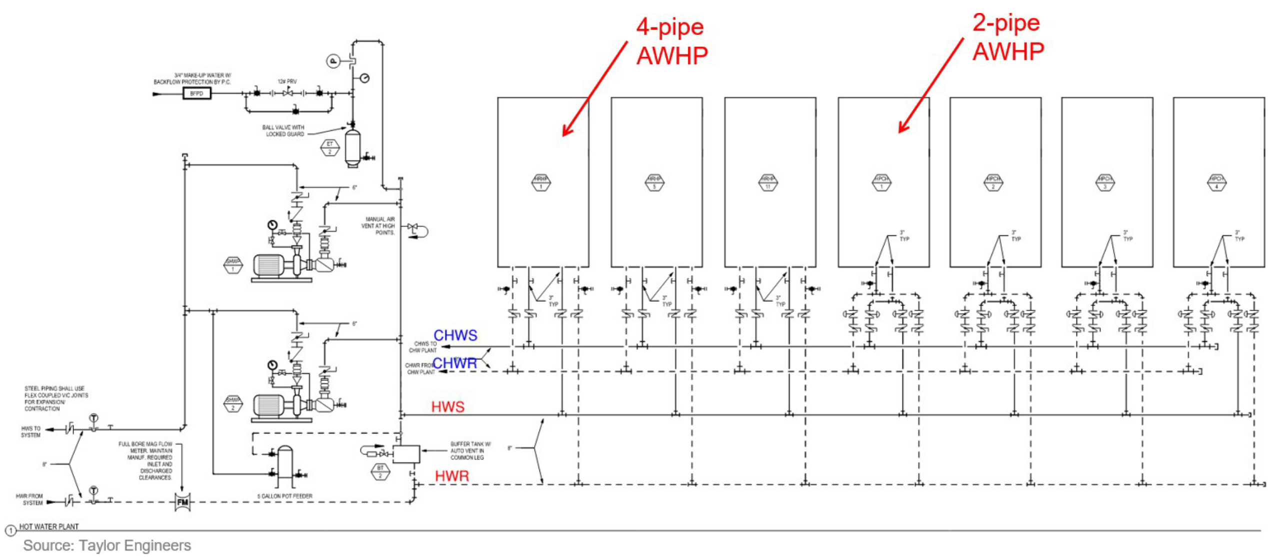
Figure 4-25: Pipe Heat Recovery Chiller (configured to reject heat from the CHW to HW loop)



Source: California Statewide CASE Team

4-pipe air-to-water heat pumps (AWHPs) that have the ability to operate like a WWHP, absorbing heat from the CHW loop and rejecting it to the HW loop, can also meet this requirement (see Figure 4-26: 4-Pipe Air-to-Water Heat Pumps with Heat Recovery Capability). It is important to recognize, however, that some 4-pipe AWHPs are not capable of heat recovery. They may be capable of simultaneous heating and cooling but only by rejecting heat to the air with one circuit and absorbing heat from the air with an independent circuit. Furthermore, there may be other requirements in the Energy Code that preclude this system (e.g., the 300 ton air-cooled chiller limitation).

Figure 4-26: 4-Pipe Air-to-Water Heat Pumps with Heat Recovery Capability



Source: California Statewide CASE Team

Other types of thermal storage heat recovery systems that could potentially satisfy the requirement include chilled water storage, hot water storage, ice storage, water-cooled VRF with condenser water storage, and water-to-air heat pumps (water-source heat pumps) with condenser water storage.

The requirement to size the heat recovery equipment to the lesser of 25% of the peak heat rejection of the cooling system or the combined capacity of the space and service water heating systems is intended to help ensure that the system is cost-effective and not oversized relative to the magnitude of the overlapping loads.

140.4(s)2 is intended to further specify the type of heat recovery system that a site with a large service water heating load should install, namely one that serves the service water heating load with the cooling heat of rejection. Similar to 140.4(s)1B, this requirement specifies the smaller of 30% of the heat rejection of the cooling system or the service water heating capacity be used to size the heat recovery system.

Buildings with a computer room heat recovery system or wastewater heat recovery system capable of providing not less than 25% of the sum of the service water heating design capacity and space heating design capacity are not subject to the service water heating heat recovery requirement.

Example 4-43

Question:

A 75,000 sf mixed-use building in climate zone 9 with office space (including a portion devoted to a server room) and commercial kitchen is under construction. The building's low density cooling load is 150 tons and its space heating capacity is 1,000 kBtuh. The building's high density cooling load is 175 tons and the commercial kitchen's service water heating load is 650 kBtuh. Would the building be required to comply with 140.4(s), and if so, what should the capacity of the heat recovery system be?

Answer:

First, test the conditions against 140.4(s)1Ai:

- CHL + 0.1*CLL ≥ 200 tons and SWHCAP + HCAP ≥ 2200 kBtuh

Replacing the terms with the values specific to this building produces:

- 175 + 15 = 190 which is not ≥ 200 tons and 650 + 1,000 = 1,650 which is not ≥ 2,200 kBtuh, so therefore the first equation is not satisfied.

Next, test the conditions against 140.4(s)1Aii:

- CCAP ≥ 300 tons and SWHCAP + 0.1 * HCAP ≥ 700 kBtuh

Again, replacing the variables with values produces:

- 150 + 175 = 325 which is ≥ 300 tons and 650 + 100 which is ≥ 700 kBtuh, so therefore the second equation is satisfied and the building must install a heat recovery system.

In order to size the heat recovery system, assume that the cooling system requires 400 tons of heat rejection capacity. 25% of this value is 100 tons or 1,200 kBtuh. 25% of the sum of SWHCAP and HCAP is 538 kBtuh, making this the required value for the heat recovery system based on 140.4(s)1B. Note that since 140.4(s)2 is also triggered (since at 650 kBtuh, SWHCAP is ≥ 500 kBtuh), then the heat recovery system must be setup to heat or preheat the service hot water. Based on 140.4(s)2B, the service hot water system would have to be sized to 30%

of SWHCAP or 195 kBtuh (since at 1,200 kBtuh, 30% of the peak heat rejection of the cooling system is greater). This does not exempt the building's overall heat recovery requirement of 538 kBtuh based on the value calculated from 140.4(s)1Bii.

Water Heating Requirements

Please refer to Chapter 4.8 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Service Water Systems Mandatory Requirements

Efficiency and Control

Please refer to Chapter 4.8.1.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Multiple Temperature Usage

Please refer to Chapter 4.8.1.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Controls for Hot Water Distribution Systems

Reference: Section 110.3(c)2

Service hot water systems with a circulating pump or with electrical heat trace shall include a control capable of automatically turning off the system when hot water is not required. Such controls include automatic time switches, interlocks with HVAC time switches, occupancy sensors, and other controls that accomplish the intended purpose.

Systems serving healthcare facilities are not subject to this requirement.

Storage Tank Insulation

Please refer to Chapter 4.8.1.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Systems with Recirculation Loops

Reference: Section 110.3(c)4

Service water systems with central recirculation distribution must include all of the following mandatory features. The intent of these measures is to optimize performance and allow for lower cost of maintenance. These requirements are applicable to nonresidential occupancies as well as multifamily and hotel/motel systems.

Air Release Valves

Reference: Section 110.3(c)4A

The constant supply of new water and leaks in system piping or components during normal operation of the pump may introduce air into the circulating water. Entrained air in the water may also contribute to increased cavitation, the formation of vapor bubbles in liquid on the low pressure (suction) side of the pump. The vapor bubbles generally condense back to the liquid state after they pass into the higher-pressure side of the pump. Cavitation contributes to a loss of head pressure and pumping capacity, may produce noise and vibration in the pump, and may result in pump impeller corrosion, all of which impacts the pumps' efficiency and life expectancy.

Entrained air and cavitation should be minimized by the installation of an air release valve. The air release valve must be located no more than 4 feet from the inlet of the pump and must be mounted on a vertical riser with a length of at least 12 inches. Alternatively, the pump shall be mounted on a vertical section of the return piping.

Recirculation Loop Backflow Prevention

Reference: Section 110.3(c)4B

Temperature and pressure differences in the water throughout a recirculation system can create potentials for backflows, resulting in cooler water from the bottom of the water heater tank and water near the end of the recirculation loop flowing backwards towards 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.

Equipment for Pump Priming/Pump Isolation Valves

Reference: Section 110.3(c)4C, Section 110.3(c)4D

Many systems are allowed to operate to complete failure due to the difficulty of repair or servicing. Repair labor costs can be reduced significantly by planning ahead and designing for easy pump replacement. Provisions for pump priming and pump isolation valves help reduces maintenance costs.

To meet the pump priming equipment requirement, a hose bibb must be installed between the pump and the water heater. In addition, an isolation valve shall be installed between the hose bibb and the water heating equipment. This configuration will allow the flow from the water heater to be shut off, allowing the hose bibb to be used for bleeding air out of the pump after replacement.

The requirement for the pump isolation valves will allow replacement of the pump without draining a large portion of the system. The 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 Section 110.3(c)5C.

Connection of Recirculation Lines

Reference: Section 110.3(c)4E

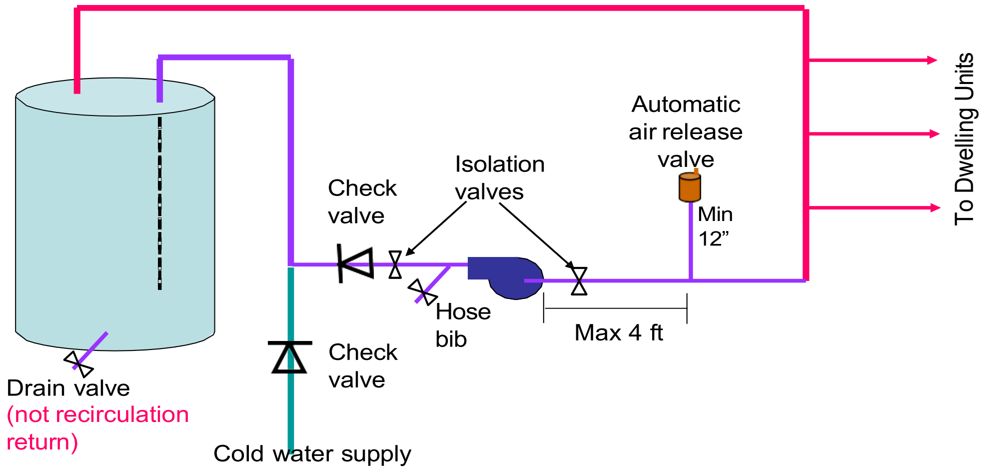
Manufacturer specifications should always be followed to assure optimal system performance. The cold-water piping and the recirculation loop piping should never be connected to the hot water storage tank drain port.

Backflow Prevention in Cold Water Supply

Reference: Section 110.3(c)4F

The dynamic between the water in the heater and the cold-water supply are similar to those in the recirculation loop. Thermosyphoning can occur on this side of the 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 shall comply with the expansion tank requirements of California Plumbing Code, Section 608.3.

Figure 4-27: Backflow Prevention



Source: California Energy Commission

Service Water Heaters in State Buildings

Please refer to Chapter 4.8.1.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Isolation Valves for Instantaneous Water Heaters

Reference: Section 110.3(c)6

All newly installed instantaneous water heaters with an input greater than 6.8 kBtu/h or 2 kW shall have isolation valves on both the incoming cold water supply and the hot water pipe leaving the water heater, to assist in the flushing of the heat exchanger and help prolong the life the water heaters. Instantaneous water heaters with integrated drain ports for servicing are acceptable to meet the requirement and will not require additional isolation valves.

Pipe Insulation

Reference: Section 120.3

All requirements of Section 120.3 also apply to service water heating in nonresidential, hotel and motel buildings. See Mandatory Measures for full details.

For pipes with conductivity ranges within those specified in Table 120.3-A-1 and Table 120.3-A-2, the nominal pipe diameters grouping ranges have changed, as well as the thickness of insulation required for each pipe diameter range.

Mandatory Requirements Applicable to Hotel/Motel

In addition to the mandatory requirements listed above, there are mandatory requirements that will apply to water heating systems for hotels and motels only. The applicability of the mandatory features listed above will change depending on whether the water heating system has a central system or uses individual water heaters.

Systems with Recirculation Loops

See Systems with Recirculation Loops.

Commercial Boilers

See Commercial Boilers.

Water Piping Insulation

Reference: Section 120.3

Nonresidential and hotel/motel domestic hot water system piping must be insulated per Table 120.3-A-1 and Table 120.3-A-2. The Energy Code also requires that pipe insulation be protected from damage by moisture, UV and physical abrasion including but not limited to the following:

- Insulation exposed to weather shall be installed with a cover suitable for outdoor service. The cover shall be water retardant and provides shielding from solar radiation that can cause degradation of the material. Insulation must be protected by an external covering unless the insulation has been approved for exterior use using a recognized federal test procedure. Adhesive tape shall not be used as protection for insulation exposed to weather.
- Insulation covering chilled water piping and refrigerant suction piping located outside the conditioned space shall have a Class I or Class II vapor retarder. All penetrations and joints of which shall be sealed.
- Pipe insulation buried below grade must have a waterproof, uncrushable casing or sleeve. The Energy Code does not define uncrushability, as any material can be crushed, given enough pressure, and thus it is left to the professional judgement of the designer The internal cross-section or diameter of the casing or sleeve shall be large enough to allow for insulation of the hot water piping. Pre-insulated pipe with an integrated protection sleeve will also meet this requirement.

There are exceptions to the requirements for pipe insulation, as described below:

- Pipes completely surrounded with at least four inches of attic insulation, 2 inches of crawlspace insulation, or 1 inch of wall insulation; any section of pipe not meeting this criterion must be insulated.
- Piping in walls meeting Quality Insulation Installation (QII) requirements as specified in the Reference Residential Appendix RA3.5. Otherwise, the section of pipe not meeting the QII specifications must be insulated.
- Factory-installed piping within space-conditioning equipment certified under 110.1 or 110.2.
- 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 assure that no contact is made with the metal framing. Insulation shall butt securely against all framing members.
- Certain process equipment including fluid pumps, steam traps, blow-off valves, and piping within process equipment.
- Valves, strainers, coil u-bends, air separators with at least 0.5 inches of insulation, and piping within process equipment.

Prescriptive Requirements Applicable to Nonresidential Occupancies

Please refer to Chapter 4.8.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Requirements Applicable to Hotel/Motel Buildings

Reference: Section 140.5(b)

For water heating systems for hotel/motel buildings, the code references to the multifamily prescriptive requirements under Section 170.2. The executive director can also approve another water heating system that uses no more energy than one described in Water Heating

Systems Serving Single Dwelling Units Solar Water Heating or Water Heating Systems Serving Multiple Dwelling Units below. The following paragraphs recap these requirements.

Water Heating Systems Serving Single Dwelling Units Solar Water Heating
Reference: Section 170.2(d)1

Systems for individual dwelling units with recirculation distribution systems must use Demand Recirculation with a manual on/off control meeting RA4.4.9.

There are two options for water heating systems serving single dwelling units:

- One 240V heat pump water heater (HPWH); a compact hot water distribution system (CHWDS) meeting RA4.4.6 is also required in climate zones s 1 & 16. A drain water heat recovery (DWHR) device meeting RA3.6.9 is also required in climate zone 16. Note that a 120 V HPWH may be installed for new dwelling units with one bedroom or less.
- One HPWH meeting NEEA Tier 3 or higher specifications. A DWHR device meeting RA3.6.9 is also required in climate zone 16.

Water Heating Systems Serving Multiple Dwelling Units
Reference: Section 170.2(d)2, Section 170.2(d)3

Systems serving multiple dwelling units must be central water heating systems with recirculation distribution systems meeting Section 110.3(c)2&5 (please see Controls for Hot Water Distribution Systems and Systems with Recirculation Loops for details), able to automatically control the pump based on hot water demand and water return temperature. Water heating systems serving buildings with 8 or fewer dwelling units do not require recirculation systems.

There are two water heating system options:

- HPWH with the following:
    - Recirculation loop return connected to a recirculation loop tank
    - If auxiliary heating is needed, the recirculation loop tank heater must be electric
    - Main tank must be set to 135°F
    - Recirculation loop tank temperature must be 10°F lower than that of the main tank; the recirculation loop tank water must be used to maintain the temperature before using recirculation loop tank heater
    - The compressor must shut off when the ambient temperature is 40°F or below.
- A gas or propane central water heater meeting the following:
    - In climate zones 1 – 9, if the input is 1MM Btu/h or greater, then any water heating equipment must have a thermal efficiency of 90% or greater. Multiple units can be used if their input capacity-weighted average of 90% or more. Water heaters of 100k Btu/h or less are not included in this calculation. There is an Exception for systems deriving 25% or more of their annual energy from site-solar or site-recovered energy.
    - Solar water heating

Solar Water Heating

Please refer to Chapter 4.8.4.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Dual Recirculation Loop Design

Please refer to Chapter 4.8.4.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Demand Recirculation Control

Please refer to Chapter 4.8.4.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Pool and Spa Heating Systems

Mandatory Requirements for Pools and Spas

Certification and Labeling Requirements

Reference: Section 110.4(a)

Electric and gas pool heaters for a pool, spa, or a pool and spa combination must be certified by the manufacturer and listed by the California Energy Commission as having:

- For equipment subject to state or federal appliance efficiency regulations, must meet Section 110.1 requirements including a listing in MAEDbS
- An on/off switch mounted on the outside of the heater in a readily accessible location that allows the heater to be shut off without adjusting the thermostat setting
- A permanent, easily readable, and weatherproof plate or card that gives the energy efficiency rating, and instructions for the energy efficient operation of the pool and/or spa heater

Installation Requirements

Reference: Section 110.4(b)

Heating equipment installed to heat pool and/or spa water shall be selected from equipment meeting the standards shown in Table 110.4-A.

If a pool and/or spa does not currently use solar heating collectors for heating 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:

- Leave at least 18 inches of vertical or horizontal pipe between the filter and heater to allow for the future addition of solar heating equipment
- Plumb separate suction and return lines to the pool dedicated to future solar heating
- Install built-up or built-in connections for future piping to solar water heating, (e.g., a built-in connection could be a capped off tee fitting between the filter and heater)

Pool and/or spa heating systems with gas or electric heaters for outdoor use shall be installed with a pool cover. The pool cover must be fitted and installed during the final inspection.

All pool systems must be installed with the following:

- Directional inlets must be provided for all pools that adequately mix the pool water.
- A time switch or similar control mechanism shall be permanently installed for pools to control the operation of the circulation control system, to allow the pump to be set or

programmed to run in the off-peak demand period, and for the minimum time necessary to maintain the water in the condition required by applicable public health standards.

Heating Source Sizing Requirements

Reference: Section 110.4(c)

Pool and/or spa heating systems or equipment must meet one of the following sizing requirements:

- For nonresidential buildings, a solar pool heating system with a solar collector surface area that is equivalent to at least 65 percent of the pool and/or spa surface area;
- A heat pump pool heater as the primary heating system that meets the HPPH manufacturer's sizing specifications, as specified in Reference Joint Appendix JA16.3. The supplementary heater can be of any energy source;
- A heating system that derives at least 60 percent of the annual heating energy from on-site renewable energy or on-site recovered energy.;
- A combination of a solar pool heating system and heat pump pool heater without any additional supplementary heater; or
- A pool heating system determined by the Executive Director to use no more energy that the systems specified in options above.

There are five allowable exceptions to the heating source sizing requirements as listed below:

- Exception 1 - Portable electric spas compliant with California's Appliance Efficiency Regulations (Title 20).
- Exception 2 - Alterations to existing pools and/or spas with existing heating systems or equipment.
- Exception 3 - A pool and/or spa that is heated solely by a solar pool heating system without any backup heater.
- Exception 4 - Heating systems which are used exclusively for permanent spa applications in existing buildings with gas availability.
- Exception 5 - 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.

Solar Pool Heating Systems

Reference: JA16.2

Solar pool heating systems shall be certified and rated by the Solar Rating and Certification Corporation (ICC-SRCC), the International Association of Plumbing and Mechanical Officials, Research and Testing (IAPMO R&T), or by a listing agency that is approved by the Executive Director.

Solar thermal collectors shall be listed and labeled in accordance with Table 110.4-A. The installed system shall meet the following eligibility criteria:

- The system shall be installed according to manufacturer's instructions.

- The system shall be installed in the exact configuration for which it was rated. The system shall have the same collector(s), piping, pump, vacuum relief valve, controls, and other components used to establish the rated condition.

Heat Pump Pool Heater Sizing

Reference: JA16.3

If the heat pump pool heater manufacturer's specifications do not include information on HPPH sizing, follow these steps:

- Determine desired pool temperature in °F.
- Determine average temperature for the coldest month of pool use in °F.
- Determine temperature rise in °F by subtracting the average temperature for the coldest month from the desired pool temperature.
- Calculate the pool volume in gallons.
- Calculate the time needed for the HPPH to achieve the 10 °F degree rise in hours. This shall not exceed 17.5 hours.
- Use the following equation to determine the Btu/h output requirement of the HPPH.

$$QQ_{ccbbff} = \frac{(NN_{dd} \times 8.33 \times \Delta LL)}{RR}$$

Where,

- Q_{out} is the output heating capacity of the HPPH
- V_p is the pool volume in gallons
- 8.33 is the weight of a gallon of water at 62°F in pounds per gallon
- ΔT is the pool temperature rise in °F, and shall not exceed 10°F
- t is the time needed for the HPPH to achieve the 10 °F degree rise in hours and shall not exceed 17.5 hours

SARA for Solar Collectors

Reference: Section 150.1(c)14

The solar access roof area defines how much of the roof area is both capable of supporting a PV and/or solar thermal and has sufficient annual exposure to generate energy.

SARA includes:

- The area of the building's roof space capable of structurally supporting a PV or a solar pool heating system, and
- The area of all roof space on covered parking areas, carports, and any other newly constructed structures on the site that are compatible with supporting a PV and/or solar pool heating system, per Title 24, Part 2, Section 1511.2.

SARA does NOT include:

- Any roof area that has less than 70% annual solar access: Annual solar access is calculated by dividing the total annual solar insolation (sunlight exposure), considering shading obstructions, by the total annual solar insolation if there were no shading obstructions. For steep slope roofs, only shading from permanent obstructions outside the dwelling (such as trees, hills, and adjacent structures) is considered. For low slope roofs, all obstructions, including those part of the building design, are considered.

- Occupied roof areas as specified by CBC Section 503.1.4.
- Roof areas that are otherwise unavailable due to compliance with other state building code requirements or local building code requirements if local building code requirements are confirmed by the CEC Executive Director.

Example 4-44

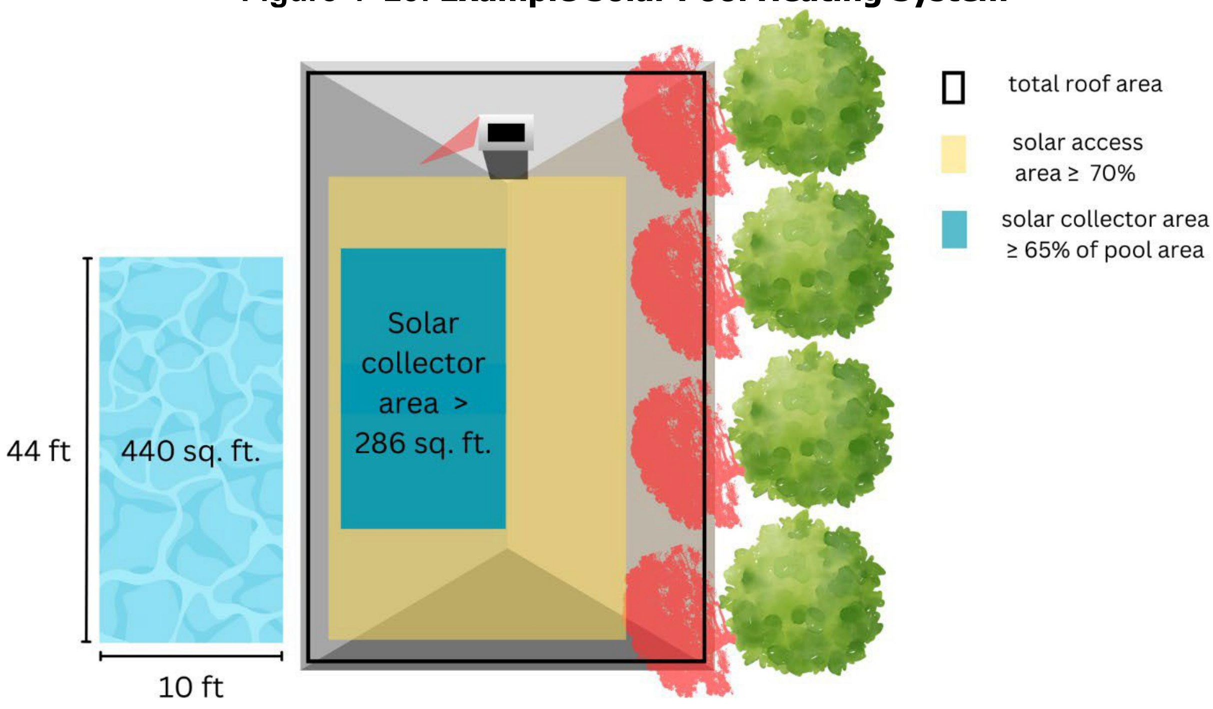
I am designing a commercial swimming pool with a surface area of 440 square feet. If I want to use a gas heater as a backup to solar, what would be the sizing requirements of my solar pool heating system?

Answer:

If you plan to use a gas heater as a backup, the solar pool heating system must have a solar collector surface area that is at least 65% of the pool's surface area. For a pool with a surface area of 440 square feet, the calculation is as follows: $440\ ft^2 \times 0.65 = 286\ ft^2$

You need to install a solar pool heating system with a collector surface area of at least 286 square feet.

Figure 4- 28: Example Solar Pool Heating System



Source: California Statewide CASE Team

Additionally, you will need to determine the SARA for your building to ensure you have sufficient space for the solar collectors. This includes:

- Assessing Planned Obstructions: Identify any trees, structures, or other potential obstructions that could shade the solar collectors and reduce their efficiency. This assessment should cover the current situation as well as future landscaping plans. For steep slope roofs, only shading from permanent obstructions outside the dwelling (such as trees, hills, and adjacent structures) is considered. For low slope roofs, all obstructions, including those part of the building design, are considered.

• Determining Annual Solar Roof Access: Calculate the annual solar access for the roof area where the solar collectors will be installed. This involves considering shading patterns throughout the year to ensure that the collectors receive adequate sunlight.

If the roof area has less than 70% annual solar access due to shading or other obstructions, it may not be suitable for a solar pool heating system as per the regulations.

Approved solar assessment tools can be found at the Energy Commission website at, https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/solar-assessment-tools

Example 4-45

Question:

I don't have sufficient solar access for a solar swimming pool heater, how do I calculate the required size of the HPPH?

Answer:

If you don't have sufficient solar access, Exception 5 applies. Per Title 24, you are not required to size the pool heating system per requirements in 110.4(c) and may choose among all pool heating system options.

Example 4-46

Question:

A gym pool with a gas heater just broke and needs to be replaced. Could the replacement be like the existing gas heater?

Answer:

Yes, the gas heater may be replaced with a similar gas heater that meets the certification requirement of 110.4(a) and equipment requirements of 110.4(b). The sizing and source requirements of 110.4(c) do not apply since alterations to existing pools with existing heating systems qualify for Exception 2 to Section 110.4(c).

Controls for Heat Pump Pool Heaters with Supplementary Heating

Reference: Section 110.4(d)

Heat pump pool heaters with supplementary heaters shall have controls:

- That prevent supplementary heater operation when the heating load can be met by the heat pump pool heater alone; and
- In which the cut-on temperature for compression heating is higher than the cut-on temperature for supplementary heating, and the cut-off temperature for compression heating is higher than the cut-off temperature for supplementary heating.

Pool and Spa Heaters: Pilot Lights Prohibited

Reference: Section 110.5

Pool and spa heaters are not allowed to have pilot lights.

Performance Approach

Please refer to Chapter 4.9 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions and Alterations

Overview

Please refer to Chapter 4.10.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Relocation of Equipment

Please refer to Chapter 4.10.1.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Measures – Additions and Alterations

New mechanical equipment or systems in additions and/or alterations must comply with the mandatory measures as listed below. Additional information on these requirements is provided in earlier sections of this Chapter.

Section 110.1 – Mandatory requirements for Appliances (see Equipment Requirements)

Reference: Section 110.1

The California Appliance Efficiency Regulations apply to small to medium sized heating equipment, cooling equipment and water heaters. These requirements are enforced for all equipment sold in California and therefore apply to all equipment used in additions or alterations.

Mandatory Requirements for Space-Conditioning Equipment (see Equipment Requirements)

Reference: Section 110.2

This section sets minimum efficiency requirements for equipment not covered by Section 110.1. Any equipment used in additions or alterations must meet these efficiency requirements.

Mandatory Requirements for Service Water-Heating Systems and Equipment (see Equipment Requirements)

Reference: Section 110.3

This section sets minimum efficiency and control requirements for water heating equipment. It also sets requirements for recirculating hot water distribution systems. All new equipment installed in additions and/or alterations shall meet the requirements. The recirculation loop requirements of Section 110.3(c)5 apply when water heating equipment and/or plumbing is changed.

Mandatory Requirements for Pool and Spa Heating Systems and Equipment (see Pool and Spa Heating Systems)

Reference: Section 110.4

The pool requirements of Section 110.4 do not apply for maintenance or repairs of existing pool heating or filtration systems.

Natural Gas Central Furnaces, Cooking Equipment, and Pool and Spa Heaters: Pilot Lights Prohibited (see Equipment Requirements)

Reference: Section 110.5

Any new gas appliances installed in additions or alterations shall not have a standing pilot light, unless one of the exceptions in Section 110.5 is satisfied.

Requirements for Ventilation (see Ventilation and Indoor Air Quality Requirements)

Reference: Section 120.1

Systems that are altered or new systems serving an addition shall meet the outside air ventilation and control requirements, as applicable.

When existing systems are extending to serve additions or when occupancy changes in an existing building (such as the conversion of office space to a large conference room), the outside air settings at the existing air handler may need to be modified and, in some cases, new controls may be necessary.

Required Controls for Space-Conditioning Systems (see HVAC System Control Requirements)

Reference: Section 120.2

Section 120.2(a) requires a thermostat for any new zones in additions or new zones created in an alteration.

Section 120.2(b) requires that new thermostats required by Section 120.2(a) meet the minimum requirements.

Section 120.2(c) applies to hotel/motel guest rooms only when the system level controls are replaced; replacement of individual thermostats are considered a repair.

Section 120.2(d) requires that new heat pumps used in either alterations or additions have controls to limit the use of electric resistance heat, per Section 110.2(b). This applies to any new heat pump installed in conjunction with an addition and/or alteration.

Section 120.2(e) requires that new systems in alterations and additions have scheduling and setback controls.

Section 120.2(f) requires that outside air dampers automatically close when the fan is not operating or during unoccupied periods and remain closed during setback heating and cooling. This applies when a new system or air handling unit is replaced in conjunction with an addition or alteration.

Section 120.2(g) requires that areas served by large systems be divided into isolation areas so that heating, cooling and/or the supply of air can be provided to only the isolation areas that need it and other isolation areas can be shut off. This applies to additions larger than 25,000 sq ft and to the replacement of existing systems when the total area served is greater than 25,000 sq ft.

Section 120.2(h) requires that direct digital controls (DDC) that operate at the zone level be programmed to enable non-critical loads to be shed during electricity emergencies. This requirement applies to additions and/or alterations anytime DDC are installed that operate at the zone level.

Section 120.2(i) requires a Fault Detection and Diagnostic System for all newly added air handler units equipped with an economizer and mechanical cooling capacity equal to or greater than 54,000 Btu/hr in accordance with Section 120.2(i)2. through Section 120.2(i)8.

Section 120.2(j) requires DDC in newly constructed buildings additions or alterations for certain applications and qualifications. It also requires certain capabilities for mandated DDC systems.

Section 120.2(k) requires optimum start/stop when DDC is to the zone level.

Requirements for Pipe Insulation (see Pipe and Duct Distribution Systems)

Reference: Section 120.3

The pipe insulation requirements apply to any new piping installed in additions or alterations.

Requirements for Air Distribution System Ducts and Plenums (see Pipe and Duct Distribution Systems)

Reference: Section 120.4

The duct insulation, construction and sealing requirements apply to any new ductwork installed in additions or alterations.

Required Nonresidential Mechanical System Acceptance (See Chapter 14)

Reference: Section 120.5

Acceptance requirements are triggered for systems or equipment installed in additions and alterations the same way they are for new buildings or systems.

Mandatory Requirements for Commercial Boilers (see Commercial Boilers)

Reference: Section 120.9

The requirements apply to any new commercial boilers installed in additions or alterations.

New or Replacement Space-Condition Systems or Components

Reference: Section 140.4

The requirements comply to systems and components other than new or replacement ducts.

Requirements for Additions

Prescriptive Approach

All new additions must comply with the following prescriptive requirements:

- Section 140.4 – Prescriptive Requirements for Space Conditioning Systems, except the condensing boiler system requirements of Section 140.4(k)8.
- Section 140.5 – Prescriptive Requirements for Service Water-Heating Systems, except the requirements of 140.5(c).

For more detailed information about the prescriptive requirements, refer to following sections of this chapter:

- HVAC System Control Requirements
- HVAC Requirements

Performance Approach

The performance approach may also be used to demonstrate compliance for new additions. When using the performance approach for additions Section 141.0(a)2B defines the characteristics of the standard design building.

For more detailed information, see Chapter 12.

Acceptance Tests

Acceptance tests must be conducted on the new equipment or systems when installed in new additions. For more detailed information, see Chapter 14.

Requirements for Alterations

Prescriptive Requirements – New or Replacement Equipment

New space conditioning systems or components other than space conditioning ducts must meet applicable prescriptive requirements of HVAC System Control Requirements and HVAC Requirements (Section 140.4).

Minor equipment maintenance (such as replacement of filters or belts) does not trigger the prescriptive requirements. Equipment replacement (such as the installation of a new air handler or cooling tower) would be subject to the prescriptive requirements. Another example is when an existing VAV system is expanded to serve additional zones, the new VAV boxes are subject to zone controls of HVAC System Control Requirements. Details on prescriptive requirements may be found in other sections of this chapter.

Replacements of electric resistance space heaters for high-rise residential apartments are also not subject to the prescriptive requirements. Replacements of electric heat or electric resistance space heaters are allowed where natural gas is not available.

Alterations to service water heating in nonresidential and hotel/motel buildings must meet all applicable requirements of Section 140.5(a)&(b) with the exception of the solar water heating requirements in Section 170.2(d)3.

For alterations there are special rules for:

- New or Replacement Space Conditioning Systems or Components in Section 141.0(b)2C.
- Altered Duct Systems in Section 141.0(b)2D.
- Altered Space – Conditioning Systems in Section 141.0(b)2E.

Prescriptive Requirements – Air Distribution Duts

Reference: Section 141.0(b)2D

When new or replacement space-conditioning ducts are installed to serve an existing building, the new ducts shall meet the requirements of Pipe and Duct Distribution Systems (e.g., insulation levels, sealing materials and methods, and duct leakage testing).

If the ducts are added to a pre-existing duct system that serves less than 5,000 sq ft and more than 25 percent of the ductwork is outdoors or in unconditioned area, the system must be tested to leak no more than 15 percent. The description of the test method can be found in Section 2.1.4.2 of Reference Nonresidential Appendix NA2. The air distribution acceptance test associated with this can be found in Reference Nonresidential Appendix NA7. This and all acceptance tests are described in Chapter 13 of this manual. If the new ducts are added to a duct system that serves more than 5,000 sq ft or less than 25 percent of the ductwork is outdoors or in unconditioned space, then the new ductwork must meet the duct leakage testing requirements of CMC Section 603.10.1.

If it is not possible to meet the duct sealing requirements of Section 141.0(b)2Dii, all accessible leaks shall be sealed and verified through a visual inspection and smoke test performed by a certified ECC rater utilizing the methods specified in Reference Nonresidential Appendix NA2.1.4.2.2.

Exception: Existing duct systems that are extended, constructed, insulated, or sealed with asbestos.

Once the ducts have been sealed and tested to leak less than the above amounts, an 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 Acceptance Test Technicians (ATT may perform these field verifications only if the Acceptance Test Technician Certification Provider (ATTCP) has been approved to provide this service.

Prescriptive Requirements – Space-Conditioning Systems Alterations

Reference: Section 141.0(b)2C, Section 141.0(b)2D, Section 141.0(b)2E

Similar requirements apply to ducts upon replacement of small (serving less than 5,000 sq ft) constant volume HVAC units or their components (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 sealing requirements are for those systems where over 25 percent of the duct area is outdoors or in unconditioned areas including attic spaces and above insulated ceilings.

One can avoid sealing the ducts by insulating the roof and sealing the attic vents as part of a larger remodel, thereby creating a conditioned space within which the ducts are located, which no longer meets the criteria of Section 140.4(l).

When a space conditioning system is altered by the installation or replacement of space conditioning 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 new or replaced space conditioning equipment, shall be sealed, as confirmed through field verification and diagnostic testing in accordance with procedures for duct sealing of existing duct systems as specified in the Reference Nonresidential Appendix NA1, to one of the requirements of Section 141.0(b)2D. In addition, the system shall include a setback thermostat that meets requirements of Section 110.12(a).

There are three exceptions to this requirement:

- Buildings altered so that the duct system no longer meets the criteria of Section 140.4(l)1, 2, and 3. Ducts would no longer have to be sealed if the roof deck was insulated and attic ventilation openings sealed.
- Duct systems that are documented to have been previously sealed as confirmed through field verification and diagnostic testing in accordance with procedures in Reference Nonresidential Appendix NA2.
- Existing duct systems constructed, insulated, or sealed with asbestos.

For all altered unitary single zone, air conditioners, heat pumps, and furnaces where the existing thermostat does not comply with Section 110.12(a), the existing thermostat must be replaced with one that does comply. All newly installed space-conditioning systems requiring a thermostat shall be equipped with a thermostat that complies with Section 110.12(a). A thermostat compliant with Section 110.12(a) is also known as an occupant controlled smart thermostat, which is capable of responding to demand response signals in the event of grid congestion and shortages during high electrical demand periods.

New or replacement single zone rooftop air conditioner that cools less than 65,000 Btu/hr must follow the rules in Table 141.0-E-1 or meet the performance standards in Section 141.0(b)3.

Performance Approach

Please refer to Chapter 4.10.4.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Acceptance Tests

Please refer to Chapter 4.10.4.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Glossary/Reference

Please refer to Chapter 4.11 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Definitions of Efficiency

Please refer to Chapter 4.11.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Definitions of Spaces and Systems

Please refer to Chapter 4.11.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Types of Air

Please refer to Chapter 4.11.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Air-Delivery Systems

Please refer to Chapter 4.11.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Return Plenums

Please refer to Chapter 4.11.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Zone Reheat, Recool, and Air Mixing

Please refer to Chapter 4.11.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Economizers

Air Economizers

Please refer to Chapter 4.11.7.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Water Economizers

Please refer to Chapter 4.11.7.1.1.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Unusual Sources of Contaminants

Please refer to Chapter 4.11.8 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Demand Controlled Ventilation (DCV)

Please refer to Chapter 4.11.9 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Intermittently Occupied Spaces

Please refer to Chapter 4.11.10 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mechanical Plan Check and Inspection Documents

Please refer to Chapter 4.12 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mechanical Inspection

Please refer to Chapter 4.12.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Acceptance Requirements

Acceptance requirements can effectively improve code compliance and help determine whether mechanical equipment meets operational goals and whether it should be adjusted to increase efficiency and effectiveness.

For more detailed information on acceptance tests, see Chapter 14.

Acceptance Process

Please refer to Chapter 4.12.2.1 the *2022 Nonresidential and Multifamily Compliance Manual*.

Administration

Please refer to Chapter 4.12.2.2 the *2022 Nonresidential and Multifamily Compliance Manual*.

Plan Review

Please refer to Chapter 4.12.2.3 the *2022 Nonresidential and Multifamily Compliance Manual*.

Testing

The construction inspection is the first step in performing the acceptance tests. In general, this inspection should identify that:

- Mechanical equipment and devices are properly located, identified, and calibrated.
- Setpoints and schedules are established.
- Documentation is available to identify settings and programs for each device.

- Select tests to verify acceptable leakage rates for air distribution systems while equipment access is available. Testing is to be performed on the following devices:
    - VAV systems
    - Constant volume systems
    - Package systems
    - Air distribution systems
    - Economizers
    - Demand control ventilation systems
    - Variable frequency drive fan systems
    - Hydronic control systems
    - Hydronic pump isolation controls and devices
    - Supply water reset controls
    - Water loop heat pump control
    - Variable frequency drive pump systems
    - System programming
    - Time clocks

Chapter 14 contains information on how to complete the acceptance documents. Example test procedures are also available in Chapter 14.

Roles and Responsibilities

Please refer to Chapter 4.12.2.5 the *2022 Nonresidential and Multifamily Compliance Manual*.

Contact Changes

Please refer to Chapter 4.12.2.6 the *2022 Nonresidential and Multifamily Compliance Manual*.

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Nonresidential Indoor Lighting

This chapter covers the Energy Code requirements for indoor lighting design, installation, and controls for nonresidential buildings (conditioned and unconditioned). The chapter includes guidance for meeting the Energy Code and also includes installation scenarios with appropriate compliance approaches to meet the Code.

Refer to Chapter 6 for and about nonresidential outdoor lighting requirements. Refer to Chapter 7 for and about sign lighting requirements.

Overview

The Energy Code requires total lighting power is within a specified budget, and lighting controls are installed for efficient lighting operation.

What's New for 2025

The nonresidential lighting section has been revised based on public members' inputs during the 2025 Energy Code development. Other significant changes and improvements to the code requirements are as follows:

- Removal of the table which specifies the multilevel lighting control requirements for light sources which include LED light source and the soon to-be-banned light sources in California.
- Editorial changes as well as clarifications changes to the manual controls (previously "manual area controls") requirements, the shut-off controls requirements, the control interactions requirements, and the PAF requirements.
- A suite of updates to the daylight responsive controls (previously "automatic daylighting controls" in the 2022 Energy Code) requirements including a new lighting wattage threshold for requiring daylight responsive controls and clarifications about controllability of linear luminaires longer than 8 feet (must be controlled in segments of 8 feet or less).
- Removal of Tailored Method as one of the three approaches (others are Complete Building Method and Area Category Method) for meeting the prescriptive requirements of indoor lighting power. New additional lighting power allowances for wall display lighting, floor display lighting, and task lighting are added for a number of lighting applications.

Scope

The nonresidential indoor lighting requirements are contained in §100.0, §110.9, §110.12, §120.8, §130.0, §130.1, §130.4, §140.0, §140.1, §140.3, §140.6, and §141.0 of the Energy Code. Supporting definitions are in §100.1.

- The nonresidential indoor lighting requirements apply to nonresidential buildings and hotel/motel occupancies (including guest rooms). Hotel/motel guest rooms are covered by portions of both the nonresidential indoor lighting requirements and the residential indoor lighting requirements. (See Chapter 6 of the Residential Compliance Manual.)
- The nonresidential indoor lighting requirements are similar for conditioned and unconditioned spaces. Lighting power trade-offs are not allowed between conditioned and unconditioned spaces.

- Qualified historical buildings are regulated by the California Historical Building Code and not by the Energy Code. However, nonhistorical components of such buildings may need to comply with the Energy Code. For more information, see Chapter 1 of the Residential Compliance Manual.

All sections and table references in this chapter refer to sections and tables contained in the Energy Code.

Refer to Chapter 6 of the Residential Compliance Manual for information on lighting requirements for single-family residential buildings. Refer to the Multifamily Compliance Manual for information about requirements of multifamily buildings.

Functional Areas in Nonresidential Buildings That Must Comply with Applicable Residential Requirements

The following functional areas in nonresidential and hotel/motel occupancies are required to comply with the applicable residential lighting requirements in §150.0(k):

- Fire station dwelling accommodations
- Hotel and motel guest rooms

  Note that hotel and motel guest rooms are required to comply with §130.1(c)8, which requires captive card key controls, occupant sensing controls, or automatic controls. In addition, hotel and motel guest rooms are required to meet the controlled receptacle requirements of §130.5(d)4.

  EXCEPTION: One luminaire in a hotel or motel guest room that meets the following criteria is exempt from the control requirement:

    - The luminaire meets the requirement of §150.0(k)1A.
    - The luminaire is switched on separately from the other lighting in the room.
    - The switch for the luminaire is located within 6 feet of the entry door.
- Outdoor lighting attached to a hotel/motel building and separately controlled from inside a guest room.

Note that the above requirements also apply to additions and alterations to functional areas of existing buildings specified above.

Indoor Lighting Power Allotments Overview

Lighting power allotments are the established maximum lighting power that can be installed based on the compliance approach used, the building type, and building area. Lighting power allotments are determined prescriptively - by either the Complete Building Method or the Area Category Method - or determined by the performance approach (method).

Complete Building Method

Applicable when the lighting system of an entire building is designed and permitted at one time and either the entire building is of one occupancy type or where one occupancy type makes up at least 90 percent of the entire building. Also, this method may be used for a tenant space in a multitenant building if at least 90 percent of the tenant space is one building occupancy type. A single lighting power density value governs the entire building or tenant space.

Area Category Method

Applicable for any permit situation including tenant improvements. Lighting power density values are assigned to each of the primary function areas of a building (offices, lobbies, corridors, etc.) as defined in Nonresidential Function Areas of §100.1. This approach allows some flexibility to accommodate special task lighting needs by providing an additional power allowance under some circumstances.

Performance Approach

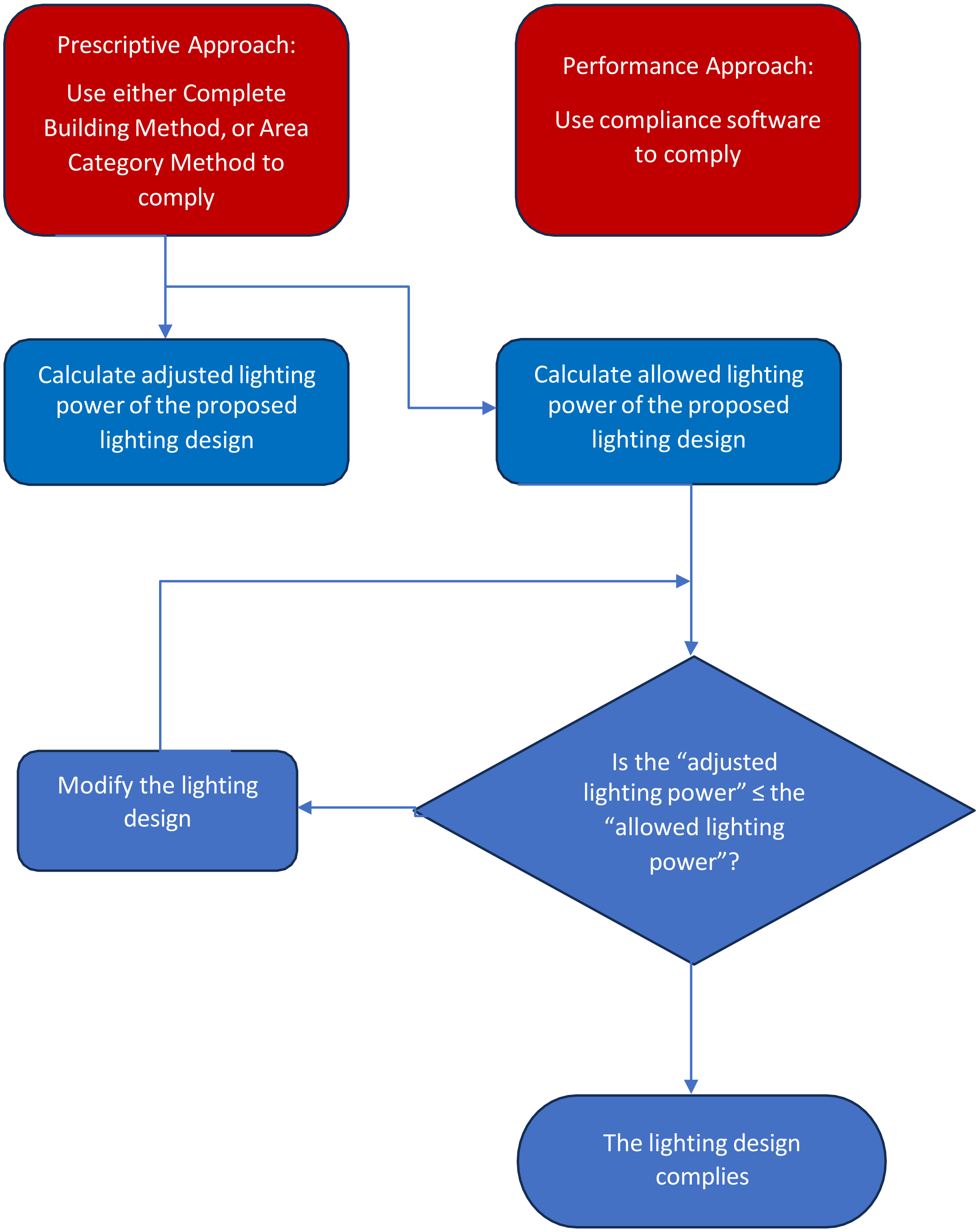
Applicable when the designer uses a California Energy Commission-certified compliance software program to demonstrate the energy consumption of the proposed building (including indoor lighting power) meets the energy budget. The performance approach incorporates one or more of the three previous methods, which establishes the custom energy budget of the building.

The performance approach allows energy allotments to be traded among space conditioning, mechanical ventilation, indoor lighting, service water heating, envelope, and covered process loads. Such trade-offs can be made only when permit applications are sought for those systems involved. For example, under the performance approach, a building with an envelope or mechanical ventilation system that is more efficient than the prescriptive efficiency requirements, may be able to meet the energy budget with more lighting power than allowed under the three prescriptive lighting approaches.

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. Therefore, the performance approach is not applicable to lighting compliance alone. The performance approach may be used only to model the performance of indoor lighting systems that are covered under the building permit application.

Figure 5-1: Indoor Lighting Power Compliance Overview Flowchart shows the process for complying with the nonresidential indoor lighting requirements.

Figure 5-1: Indoor Lighting Power Compliance Overview Flowchart



Source: California Energy Commission

- Choose an Indoor Lighting Power Compliance Approach (Refer to the Top Part of Figure 5-1: Indoor Lighting Power Compliance Overview Flowchart):

First, select either the prescriptive or performance approach for complying with the nonresidential indoor lighting power requirements of the Energy Code.

For the performance approach, lighting power calculations can be performed using an approved software program. Refer to the compliance software documentation for details.

For the prescriptive approach, choose from among the Complete Building Method or the Area Category Method.

Calculate the "allowed" lighting power using the chosen method. Allowed lighting power is the maximum lighting wattage that may be installed for the project (using lighting power values from Table 140.6-B and C).

Next, calculate the "adjusted" lighting power. Adjusted lighting power is designed lighting power *minus* lighting control credits *minus* lighting power reduction.

- Evaluate the Calculations — Allowed Lighting Power vs. Adjusted Lighting Power:

If the adjusted lighting power is less than or equal to the allowed lighting power, the proposed lighting complies with the Energy Code.

If the adjusted lighting power is greater than the allowed lighting power, the proposed lighting does not comply with the Energy Code. To comply, the proposed lighting power must be reduced by redesigning the lighting system, or, if using the performance approach, additional lighting credits may be acquired through improved efficiency in other systems.

Compliance Process – Forms, Plan Check, Inspection, Installation, and Acceptance Tests

Please refer to Chapter 5.1.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

General Requirements

Some requirements in the Energy Code are classified as "mandatory requirements" because they are required regardless of the compliance approach used. All projects must comply with all mandatory requirements.

It is the responsibility of the designer to design a lighting system and specify products that meet these requirements. It is the responsibility of the installer to install the lighting and controls specified on the plans. It is the responsibility of code enforcement officials to verify that the mandatory requirements are included on the plans and installed in the field.

The mandatory requirements for nonresidential indoor lighting include the following:

- Certain functional areas in nonresidential buildings must comply with the residential lighting requirements in §130.0(b).
- Manufactured lighting equipment, products, and devices must be appropriately certified or meet functionality requirements in §110.0(b), §110.1, and §110.9(a).
- Requirements for how luminaires shall be classified (according to technology) and how luminaire power shall be determined in §130.0(c).
- Required indoor lighting controls in §130.1.
- Lighting control acceptance testing in §130.4(a).
- Lighting control certificates of installation in §130.4(b).

The Energy Code also includes mandatory requirements for electrical power distribution systems. See Chapter 8 for more information.

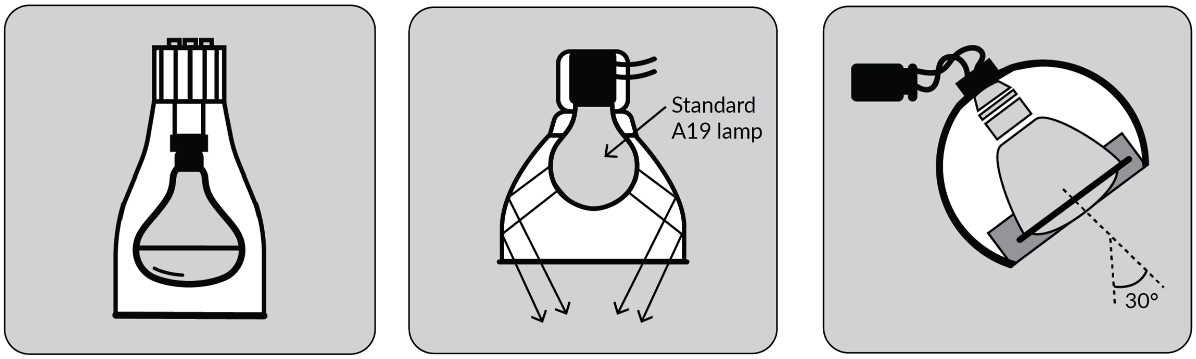
Luminaire Classification and Lighting Terms

Please refer to Chapter 5.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Luminaires with Line-Voltage Lamp Holders

The wattage of luminaires with line-voltage lamp holders not served by drivers, ballasts, or transformers shall be the maximum-rated wattage of the luminaire as labeled in accordance with Section 130.0(c)1.

Figure 5- 2: Examples of Luminaires With Line-Voltage Lamp Holders



Source: Energy Solutions

Luminaires with Ballasts

Please refer to Chapter 5.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Inseparable SSL Luminaires and SSL Luminaires with Remotely Mounted Drivers

The wattage of inseparable SSL luminaires and SSL luminaires with remote ballasts shall be the maximum-rated input wattage of the SSL luminaire.

Inseparable SSL luminaires are luminaires manufactured with solid-state lighting components that are not readily removed or replaced from the luminaires by the end users.

SSL luminaires shall be tested as specified in Section 130.0(c)4 in accordance with UL 1598, 2108, or 8750, or IES LM-79.

Figure 5-3: Examples of SSL Luminaires: Recessed Downlight Luminaires

Source: Lutron Electronics Co., Inc.

LED Tape Lighting and LED Linear Lighting

Please refer to Chapter 5.3.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Modular Lighting Systems

Please refer to Chapter 5.3.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Other Lighting Equipment

Please refer to Chapter 5.3.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Lighting Terms

The following is a selection of lighting terms defined in §100.1 and included here to help readers understand the requirements.

General Lighting

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.)

Decorative, Display, Task, and Special Effects Lighting

Section 100.1 also defines decorative, display, task, and special effects lighting as follows:

- *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.
- *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.
- *Task lighting* is lighting directed to a specific surface or area providing illumination for visual tasks. Task lighting is not general lighting.
- *Special effects lighting* is different from decorative lighting. Special effects lighting is lighting installed to give off luminance instead of providing illuminance, which does not serve as general, task, or display lighting.

The Area Category Method (Table 140.6-C) provides additional lighting power allowances for lighting that is not considered general lighting; however, to claim these allowances, the non-general lighting systems must be separately switched.

For layered lighting designs with multiple luminaire types, compliance documentation will require allocating some or all non-general lighting power to the additional lighting power allowances and the rest of the lighting wattage to the general lighting power allowance. Only the general lighting power allowance is able to be shared across different spaces.

When there is only one lighting system type in a space, such as is the case when a monolithic design approach is taken, 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.

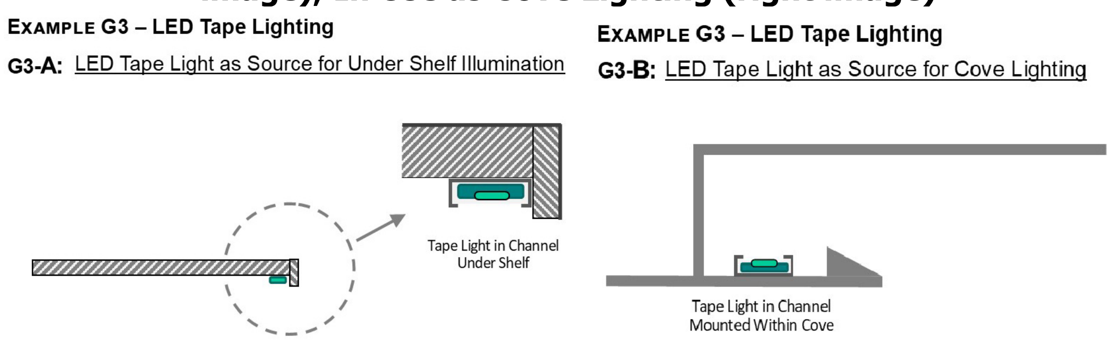
Example 5-1: LED Tape Lighting

LED tape lighting may be classified as Decorative Lighting, Task Lighting, or General Lighting, based on how it is used. Figure 5-4: Examples of LED Tape Lighting: In Use as Undershelf Lighting (left image); In Use as Cove Lighting (right image) shows two applications of LED tape lighting.

The image G3-A on the left shows LED tape lighting that is installed in a channel mounted to the underside of a shelf or cabinet or installed directly with adhesive material. This use would be classified as display or task lighting. Such applications are not considered General Lighting.

The image G3-B on the right shows an architectural cove with tape lighting installed in a channel mounted within the cove or installed directly with adhesive material. This use may be classified as Decorative or Display Lighting or considered General Lighting, based on whether the illumination emanating from the cove is the only source of uniform lighting in the space.

Figure 5-4: Examples of LED Tape Lighting: In Use as Undershelf Lighting (left image); In Use as Cove Lighting (right image)



Source: Bernie Bauer

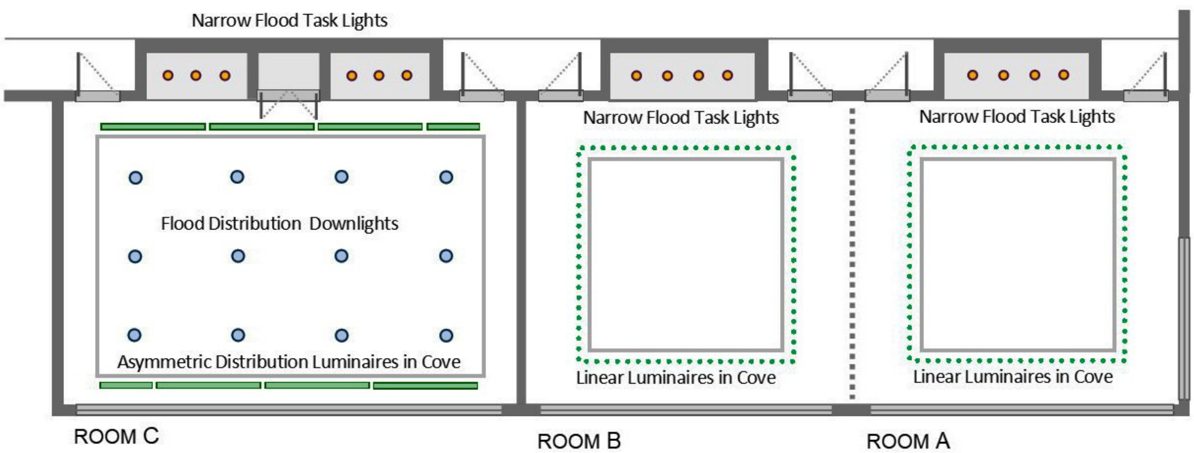
Example 5-2: Cove Lighting

Room A & Room B have two lighting systems: The first system consists of linear luminaires mounted in a cove to provide up-lighting bouncing off the ceiling and providing general illumination. The other system is a series of downlights providing task illumination over an alcove in the room. Cove lighting may be classified as decorative or display lighting when there are other luminaires providing general illumination. However, the cove lighting in Room A and Room B of this example also provides general illumination. Therefore, the cove lighting luminaire power is applied to the allowed general lighting LPD shown in Table 140.6-C Area Category Method instead of as a decorative or display allowance from Table 140.6-C. The lighting power of the downlights providing task illumination are assigned to Additional Lighting Power in Table 140.6-C, provided they are on a separate circuit. If they are on the same circuit as the cove lights, they must also be included in the base lighting allowance.

Room C has three lighting systems:

- Asymmetric distribution luminaires mounted on two sides of the cove to provide up-lighting bouncing off the ceiling for visual enhancement.
- A grid of flood downlights designed to provide general illumination.
- A series of downlights providing task illumination over two alcoves in the room. Cove lighting in this scenario may be classified as decorative or display lighting and can use the decorative/display allowances shown in Table 140.6-C, provided one is available for the space type in which the cove is located, and the cove is separately circuited from the downlights. The flood downlights are designed to provide general/ambient illumination; therefore, the general lighting LPD allowances in Table 140.6-C or 140.6-D apply. As with the cove lights, the downlights providing task illumination can use the appropriate additional allowances in Table 140.6-C or 140.6-D, provided one is available and they are separately circuited.

Figure 5-5: Examples of Cove Lighting: Asymmetric Distribution Luminaires in Cove (Room C); Linear Luminaires in Cove (Rooms A and B)



Source: Bernie Bauer

Mandatory Lighting Controls

Reference: Section 130.1

This section contains information about lighting controls that must be installed regardless of the method used to comply with the lighting power requirements**.**

All lighting controls and equipment must comply with the applicable requirements in §110.9, 130.1, and 130.2 and must be installed in accordance with the manufacturer's instructions (§130.0(d)).

Mandatory nonresidential indoor lighting controls include the following:

- Manual controls, allowing on and off control manually for each area separately.
- Multilevel controls, allowing the ability to use all, some, or none of the light in an area.
- Shut-off controls, which, automatically shut off or reduce light output when a space is vacant.
- Daylight responsive controls, which separately control general lighting in the daylit area based on the amount of daylight in the space.

- Demand-responsive lighting controls, which are capable of receiving and automatically responding to a demand response signal.

Manual Controls

Reference: Section 130.1(a); Section 10-103(a)2

Each building space shall be provided with lighting controls that allow lighting in that space to be manually turned on and off. Manual controls allow building occupants to control the light while they are in the space.

Manual Controls: The manual controls shall be readily accessible and located in the same space or be located so that the controlled lighting or the status of the controlled lighting can be seen when operating the controls.

EXCEPTION to the readily accessible requirement: 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.

EXCEPTION to the same-space requirement: Healthcare facility restrooms and bathing rooms intended for a single occupant can have lighting controls located outside the enclosed area but directly adjacent to the door.

Separate Controls for Lighting Types: In addition, provide separate control for each type of lighting (including general lighting, floor display lighting, wall display lighting, window display lighting, case display lighting, decorative lighting, and special effects lighting) such that each can be turned on and off without turning on or off other types of lighting or other equipment.

Note: 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.

Egress Lighting: For egress lighting required by the California Building Code, up to 0.1 W/sq. ft. of indoor lighting may be continuously illuminated during occupancy. Egress lighting that complies with this wattage limitation is not required to comply with the manual control requirements if:

- The space designated for means of egress is shown on the building plans and specifications submitted to the local enforcement agency under Section 10-103(a)2 of Part 1 (California Code of Regulations, Title 24); and
- The egress lighting controls are not controllable by unauthorized personnel during a normal power failure.

The following are some examples of spaces that are deemed to be appropriate to locate the manual controls outside of the controlled areas. Still, the manual control is preferred to be located so that a person using the control can see the lights or area controlled by that control or have a visual signal or display showing the current state of the controlled lighting.

- Malls and atria, main entry lobbies, auditorium areas, dining areas, retail merchandise sales areas, wholesale showroom areas, commercial and industrial storage areas, general commercial and industrial work areas, convention centers, arenas, psychiatric and secure areas in healthcare facilities, and other areas where placement of a manual control poses no health and safety hazard.

Multilevel Lighting Controls

Reference: Section 130.1(b)

Multilevel lighting controls allow the lighting intensity to be adjusted in order to accommodate to the activities in the space.

This requirement applies to general lighting in enclosed spaces 100 sq. ft. or larger with a connected general lighting load greater than 0.5 W/sq. ft. General lighting does not include task, display, or decorative lighting.

The multilevel control must enable continuous dimming from 100 percent to 10 percent or lower of lighting power.

EXCEPTION: The following applications are not required to comply with the multilevel lighting control requirements:

- An indoor space that has only one luminaire.
- Restrooms.
- Healthcare facilities.
- General lighting with light source of HID and induction that have a minimum of one control step between 30 and 70 percent of full rated power.

Shut-Off Controls

Reference: Section 130.1(c)

All installed indoor lighting 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. For example, an office building is typically unoccupied at night and on weekends; automatic shutoff controls ensure that lighting is off during these periods.

In addition to lighting controls installed to comply with §130.1(a) (manual on and off controls located in each area) and §130.1(b) (multilevel lighting controls), all installed indoor lighting shall be equipped with shut off controls that meet the following requirements (§130.1(c)1):

- One or more of the following automatic shut off controls:
    - Occupant sensing control set to no more than a 20-minute time delay; or
    - Automatic time-switch control; or
    - Other control capable of automatically shutting off all lighting when the space is typically unoccupied.
- Separate controls for lighting on each floor, other than lighting in stairwells; and
- Separate control zones for a space enclosed by ceiling-height partitions not exceeding 5,000 square feet. Note that spaces larger than 5,000 square feet will have more than one separately controlled zone (where each zone does not exceed 5,000 square feet).

EXCEPTION: The area controlled may not exceed 20,000 square feet in the following function areas: malls, auditoriums, single-tenant retail, industrial, convention centers, and arenas

The following applications are exempt from the shut off control requirements of §130.1(c)1:

- An area that is in 24-hour use every day of the year.
- Lighting complying with the occupant sensing control requirements of §130.1(c)5.
    - This exception applies to those areas where occupant sensing controls are required to shut off all lighting. These areas include offices 250 sq. ft. or smaller, multipurpose rooms of less than 1,000 sq. ft., classrooms, conference rooms, or restrooms.
- Lighting complying with the occupant sensing control requirements of §130.1(c)6E.
- Lighting complying with the occupant sensing control requirements of §130.1(c)6C:
    - This exception applies to lighting in stairwells and common area corridors that provide access to guestrooms of hotel/motels and complying with Section 130.1(c)6C.
- Electrical equipment rooms covered by Article 110.26(D) of the California Electrical Code.
- Lighting designated as emergency lighting, connected to emergency power source or batter supply, and functions in emergency mode only when normal power is absent.

The following applications are exempt from shut-off controls identified in Section 130.1(c):

- Healthcare facilities are not required to meet the shut off control requirements of §130.1(c).
- Egress Lighting: Lighting up to 0.1 watts per sq. ft. may be continuously illuminated for egress illumination and is not required to meet the shut off control requirements of §130.1(c). Lighting providing "egress illumination," as used in the California Building Code, shall provide no less light than required by California Building Code Section 1008 while in the partial-off mode.

Use of Countdown Timer Switches

Countdown timer switches may be used to comply with the automatic shut off control requirements in §130.1(c)1 only in enclosures or rooms smaller than 70 sq. ft. and server aisles in server rooms.

The maximum timer setting shall be 10 minutes for enclosures or rooms and 30 minutes for server aisles.

Automatic Time-Switch Controls with Manual Override

Automatic time-switch controls shall include a manual override control that allows the lighting to remain on for no more than two hours when an override is initiated.

EXCEPTION: In the following functional areas, the override time may exceed two hours if a captive-key override is used:

- Malls, Auditoriums, Single-tenant retail, Industrial, Laboratories, and Arenas.

EXCEPTION: Areas where occupant sensing controls are installed.

Automatic Time-Switch Control Holiday Shut Off Feature

An automatic holiday shut off feature shall be incorporated with the automatic time-switch control that turns off all loads for at least 24 hours and then resumes the normally scheduled operation.

EXCEPTION: The following are not required to incorporate the automatic holiday shut-off features:

- Retail stores, associated malls, restaurants, grocery stores, churches, and theaters.

EXCEPTION: Areas where occupant sensing controls are installed.

Areas Where Occupant Sensing Controls are Required to Shut Off All Lighting After Occupancy

Reference: Section 130.1(c)5

Lighting in the following areas 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 addition, controls shall be provided that allow the lights to be manually shut off in accordance with §130.1(a) regardless of the sensor status:

- Offices 250 sq. ft. or smaller
- Multipurpose rooms smaller than 1,000 sq. ft.
- Classrooms
- Conference rooms
- Restrooms

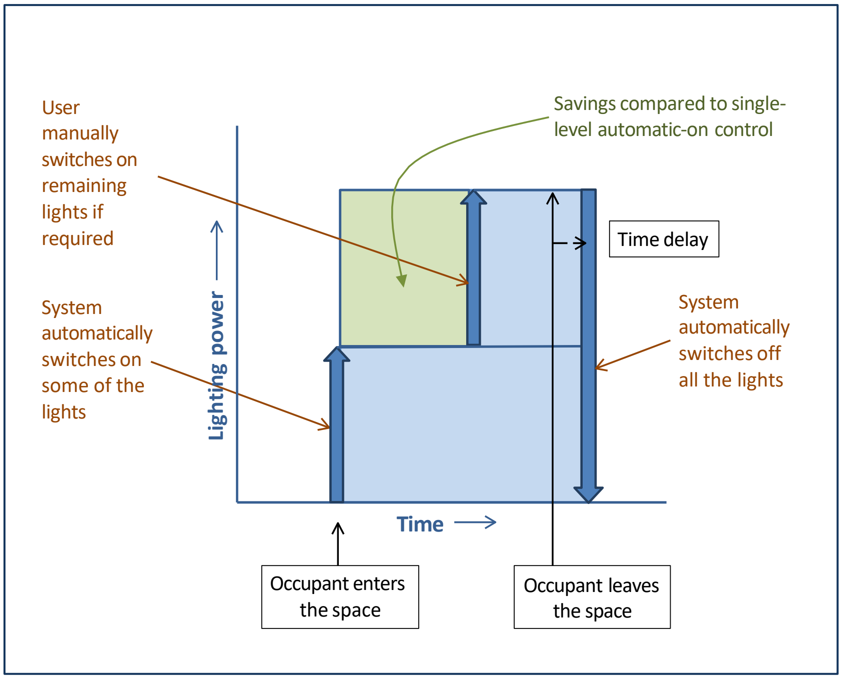
In areas required by §130.1(b) to have multilevel lighting controls, the occupant sensing controls shall function as one of the following:

- A partial-on occupant-sensing control capable of automatically activating between 50 and 70 percent of controlled lighting power (requires lights to be turned ON manually to 100 percent) and automatically turns lights off when the space is unoccupied
- A vacancy-sensing control that automatically turns lights off after an area is vacated and requires lights to be turned on manually

For areas not required by §130.1(b) to have multilevel lighting controls, occupant sensing controls may function as one of the following:

- An automatic full-on occupant-sensing control , or
- A partial-on occupant-sensing control, or
- A vacancy-sensing control, where all lighting responds to a manual on input only.

Figure 5-6: Functional Diagram for Partial-ON Occupant Sensor



Source: California Energy Commission

Areas Where Full or Partial-Off Occupant Sensing Controls are Required in Addition to Complying With §130.1(c)1

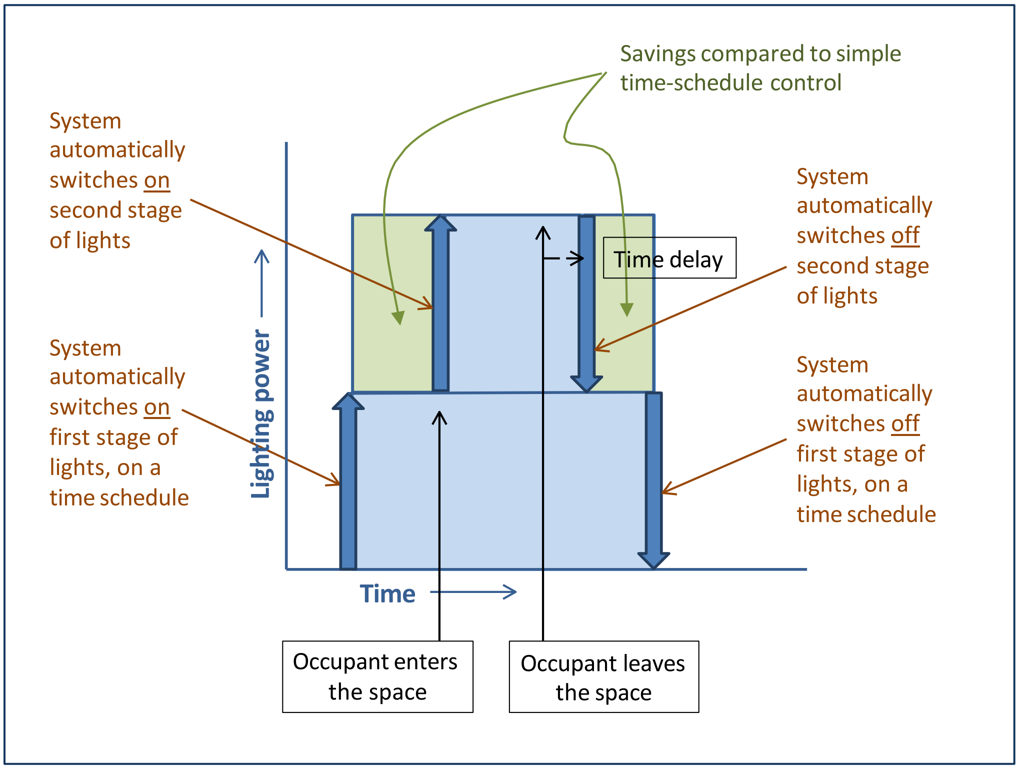
Reference: Section 130.1(c)6

In addition to the basic shut off requirements in §130.1(c)1, §130.1(c)6 requires full or partial off occupant sensing controls to turn off or reduce lighting when an area is unoccupied.

In warehouse aisle ways and warehouse open areas, library book stack aisles, stairwells, and corridors, lighting power must reduce by at least 50 percent when the areas are unoccupied. The decision to reduce or turn lighting off may be made by the designer.

Lighting in these spaces must also comply with §130.1(c)1, which requires lighting to be capable of shutting off when the building is unoccupied. If a partial off occupancy sensor is used to reduce lighting when a space is unoccupied, it can be paired with an automatic time switch to shut lighting off when the building is typically unoccupied.

Figure 5-7: Functional Diagram for Partial Off Occupant Sensor



Source: California Energy Commission

- In warehouse aisle and warehouse open areas, lighting shall be controlled with occupant sensing controls that automatically reduce lighting power by at least 50 percent when the areas are unoccupied. The occupant sensing controls must have independent zoning for each aisle, and the aisle zones must not extend beyond the aisle into the open area of the warehouse.

  EXCEPTION: The following conditions exempt the lighting system from this requirement, but it must meet the additional listed requirements:

  - When metal halide lighting or high-pressure sodium lighting is installed in warehouses, occupant sensing controls shall reduce lighting power by at least 40 percent (instead of the 50 percent required above). This exception is due to limitations of dimming or bilevel ballast technology for high-intensity discharge (HID) light sources.

- In the following library book stack aisles, lighting shall be controlled with occupant sensing controls that automatically reduce lighting power by at least 50 percent when the areas are unoccupied:

  - Library book stack aisles 10 feet or longer that are accessible from only one end
  - Library book stack aisles 20 feet or longer that are accessible from both ends

  The occupant sensing controls shall independently control lighting in each aisle way and shall not control lighting beyond the aisle way being controlled by the sensor.

- 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 turning the lighting fully on automatically only in the separately controlled space and shall be automatically activated from all designed paths of egress.

- In office spaces greater than 250 sq. ft., general lighting shall be controlled by occupant sensing controls that meet all of the following requirements.

  These requirements apply exclusively to luminaires providing general lighting. Luminaires not meant to provide general lighting can either be controlled following the same occupant sensing controls requirements as general lighting as specified in §130.1(c)1 using time-switch controls or separate occupant sensing controls.

  - The occupant sensing controls shall be configured so that lighting is controlled separately in control zones not greater than 600 sq. ft.
  - In 20 minutes or less after the control zone is unoccupied, the occupant 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).
  - In 20 minutes or less after the entire office space is unoccupied, the occupant sensing controls shall automatically turn off lighting in all control zones in the space.
  - 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 the mandatory occupant sensing controls for offices greater than 250 sq. ft.: Under-shelf or furniture-mounted task lighting that is already controlled by a local switch and either a time clock or an occupancy sensor does not need to be included in the control zones of the occupant sensing controls.

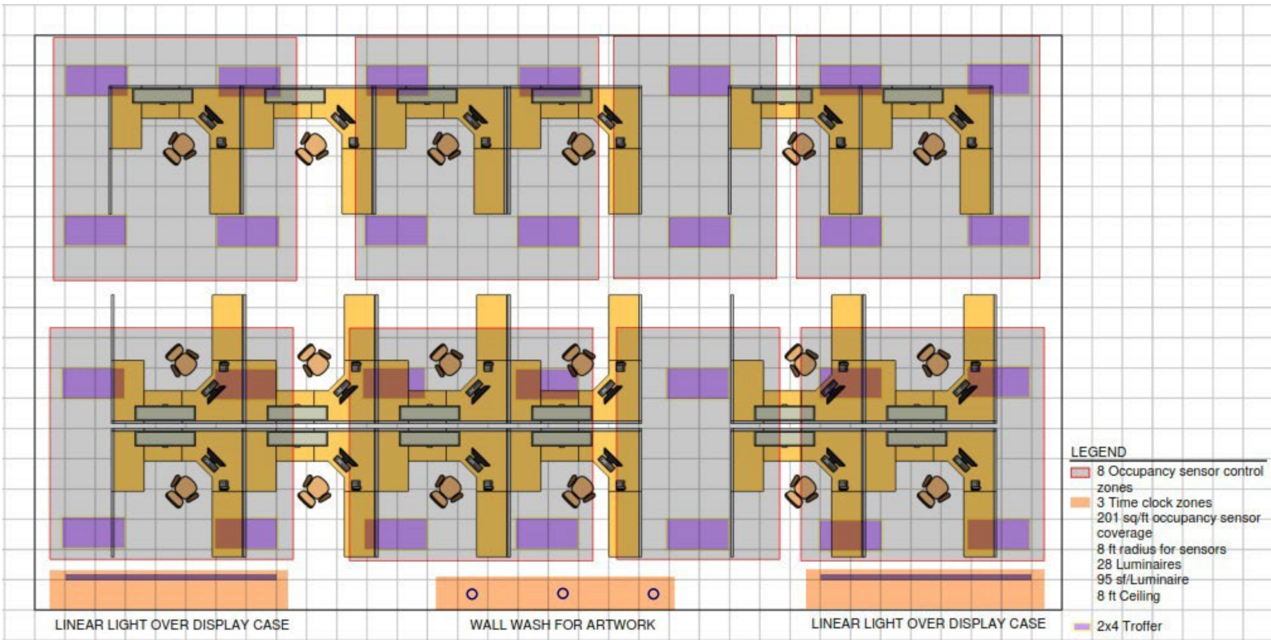
Example 5-3: An Office with Luminaires Serving Different Lighting Purposes

An office of 2,584 square feet has three types of luminaires, as shown in the figure below:

- Overhead luminaires providing general lighting to the cubicles (the 28 purple rectangles).
- Linear lights over display cases near the wall highlighting the objects in the cases (bottom left and right).
- Wall wash lighting along the wall highlighting artwork (bottom center).

Only the overhead luminaires providing general lighting are subject to the occupant sensing control requirements in §130.1(c)6D. Different approaches and options to meet the requirements are discussed in the next example. The linear display lighting and wall wash are grouped together and controlled by a time clock to comply with the shut off requirements in §130.1(c)1.

Figure 5-8: (for Example 5-3) An Office Plan With Occupant Sensing Control Zone Layout



Source: Energy Solutions

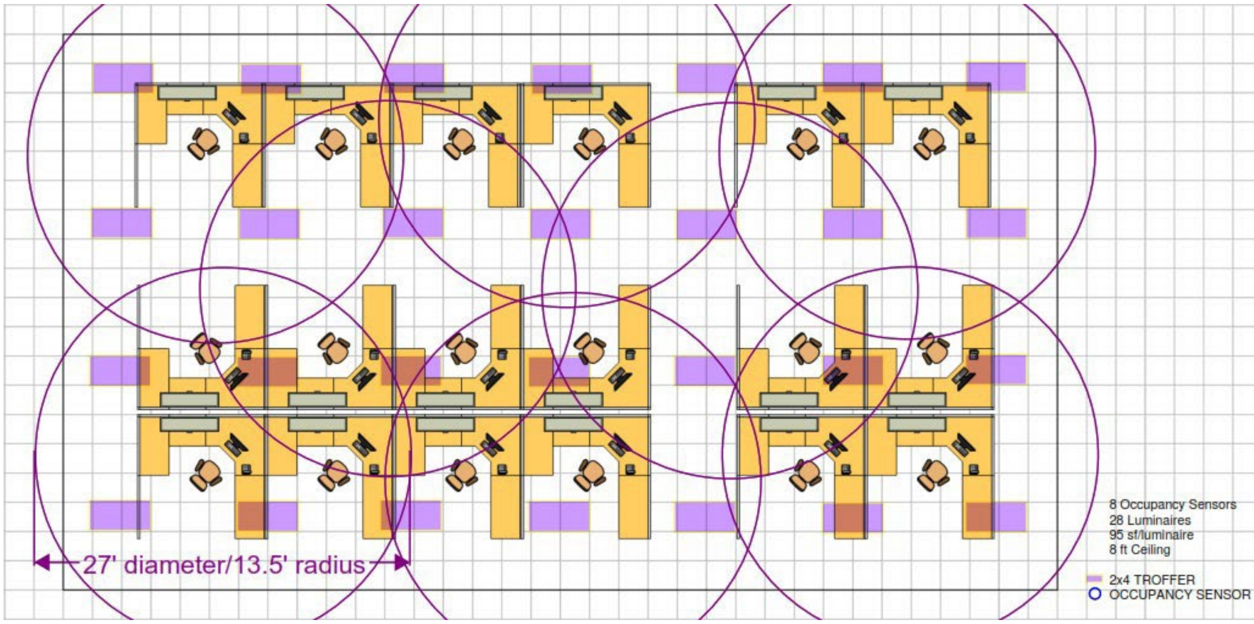
Example 5-4: Occupant Sensing Control Zones for Office Spaces Greater Than 250 Square Feet

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.

The figure below provides an example of the same 2,584 square foot office as in the previous example 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 §140.6(a)2I for occupant sensing controls in offices larger than 250 square feet. Refer to Calculation of Adjusted Indoor Lighting Power for more information on the PAF.

Figure 5-9: (for Example 5-4) An Office Plan With Occupant Sensing Control Zone Layout



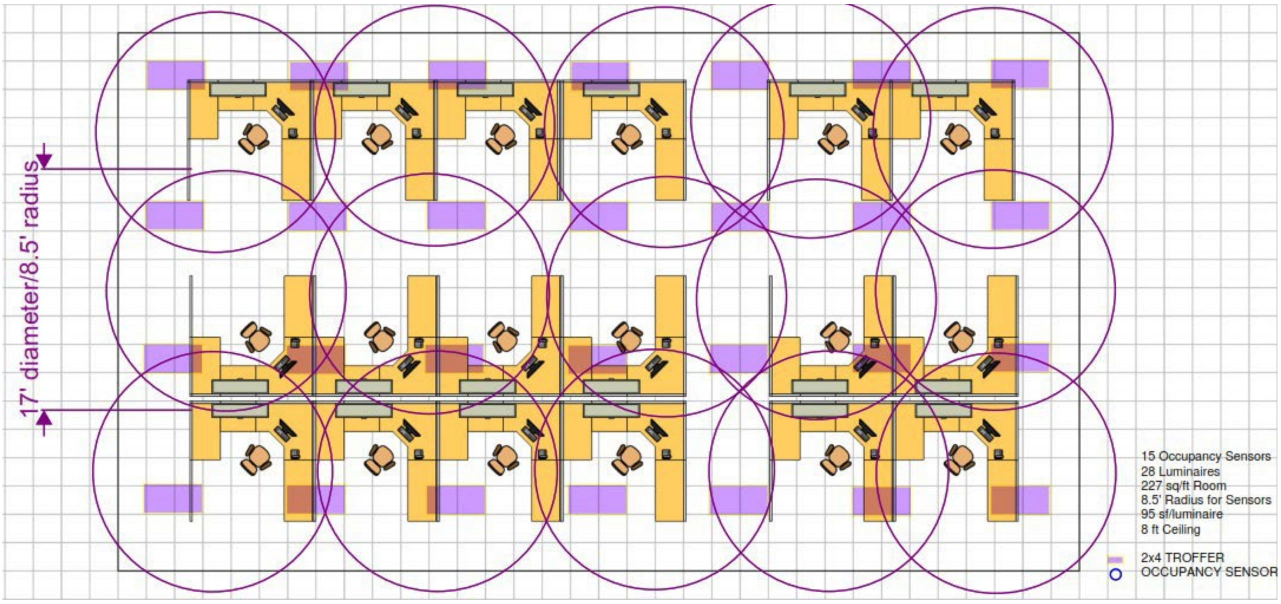
Source: Energy Solutions

Example 5-5: Occupant Sensing Control Zone in a Large Office Using Power Adjustment Factor

The figure 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 140.6-A. Refer to §140.6(a)2I and Section 5.6.2 of this compliance manual for detailed requirements on using the PAF for occupant sensing controls in offices larger than 250 square feet.

Note: 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 the figure below had a coverage area greater than 250 sq. ft., the design would not qualify to use the PAF.

Figure 5-10: (for Example 5-5) An Office Plan With Occupant Sensing Control Zone Layout



Source: Energy Solutions

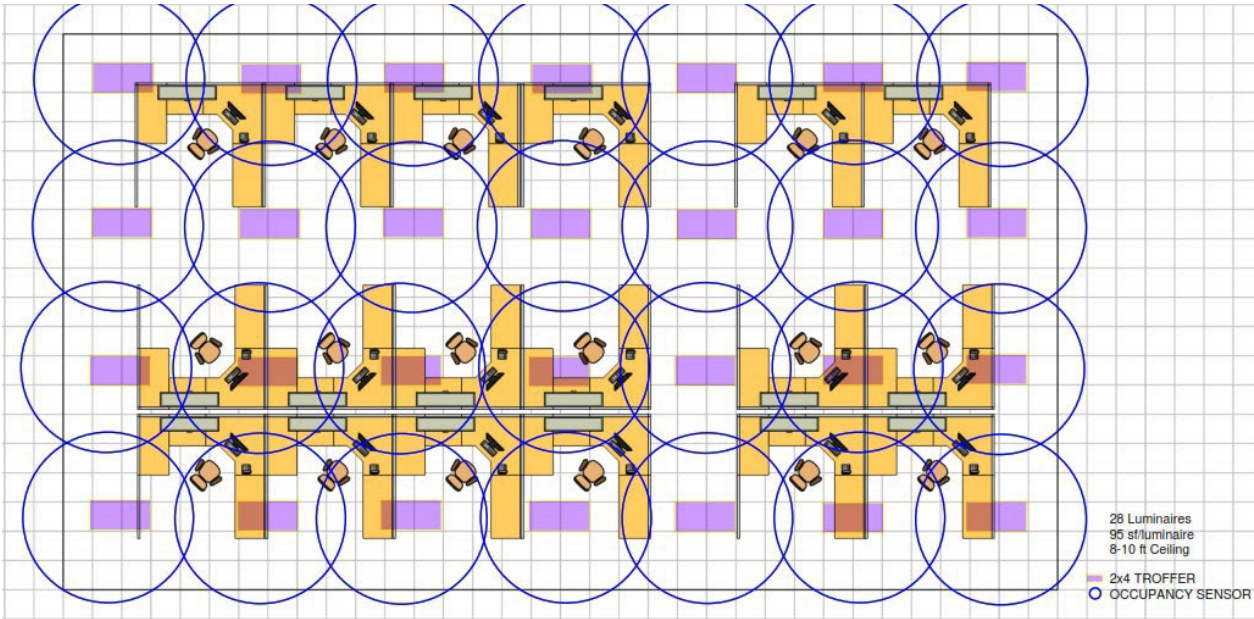
Example 5-6: Occupant Sensing Control Zones for Luminaires with Integral Occupant Sensors

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 §140.6(a)2I for occupant sensing controls in offices larger than 250 square feet. Refer to Calculation of Adjusted Indoor Lighting Power for more about using the PAF.

Note: 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.

The figure 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 140.6-A).

Figure 5-11: (for Example 5-6) An Office Plan With Occupant Sensing Control Zone Layout

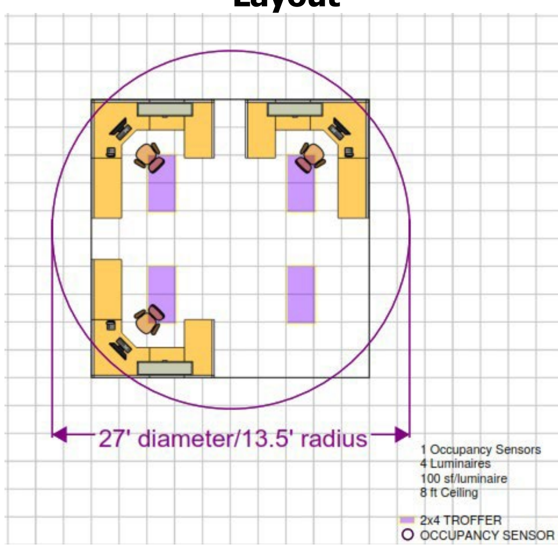


Source: Energy Solutions

Example 5-7: 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. The figure 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 5-12: (for Example 5-7) An Office Plan With Occupant Sensing Control Zone Layout



Source: Energy Solutions

Notes About Occupant Sensing Ventilation Controls And Occupant Sensing Lighting Controls

Note 1: Occupant sensing ventilation controls for offices greater than 250 sq. ft. are required because this space type meets both criteria. Because of this, occupant sensing zone controls for the space-conditioning system are also required. Refer to §120.1(d)5 and §120.2(e)3 in the Energy Code as well as Chapter 4 of this manual to ensure occupant sensor ventilation controls and occupant sensing zone controls are properly implemented on the mechanical systems. Corridors are another space type covered by §130.1(c)6, where ventilation air is allowed to go to zero during occupied standby mode, and thus are required to meet occupant sensing ventilation control requirements.

Note 2: This occupant sensing controls requirement in §130.1(c)6D does not negate other lighting controls provisions in §130.1. For example, for office spaces greater than 250 sq. ft. where daylight Responsive controls are also required per §130.1(d), lighting in the occupied occupant sensing control zones shall be dimmed in response to the available daylight. Refer to Lighting Control Interactions — Considerations for Spaces With Daylight Responsive Controls and Multilevel Lighting Controls of this manual to ensure the proper interactions among the required lighting controls.

Areas Where Partial-Off Occupant Sensing Controls Are Required Instead of Complying With §130.1(c)1

Reference: Section 130.1(c)6E

In parking garages and parking areas, and in loading and unloading areas, lighting is required to have partial off occupant sensing controls instead of meeting the shut off requirements of §130.1(c)1. Lighting in these spaces may operate full time at the minimum setback level and is not required to be shut off after hours. The decision to turn the lights off fully may be made by the designer.

The general lighting shall meet the following requirements:

- Be controlled by occupant sensing controls having at least one control step between 20 percent and 50 percent of design lighting power.
- No more than 500 watts of rated lighting power shall be controlled together as a single zone.
- Occupant sensing controls shall be capable of automatically turning the lighting fully on only in each separately controlled space.
- The occupant sensing controls shall be automatically activated from all designed paths of egress.

For these spaces, 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.

Reference: Section 130.1(c)6C

Similarly, lighting in stairwells and common area corridors that provide access to guestrooms of hotel/motels is required to have partial off occupant sensing controls instead of meeting of Section 130.1(c)1.

Daylight Responsive Controls

Reference: Section 130.1(d)

Daylighting (aka daylight harvesting) can be used as an effective strategy to reduce electric lighting energy use by reducing electric lighting power in response to available daylight. Section 130.1(d) addresses mandatory requirements of daylight responsive controls for adjustments of the electric lighting in response to available daylight.

Daylight Responsive controls are required in all daylit zones (primary and secondary sidelit daylit zones; skylit daylit zones) to automatically reduce general lighting when sufficient daylight is available. Read further on applicability and exceptions.

Daylit Zones and Controlling Lighting in Daylit Zones

The terms of the three types of daylit zones:

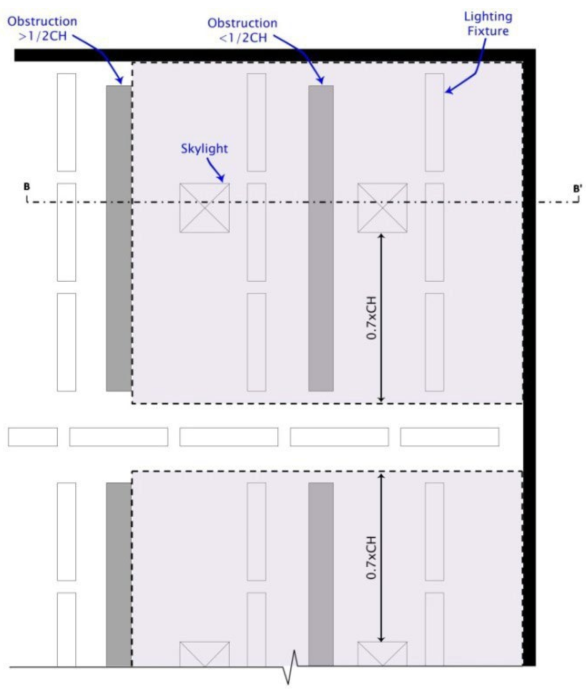
Skylit Daylit Zone is the rough area in plan view under each skylight, plus 0.7 times the average ceiling height in each direction from the edge of the rough opening of the skylight, minus any area on a plan beyond a permanent obstruction that is taller than one-half the distance from the floor to the 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.

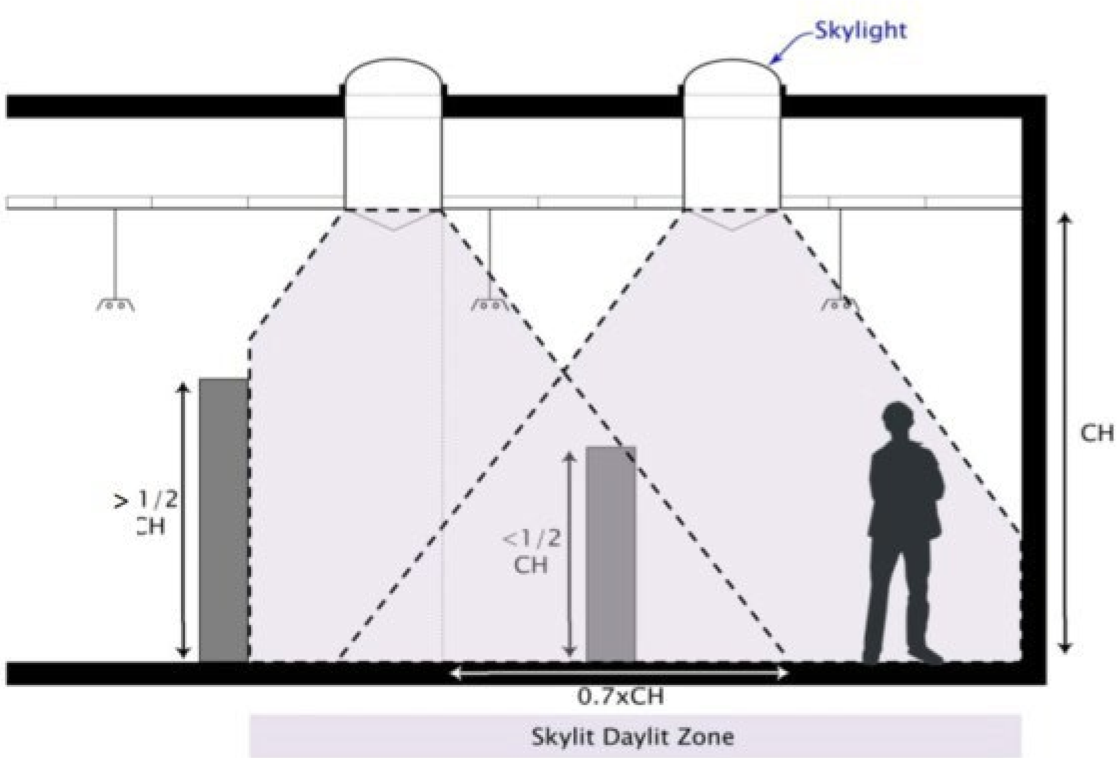
For determining the skylit daylit zone, the geometric shape of the skylit daylit zone shall be identical to the plan view geometric shape of the rough opening of the skylight. For example, the skylit daylit zone for a rectangular skylight must be rectangular; for a circular skylight, the skylit daylit zone must be circular.

Figure 5-13: Example of Skylit Daylit Zone Layout in Overhead View



Source: California Energy Commission

Figure 5-14: Example of Skylit Daylit Zone Layout in Side View

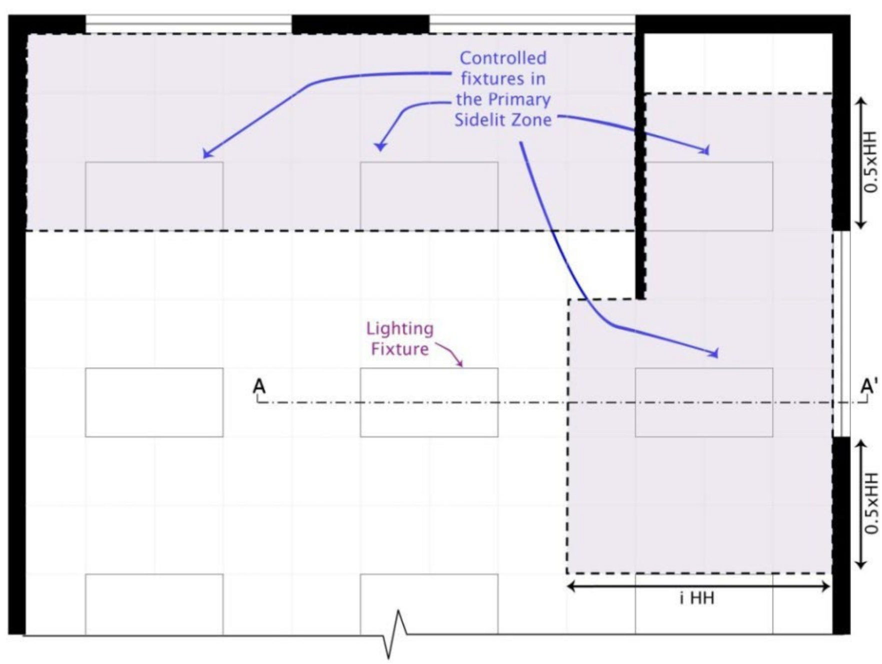


Source: California Energy Commission

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.

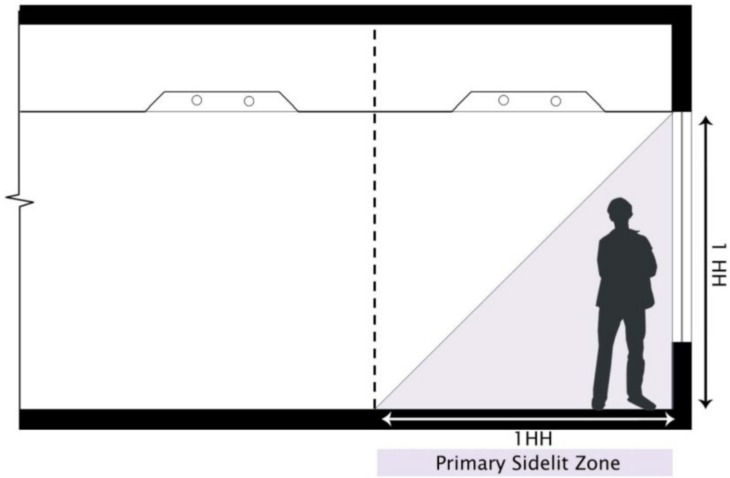
Note: Modular furniture walls should not be considered a permanent obstruction.

Figure 5-15: Example of Primary Sidelit Daylit Zone Layout in Overhead View



Source: California Energy Commission

Figure 5-16: Example of Primary Sidelit Daylit Zone Layout in Side View



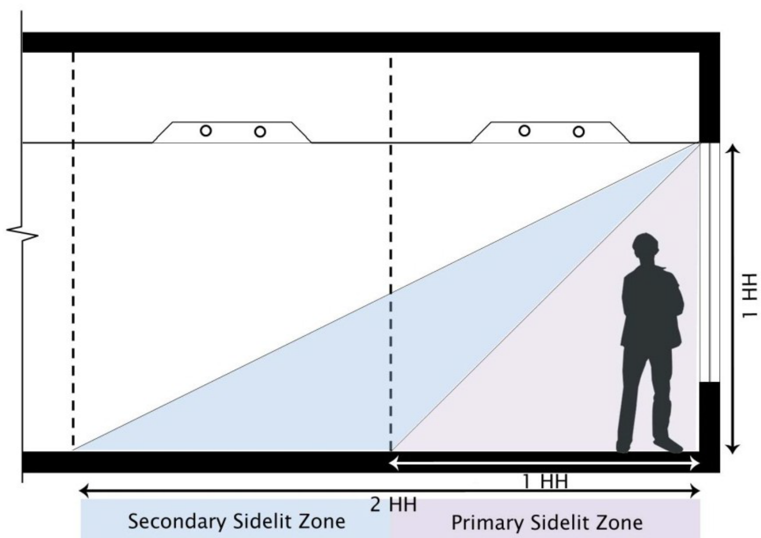
Source: California Energy Commission

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: "Window Head Height" is the vertical distance from the finished floor level to the top of a window or vertical fenestration. This is important to know in order to figure out the sidelit daylit zone where there is a window or there are windows.

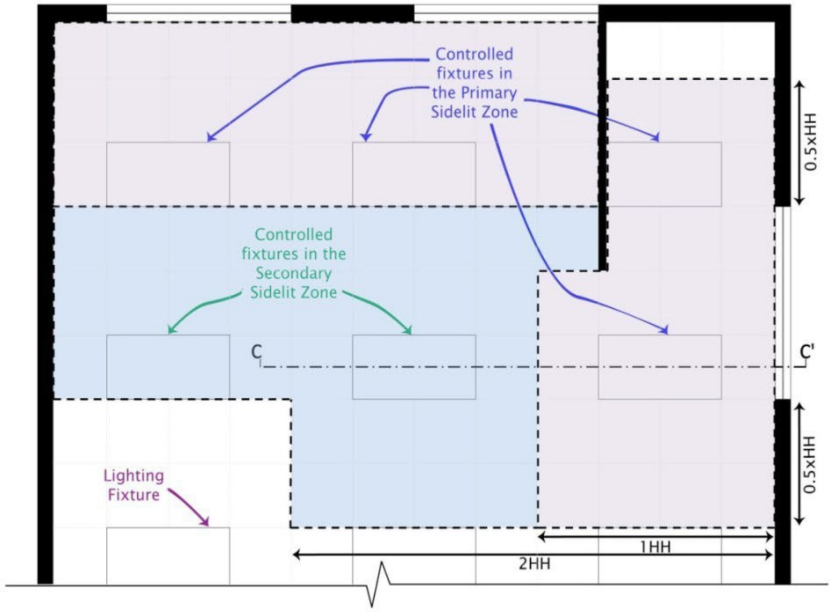
Note: Modular furniture walls should not be considered a permanent obstruction.

Figure 5-17: Example of Secondary Sidelit Daylit Zone in Side View



Source: California Energy Commission

Figure 5-18: Example of Secondary Sidelit Daylit Zone in Overhead View



Source: California Energy Commission

Daylight Responsive Controls in Indoor Spaces (Not Including Parking Garages)
Daylight responsive controls are required for general lighting in skylit daylit zones and primary sidelit daylit zones where the total installed general lighting wattage is 75 watts or greater.

Daylight responsive controls are also required for general lighting in secondary sidelit daylit zones when one of the following two conditions is met:

- Secondary sidelit daylit zones have a total installed general lighting wattage of 75 watts or greater and also daylight responsive controls for primary sidelit daylit zones are required in the same enclosed space.
- Secondary sidelit daylit zones have a total installed general lighting wattage of 75 watts or greater and also daylight responsive controls for primary sidelit daylit zones are not required in the same enclosed space.

Luminaires providing general lighting in the skylit daylit zone, primary sidelit daylit zone, or secondary sidelit daylit zone shall be controlled by daylight responsive controls specific to the conditions in the different type of zone that meet the applicable requirements:

- Building Plans: All skylit daylit zones, primary sidelit daylit zones, and secondary sidelit daylit zones must be shown on the building plans.
- Separate Control Zones: The daylight responsive controls shall provide separate control for general lighting in each type of daylit zone. General lighting luminaires in the skylit daylit zone must be controlled separately from those in the primary sidelit daylit zone and secondary sidelit daylit zone.

  In spaces where skylights are near exterior walls with windows, the skylit daylit zone may overlap with either the primary or secondary sidelit daylit zone. The skylit daylit zone takes precedence, and the general lighting luminaires in the overlapping area must be controlled as part of the skylit daylit zone.

- Overlapping Daylight Zones: Where the primary sidelit daylit zone and the secondary sidelit daylit zone overlap, such as in corner spaces, the primary sidelit daylit zone takes precedence and the general lighting luminaires in the overlapping area must be controlled as part of the primary sidelit daylit zone.
- Luminaires in Overlapping Daylit Zones (part 1): A general lighting luminaire that crosses both primary sidelit daylit zone and secondary sidelit daylit zone must be controlled as part of the primary sidelit daylit zone regardless of how much of the luminaire is in each zone. A general lighting luminaire that crosses both the secondary sidelit daylit zone and a non-daylit zone must be controlled as part of the secondary sidelit daylit zone regardless of how much of the luminaire is in each zone. Example 5-10 illustrates how to control an 8-foot luminaire for daylight dimming when it crosses both the primary and secondary sidelit daylit zones.
- Luminaires in Overlapping Daylit Zones (part 2): The code does not prevent segmenting luminaires into shorter segments, and as long as the segments are 8 feet and less, these segments are controlled according to the type of daylit zone where the segment is primarily located (a hierarchy of first skylit then primary sidelit and last secondary sidelit).
- Secondary Daylit Zones: General lighting in the secondary sidelit daylit zones must be controlled independently of general lighting in the primary sidelit daylit zones. However, a single sensor can be used to control both the primary and secondary sidelit daylit zones provided that the control system can make separate and appropriate light level adjustments in each zone.

Example 5-8: Controlling Luminaires Across Daylit Zones

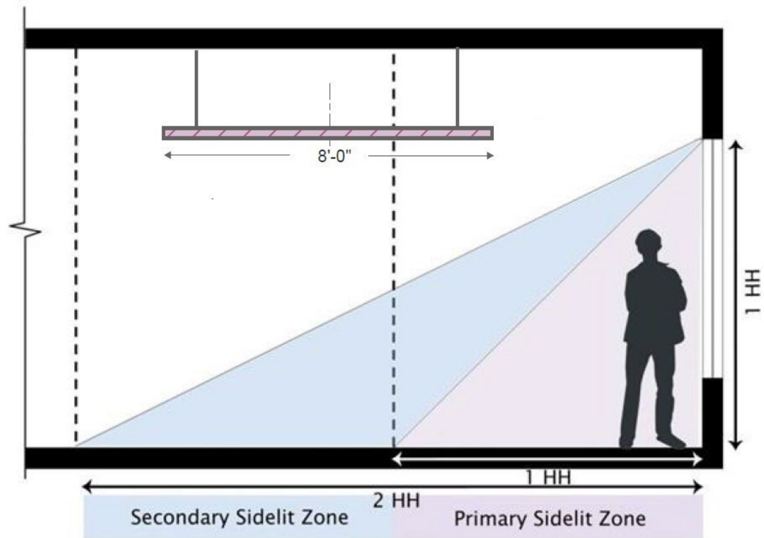
The general lighting in the space depicted in Figure 5-19: (Example 5-8) Controlling Luminaires Across Daylit Zones is provided by a few rows of 8-foot linear pendant luminaires perpendicular to the window. Each luminaire crosses two daylit zones with about 2 feet in the primary sidelit daylit zone and 6 feet in the secondary sidelit daylit zone.

Because the luminaires are only 8-foot long, it does not need to be segmented into smaller sections for daylight responsive controls. And because the luminaires are in both the primary and secondary sidelit daylit zones, they must be controlled as part of the primary sidelit daylit zone when the entire luminaire is controlled as a single section.

Alternatively, each luminaire is allowed to be controlled in two 4-foot long segments, the first segment being the 4-foot section in the primary sidelit daylit zone and the other 4-foot segment in the secondary sidelit daylit zone. In this case, only the segment that is partially in the primary sidelit zone must be controlled as part of the primary sidelit daylit zone, and the other half that is entirely in the secondary sidelit zone can be controlled as part of the secondary sidelit daylit zone.

It is also allowed and good practice to segment the control of the luminaire with a 2 foot section in the primary sidelit zone and controlled as part of the primary sidelit zone. In this case the remaining 6 feet of the luminaire would be in the secondary sidelit zone and controlled as part of the secondary sidelit zone.

Figure 5-19: (Example 5-8) Controlling Luminaires Across Daylit Zones



Source: California Energy Commission

- Controlled Segmentation of luminaires (part 1): General lighting luminaires that are long such as linear pendants, strip lights, tape lights, and cover lights shall be segmented into control sections so that lighting is evaluated and controlled separately in each type of daylit zone (skylit daylit zones: primary sidelit daylit zones, secondary sidelit daylit zones, and non-daylit zones). Each controlled segment must be 8 feet or shorter.
    - Evaluation of installed wattage in each daylit zone: The lighting power of each luminaire segment shall be allocated to the daylit zone in which the segment would be controlled. In most cases where the luminaire or luminaire segment is 8 feet long or less, this allocation to daylit zone is based on which of the various daylit zones the luminaire is in or partially in according to the hierarchy of first skylit, then primary sidelit and lastly secondary sidelit. For luminaires with premanufactured housings longer than 8 feet, the rules about controlling these luminaires are different as are the allocation of watts to the daylit zone. This is described in the exception in item 8 below.
    - Separate control for each daylit zone: In daylit zones where daylight responsive controls are required, each luminaire segment must be separately controlled according to the type of daylit zone in which the segment is primarily located.

Example 5-9 shows how long luminaires should be segmented in evaluating lighting power to each daylit zone and controlling them for daylight dimming.

Example 5-9: Evaluating and Controlling Luminaires Longer than 8 Feet but with Segments 8 feet and Shorter

Luminaires that are longer than 8 feet and with segments of 8 feet and less are controlled based on a hierarchy of where the segment are primarily located - first, controlled as part of the skylit daylit zone if the segment is primarily located; next, controlled as the primary sidelit daylit zone if primarily located; lastly controlled as the secondary sidelit if located in there. General lighting in Figure 5-20: (Example 5-9) Evaluating and Controlling Long Luminaires with

Segments Less than 8 Feet is provided by three rows of 12-foot linear pendant luminaires, and each row of luminaire is made up of three factory assembled 4-foot sections shipped to the site and joined together on-site.

The first row from the right-hand side of the image is entirely in the primary sidelit daylit zone, therefore, even though it is longer than 8 feet, it does not need to be segmented for daylight responsive controls. The entire row must be controlled as part of the primary sidelit daylit zone.

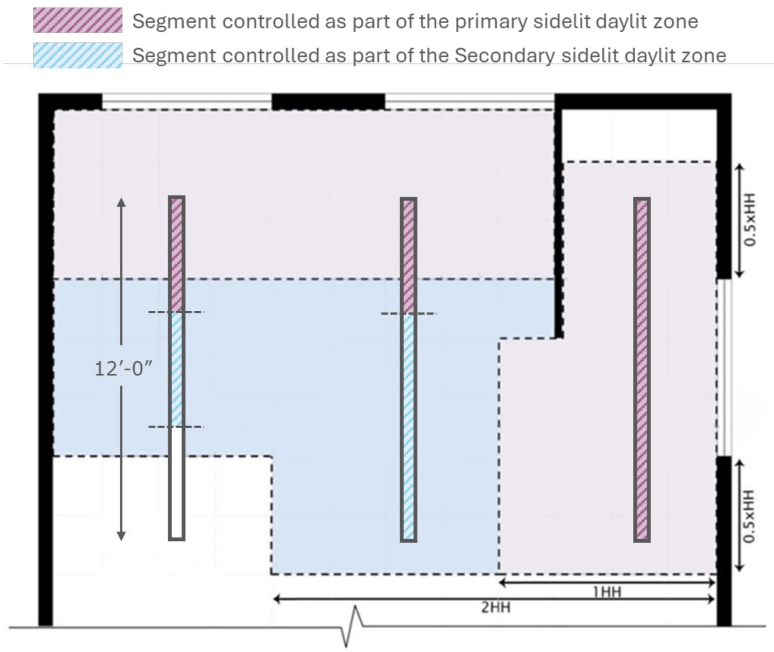
The middle row crosses both the primary and secondary sidelit daylit zones. Since it is longer than 8 feet, it must be controlled in segments of 8 feet or less. The sensible segmentation choice would be to segment it into one 4-foot and one 8-foot sections as depicted in the figure. Since the 4-foot segment is partially in the primary sidelit daylit zone and according to the hierarchy of allocating to daylit zones, its lighting power must be allocated to the primary sidelit daylit zone, and it must be controlled as part of the primary sidelit daylit zone. The 8-foot segment is entirely in the secondary sidelit daylit zone, and therefore, its lighting power is allocated to the secondary sidelit daylit zone, and the segment must be controlled as part of the secondary sidelit daylit zone.

The third row, the left-most row, crosses the primary and secondary sidelit daylit zones as well as the non-daylit zone. There are multiple ways to segment the luminaire to meet the daylight responsive controls requirements:

Option 1 (not shown in the figure): Segment it the same way as the luminaire in the middle row. Since the 4-foot segment is primarily in the primary sidelit daylit zone, its lighting power must be allocated to the primary sidelit daylit zone, and it must be controlled as part of the primary sidelit daylit zone. The 8-foot segment is primarily in the secondary sidelit daylit zone, and therefore, its lighting power is allocated to the secondary sidelit daylit zone, and the segment must be controlled as part of the secondary sidelit daylit zone.

Option 2: Segment the two luminaires (the middle and the third row) into three 4-foot segments as shown in the figure. Note that the code only requires the luminaire to be segmented in segments of 8 feet or less and does not stipulate the number and length of the segments as long as each segment is no longer than 8 feet. In this case, the first 4-foot segment of the middle-row luminaire is primarily in the primary sidelit daylit zone, its lighting power must be allocated to the primary sidelit daylit zone, and it must be controlled as part of the primary sidelit daylit zone. The other 4-foot segments of the middle-row luminaire are entirely in the secondary sidelit daylit zone, so its lighting power is allocated to the secondary sidelit daylit zone, and the segments must be controlled as part of the secondary sidelit daylit zone. The luminaire (the third-row luminaire) on the left side of the figure where the bottom 4-foot segment is primarily in the non-daylit zone, also is partially in the secondary sidelit zone and therefore, its lighting power is allocated to the secondary sidelit zone.

Figure 5-20: (Example 5-9) Evaluating and Controlling Long Luminaires with Segments Less than 8 Feet



Source: California Energy Commission

- Controlled Segmentation of luminaires (part 2): In the scenario in which the installed luminaires are manufactured with factory assembled housing longer than 8 feet, the luminaire is allowed to be controlled as a single segment according to the type of daylit zone in which it is primarily located. A lighting configuration that looks continuous and uninterrupted but is made up by joining multiple segments during field installation does not qualify for this exception and must be controlled in segments of 8 feet or shorter. An example is the usage of a luminaire with an extruded aluminum body over 8 feet and it is not assembled from shorter segments in the field during installation. Examples 5-10 to 5-12 provide examples of what types of luminaires qualify for this exception. When calculating the general lighting wattage in various daylit zones, the wattage of these long luminaires is fully allocated to the daylit zone the luminaire is "primarily" in. Calculation of primarily is based on the amount of luminaire area in each daylit zone and the zone with highest fraction of luminaire areas is considered the zone which the luminaire is primarily in. When considering daylit areas – this could also include "non-daylit" areas.
- Luminaires without housings. Some lighting systems do not have housings. The most common configuration is tape lighting which can be used as cove lighting. Cove lighting is often installed to serve as "decorative lighting" and is not subject to the requirements for general lighting. When cove lighting is the only light source for a space or portion of a space, then it is providing general lighting and shall be controlled by daylight responsive controls if there is sufficient wattage in the daylit zones. As general lighting when the tape lighting crosses from daylit to non-daylight zones or across daylit zone types, the tape light shall be controlled in segments of 8 feet or less according to the daylit zone the segment is partially in and controlled according to the daylit area type according to the hierarchy - first skylit then primary sidelit and finally secondary sidelit daylight zone.
- EXCEPTIONS: Daylight responsive controls are not required for any of the following conditions:

  - 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.
  - 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.
  - Rooms that have a total glazing area of less than 24 square feet.
  - Luminaires in sidelit daylit zones in retail merchandise sales and wholesale showroom areas.

Daylight Responsive Control Installations and Configurations

Daylight responsive controls must be installed and configured according to the following requirements:

- In spaces where multilevel lighting is available for the general lighting, regardless of whether the availability is triggered by the requirements under §130.1(b):
  - If general lighting is continuously dimmable, daylight responsive controls must have more than 10 light output levels and at least one of the levels must reduce the lighting power by 90 percent of full power or more.

    Note: Per Reference Appendices NA7.6.1.4, continuous dimming is defined as having the capability to provide more than 10 levels of controlled light output.
  - The daylight responsive controls must be dimmable if the general lighting meets the criteria of Section 130.1(b). See Lighting Control Interactions — Considerations for Spaces With Daylight Responsive Controls and Multilevel Lighting Controls for more details on these criteria (more than 0.5 W/sf, more than one light fixture in the room and not HID or induction lighting).
  - If general lighting is not dimmable, namely, multilevel lighting controls are not required and not available, the light can remain at full output before daylight reaches 150 percent of the design illuminance on the task surface. Daylight responsive controls must turn the lights OFF when daylight is at 150 percent of the design illuminance. However, with the broad use of LED sources which often are dimmable, there are a number of reasons why the designer specifies dimmable daylight responsive lighting controls.
    - Section 130.1(c)6 requires partial off occupancy sensing in warehouses, open plan offices, corridors etc.; this is frequently achieved by dimming the light source to its partial off setting when occupancy sensor does not sense any occupancy. Thus the dimming daylight responsive control is compatible with the continuous dimming capability of the LED driver that is being served by both the daylighting controls and the partial off occupancy sensor.

      - Dimmable daylight responsive controls are specified for occupant comfort reasons, a control that dims lighting in response to daylight is less intrusive than a control that turns the lights completely on and off.
      - The dimmable daylight responsive controls are selected to yield more savings for the occupants.

    When dimmable daylight responsive lighting controls are specified, regardless of they were required, then the correct operation of the controls shall be verified by the acceptance test NA7.6.1.4 *Continuous Dimming Control Systems Functional Testing*.

  - For those general lighting systems that do not have dimmable daylight responsive controls because they do not meet the criteria of Section 130.1(b) and the designer has specified the minimally compliant on/off controls, the correct operation of the controls shall be verified by the acceptance test NA7.6.1.5 *Stepped Switching or Stepped Dimming Control Systems Functional Testing*. Item (d) of this test, *partial daylight test*, only applies if the control has an intermediate control step. Though not required for the daylight responsive control, the designer might specify the intermediate step for HID or induction lighting systems which make use of Exception 4 to Section 130.1(b).

  When the requirements of §130.1(d) are triggered by the addition of skylights to an existing building and the lighting system is not recircuited, the daylighting control is not required to meet the multilevel requirements in §130.1(d)2Ci. The daylighting control may provide on/off control in accordance with §141.0(b)2G for alterations.

- In all portions of the daylight zone, the combined illuminance from the controlled lighting and daylight shall not be less than the illuminance from controlled lighting when no daylight is available.

  In the darkest portion of the daylit zone (the "reference location" in the Reference Appendix NA7.6 *Indoor Lighting Controls Acceptance Tests*), the control should not overdim the lights.

- When the daylight illuminance, in the darkest portion of the daylit zone, is greater than 150 percent of the illuminance provided by the controlled lighting when no daylight is available, the controlled lighting power in that daylight zone shall be reduced by a minimum of 90 percent.

  The best control would fully dim the system when daylight levels in the darkest portion of the daylit zone are at 100 percent of the illuminance from controlled lighting when no daylight is available. The 150 percent/90 percent requirement allows some tolerance for error while obtaining most of the energy savings.

- Photosensors, the device that senses light levels and transmits this to the photocontrol, shall be located so they are not readily accessible to unauthorized personnel. This location helps prevent unauthorized modification or disabling of the light sensor. The location where calibration adjustments are made to automatic daylight responsive controls shall be readily accessible to authorized personnel and may be inside a locked case or under a cover that requires a tool for access. These adjustments allow the authorized personnel (such as the lighting technician) to modify the response of the photocontrol (daylight responsive control) so the combination of daylit and electric light provides sufficient interior illuminance under all daylight conditions while reducing electric lighting in response to daylight availability and saving energy. Access to controls can be limited by placing locks or screws on enclosures or under a cover plate so a tool or key is needed to gain access. Initial commissioning and retrocommissioning of the controls are simplified if the calibration adjustments are readily accessible to authorized personnel so that a lift or a ladder is not required to access the location where calibration adjustment are made.

Some controls have wireless remotes for adjusting settings. This allows one person with a light meter and the wireless calibration tool to be located at the edge of the daylit zone and make the calibration adjustments without having to run back and forth between taking the measurement and making the adjustment.

- Manual controls, as required by §130.1(a), shall interact with daylight responsive controls in the following ways:
    - Manual controls must be able to turn off the lights at any time.
    - Manual controls must be able to reduce the light output below the light level set by the daylight responsive controls.

Example 5-13: Complying With the 150 Percent of the Design Illuminance Daylighting Requirement and "Reference Location" (from NA7.6.1)

When the illuminance received from daylight is greater than 150 percent of the design illuminance (or nighttime electric lighting illuminance), the general lighting power in the daylit zone must reduce by a minimum of 90 percent.

For example, a space has 500 watts of general lighting power in the daylit zones. The design illuminance for the space is 50 foot-candles (fc). When the available daylight in the space reaches 75 fc (that is, 150 percent of 50 fc), then the power consumed by the general lighting in the daylit zones should be 50 watts or lower.

Without checking all points in the daylit zone served by controlled lighting, verifying that the requirements are met at a worst-case location far away from windows or skylights is sufficient. This location is referred as the "Reference Location" in Reference Appendix NA7.6.1.4(a) and NA7.6.1.5(a).

Daylight Responsive Controls in Parking Garages

For parking garage areas, daylight responsive controls are required in both primary and secondary sidelit daylit zones when all the following criteria are met:

- The total installed wattage of general lighting in the primary and secondary sidelit daylit zones is 60 watts or greater.
- The areas have a combined total of 36 square feet or more of glazing or opening.

When daylight responsive controls are required, luminaires providing general lighting that are in the combined primary and secondary sidelit daylit zones shall be controlled independently from other lighting in the parking garage.

Parking areas on the roof of a parking structure are outdoor hardscape and daylight responsive control requirements do not apply to these spaces.

The primary differences between the automatic daylight control requirements in parking garages and the rest of interior lighting spaces are the following:

- The primary and secondary sidelit daylit zones are controlled together in parking garages, whereas they must be separately controlled in other spaces. However, it is permissible that in either space type, a single sensor can be used if the control system can make the appropriate light level adjustments in each zone.
- In parking garages, when the daylight illuminance is 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 zone shall be reduced by 100 percent. In other words, the light must be turned off. (In other interior spaces, the lighting power must be reduced by 90 percent.)
- Egress lighting for the parking garage may be controlled by daylight responsive controls, but a fail-safe mechanism must be in place to ensure that the egress lighting is functioning and stays on if the photosensor fails.

EXCEPTION: Daylight responsive controls are not required for luminaires in the daylight adaptation zone within the parking garage areas. Daylight adaptation zone in a parking garage is the interior path of travel for vehicles adjacent to the entrance or exit of a parking garage, from the portal or physical building line to about 66 feet inside the structure, as needed for visual adaption to transition from exterior daylight levels to interior light levels.

Demand-Responsive Lighting Controls

Reference: Section 130.1(e), Section 110.12

Buildings with nonresidential lighting systems having a total installed lighting power of 4,000 watts or greater that are subject to the multilevel requirements in §130.1(b) must meet demand-responsive lighting control requirements.

The demand-responsive control must be capable of reducing the total lighting power by 15 percent or greater.

EXCEPTION: Spaces where a health or life safety statute, ordinance, or regulation does not permit the general lighting to be reduced are exempted from the requirement and do not count toward the 4,000 watt threshold.

See Appendix D for guidance on compliance with the demand-responsive control requirements.

Example 5-14: Demand-Responsive Lighting Controls 15 Percent Reduction in Lighting Power

Question:

What lighting counts toward the 4,000 watt demand-responsive lighting threshold? If this threshold is exceeded, what lighting must have demand-responsive lighting controls? What lighting counts toward the 15 percent minimum reduction?

Answer:

Only general lighting that is subject to multilevel requirements in §130.1(b) counts toward the 4,000 watt threshold. When this threshold is exceeded, demand-responsive controls are required for general lighting.

The demand-responsive controls must be capable of reducing the total lighting power by a minimum of 15 percent. This includes general lighting and any additional lighting such as task, display, or other lighting. For example, consider an office that has 5,000 total installed watts of general lighting subject to §130.1(b) and 2,000 watts of additional lighting power. While only the 5,000 watts of general lighting are required to have demand response controls per §110.12(c), the 15 percent reduction is based on the 7,000 total installed watts in the office.

Lighting Control Interactions — Considerations for Spaces With Daylight Responsive Controls and Multilevel Lighting Controls

Reference: Section 130.1(d)2F

Indoor lighting systems subject to §130.1 require multiple types of lighting controls. Section 130.1(d)2F includes the requirements for control interactions between multilevel controls and daylight responsive controls (daylighting controls).

Example 5-15: Interaction Between Manual Controls and Daylight Responsive Controls

Question:

For a space with manual dimming control and daylight responsive controls, can the manual dimming control override the daylight responsive control?

Answer:

Yes. Section 130.1(d)2F includes requirements for control interactions between lighting control types.

The daylight responsive control must allow the manual control to turn off or to dim the level of lighting. This means an occupant can use the dimming control to decrease the lighting level as necessary and override the daylight responsive control.

Practical Considerations

Please refer to Chapter 5.4.6.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Lighting Control Functionality

Reference: Section 110.9(b)

All installed lighting control devices and systems must meet the functionality requirements in §110.9(b). In addition, all components of a lighting control system installed together must meet the applicable requirements in §130.0 through §130.5, §140.6 through §140.8, §141.0, and §150.0(k).

To ensure compliance with the requirements of §110.9(b), designers and installers should review features of their specified lighting control products as part of code compliance.

- Time-Switch Lighting Controls

Time-switch lighting control products shall provide the functionality listed in §110.9(b)1.

- Daylight Responsive Controls

Daylight responsive control products shall provide the functionality listed in §110.9(b)2.

- Dimmers

Dimmer products shall provide the functionality listed in §110.9(b)3.

- Occupant Sensing Controls

Occupant sensing control products (including occupant sensors, partial-on occupant sensors, partial-off occupant sensors, motion sensors, and vacancy sensor controls) shall provide the functionality listed in §110.9(b)4 and §110.9(b)6.

Occupant sensing controls must be capable of automatically reducing the lighting or turning the lighting off within 20 minutes after the area has been vacated.

Track Lighting Integral Current Limiters and Track Lighting Supplementary Overcurrent Protection Panels

Please refer to Chapter 5.4.8 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Requirements for Daylighting Devices and for Large Enclosed Spaces

Please refer to Chapter 5.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Daylighting Device (Clerestories, Horizontal Slate, and Light Shelves) Power Adjustment Factors

Reference: Section 140.6(a)2L

Certain design features and technologies can increase the daylighting potential of spaces. Some of these design features and technologies may be used in conjunction with daylight responsive controls to receive PAFs from Table 140.6-A or as a performance compliance option in the performance method.

A careful analysis should be performed to avoid glare when including daylighting devices in a design. For example, specularly reflective (e.g., polished or mirror-finished) slats may redirect sunlight and cause uncomfortable glare. Since that is not the only consideration to make when considering daylighting design features, a careful daylighting analysis should be performed on a space-by-space, project-by-project basis.

The daylight dimming plus off PAF and institutional tuning in daylit areas may be added to any of the daylighting design PAFs to create a combined total PAF.

In addition, the horizontal slat PAF can be added to the clerestory fenestration PAF if the requirements for both are met.

In the performance method, a variety of control strategies is available in the compliance software to take advantage of further savings.

At permit application, use form NRCC-LTI-E to document daylighting device PAFs.

Daylighting Requirements for Large, Enclosed Spaces

Reference: Section 140.3(c)

Section 140.3 has prescriptive requirements for building envelopes, including daylighting for large, enclosed spaces directly under roofs. Lighting installed in these spaces is required to comply with all lighting control requirements, including the daylight responsive control requirements. Mandatory daylighting control requirements are covered in Daylight Responsive Controlsof this chapter.

For projects that comply with the prescriptive daylighting requirements by installing daylight openings in large, enclosed spaces directly under roofs, the daylit areas may require daylight responsive controls. However, for projects using the performance approach, it is possible to displace the daylighting openings and daylight responsive controls with other building efficiency options

Large, Enclosed Spaces Requiring Daylighting – Qualifying Criteria

Please refer to Chapter 5.5.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Daylighting Requirements

Please refer to Chapter 5.5.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Compliance Approach for Indoor Lighting – Introduction

Requirements for a Compliant Building

Please refer to Chapter 5.6.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Calculation of Adjusted Indoor Lighting Power

The adjusted indoor lighting power of all building areas is the total watts of all planned permanent and portable lighting systems in the proposed building.

Some adjustments are available to reduce the reported indoor lighting power. These adjustments are discussed below.

Power Adjustment Factors or Reduction of Wattage Through Controls

The Energy Code provides an option for a lighting power reduction credit when specific lighting controls are installed, provided those lighting controls are not 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.

In calculating adjusted indoor lighting power, the installed watts of a luminaire providing general lighting in a functional area listed in Table 140.6-C may be reduced by multiplying the watts controlled by the applicable power adjustment PAF, per Table 140.6-A.

To qualify for a PAF, the following conditions must be met:

- 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 a PAF will be allowed for compliance with §140.6. If any of the requirements in this Certificate of Installation are not met, the installation shall not be eligible to use the PAF.

- Luminaires and controls meet the applicable requirements of §110.9, and §130.0 through §130.5.
- The controlled lighting is permanently installed general lighting systems and the controls are permanently installed nonresidential-rated lighting controls (portable lighting, portable lighting controls, and residential rated lighting controls do not qualify for PAFs).

  When used for determining PAFs for general lighting in offices, furniture-mounted luminaires shall qualify as permanently installed general lighting systems if:

  - They are installed no later than the time of building permit inspection.
  - They are permanently hardwired.
  - They are designed to provide indirect general lighting. (They may also have elements that provide direct task lighting.)
  - The lighting control for the furniture mounted luminaire complies with all other applicable requirements in §140.6(a)2.

    Before multiplying the installed watts of the furniture-mounted luminaire by the applicable PAF, 2 watts per square foot of the area illuminated by the furniture mounted luminaires shall be subtracted from installed watts of the furniture mounted luminaires to account for portable lighting.
- At least 50 percent of the light output of the controlled luminaire is within the applicable area listed in Table 140.6-A. Luminaires on lighting tracks must be within the applicable area to qualify for a PAF.
- Only one PAF from Table 140.6-A may be used for each qualifying luminaire. PAFs shall not be added together unless specifically allowed in Table 140.6-A.
- Only lighting wattage directly controlled in accordance with §140.6(a)2 shall be used to reduce the calculated adjusted indoor lighting power as allowed by §140.6(a)2. If only a portion of the wattage in a luminaire is controlled in accordance with §140.6(a)2, then only that portion of controlled wattage may be reduced in calculating adjusted indoor lighting power.
- Lighting controls used to qualify for a PAF shall be designed and installed in addition to manual, multilevel, and automatic lighting controls required in §130.1, and in addition to any other lighting controls required by the Energy Code.
- To qualify for the PAF for daylight continuous dimming plus off control, the following requirements must be met:
  - The daylight control and controlled luminaires must meet the requirements of §130.1(d), 130.4(a)3, and 130.4(a)7.
  - The daylight control 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.

- To qualify for the PAF for an occupant sensing control controlling the general lighting in large office areas above workstations, in accordance with Table 140.6-A, each occupant sensing control zone must be 250 square feet or smaller and the following requirements must be met (note that occupant sensing controls are already required in offices greater than 250 square feet per §130.1(c)6D, and each occupant sensing control zone may not be greater than 600 square feet (refer to Shut-Off Controls for more information); This PAF is provided when the occupant sensing control zones are 250 square feet or smaller):
    - The office area must be greater than 250 square feet.
    - This PAF is available only in office areas with workstations.
    - Controlled luminaires may only be those that provide general lighting directly above the controlled area or furniture-mounted luminaires that comply with §140.6(a)2 and provide general lighting directly above the controlled area.
    - Qualifying luminaires must be controlled by occupant sensing controls that meet the following requirements, as applicable:
        - Infrared sensors shall be equipped (either by the manufacturer or in the field by the installer) with lenses or shrouds to prevent them from being triggered by movement outside the controlled area.
        - Ultrasonic sensors shall be tuned to reduce their sensitivity, to prevent them from being triggered by movements outside the controlled area.
        - All other sensors shall be installed and adjusted as necessary to prevent them from being triggered by movements outside the controlled area.
    - The PAF shall be applied only to the portion of the installed lighting power that is controlled by the occupant sensors, not to the total installed lighting power.
    - The value of the PAF (0.2 or 0.3) depends on the square footage controlled by each occupant sensor.
    - Show the occupant sensing control zones of the offices (offices greater than 250 square feet) on the plans.
- The following requirements must be met to qualify for the institutional tuning PAF:
    - The lighting controls must 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.
    - The means of setting the limit must be accessible only to authorized personnel.
    - The setting of the limit must be verified by the acceptance test required by §130.4(a)7.
    - The construction documents must specify which lighting systems will have their maximum light output or maximum power draw set to no greater than 85 percent of full light output or full power draw.

- To qualify for the Demand Responsive Control PAF, the general lighting wattage receiving the PAF must not be within the scope of §110.12(c) and all of the following requirements must be met:
    - The controlled lighting must be capable of being automatically reduced in response to a demand response signal.
    - General lighting must be reduced in a manner consistent with the requirements of Section 130.1(b) - the general lighting shall be capable of being dimmed continuously from 100 percent to 10 percent or lower of lighting power.

  Requirements of §110.12(c): Buildings with nonresidential lighting systems having a total installed lighting power of 4,000 watts or greater that is subject to the requirements of §130.1(b) shall install controls capable of automatically reducing lighting power in response to a Demand Response Signal. See Demand-Responsive Lighting Controls of this manual for more information.
- To qualify for the PAF for daylighting devices (including clerestories, light shelves, and horizontal slats) in Table 140.6-A, the daylighting devices must meet the requirements in §140.3(d). The PAFs shall only apply to lighting in a primary or secondary sidelit daylit zone where continuous dimming daylighting controls meeting the requirements of §130.1(d) are installed.

  Refer to Chapter 3 for more information on the requirements for daylighting devices that qualify for a PAF.

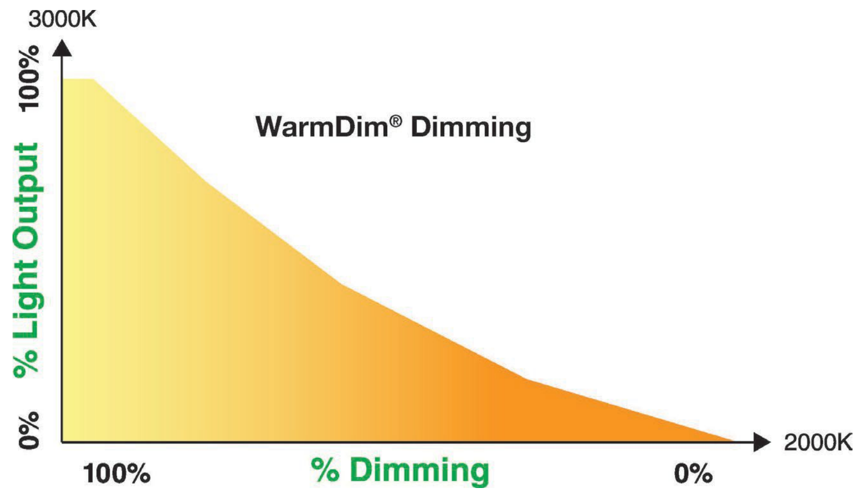
Luminaire Power Adjustment

Color-tunable LED lighting technologies are available for lighting applications including hospitality, healthcare, and other uses. This technology produces correlated color temperatures (CCT) that match the current use of a space.

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 0.80 if the luminaire meet all of the requirements of §140.6(a)4B, paragraphed below:

- 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.
- 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.
- Controls: Connected to controls that allow color changing of the illumination.

Figure 5-21: Relationship of Dimming to Change in Correlated Color Temperature of Dim-to-Warm (aka "WarmDim") Lighting Technology



Source: Juno WarmDimming® Dimming courtesy of Acuity Brands Lighting, Inc.

Portable Lighting in Office Areas

Section 140.6(a) of the Energy Code requires that all planned lighting, including portable and permanent lighting systems, be counted toward the lighting energy use of the building, regardless of when it is planned to be installed.

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. When using the area category method for offices with portable lighting, the additional lighting power provision is available for portable lighting and decorative/display lighting. Refer to Area Category Method (One of Two Prescriptive Compliance Approaches) for more information about the area category method.

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.

Two Interlocked Lighting Systems

Within the following five functional areas, as defined in §100.1, two lighting systems may be installed provided they are interlocked so that both lighting systems cannot operate simultaneously. All other functional areas are permitted to install only one lighting system.

- Auditorium
- Convention center
- Conference room
- Multipurpose room
- Theater

No more than two lighting systems may be used for these five specifically defined functional areas, and if there are two lighting systems, they must be interlocked.

Where there are two interlocked lighting systems, the lower-wattage system may be excluded from determining the adjusted indoor lighting power if:

- 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.
- If any of the requirements in the certificate of installation are not met, the two interlocked lighting systems will not be recognized for compliance.
- 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.

Lighting Wattage Not Counted Toward Building Load

The Energy Code does not require the lighting power of certain types of luminaires in specific functional areas, or for specific purposes, to be counted toward the installed lighting power of a building. For example, lighting in the guest rooms of hotels is not required to be counted for compliance with §140.6. However, lighting in all other function areas within a hotel are required to comply with all applicable requirements in §140.6. Lighting in guest rooms is, however, regulated by the low-rise residential lighting standards.

The wattage of the following indoor lighting applications may be excluded from the adjusted (installed) indoor lighting power:

- Lighting for themes and special effects in theme parks.
- Studio lighting for film or photography provided that these lighting systems are in addition to and separately switched from a general lighting system.
- Lighting for dance floors, theatrical and other live performances, and religious worship provided that these lighting systems are in addition to a general lighting system and are separately controlled by a multiscene or theatrical cross-fade control station accessible only to authorized operators.
- Lighting intended for makeup, hair, and costume preparation in performance arts facility dressing rooms if the lighting is switched separately from the general lighting system, switched independently at each dressing station, and controlled with a vacancy sensor.
- Lighting for temporary exhibits in civic facilities, transportation facilities, convention centers, and hotel function areas if the lighting is an addition to a general lighting system and is separately controlled from a panel accessible only to authorized operators.
- Lighting installed by the manufacturer in walk-in freezers, vending machines, food preparation equipment, and scientific and industrial equipment.

- Examination and surgical lights, low-ambient night-lights, and lighting integral to medical equipment, if this lighting is in addition to and switched separately from a general lighting system.
- Lighting for plant growth or maintenance in non-controlled environment horticulture spaces, if it is controlled by a multilevel astronomical time-switch control that complies with the applicable provisions of §110.9.
- Lighting equipment that is for sale.
- Lighting demonstration equipment in lighting education facilities.
- Lighting that is required for exit signs subject to the CBC. Exit signs shall meet the requirements of the Appliance Efficiency Regulations.
- Exit way or egress illumination that is normally off and that is subject to the CBC.
- In hotel/motel buildings: Lighting in guest rooms (lighting in hotel/motel guest rooms must comply with §130.0(b). (Indoor lighting not in guest rooms must be in compliance with all applicable nonresidential lighting requirements in the Energy Code.)
- Temporary lighting systems. Temporary lighting is defined as a lighting installation with plug-in connections that does not persist beyond the time constraints specified in California Electrical Code – not exceeding 90 days for holiday decorative lighting and similar purposes.
- Lighting in Occupancy Group U buildings smaller than 1,000 sq. ft.
- Lighting in unconditioned agricultural buildings smaller than 2,500 sq. ft.
- Lighting systems in qualified historic buildings, as defined in the State Historic Building Code (Title 24, Part 8), are exempt from the lighting power 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 replica components are exempt. All other lighting systems in qualified historic buildings shall comply with the lighting power allowances.
- Lighting in nonresidential parking garages for seven or fewer vehicles must comply with the applicable residential parking garage provisions of §150.0(k).
- Lighting for signs must comply with §140.8.
- Lighting in refrigerated cases smaller than 3,000 sq ft. must comply with the Appliance Efficiency Regulations.
- Lighting in elevators meeting the requirements in §120.6(f).
- Lighting connected to a life safety branch or critical branch, as specified in Section 517 of the California Electrical Code.
- Horticultural lighting in Controlled Environment Horticulture (CEH) spaces (indoor growing and greenhouses) complying with Section 120.6(h).

Nonresidential indoor lighting applications not listed above must comply with all applicable nonresidential indoor lighting requirements.

Example 5-16: Lighting Power Exceptions and Control Requirements

Question:

For indoor lighting, if lighting is excluded from the indoor power limitations per §140.6(a)3, is that lighting also excluded from the indoor lighting control requirements of §130.1?

Answer:

No. Indoor lighting excluded from the power limitations of §140.6 is not necessarily exempt from the mandatory control requirements of §130.1. These sections are independent of each other.

Prescriptive Compliance Approach for Indoor Lighting – Allowed Indoor Lighting Power

General Rules for Calculation of Allowed Indoor Lighting Power

Reference: Section 140.6(b)

The Energy Code limits the amount of lighting power that may be installed in a building. The following are the general rules for calculating allowed indoor lighting power.

- There shall be no lighting power allotment trade-offs between the separate conditioned and unconditioned indoor function areas. Indoor conditioned and indoor unconditioned lighting power allotments must each be separately determined on compliance documentation.
- There shall be no lighting power allotment trade-offs between the separate indoor and outdoor function areas. Indoor and outdoor lighting power allotments must each be separately determined on compliance documentation.

Complete Building Method (One of the Three Prescriptive Compliance Approaches)

Please refer to Chapter 5.7.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Requirements for Using the Complete Building Method

Please refer to Chapter 5.7.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Definitions of Complete Building Types

When using the Complete Building Method, qualifying building types are those in which a minimum of 90 percent of the building floor area functions as one of the building types listed in Table 140.6-B, (as defined below), and which do not qualify as any other building occupancy type more specifically defined in §100.1 (the occupancy type information are provided below), and which do not have a combined total of more than 10 percent of the area functioning as any nonresidential function areas specifically defined in §100.1.

Definitions of Nonresidential Building Occupancy Types (Below are partial list from §100.1):

Assembly Building is a building with meeting halls in which people gather for civic, social, or recreational activities. These include civic centers, convention centers and auditoriums.

Financial Institution Building is a building with floor areas used by an institution which collects funds from the public and places them in financial assets, such as deposits, loans, and bonds.

Grocery Store Building is a building with building floor areas used for the display and sale of food.

Gymnasium Building is a building with building floor areas used for physical exercises and recreational sport events and activities.

Healthcare Facility is any building or portion thereof licensed pursuant to California Health and Safety Code Division 2, Chapter 1, section 1204 or Chapter 2, section 1250.

Industrial/Manufacturing Facility Building is a building with building floor areas used for performing a craft, assembly, or manufacturing operation.

Library Building is a building with building floor area used for repository of literary materials, and for reading reference such as books, periodicals, newspapers, pamphlets and prints.

Motion Picture Theater Building is a building with building floor areas used for showing motion pictures to audiences.

Museum Building is a building with building floor areas in which objects of historical, scientific, artistic or cultural interests are curated, treated, preserved, exhibited and stored.

Office Building is a building of CBC Group B Occupancy with building floor areas in which business, clerical or professional activities are conducted.

Parking Garage Building is a building with building floor areas used for parking vehicles and consists of at least a roof over the parking area enclosed with walls on all sides. The building includes areas for vehicle maneuvering to reach designated parking spaces. If the roof of a parking structure is also used for parking, the section without an overhead roof is considered an outdoor parking lot instead of a parking garage.

Performance Arts Theater Building is a building with building floor areas used for showing performing arts that include plays, music, or dance to audiences.

Restaurant Building is a building with building floor areas in which food and drink are prepared and served to customers in return for money.

Retail Store Building is a building with building floor areas used for the display and sale of merchandise except food.

School Building is a building used by an educational institution. The building floor area can include classrooms or educational laboratories, and may include an auditorium, gymnasium, kitchen, library, multipurpose room, cafeteria, student union, or workroom. A maintenance or storage building is not a school building.

Sports Arena Building is a building with building floor areas used for public viewing of sporting events and activities.

Area Category Method (One of Two Prescriptive Compliance Approaches)

Reference: Section 140.6(c)2

Area Category Method General Lighting Power Allotment

Please refer to Chapter 5.7.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additional Lighting Power – Area Category Method

In addition to the allowed indoor lighting power calculated according to §140.6-B through F, the building may add additional lighting power allowances for qualifying lighting systems as specified in the Qualifying Lighting Systems column in Table 140.6-C under the following conditions:

- Only primary function areas having a lighting system as specified in the Qualifying Lighting Systems column in Table 140.6-C and in accordance with the corresponding footnote of the table shall qualify for the additional lighting power allowances.
- 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.
- 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.
- The additional lighting power allowances shall not utilize any type of luminaires that are used for general lighting in the building.
- The additional lighting power allowances are used only for areas complying with the Area Category Method. The allowances shall not be used when using the Complete Building Method.
- The additional lighting power allowed is the smaller of:
    - The lighting power density listed in the "Allowed Additional Lighting LPD" column in Table 140.6-C, times the sq. ft. of the primary function, or
    - The adjusted indoor lighting power of the applicable lighting.
- In addition to meeting §140.6(c)2Gi through vi, additional lighting power for videoconferencing as specified in Table 140.6-C shall be allowed in a videoconferencing studio, as defined in §100.1, provided the following conditions are met:
    - Before the Additional Videoconference Studio Lighting power allotment will be allowed for compliance with §140.6 of the Energy Code, 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 shall sign and submit the certificate of installation.

      If any of the requirements in this certificate of installation are not met, the Additional Videoconference Studio Lighting installation shall not be eligible for the additional lighting power allotment.
    - The Videoconferencing Studio is a room with permanently installed videoconferencing cameras, audio equipment, and playback equipment for both audio-based and video-based two-way communication between local and remote sites.
    - General lighting is controlled in accordance with Table 130.1-A.
    - Wall wash lighting is separately switched from the general lighting system.
    - All of the lighting in the studio, including general lighting and additional lighting power allowed by §140.6(c)2Gvii is controlled by a multi-scene programmable control system (also known as a scene preset control system).
- Qualified wall display lighting for the additional lighting power allowances:

- Must be a lighting system type appropriate for wall lighting. Lighting systems appropriate for wall lighting are lighting track adjacent to the wall, wall-washer luminaires, luminaires behind a wall valance or wall cove, or accent light.
- Must be mounted within 10 feet of the wall having the wall display.
- Additional allowed power for wall display lighting is available only for lighting that illuminates walls having wall display. The length of display walls must include the length of the perimeter walls, including but not limited to closable openings and permanent full height interior partitions.
- Must not be used for floor display lighting.

Lighting Terms:

(related to Area Category Method)

General Lighting is installed electric lighting that provides a uniform level of illumination throughout an area, exclusive of any provision for special visual tasks or decorative effect, exclusive of daylighting, and also known as ambient lighting.

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.

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 of artwork, which is not displayed against a wall.

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 merchandise on a shelf or wall-mounted artwork, which is displayed on perimeter walls.

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 merchandise, goods, and artifacts, in a show window, to be viewed from the outside of a space through a window.

Example 5-17: Lighting Power Allowance for Non-General Lighting (Such as Decorative Lighting)

The area category method (Table 140.6-C) provides additional lighting power allowances for lighting that is not considered general lighting; however, to claim these allowances, the other lighting systems must be separately switched.

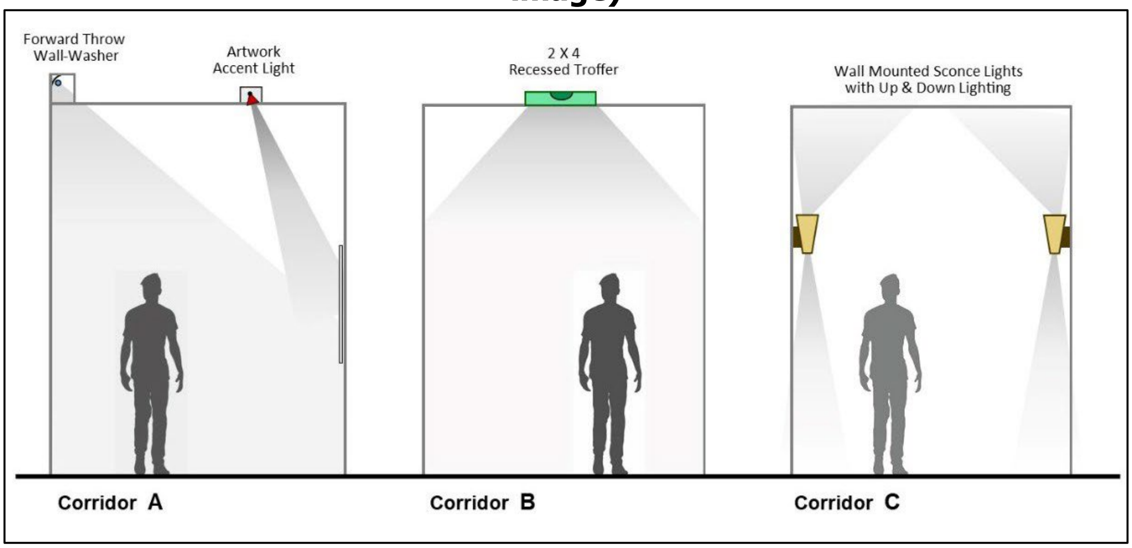
Under layered lighting design scenarios with multiple luminaire types, compliance documentation will require allocating some or all of non-general lighting power to the additional lighting power allowances and the rest of the lighting wattage to the general lighting power allowance. Only the general lighting power allowance is able to be shared across different spaces.

When there is only one lighting system type in a space, such as is the case when a monolithic design approach is taken, that system type will be treated as general lighting. Thus, light fixtures that might ordinarily be considered ornamental or display luminaires are considered general lighting luminaires if they are the only system type in a given enclosed space.

Example 5-18: Corridor With Accent Lighting and General Lighting

A corridor may have a lighting system to provide both decorative lighting and general lighting as illustrated in the following images about three different corridor scenarios.

Figure 5-22: Corridors with General Lighting and Non-General Lighting: A Corridor With Wall Washer and Accent Luminaires (left image), a Corridor With Recessed Troffer Luminaires (center image), and a Corridor With Scone Luminaires (right image)



Source: Bernie Bauer

Corridor A has two lighting systems: forward wall-washers which provides 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 per Table 140.6-C Area Category Method are allowed up to the 0.40 W per sq. ft general lighting allowance 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 0.25 W per sq. ft. decorative/display lighting allowance listed under the "Additional Lighting Power" column of Table 140.6-C.

One option: provided the total lighting power of the wall-washers and accent lights is equal to or less than the allowed 0.4 W per sq. ft. general lighting power allowance for corridor spaces under Table 140.6-C, both luminaires may use the general lighting power allowance.

Another option: if the total lighting power of the wall-washers and accent lights exceeds the 0.4 W per sq. ft. general lighting power allowance for corridor spaces under Table 140.6-C, an additional 0.25 W per sq. ft. decorative/display lighting allowance may be used for the accent lights provided that the accent lights are separately switched from the wall washers. The additional lighting power allowed will be the lower of the calculated additional allowance for decorative/display lighting or the proposed wattage of the accent lighting.

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 0.4 W per sq. ft. general lighting power allowance for corridor spaces listed in Table 140.6-C. The 0.25 W per sq. ft. 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 are assigned the 0.40 W per sq. ft. general lighting power allowance for corridor spaces as listed in Table 140.6-C. If needed, the 0.25 W per sq. ft. 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.

Example 5-19: Calculating the Allowed Lighting Power Using Area Category Method

Question:

What is the allowed lighting power for a 10,000-ft² multi-use building with the following area types?

- Main entry lobby of 500 ft²,
- Corridors of 1,500 ft²,
- Grocery store (Grocery Sales) of 3,000 ft²,
- Retail store (Retail Merchandise Sales) of 2,500 ft²
- Restrooms of 500 ft²
- Future development of 2,000 ft²

Answer:

Most of the functional area types and corresponding lighting power density values can be found in Table 140.6-C. The future development area type is unknown with no built-out plan at the time of permitting, therefore the function area type is designated as "All other" with LPD of 0.4 W/ft².

- Main Entry: 0.7 W/ft^2 x 500 ft^2 = 350 W
- Corridors: 0.4 W/ft^2 x 1,500 ft^2 = 600 W
- Grocery Store (Grocery Sales): 1 W/ft^2 x 3,000 ft^2 = 3,000 W
- Retail Store (Merchandise Sales): 0.95 W/ft^2 x 2,500 ft^2 = 2,375 W
- Restrooms: 0.65 W/ft^2 x 500 ft^2 = 325 W
- Future Development (All other): 0.4 W/ft^2 x 2,000 ft^2 = 800 W
- Total = 7,450 watts for 10,000 ft^2

Example 5-20: Tunable-White and Dim-to-Warm Luminaires

Question:

Which tunable-white and dim-to-warm luminaires qualify for the additional lighting power allowance for applications in healthcare facilities?

Answer:

There is additional lighting power allowance for tunable-white and dim-to-warm luminaires for most of the healthcare/hospital function areas as specified in Table 140.6-C.

The qualified tunable-white luminaires shall be capable of color change ≥ 2000K CCT.

The qualified dim-to-warm luminaires shall be capable of color change ≥ 500K CCT.

A dim-to-warm luminaire product capable of color tune from 2700K to 1800K is acceptable and qualifies for the additional light power.

Performance Compliance Approaches

The performance approach is an alternative to the prescriptive approach. The allowed lighting power is calculated as part of the energy budget for the proposed design building. A building complies with the performance approach if the energy budget calculated for the proposed design building is no greater than the energy budget calculated for the standard design building.

Under the performance approach, the energy use of the building is modeled using a compliance software program approved by the CEC. In this energy analysis, the standard lighting power density for the building is determined by the compliance software program based on occupancy type, in accordance with either the complete building or area category method described above. This standard lighting power density is used to determine the energy budget for the building.

When a lighting permit is sought under the performance approach, the applicant uses a proposed lighting power density to determine whether or not the building meets the energy budget. If it does, this proposed lighting power density is automatically translated into the allowed lighting power for the building (by multiplying by the area of the building).

If the building envelope or mechanical systems are included in the performance analysis (because they are part of the current permit application), then the performance approach allows energy trade-offs between systems that can let the allowed lighting power go higher than any other method. Alternatively, it allows lighting power to be traded away to other systems, which would result in a lower allowed lighting power. This flexibility in establishing allowed lighting power is one of the more attractive benefits of the performance approach.

General lighting power is the power used by installed electric lighting that provides a uniform level of illumination throughout an area, exclusive of any provision for special visual tasks or decorative effect, exclusive of daylighting, and also known as ambient lighting.

Trade-offs in general lighting power are allowed between all spaces using the Area Category Method.

Also, with the Area Category Method, the Energy Code provides an additional lighting power allowance for special cases. Each of these lighting system cases is treated separately as "use-it-or-lose-it" lighting. The user receives no credit (standard design matches proposed), but there is a maximum power allowance for each item.

See the Nonresidential ACM Reference Manual for additional information.

Lighting Control Installation and Acceptance Requirements for Installers and Acceptance Test Technicians

Please refer to Chapter 5.9 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Lighting Installation Certificate Requirements (Section 130.4(b))

Please refer to Chapter 5.9.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Lighting Control Acceptance Requirements (Section 130.4(a))

Acceptance testing must be performed by a certified lighting controls acceptance test technician to certify the indoor and outdoor lighting controls serving the building, area, or site will meet the acceptance requirements.

A certificate of acceptance shall be submitted to the local enforcement agency under §10-103(a) of Part 1 and §130.4(a), that:

- Certifies that all of the lighting acceptance testing necessary to meet the requirements of Part 6 is completed.
- Certifies that the applicable procedures in Reference Nonresidential Appendix NA7.6 and NA7.8 have been followed.
- Certifies that daylight responsive controls comply with Reference Nonresidential Appendix NA7.6.1.
- Certifies that lighting shut-off controls comply with Reference Nonresidential Appendix NA7.6.2.
- Certifies that demand responsive lighting controls comply with Reference Nonresidential Appendix NA7.6.3.
- Certifies that outdoor lighting controls comply with Reference Nonresidential Appendix NA7.8.
- Certifies that lighting systems receiving the institutional tuning power adjustment factor comply with Reference Nonresidential Appendix NA7.6.4.
- Certified that demand responsive controlled receptacles comply with Reference Nonresidential Appendix NA7.6.5.

Additions and Alterations

Overview

Please refer to Chapter 5.10.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions

Please refer to Chapter 5.10.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Alterations – General Information

Scope

Please refer to Chapter 5.10.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Indoor Lighting Alteration Exceptions

Please refer to Chapter 5.10.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Skylight Exception

Please refer to Chapter 5.10.3.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Alterations – Performance Approach

Please refer to Chapter 5.10.3.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Alterations – Prescriptive Approach

Please refer to Chapter 5.10.3.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Indoor Lighting Alterations

Please refer to Chapter 5.10.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Indoor Lighting Alteration Control Requirements

The control requirements for each option are described in Table 141.0-F.

Option 1 requires indoor lighting alterations to meet all the mandatory control requirements that are applicable to the project. The control requirements include manual controls, multilevel controls, automatic shutoff controls, daylighting controls, and demand-responsive controls.

Options 2 and 3 are likely to result in a lower lighting power than Option 1; therefore, indoor lighting alterations must meet manual control and automatic shut off control requirements. In offices larger than 250 square feet, occupant sensing shutoff controls are not required for Options 2 and 3. Multilevel lighting controls (§130.1(b)), daylighting controls (§130.1(d)), and demand-responsive controls (§130.1(e)) are not required for Options 2 and 3.

Alterations to indoor lighting systems shall not prevent the operation of existing, unaltered controls and shall not alter controls to remove functions specified in §130.1. 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 §130.1(a)4 and 130.1(c)1D.

The acceptance testing requirement of §130.4 is not required for alterations where lighting controls are added to control 20 or fewer luminaires for the entire alteration project.

Example 5-21: Warehouse Luminaire Alteration With 40 Percent Lighting Power Reduction

Question:

All existing luminaires in a warehouse facility of 5,000 sq. ft. are proposed to be replaced by LED luminaires (shown below). There are 100 existing metal halide luminaires, and each uses 250 watts, all of which will be replaced. The replacement LED luminaires use 150 watts each. How is compliance being determined, and what controls are required?

Answer:

The compliance option of §141.0(b)2Iiii requires a 40 percent reduction in installed lighting power for one-to-one luminaire alterations within a building or tenant space of 5,000 square feet or less. Thus, enter the number and wattage of the existing luminaires into NRCC-LTI, and use the form to calculate both the existing installed lighting power (100 x 250 W = 25,000 W) and the maximum allowance based on a 40 percent reduction (25,000 W x 0.6 = 15,000 W). Enter the number and wattage of the new luminaires into NRCC-LTI, just like any other project. This is a one-for-one replacement, so the total lighting power of the new luminaires meets the allowance (100 x 150 W = 15,000 W).

Since the alteration meets §141.0(b)2Iiii, only manual controls and automatic shut off controls are mandatory as specified in Table 141.0-F.

Example 5-22: Lighting Wiring Alterations

Question:

If the lighting system is being rewired as part of a lighting alteration project, which Energy Code requirements must be complied with?

Answer:

Alterations to lighting wiring are considered alterations to the lighting system, so the requirements are the same as for lighting system alterations. Only altered components of the alteration must meet applicable requirements. For example, rewiring or relocating existing controls will trigger applicable requirements for the existing controls. If existing luminaires are not altered, they would not be held to alteration requirements such as lighting power allowance requirements or additional control requirements in §141.0(b)2I.

Altered lighting circuits must comply with the control requirements as specified in §130.1(a)3.

The acceptance testing requirements are triggered if controls are added to control more than 20 luminaires.

Example 5-23: Alterations Projects Replacing Both Lamps and Ballasts of the Luminaires

Question:

There are 100 lighting fixtures in an existing office space. For 20 fixtures, the internal components (lamps and ballasts) are being replaced with retrofit kits.

Which Energy Code requirements apply?

Answer:

Because 20 out of 100 (or 20 percent) of the luminaires are altered, which is more than the 10 percent of existing luminaires in the space, the alteration must meet either §141.0(b)2Ii or §141.0(b)2Iii. Moreover, removing and replacing both lamps and ballasts with retrofit kits are considered one-for-one luminaire alteration. Therefore, the alteration could meet §141.0(b)2Iiii instead of §141.0(b)2Ii or §141.0(b)2Iii if the total wattage of the altered luminaires has been reduced by at least 40 percent and if the altered building or tenant space is 5,000 square feet or less.

Example 5-24: One-for-One Alterations in Enclosed Spaces With One Luminaire

Question:

A project includes more than 50 luminaires with one-for-one alterations on a floor, but a portion of those altered luminaires are in enclosed spaces containing one luminaire.

How are the luminaires in the enclosed spaces counted toward the trigger threshold of 50 luminaires under §141.0(b)2I in a one-for-one luminaire alteration?

Answer:

Although Exception 2 to §141.0(b)2I exempts enclosed spaces with one luminaire from the requirements of §141.0(b)2I, it does not reduce the total luminaire count on a floor or a tenant space. Therefore, the altered luminaires on the floor that are not in the spaces with one luminaire are required to meet the requirements of either §141.0(b)2Ii, §141.0(b)2Iii, or §141.0(b)2Iiii.

Example 5-25: A Project with an addition of a lighting control

Question:

There is a proposed project with a 4'6" tall partition wall between two named rooms. If the partition is removed from the space and all existing luminaires are staying and an occupancy sensor is added , does it trigger the requirements of §141.0(b)2I (Indoor Lighting Alterations)?

Answer:

No, since the alterations are limited to the addition of an occupancy sensing control, it does not trigger any of the requirements of §141.0(b)2I.

Example 5-26: Daylighting Requirements for Large Enclosed Spaces

Question:

A 30,000 ft^2 addition has a 16,000 ft^2 space with an 18-ft. high ceiling and a separate 14,000 ft^2 space with a 13 ft high ceiling. The lighting power density in this building is 1 W/ft^2. Do skylights have to be installed in the portion of the building with 18-foot ceiling?

Answer:

Yes. Section 140.3(c) requires daylighting in enclosed spaces that are greater than 5,000 ft^2 directly under a roof with a ceiling height over 15 feet. In this example the area with a ceiling height greater than 15 feet is 16,000 ft^2; therefore, prescriptive daylighting requirements apply. (Note: Daylighting requirements do not apply in Climate Zones 1 and 16).

Example 5-27: Daylighting Requirements for Alterations

Question:

A preexisting air-conditioned 30,000 ft^2 warehouse with a 30 ft. ceiling and no skylights will have its general lighting system replaced as part of a conversion to a big box retail store. Are skylights prescriptively required?

Answer:

No. The general lighting system is being replaced and is not "installed for the first time." Thus, §141.0(b)2F does not apply and therefore does not trigger the requirements in §140.3(c) for daylighting.

Indoor Lighting Compliance Documents

Overview

Please refer to Chapter 5.11.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Submitting Compliance Documentation

Please refer to Chapter 5.11.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Separately Documenting Conditioned and Unconditioned Spaces

Please refer to Chapter 5.11.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compliance Documentation Numbering

Please refer to Chapter 5.11.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Certificate of Compliance Documents

Please refer to Chapter 5.11.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Certificates of Installation Documents

See Lighting Installation Certificate Requirements (Section 130.4(b)) of this chapter for additional information.

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 certificate of installation documents installed energy management control system (EMCS), two interlocked systems, lighting power adjustment factor (PAF), and additional wattage installed in a video conferencing studio.

If any of the requirements in any of these certificates of installation fail the respective installation requirements, then that application shall not be recognized for compliance with the lighting standards.

Certificate of Acceptance

Acceptance requirements ensure that equipment, controls, and systems operate as required by the Energy Code. Acceptance testing consists of:

- Visual inspection of the equipment and installation.
- 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, §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.

The acceptance tests required for nonresidential indoor lighting include:

- Shutoff controls.
- Daylight responsive controls.
- Demand-responsive lighting controls and demand-responsive controlled receptacles.
- Institutional tuning controls that qualify for a power adjustment factor.

Instructions for completing the certificates of acceptance are imbedded in the certificates. The lighting controls acceptance testing procedures are included in Nonresidential Reference Appendix NA7.6.

See Chapter 14 of this manual for additional information about acceptance requirements.

For Manufacturers and Installers

Please refer to Chapter 5.12 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Luminaire Labeling

Please refer to Chapter 5.12.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

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Outdoor Lighting

Overview

This chapter covers the Title 24, California Code of Regulations, Part 6 (Energy Code) requirements for nonresidential outdoor lighting systems design, installation, luminaires, and lighting controls. The chapter includes guidance for meeting the Energy Code and also includes installation scenarios with appropriate compliance approaches to meet the Code.

This chapter is addressed primarily to lighting designers, electrical engineers, electrical contractors, energy consultants, manufacturers, local enforcement agency staff, others working on behalf of local government building departments, and others who provide outreach and education of the Energy Code.

The 2025 Energy Code includes some updates that clarify the requirements of motion sensing controls and aid the usage of Table 140.7-B for lighting power allowance for specific applications.

Scope, Approach, and Applications

This chapter applies to all nonresidential outdoor lighting, whether attached to buildings, poles, structures or self-supporting, including, but not limited to, lighting for hardscape areas such as parking lots, lighting for building entrances, lighting for all outdoor sales areas, and lighting for building façades.

The nonresidential outdoor lighting part of the Energy Code includes minimum control requirements, maximum allowable lighting power, and shielding (uplight and glare) zonal lumen limits for outdoor luminaires.

All section and table references in this chapter refer to sections and tables contained in the Energy Code.

Refer to Chapter 7 of this manual for the sign lighting requirements.

Refer to Residential Compliance Manual Chapter 6 for information on lighting requirements for single-family residential buildings.

Refer to Multifamily Compliance Manual Chapter 6 for information on lighting requirements for multifamily buildings.

Outdoor Lighting Power Compliance Approach

Please refer to Chapter 6.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Lighting Power Trade-Offs

The Energy Code does not allow trade-offs between outdoor lighting power allowances and indoor lighting, sign lighting, heating, ventilation, and air-conditioning (HVAC) system, building envelope, or water heating (Section 140.7(a)).

There is only one type of trade-off permitted for outdoor lighting power. Allowed lighting power determined according to Section 140.7(d)1 and Table 140.7-A for general hardscape lighting may be traded to specific applications in Section 140.7(d)2 and Table 140.7-B, provided the luminaires used to determine the illuminated area are installed as designed. This means that if luminaires used to determine the total illuminated area are removed from the design, resulting in a smaller illuminated area, then the general hardscape lighting power allowance must also be reduced accordingly.

Allowed lighting power for specific applications may not be traded between specific applications or to hardscape lighting in Section 140.7(d)1. This means that for each specific application, the allowed lighting power is the smaller of the allowed power determined for that specific application according to Section 140.7(d)2, or the actual installed lighting power that is used in that specific application. These additional power allowances are "use it or lose it" allowances.

Table 6-1: Scope of the Outdoor Lighting Requirements

Lighting Applications Covered **General Hardscape (trade-offs permitted)**	**Lighting Applications Covered** **Specific Applications (trade-offs not permitted)**	**Lighting Applications Not Regulated** **(only as detailed in Section 140.7)**
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.	Canopies: Sales and Non-sales; Tunnels; Vehicle Service Station: Canopies, Hardscape, and Uncovered Fuel Dispensers; Drive-Up Windows; Building Entrances or Exits; Building Facades; Guard Stations; Hardscape Ornamental Lighting; Outdoor Dining; Primary Entrances to Senior Care Facilities, Police Stations, Healthcare Facilities, Fire Stations, and Emergency Vehicle Facilities; Outdoor Sales Lots and Frontage; Student Pick-up/Drop-off zones;	Temporary outdoor lighting. Required and regulated by the Federal Aviation Administration (FAA) and the Coast Guard. For public streets, roadways, highways, and traffic signage lighting, and lighting for driveway entrances occurring in the public right-of-way. For sports and athletic fields, and children's playground. For industrial sites. For public monuments. Signs regulated by Section 130.3 and Section 140.8. For stairs, and wheelchair elevator lifts for American with Disabilities Act compliance. For ramps that are not parking garage ramps.

	ATM Lighting; Special Security Lighting for Retail Parking and Pedestrian Hardscape; and Security Cameras.	Landscape lighting. For themes and special effects in theme parks. For outdoor theatrical and other outdoor live performances. For qualified historic buildings.

Source: California Energy Commission

Other outdoor lighting applications that are not included in Energy Code Tables 140.7-A or 140.7-B 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. The text in the above list of lighting applications that are not regulated has been shortened for brevity. Please see Outdoor Lighting Applications Not Regulated by Section 140.7 for details about unregulated lighting applications.

Outdoor Lighting Applications Not Regulated by Section 140.7

When a luminaire is installed only to illuminate one or more of the following applications, the lighting power for that luminaire shall not be required to comply with the lighting power requirements in Section 140.7(a). Refer to the right column of Table 6- 1: Scope of the Outdoor Lighting Requirements for a quick reference to the lighting applications that are not required. Also, the Energy Code clarifies that at least 50 percent of the light from the luminaire must fall within an application to qualify as being installed for that application.

Outdoor Lighting Zones

Reference: Section 10-114(a), Section 10-114(b), Section 10-114(c)

The Energy Code allows outdoor lighting power based on the brightness of the surrounding conditions. Lighting power allowances for new lighting installations and specific alterations depend on the lighting zone (LZ) in which the project is located.

The outdoor lighting zones types as defined are: LZ0, LZ1, LZ2, LZ3, and LZ4. LZ0 is intended for undeveloped spaces in parks and wildlife preserves and is very low ambient illumination - such as in national parks and other areas intended to be very dark at night. LZ1 is assigned with the least power, and increasingly more power is allowed in LZ2, LZ3, and LZ4. LZ1, LZ2, and LZ3 are designated according to 2020 U.S. Census definitions for rural areas and urban areas. LZ4 is intended for high-intensity nighttime use, such as entertainment or commercial districts or areas with special security considerations requiring very high light levels.

The eyes adapt to darker surrounding conditions, and less light is required to properly see. When the surrounding conditions get brighter, more light is needed to see. Providing greater power than is needed potentially leads to debilitating glare and an increasing spiral of brightness as overbright projects populate surrounding conditions causing future projects to unnecessarily require greater power resulting in wasted energy.

Table 10-114-A tabulates the statewide default locations for outdoor lighting zones. See Parks, Recreation Areas, and Wildlife Preserves (Very Low Ambient Illumination) through Urban Areas (With Moderately High Ambient Illumination) for narratives about outdoor lighting zone types and Determining the Lighting Zone for an Outdoor Lighting Project for how to determine their designations.

Parks, Recreation Areas, and Wildlife Preserves (Very Low Ambient Illumination)

Please refer to Chapter 6.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Rural Areas (Low Ambient Illumination)

Please refer to Chapter 6.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Urban Areas (With Moderate Ambient Illumination)

The default lighting zone for urban areas as defined by the U.S. Census Bureau is Lighting Zone 2 and it depends on what the building types are located on the zone for the determination of Lighting Zone 2. For example, an urban area with multifamily housing, mixed use residential neighborhoods, religious facilities, schools, light commercial business districts, and industrial zoning districts is deemed (defaulted) to be in Lighting Zone 2.

However, local jurisdictions may designate certain areas as either Lighting Zone 3 or Lighting Zone 4. Examples of areas that might be designated Lighting Zone 3 are special commercial districts or areas with special security considerations located within a mixed-use residential area or city center.

Local jurisdictions also may designate default Lighting Zone 2 areas as Lighting Zone 1, which would establish lower lighting power for outdoor areas with lower surrounding brightness. An example of an area that might be changed to Lighting Zone 1 would include an undeveloped, environmentally sensitive, or predominately residential area within a default Lighting Zone 2 area.

Urban Areas (With Moderately High Ambient Illumination)

Lighting Zone 3 is the default for urban areas, as defined by the U.S. Census Bureau and it depends on what the building types are located on the zone for the determination of Lighting Zone 3. For example, an urban area with high intensity commercial corridors, entertainment centers, heavy industrial zone districts, and manufacturing zone districts is deemed to be in Lighting Zone 3. Local jurisdictions may designate areas as Lighting Zone 4 for high-intensity nighttime use, such as entertainment, commercial districts, or areas with special security considerations requiring very high light levels.

Local jurisdictions also may designate default Lighting Zone 3 areas as Lighting Zone 2 or Lighting Zone 1 if deemed appropriate.

Determining the Lighting Zone for an Outdoor Lighting Project

Permit applicants may determine the lighting zone for a particular property using the following steps.

For government-designated parks, recreation areas, wildlife preserves and Lighting Zone 4 (LZ4):

- 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:

- 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.
- The U.S. Census Bureau website can be used to determine if the property is within rural areas or urban areas – a rural area is defaulted as Lighting Zone 1 (LZ1), an urban area is defaulted as Lighting Zone 2 or 3. Using an online tool provided by the U.S. Census Bureau on https://geocoding.geo.census.gov/geocoder/geographies/address?form can be entered to look up geography results indicating whether the address is within a rural area or an urban area. Figure 6-1: Example-1 of U.S. Census Bureau Tool, Figure 6-2: Example-2 of U.S. Census Bureau Tool, and Figure 6-3: Example-3 of U.S. Census Bureau Tool shows screen images of using the U.S. Census Bureau online tool.

Figure 6-1: Example-1 of U.S. Census Bureau Tool

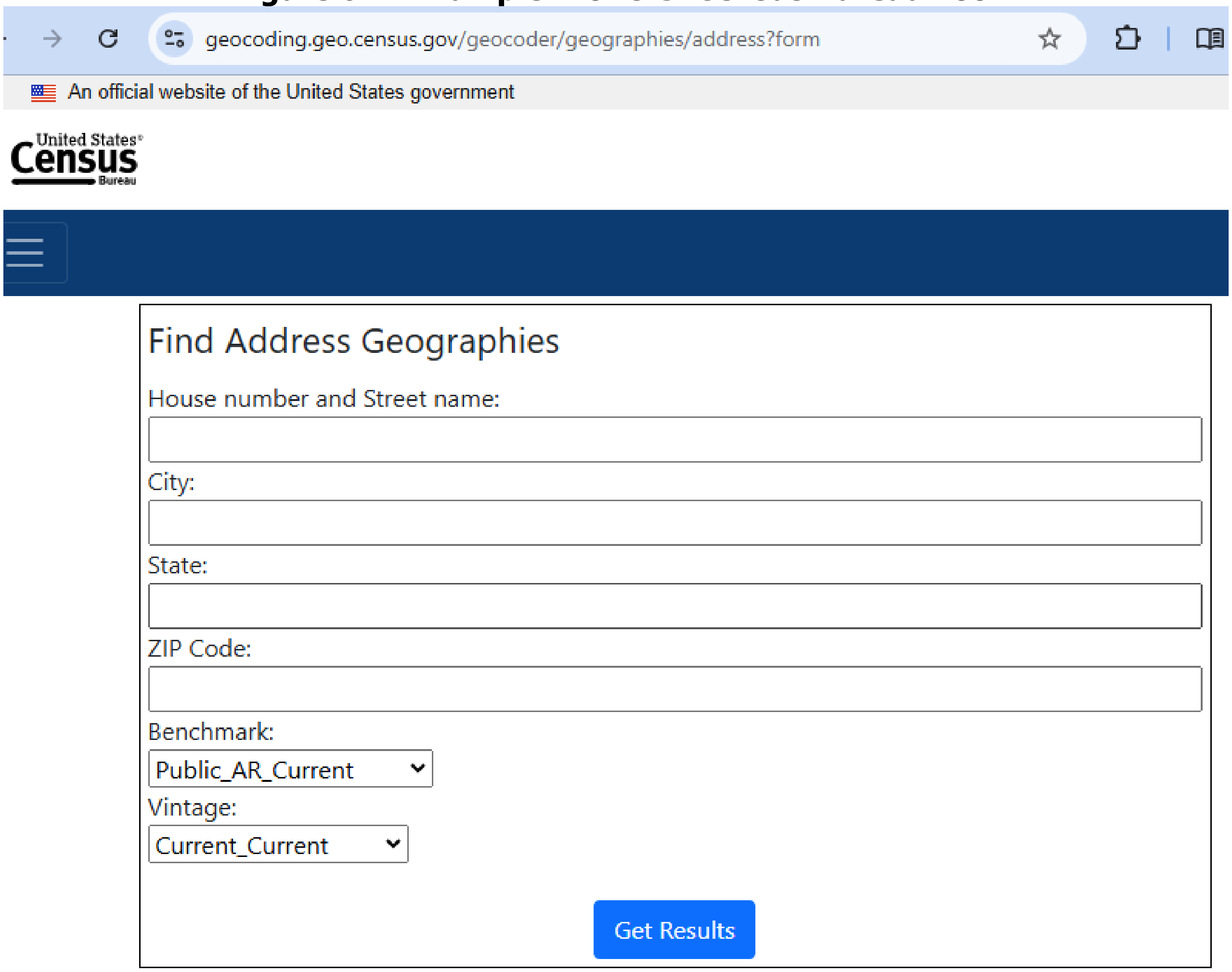


Image Source: California Energy Commission (the image is extracted from the U.S. Census Bureau website)

Figure 6-2: Example-2 of U.S. Census Bureau Tool

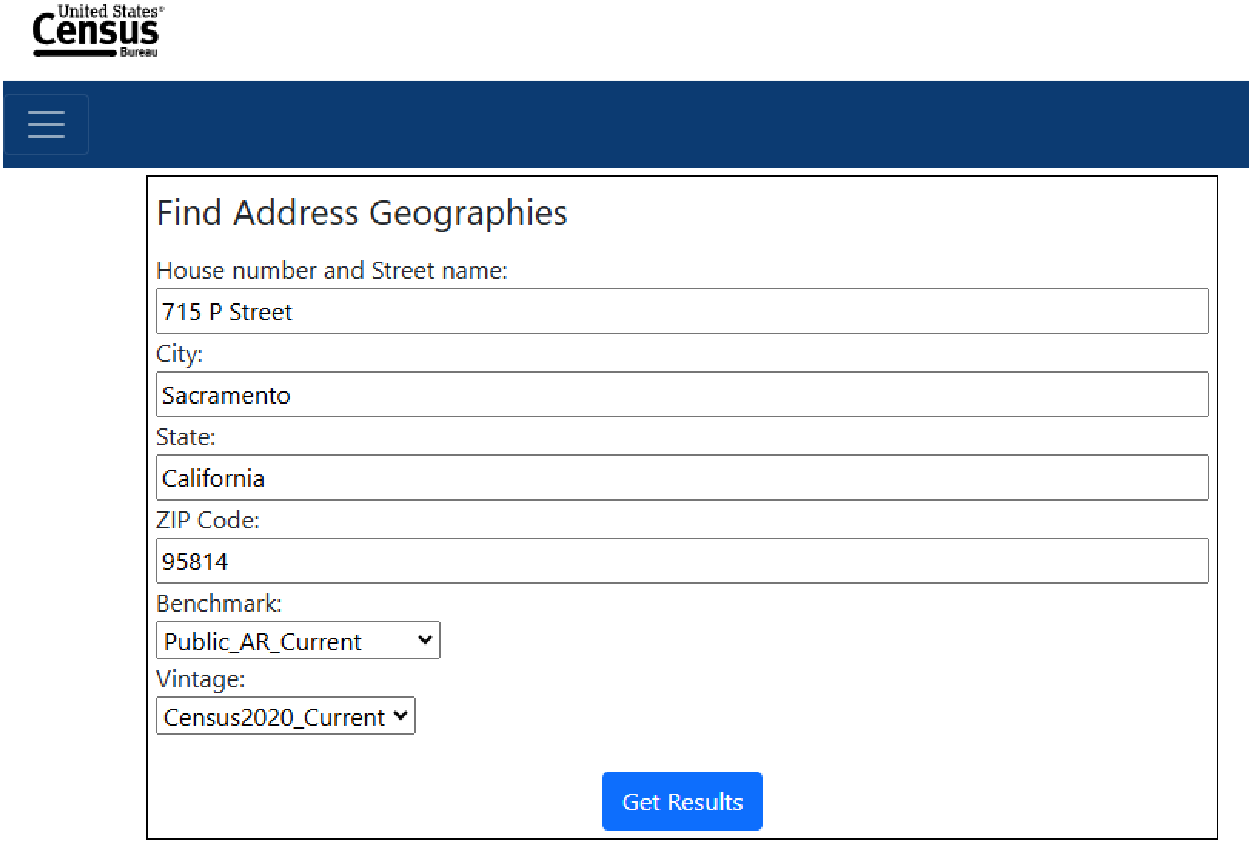


Image Source: California Energy Commission (the images are extracted from the U.S. Census Bureau website)

Figure 6-3: Example-3 of U.S. Census Bureau Tool

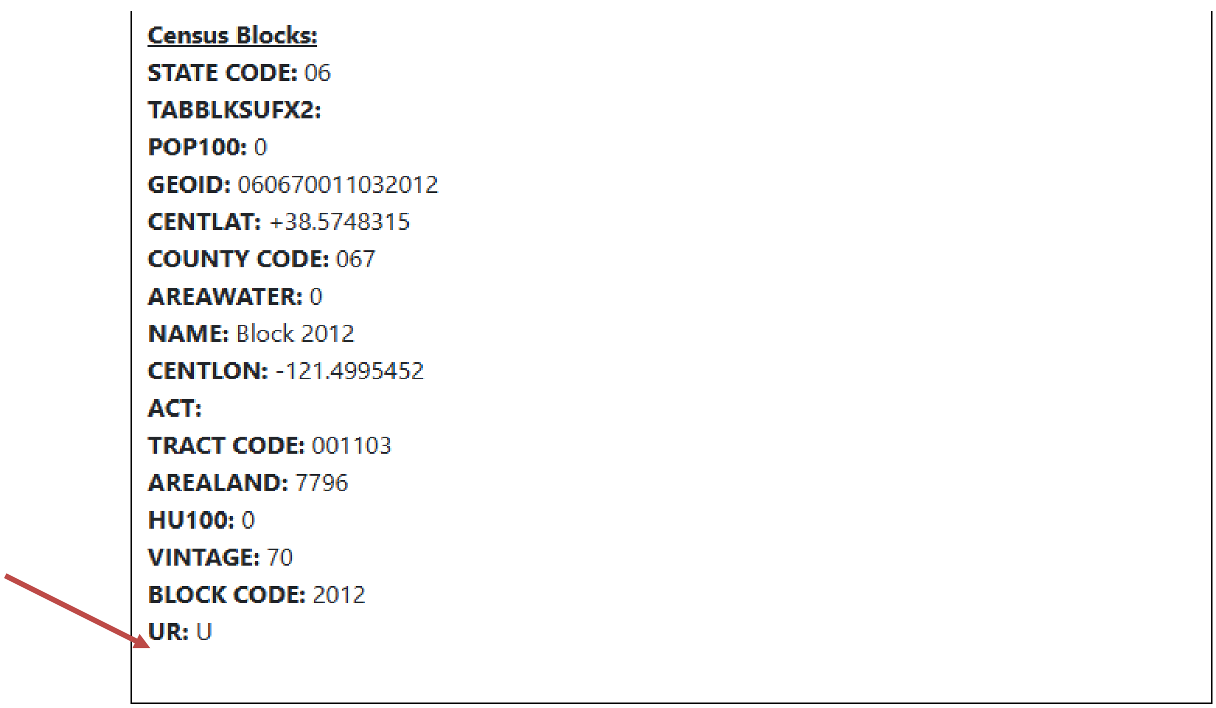


Image Source: California Energy Commission (the images are extracted from the U.S. Census Bureau website)

Lighting Zone Adjustments by Local Jurisdictions

Reference: Section 10-114, Table 10-114-A

The CEC sets statewide default lighting zones. However, local jurisdictions (usually a city or county) may change lighting zones to accommodate local conditions. A local jurisdiction may designate a portion of Lighting Zones 2 or 3 as Lighting Zone 3 or 4. The local jurisdiction also may designate a portion of Lighting Zone 3 to Lighting Zone 2 or even Lighting Zone 1. 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.

Example 6-1: Changing the Default Lighting Zone

Question:

I want to have the default outdoor lighting zone for a particular piece of property changed. How do I accomplish that?

Answer:

Check with the local jurisdiction having authority over the property and ask them how to petition to have the default outdoor lighting zone officially adjusted.

Mandatory Requirements

Please refer to Chapter 6.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Luminaire Shielding and CALGreen BUG Requirements

Reference: Section 130.2(b)

The Energy Code includes outdoor luminaire shielding requirements based on the luminaire's initial lumen rating. All outdoor luminaires that emit 6,200 initial lumens or greater must comply with backlight, uplight, and glare (BUG) requirements contained in Section 5.106.8 of the CALGreen Code (Title 24, Part 11).

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 neighbors' properties is reduced. The BUG requirements vary by outdoor lighting zones, which are described in Outdoor Lighting Zones.

Luminaire manufacturers are aware of the technical details of the BUG ratings and 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 CALGreen and the Energy Code.

The following are the exceptions in CALGreen Section 5.106.8: (The information is extracted from the CALGreen Code):

- Luminaires that qualify as exceptions in Sections 130.2(b) and 140.7 of the California Energy Code
- Emergency lighting
- Building façade meeting the requirements in Table 140.7-B of the California Energy Code, Part 6
- Custom features as allowed by the local enforcing agency, as permitted by Section 101.8 Alternate materials, designs and methods of construction (of the CALGreen Code).
- Luminaires with less than 6,200 initial luminaire lumens

The following are exceptions in Section 130.2 of the Energy Code for outdoor lighting applications that are not required to meet the luminaire shielding requirements. In some of these applications, lighting directed sideways and upwards may be desirable.

- Signs.
- Lighting for building façades, public monuments, public art, statues, and vertical surfaces of bridges.
- Lighting required by a health or life safety statute, ordinance, or regulation that may fail to meet the uplight and glare limits due to application limitations.
- Temporary outdoor lighting that does not persist beyond 60 consecutive days or more than 120 days per year.
- Replacement of existing pole mounted luminaires in hardscape areas that are spaced more than six times the mounting height of the existing luminaires and the replacement luminaire wattage is less than or equal to the wattage of the original luminaires. In addition:
    - Where the existing luminaire does not meet the BUG requirements in Section 130.2(b).
    - Where no additional poles are being added to the site.
    - Where new wiring to the luminaires is not being installed.
- Luminaires that light the public right of way including publicly maintained or utility-maintained roads, sidewalks, or bikeways.
- Luminaires that qualify as exceptions in Section 140.7(a).

In addition, a local ordinance may have a more stringent outdoor lighting BUG requirements than that of the CALGreen Code — the local ordinance would govern the outdoor lighting BUG requirements in that scenario.

Example 6-2

Question:

Which outdoor lighting are not required to meet the CALGreen requirements in Section 5.106.8?

Answer:

Certain categories of outdoor lighting luminaires are not required to meet the light pollution reduction requirements of CALGreen Code Section 5.106.8, and they are as follows.

First, outdoor lighting luminaires with less than 6,200 initial luminaire lumens are not required.

Second, listed below are additional outdoor lighting luminaires which are also not required. (Listed below are for a quick reference. For more details, see the box further below.)

- Outdoor lighting with custom features as allowed by Section 5.106.8 of the California CALGreen Code.
- Outdoor luminaires that are not required to meet as specified in Section 130.2(b) and Section 140.7 of the California Energy Code.
- Building façade lighting indicated in Table 140.7-B of the California Energy Code.
- Emergency lighting.

Example 6-3

Question:

How do you determine the glare rating for a luminaire located in Lighting Zone 3?

Reference:

(Relevant information extracted from the CALGreen Code and they are included here for reference.)

CALGreen 5.106.8.2 Facing – Glare.

For luminaires covered by Section 5.106.8.1 of the CALGreen Code, if a property line also exists within or extends into the front hemisphere within two mounting heights (2 MH) of the luminaire, then the luminaire shall comply with the more stringent glare rating specified in Table 5.106.8 based on the lighting zone and distance to the nearest point on the nearest property line within the front hemisphere.

Figure 6-4: CALGreen Table 5.106.8

TABLE 5.106.8 [N]
MAXIMUM ALLOWABLE BACKLIGHT, UPLIGHT AND GLARE (BUG) RATINGS[1,2]

ALLOWABLE RATING	LIGHTING ZONE LZ0	LIGHTING ZONE LZ1	LIGHTING ZONE LZ2	LIGHTING ZONE LZ3	LIGHTING ZONE LZ4
Maximum Allowable Backlight Rating (B)					
Luminaire greater than 2 mounting heights (MH) from property line	N/A	No Limit	No Limit	No Limit	No Limit
Luminaire back hemisphere is 1 – 2 MH from property line	N/A	B2	B3	B4	B4
Luminaire back hemisphere is 0.5 – 1 MH from property line	N/A	B1	B2	B3	B3
Luminaire back hemisphere is less than 0.5 MH from property line	N/A	B0	B0	B1	B2
Maximum Allowable Uplight Rating (U)					
For area lighting[3]	N/A	U0	U0	U0	U0
For all other outdoor lighting, including decorative luminaires	N/A	U1	U2	U3	U4
Maximum Allowable Glare Rating (G)					
Luminaire greater than 2 MH from property line	N/A	G1	G2	G3	G4
Luminaire front hemisphere is 1 – 2 MH from property line	N/A	G0	G1	G1	G2
Luminaire front hemisphere is 0.5 – 1 MH from property line	N/A	G0	G0	G1	G1
Luminaire front hemisphere is less than 0.5 MH from property line	N/A	G0	G0	G0	G1

1. IESNA Lighting Zones 0 are not applicable; refer to Lighting Zones as defined in the *California Energy Code* and Chapter 10 of the *California Administrative Code*.
2. For property lines that abut public walkways, bikeways, plazas and parking lots, the property line may be considered to be 5 feet beyond the actual property line for purpose of determining compliance with this section. For property lines that abut public roadways and public transit corridors, the property line may be considered to be the centerline of the public roadway or public transit corridor for the purpose of determining compliance with this section.
3. General lighting luminaires in areas such as outdoor parking, sales or storage lots shall meet these reduced ratings. Decorative luminaires located in these areas shall meet *U*-value limits for "all other outdoo lighting."

5.106.8.1 Facing – Backlight.

Images Source: California Energy Commission. (The information is extracted from the CALGreen Code and included here for reference.)

Answer:

Start by looking up Table 5.106.8 of CALGreen Code.

Refer to Column 5 for Lighting Zone 3. The top rows show the backlight rating, the two rows in the middle show the uplight rating, and the bottom rows show the glare rating.

Next, determine the glare rating from the bottom rows and locate the values from Column 5.

See below for a summary of information related to the luminaires in this example for Lighting Zone 3.

Figure 6-5: Extract From CALGreen Code

Luminaire greater than 2 mounting heights (MH) from property line	Glare rating of G3 or less
Luminaire back/front hemisphere is 1 — 2 MH from property line	Glare rating of G1 or less
Luminaire back/front hemisphere is 0.5 — 1 MH from property line	Glare rating of G1 or less
Luminaire back/front hemisphere is less than 0.5 MH from property line	Glare rating of G0 or less

Images Source: California Energy Commission. (The information is extracted from the CALGreen Code and included here for reference to the above example.)

The maximum allowable glare rating for Lighting Zone 3 ranges from G3, G2, G1, and G0 and the glare rating would depend on the location of the luminaire from a property line.

The glare rating is the maximum allowable rating and therefore any rating that is less than the maximum rating is also allowed. For luminaires located greater than two mounting heights from a property line, a luminaire with a glare rating of G3, G2, G1, or G1 meets the requirement.

Example 6-4

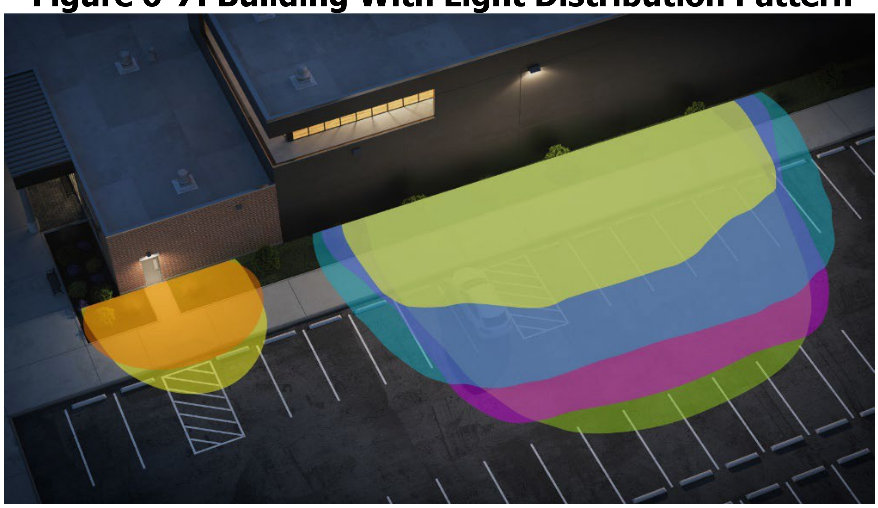
Question:

How do you determine glare requirements for the luminaires shown in the pictures below and are located in Lighting Zone 3?

Figure 6-6: Building With Wall-Mounted Luminaires

Source: courtesy of Lithonia Lighting, a part of Acuity Brands Lighting & Controls.

Figure 6-7: Building With Light Distribution Pattern



Source: courtesy of Lithonia Lighting, a part of Acuity Brands Lighting & Controls.

Answer:

First, determine if the luminaire is located within two mounting heights (2 MH) of distance from property line, and refer to Table 5.106.8 of the CALGreen code for the allowable glare rating.

If the distance is greater than 2 MH, the glare rating of the luminaire must be G3 or less (i.e., G2, G1 or G0).

If the distance is within one to two mounting heights (MH) of distance from the property line, the glare rating of the luminaire must be G1 or less (i.e., G0).

Similarly, if the distance is within a half to one mounting height of distance from the property line, the glare rating of the luminaire must be G1 or less (i.e., G0).

If the distance is less than a half mounting height of distance from the property line, the glare rating of the luminaire must be G0.

The above could also be summarized in a tabular format as follows.

Figure 6-8: Extract From CALGreen Code

Luminaire greater than 2 mounting heights (MH) from property line	Glare rating of G3 or less
Luminaire back/front hemisphere is 1 — 2 MH from property line	Glare rating of G1 or less
Luminaire back/front hemisphere is 0.5 — 1 MH from property line	Glare rating of G1 or less
Luminaire back/front hemisphere is less than 0.5 MH from property line	Glare rating of G0 or less

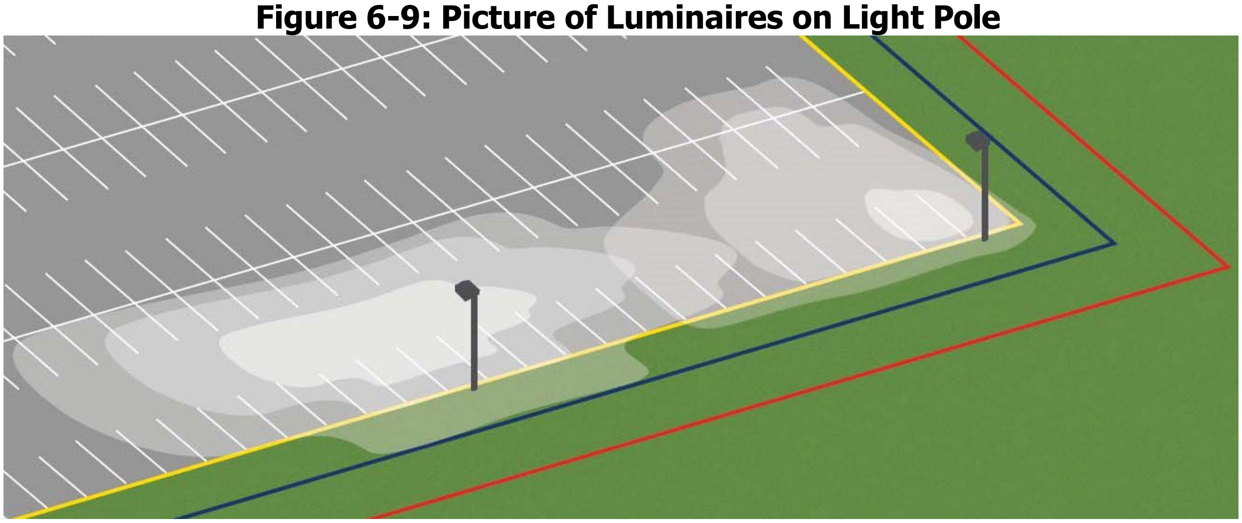
Source: California Energy Commission. (The information is extracted from the CALGreen Code Table 150.6.8 and included here for reference to the above example.)

Example 6-5

Question:

How do you determine backlight requirements for the luminaire shown in the picture below and the luminaires are located in Lighting Zone 3?

Figure 6-9: Picture of Luminaires on Light Pole



Source: courtesy of Lithonia Lighting, a part of Acuity Brands Lighting & Controls.

Reference:

(This information below is extracted from the CALGreen Code and included here for reference.)

CALGreen 5.106.8.1 Facing — Backlight
Luminaires within two mounting heights (2 MH) of a property line shall be oriented so that the nearest property line is behind the fixture and shall comply with the backlight rating specified in Table 5.106.8 based on the lighting zone and distance to the nearest point of that property line.
Exception: Corners. If two property lines (or two segments of the same property line) have equidistant points to the luminaire, then the luminaire may be oriented so that the intersection of the two lines (the corner) is directly behind the luminaire. The luminaire shall still use the distance to the nearest point(s) on the property lines to determine the required backlight rating.

Figure 6-10: CALGreen Table 5.106.8

TABLE 5.106.8 [N]
MAXIMUM ALLOWABLE BACKLIGHT, UPLIGHT AND GLARE (BUG) RATINGS[1,2]

ALLOWABLE RATING	LIGHTING ZONE LZ0	LIGHTING ZONE LZ1	LIGHTING ZONE LZ2	LIGHTING ZONE LZ3	LIGHTING ZONE LZ4
> **Maximum Allowable Backlight Rating (B)**					
Luminaire greater than 2 mounting heights (MH) from property line	N/A	No Limit	No Limit	No Limit	No Limit
Luminaire back hemisphere is 1 – 2 MH from property line	N/A	B2	B3	B4	B4
Luminaire back hemisphere is 0.5 – 1 MH from property line	N/A	B1	B2	B3	B3
Luminaire back hemisphere is less than 0.5 MH from property line	N/A	B0	B0	B1	B2
Maximum Allowable Uplight Rating (U)					
For area lighting[3]	N/A	U0	U0	U0	U0
For all other outdoor lighting, including decorative luminaires	N/A	U1	U2	U3	U4
> **Maximum Allowable Glare Rating (G)**					
Luminaire greater than 2 MH from property line	N/A	G1	G2	G3	G4
Luminaire front hemisphere is 1 – 2 MH from property line	N/A	G0	G1	G1	G2
Luminaire front hemisphere is 0.5 – 1 MH from property line	N/A	G0	G0	G1	G1
Luminaire front hemisphere is less than 0.5 MH from property line	N/A	G0	G0	G0	G1

1. IESNA Lighting Zones 0 are not applicable; refer to Lighting Zones as defined in the *California Energy Code* and Chapter 10 of the *California Administrative Code*.
2. For property lines that abut public walkways, bikeways, plazas and parking lots, the property line may be considered to be 5 feet beyond the actual property line for purpose of determining compliance with this section. For property lines that abut public roadways and public transit corridors, the property line may be considered to be the centerline of the public roadway or public transit corridor for the purpose of determining compliance with this section.

\> 3. General lighting luminaires in areas such as outdoor parking, sales or storage lots shall meet these reduced ratings. Decorative luminaires located in these areas shall meet *U*-value limits for "all other outdoo lighting."

\>

5.106.8.1 Facing – Backlight.

Images Source: California Energy Commission. (The information is extracted from the CALGreen Code and included here for reference.)

(The above information is extracted from the CALGreen Code and included here for reference.)

Answer:

First, if the luminaire is located at more than two mounting height (2 MH) of distance from the property line, there is no mandatory backlight rating (no limit on backlight) for the luminaire.

For a luminaire located within two mounting height (2 MH) of distance from the property line and that is not exempt, the luminaire must comply with the backlight rating listed in Table 5.106.8.

For a luminaire located in Lighting Zone 3 (LZ3) and within one to two mounting heights (MH) of distance from the property line, the backlight rating of the luminaire must be B4 or less (i.e., B3, B2, B1 or B0).

For the same luminaire in LZ3 and within a half to one mounting height of distance from the property line, the backlight rating of the luminaire must be B3 or less (i.e., B2, B1 or B0).

For the same luminaire in LZ3 and located less than a half mounting height of distance from the property line, the backlight rating of the luminaire must be B1 or less (i.e., B0).

The above information could also be summarized in a tabular format below.

Figure 6-11: Extract From CALGreen Code

Luminaire greater than 2 mounting heights (MH) from property line	No limit
Luminaire back hemisphere is 1 - 2 MH from property line	B4 or less
Luminaire back hemisphere is 0.5 - 1 MH from property line	B3 or less
Luminaire back hemisphere is less than 0.5 MH from property line	B1 or less

Images Source: California Energy Commission. (The information is extracted from the CALGreen Code Table 150.6.8 and included here for reference to the above example.)

(This information is extracted from the CALGreen Code.)

Example 6-6: Defining the Property Line for the Purpose of BUG Rating Compliance

Question:

Where is the property line if the area under construction is located next to a public road?

Answer:

For a property line that abuts a public roadway or transit corridor, the property line may be the centerline of the public roadway or transit corridor.

For a property line that is next to a public walkway, bikeway, plaza, or parking lot, the property line may be 5 feet beyond the actual property line.

Example 6-7: Luminaire Classification for Outdoor Luminaires

Question:

What is the IES BUG system for outdoor luminaires?

Answer:

Illuminating Engineering Society (IES) published the technical memorandum ’Luminaire Classification for Outdoor Luminaires’ (document TM-15-20). This document defines three-dimensional regions of analysis for exterior luminaires and further establishes zonal lumen limits for these regions as part of a larger method of categorizing outdoor lighting equipment into backlight, uplight, and glare components. Collectively, the three components are referred to as the BUG system.

The zonal lumen limits per secondary solid angles for uplight and glare are based upon the methodology found in TM-15. The lighting zone in which the project is located determines the maximum zonal lumens for backlight, uplight, and glare.

To comply with this mandatory measure, the luminaire must not exceed the maximum zonal lumen limits for each secondary solid angle region per lighting zone. The zonal lumen values in a photometric test report must include any tilt or other nonlevel mounting condition of the installed luminaire. The BUG rating requirements can be found in CALGreen Code Section 5.106.8.

The BUG rating for luminaires may be determined with outdoor lighting software or by contacting the manufacturer. There is also software available to produce a BUG rating for a tilted luminaire condition (which is not a typical circumstance for most applications). Since the California BUG limits and calculation procedures match the IES, no deviation from the IES BUG rating is necessary.

Example 6-8: Wallpacks and Zonal Lumen Limits

Question:

A new parking lot adjacent to a building is being designed to be illuminated by wall packs rated at 7,000 initial luminaire lumens. The wall packs are mounted on the side of the building, and their main purpose is parking lot illumination. But they are also illuminating the façade of the building. Do these wall packs have to meet the backlight, uplight, and glare (BUG) rating limits?

Answer:

Yes, these 7,000 lumen wall packs will have to meet the BUG rating requirements because the main purpose is parking lot illumination. Luminaire mounting methods or locations do not necessarily determine the purpose of the illumination. Define the function of the luminaire by determining what the majority of the light is striking. For a typical wall pack, 80% or more of the light is likely striking the parking lot or sidewalk in front of the building, and only 20% or less on the façade, so BUG rating limits apply.

Each luminaire must be appropriately assigned to the function area that it is illuminating, whether it is mounted to a pole, building, or other structure. Only luminaires that are rated less than 6,200 initial luminaire lumens or outdoor lighting applications that are not required to meet the backlight, uplight, and glare (BUG) requirements in the Energy Code.

Example 6-9: Tilted Luminaires Meeting the BUG Requirements

Question:

If a low BUG rating luminaire is mounted at a tilt, does it still meet the BUG requirements?

Answer:

It depends. Luminaires that meet the zonal lumen limits when mounted at 90° to nadir may or may not comply with the BUG rating limits when they are mounted at a tilt.

For a tilted luminaire to meet this requirement, a photometric test report must be provided showing that the luminaire meets the zonal lumen limits at the proposed tilt. There are lighting design software available to calculate a BUG rating for a tilted luminaire, or this can be provided by the manufacturer.

Requirements for Outdoor Lighting Controls

Reference: Section 130.2(c)

The primary requirements for outdoor lighting controls are as follows:

- Daylight Availability: All outdoor lighting shall be automatically controlled so that lighting is off when daylight is available (Section 130.2(c)1).
- Automatic Scheduling Controls: All outdoor lighting shall be automatically controlled by a time-based scheduling control (Section 130.(c)2).
- Motion-Sensing Controls: Outdoor luminaires greater than 40 watts and mounted 24 ft or less above the ground shall be controlled by motion-sensing controls. This applies to luminaires providing general hardscape lighting, outdoor sales lot lighting, vehicle service station hardscape lighting, or vehicle service station canopy lighting (Section 130.2(c)3).

Outdoor lighting control requirements do not apply to any of the following lighting applications:

- Lighting where a health or life safety statute, ordinance, or regulation prohibits outdoor lighting to be turned OFF or reduced.
- Lighting in tunnels required to be illuminated 24 hours per day and 365 days per year.

Example 6-10: Circuiting of Non-Outdoor Lighting Load

Question:

Can irrigation controllers be on the same power circuit as lighting?

Answer:

The outdoor lighting load may be on the same circuit with other electrical loads if the outdoor lighting load is independently controlled from all other electrical loads.

Daylight Availability

Reference: Section 130.2(c)1

All installed outdoor lighting must be controlled by a photocontrol, astronomical time-switch control, or other controls that automatically turns off the outdoor lighting when daylight is available.

- 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.
- Astronomical time-switch controls require an initial setup of the time clock device, which may include the entry of the current date and time (and 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.

Automatic Scheduling Controls

Reference: Section 130.2(c)2

All installed outdoor lighting 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.

There are applications in which there are benefits to employ both motion-sensing controls and automatic scheduling controls. Some lighting applications will require both control types.

Example 6-11: Using Automatic Scheduling Controls Plus Some Other Controls

Question:

Can motion-sensing controls be used together with automatic scheduling controls?

Answer:

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.

Example 6-12: Using Automatic Scheduling Controls for Buildings That Operate 24x7

Question:

Is the automatic scheduling control requirement applicable to a building occupied 24 hours per day, seven days per week?

Answer:

Yes, automatic scheduling controls are required for buildings that are occupied 24 hours per day, seven days per week.

Business activities can change over time as business models and hours of operation evolve. The required nighttime periods of a scheduled occupied period and a scheduled unoccupied period are decided by the building owner or the building operator, as appropriate, to suit the business needs.

Acceptance Tests Required for Automatic Scheduling Controls

Outdoor automatic scheduling controls are required to have acceptance testing conducted to confirm the appropriate schedules are programmed and the controls operate per the programmed schedule. The acceptance test procedures are detailed in Reference

Nonresidential Appendix NA7.8.5. Refer to Acceptance Testing of this manual for details about outdoor lighting controls acceptance test.

Motion-Sensing Controls

Reference: Section 130.2(c)3

Outdoor luminaires greater than 40 watts, where the bottom of the luminaire is mounted 24 ft. or less above the ground, shall be operated with motion-sensing controls if they are used in the following applications:

- General hardscape lighting including parking lot lighting.
- Lighting for vehicle service station hardscape and vehicle service station canopy
- Lighting for outdoor sales lots, sales canopies, and non-sales canopies

The motion sensing controls shall:

- Be capable of reducing the lighting power of each luminaire by 50 to 90 percent, and separately be capable of turning the luminaire off during unoccupied periods.
- Be capable of reducing the lighting to the dim or off state within 15 minutes of vacancy detection and turning the lighting back on upon occupancy.
- Control no more than 1,500 watts of lighting power by a single sensor or as a single zone.

Exceptions to Motion-Sensing Control Requirements

Luminaires serving the following applications are not required to have motion-sensing controls:

- Lighting for building façades, ornamental hardscape, and outdoor dining.
- Luminaires with a rated wattage of 40 watts or less.
- Building mounted luminaires, pole-mounted luminaries, and other outdoor luminaires mounted greater than 24 feet above grade.
- Lighting subject to 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.

In addition, the lighting applications listed as exceptions to Section 140.7(a) are not required to meet the motion controls requirements of Section 130.2(c)3 when more than 50 percent of the light is from a luminaire of the listed lighting application. The applications include temporary outdoor lighting, lighting of signs, lighting for public monuments, and landscape lighting. The complete listing can be found in Section 140.7(a). Exempt lighting applications are also provided in Table 6-1: Scope of the Outdoor Lighting Requirements.

Acceptance Tests Required for Motion-Sensing Controls

Motion-sensing controls are required to have an acceptance testing conducted to confirm that the sensor can sense activity within the detection zone and turn lighting on when occupancy is detected and reduce or turn lighting off within 15 minutes of vacancy detected. The acceptance test procedures are detailed in Reference Nonresidential Appendix NA7.8.1. Refer to Acceptance Testing of this manual for details about outdoor lighting controls acceptance test.

Lighting Control Functionality

Please refer to Chapter 6.4.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Requirements

Outdoor Lighting Power Compliance

Please refer to Chapter 6.5.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

General Hardscape Lighting Power Allowance

The general hardscape allowance is calculated based on the general hardscape area, perimeter length, and lighting zone that the property is located in.

Calculation of Allowed Lighting Power — General Hardscape Lighting Power Allowance

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.

Determine the general hardscape lighting power allowances as follows:

- 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. 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 10 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 140.7-A for the appropriate lighting zone.
- Determine the perimeter length of the general hardscape area. The total hardscape perimeter is the length of the actual perimeter of the illuminated hardscape on the property. It shall not include portions of hardscape that are not illuminated according to Section 140.7(d)1A. Multiply the hardscape perimeter by the linear wattage allowance (LWA) for hardscape from Table 140.7-A for the appropriate lighting zone. Generally, if there is an enclosed exclusion in the area AWA calculation, the perimeter may be included in the LWA calculation.
- The perimeter length for hardscape around landscaped areas and permanent planters shall be determined as follows:
    - Landscaped areas completely enclosed within the hardscape area, and with a width or length a minimum of 10 feet wide, shall have the perimeter of the

    - landscaped areas or permanent planter added to the hardscape perimeter length.
    - Landscaped areas completely enclosed within the hardscape area, and with a width or length less than 10 feet wide, shall not be added to the hardscape perimeter length.
    - Landscaped edges that are not abutting the hardscape shall not be added to the hardscape perimeter length.
- Determine the initial wattage allowance (IWA). The IWA can be used one time per site. The purpose is to provide additional watts for small sites, or for odd hardscape geometries. Add the IWA for general hardscape lighting from Table 140.7-A for the appropriate lighting zone.
- The general hardscape lighting allowance shall be the sum of the allowed watts determined from the first three bullet points above.

Refer to Outdoor Lighting Power Compliance Approach for a concept layout of the general hardscape lighting allowance for area, and perimeter, as well as initial wattage allowance.

The allowed lighting power for general hardscape lighting is calculated using the following components:

- Area wattage allowance (AWA), which is expressed in watts per sq. ft.
- Linear wattage allowance (LWA), which is expressed in watts per linear foot.
- Initial wattage allowance (IWA), which is a flat allowance for each property and is expressed in watts.

To determine the total allowed power for general hardscape lighting, use the equation:

- General Hardscape Lighting Power Allowance = (Hardscape Area x AWA) + (Perimeter Length of Hardscape Area x LWA) + IWA

Example 6-15: Outdoor Lighting for Healthcare Facilities

Question:

Is the parking lot outside of a healthcare facility ("I" occupancy) regulated by the Energy Code?

Answer:

Healthcare facilities overseen by the California Department of Health Care Access and Information (HCAi) (previously California Office of Statewide Health Planning and Development (OSHPD must comply with California Energy Code including the outdoor lighting requirements for all outdoor areas of healthcare facilities. For outdoor lighting, a licensed healthcare facility must meet the outdoor lighting power requirements as specified in Section 140.7 as well as the outdoor lighting control requirements in Section 130.2.

Example 6-16: Hardscape Materials for Parking Lots

Question:

Our overflow parking lot is covered with gravel. Is this parking lot considered "hardscape," and must it comply with the Energy Code?

Answer:

Yes, parking lots covered with gravel, or any other material used to enhance the surface to accommodate parking or travel, such as pavers, asphalt, cement, deck board, or other pervious or impervious materials are considered hardscape and must comply with the requirements for hardscape areas. Note that the updates to 140.7-A now cover all hardscape materials to the same power allowances.

Example 6-17: Power Allowance for a Parking Lot

Question:

In a parking lot in front of a retail store, we are not using the full general lighting power allowed according to Table 140.7-A. Can we use the remaining allowance to illuminate the building entrance and the walkways near the store to a higher level?

Answer:

Yes. Because the general hardscape power allowance is tradable, you may use the unused portion of the power allowance from the parking lot to increase the illumination levels for other lighting applications, including building entrance and walkway areas.

Example 6-18: Calculating the Illuminated Area of a Parking Lot

Question:

A parking lot is illuminated by five cut-off wall packs mounted to an adjacent building. The parking lot extends 100 ft. from the building. The luminaires are mounted at a height of 15 ft. above the ground and spaced 50 ft. apart. How large is the illuminated area?

Answer:

The illuminated area extends a distance equal to five times the mounting height in three directions. (The fourth direction is not counted because it is obstructed by the building.) The illuminated area, therefore, extends from the building 75 ft. The total illuminated area is 75 ft. x 350 ft. or 26,250 ft.^{2}

Example 6-19: Calculating the Illuminated Area

Question 1:

If a pole-mounted luminaire has a height of 15 ft., what are the dimensions of the illuminated area used for power calculations?

Answer 1:

The illuminated area is defined as any 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. It does not include any area that is within a building, under a canopy, beyond property lines, or obstructed by a sign or structure. Therefore, for a 15 ft. pole-mounted luminaire, the area will be described by a square that is 150 ft. (15 ft. x 10) on each side, or 22,500 ft^2 (150 ft. x 150 ft.), minus areas that are beyond the property line or other obstructions.

Question 2:

If two poles are separated by a distance greater than 10 times the mounting height, will all of the square footage between them be included in the general hardscape area?

Answer 2:

In most applications, such as parking lots, these square patterns will typically overlap, so the entire area of the parking lot between poles will typically be included in the general hardscape area when determining the lighting power budget. However, if the poles are so far apart that they exceed 10 times the mounting height of the luminaires on the poles, and the coverage squares do not overlap, then the nonilluminated areas between poles cannot be included in the general hardscape area.

Example 6-20: Calculating the Power Allowance for a Parking Lot

Question:

The parking lot illustrated below has two luminaires that are mounted at a height of 25 ft. What is the illuminated hardscape area and what is the general hardscape lighting power allowance? The lot is in Lighting Zone 3.

Figure 6-12: Image of Parking Lot

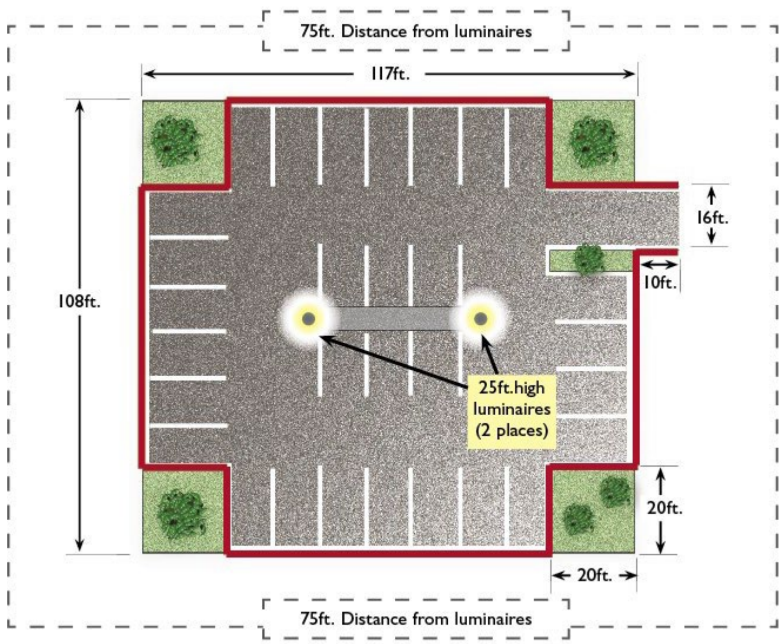


Image Source: California Energy Commission

Answer:

The poles are 40 ft. apart, and using the 10 times mounting height rule, the illuminated area can be as large as 250 ft. by 290 ft. The boundary of this illuminated area extends beyond the edges of the parking lot as well as the entrance driveway, so the entire paved area is considered illuminated. The landscaped island in middle and peninsula below the entrance driveway are less than 10 ft. wide, so they are included as part of the illuminated area, but not part of the hardscape perimeter. The landscaped cutouts (20 x 20 ft.) in the corners of the parking lot are bound by pavement on only two sides so they are not included. The total paved area is 11,196 sq. ft. [(12,636 sq. ft. + 160 sq. ft. (driveway) – 1,600 sq. ft (cutouts)]. The perimeter of the hardscape is 470 ft. [(2 x 77 ft.) + (2 x 68 ft.) + (8 x 20 ft.) + (2 X10 ft.)].

Three allowances make up the general hardscape allowance: Area, Linear, and Initial. All allowances are based on Lighting Zone 3 and found in Table 140.7-A of the Energy Code.

The area wattage allowance is equal to 235.1 W.

The linear wattage allowance is equal to 94 W.

The initial wattage allowance (IWA) is 250 W for the entire site.

The sum of these three allowances gives a total wattage allowance for the site of 579.1 W.

The calculations are tabulated below:

- Initial: 250 W
- Area: 0.021 W/ft^2 x 11,196 ft^{2}ft = 235.1 W
- Perimeter: 0.2 W/LF x 470 ft = 94 W
- Total Power Allowance: 579.1 W

Example 6-21: General Hardscape Surface Question

Question:

Before the Energy Code, Title 24-2019 allowed a higher lighting power allowance for concrete hardscape surface. If I have a concrete plaza, what is the allowed lighting power allowance I should use for Title 24? The plaza is 115 ft. long and 105 ft. wide in a Lighting Zone 3 location.

Answer:

The distinction between different surface material types was removed in Title 24-. The lighting power allowance will be based on the Lighting Zone of the project location.

For a plaza located in Lighting Zone 3 the hardscape area must first be calculated. The general hardscape area is 115 ft. x 105 ft. or 12,075 sq. ft. The linear perimeter of this hardscape is the sum of the sides 115 ft. + 105 ft. + 115 ft. + 105 ft. or 440 ft.

Three allowances make up the total power allowance: Area, Linear, and Initial.

However, the initial wattage allowance applies one time to the entire site. It will be considered for usage for this plaza assuming that there is no associated parking lot or other general hardscape area. All allowances are based on the general hardscape Lighting Zone 3 application and can be found in Table 140.7-A of the Energy Code.

The initial wattage allowance is equal to 250 W.

The area wattage allowance is equal to 253.6 W.

The linear wattage allowance is equal to 88.0 W.

The sum of these allowances gives a total wattage allowance for the plaza of 591.6 W.

The calculation can also be tabulated as below.

- Initial: 250 W
- Area: 0.021 W/ft^2 x 12,075 ft^{2}ft = 253.6 W
- Perimeter: 0.2 W/LF x 615 ft = 88 W
- Total Power Allowance: 591.6 W

Example 6-22: Calculating the Power Allowance for a Roadway

Question:

A 300-ft.-long, 15-ft.-wide roadway leads through a wooded area to a hotel entrance in Lighting Zone 2, and the owner wants to light the roadway with luminaires mounted at a height of 20 ft. What is the allowed lighting power for this roadway with asphalt surface?

Answer:

The hardscape area for the roadway must first be calculated. If the entire roadway will be lit, then the 20 ft. poles will not be spaced more than 200 ft. apart and not more than 100 ft. from the ends of the roadway. (Lighted area is 10 times the pole height.) The hardscape area therefore is 15 ft. x 300 ft. or 4,500 sq. ft. The linear perimeter of this hardscape is the sum of the sides (not including the side that connects to the larger site) 300 ft. + 15 ft. + 300 ft. or 615 ft.

Three allowances make up the total power allowance: area, linear, and initial. However, the initial wattage allowance applies one time to the entire site. It is not considered for usage for this roadway piece which would only be one small part of the site. All allowances are based on Lighting Zone 2 and can be found in Table 6-4 (Table 140.7-A of the Energy Code).

The area wattage allowance is equal to 85.5 W.

The linear wattage allowance is equal to 92.3 W.

The sum of these allowances gives a total wattage allowance for the roadway of 177.8 W.

The calculation is tabulated below:

- Initial: 200 W
- Area: 0.019 W/ft^2 x 4,500 ft^{2}ft = 85.5 W
- Perimeter: 0.15 W/LF x 615 ft = 92.3 W
- Total Power Allowance: 177.8 W

Example 6-23: Flagpole Lighting

Question:

Is the lighting power for a flagpole exempt from the 2025 Energy Code?

Answer:

Yes. Lighting for a flagpole is considered lighting for a public monument. As described in the exceptions to Section 140.7(a), lighting power for public monuments is exempt from Section 140.7 of the 2025 Energy Code. Note that while the power is exempt, this lighting is still subject to the applicable control requirements of 130.2(c)1, and Section 130.2(c)2 of the 2025 Energy Code.

Example 6-24: Lighting for Private Streets

Question:

Does street lighting inside a gated community with private streets have to meet any lighting requirements?

Answer:

Yes. Lighting of private streets must meet the nonresidential outdoor lighting requirements. There are no exceptions to Section 140.7(a) for private streets. The lights must meet all applicable sections of the nonresidential lighting requirements. (The third exception to Section 140.7(a) is specific to public streets.)

Example 6-25: Lighting Control Requirements for Outdoor Lighting Exempt From Section 140.7(a)

Question:

For outdoor lighting, if lighting is excluded from the outdoor power limitations per the exceptions to Section 140.7(a), is that lighting also excluded from the outdoor lighting control requirements of Section 130.2?

Answer:

No. The only outdoor lighting control exception that aligns with the outdoor power exceptions is Exception 2 to Section 130.2(c)3. This means that if the lighting in question is exempt from the power limitations, it is also exempt from the motion sensing control requirements of Section 130.2(c)3. All other sections still apply.

Calculation of Allowed Lighting Power — Narrow Band Spectrum Light Source Applications

The 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 140.7-A (footnote 3) which reads, "Footnote 3: Narrow band spectrum light sources with a dominant peak wavelength greater than 580 nm – as mandated by local, state, or federal agencies to minimize the impact on local, active professional astronomy or nocturnal habitat of specific local fauna, shall be allowed a 2.0 lighting power allowance multiplier."

Example 6-26: Calculating Allowed Lighting Power for Narrow Band Spectrum Lighting

The lighting system for a lot in Lighting Zone 2 is being designed next to an active, professional astronomical observatory. The parking lot is 800 sq. ft. with a perimeter of 280 linear feet. All lighting within 10 miles of the observatory is required by a local ordinance to use a narrow band spectrum light source with a wavelength above 580 nm to be compatible within the telescopes' ability to filter out stray light while capturing most of the wavelengths of light from the night sky. Spectral power distributions of two amber light sources are shown in the two images in Figure 6-13: Spectral Distribution of Light Source Product A and B.

Figure 6-13: Spectral Distribution of Light Source Product A and B

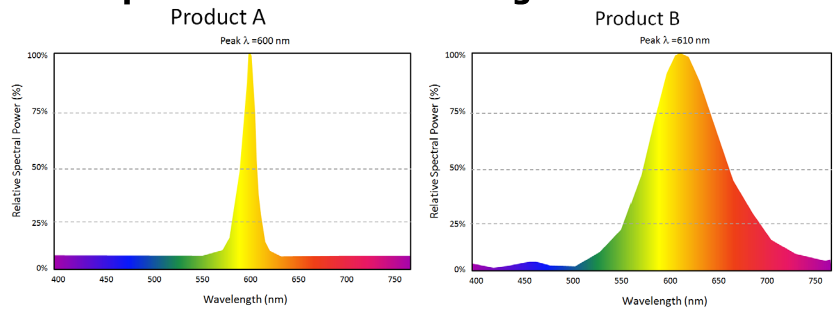


Image Source: Clanton & Associates

Question 1: Which of these products meet criteria for "narrow band spectrum" light sources?

Answer 1:

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.

Between 20 to 75 nm from peak wavelength, the spectral power shall be no greater than 50% of the peak spectral power.

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- 14: Spectral Distribution with Narrow Band Criteria Superimposed. As shown in the figure, Product A is a narrow band spectrum light source as it fits within the spectral power criteria, whereas Product B does not comply as the spectral power exceeds the narrow band criteria.

Figure 6-14: Spectral Distribution With Narrow Band Criteria Superimposed

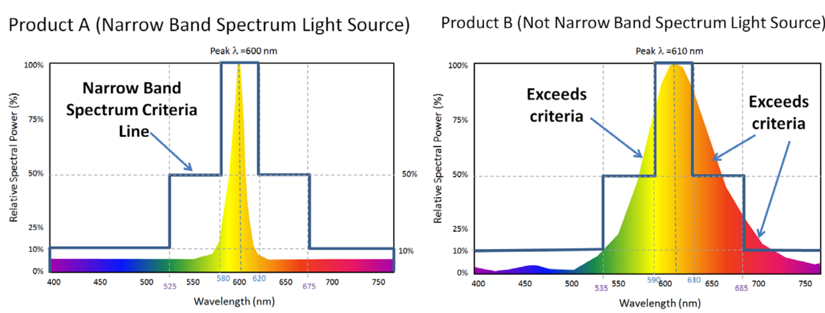


Image Source: Clanton & Associates

Question 2:

What is the allowed lighting power for this parking lot with and without the use of a narrow band spectrum light source?

Answer 2:

To claim the two times multiplier for narrow band spectrum light sources, as described in footnote 3 to Table 140.7-A, the project must comply with all three of the following criteria:

- The light source must have a narrow band spectrum (true for product A).
- The dominant peak wavelength must be greater than 580 nm (true for product A with a peak wavelength of 600 nm).
- The narrow band spectrum and dominant peak wavelength of the light source must be greater than 580 nm as mandated by local, state, federal agencies, to minimize the impact on local, active professional astronomy or on the nocturnal habitat of specific local fauna. (The credit is not available unless the ordinance specifically calls out a requirement for a narrow band spectrum.)

The allowed wattage without the narrow spectrum multiplier is calculated as follows:

Allowed Wattage = (Area Wattage Allowance) x (Area, sq. ft.) + (Linear Wattage Allowance) x (Perimeter Length, linear ft.) + (Initial Wattage Allowance)

The asphalt parking lot is 800 sq. ft. with a perimeter of 280 linear feet and is in Lighting Zone 2. From Table 140.7-A in the asphalt column of Lighting Zone 2, the power allowance factors are:

Area Wattage Allowance = 0.019 W/sq. ft., Linear Wattage Allowance = 0.15 W/lf, and Initial Wattage Allowance = 200 Watts.

Allowed Wattage = (0.019 W/sq. ft) x (800 sq. ft.) + (0.15 W/lf) x (280 lf) + (200 W) = 257.2 Watts

If the design makes use of narrow band light sources and meets all three criteria of footnote 3 to Table 140.7-A, the allowed wattage is multiplied by 2.

Narrow Band Allowed Wattage = Allowed Wattage x 2 = 257.2 W x 2 = 514.4 Watts.

Example 6-27: Low Blue Content Light Source Design

Question:

A lighting system is being designed for a similar parking lot as in Example 6-23 except that it is next to a wildlife refuge and all outdoor lighting near the refuge is required by a local ordinance to use low blue content light sources to minimize the lighting impact on nocturnal animals.

If the designer specifies a narrow band spectrum light source (such as Product A in Example 6-23), can the designer make use of the narrow band spectrum lighting power allowance multiplier in determining the lighting power allowance?

Answer:

To claim the two-times multiplier for narrow band spectrum light sources, as described in footnote 3 to Table 140.7-A, the project must comply with all three of the following criteria:

- The light source must have a narrow band spectrum.

- The dominant peak wavelength must be greater than 580 nm.
- The narrow band spectrum and dominant peak wavelength of the light source be greater than 580 nm, as mandated by local, state, federal agencies to minimize the impact on local, active professional astronomy or on the nocturnal habitat of specific local fauna (The credit is not available unless the ordinance specifically calls out a requirement for a narrow band spectrum.)

For this example, the narrow band spectrum credit is not available since the local ordinance called for low blue light content without specifying this had to be accomplished with narrow band spectrum light sources with a dominant peak wavelength greater than 580 nm. As a result, the two-times multiplier for narrow band spectrum light sources cannot be used in calculating the lighting power allowance for this project.

Additional Lighting Power Allowances and Requirements by Application

Please refer to Chapter 6.5.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Further Discussion About Additional Lighting Power Allowance for Specific Applications

Please refer to Chapter 6.5.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Alterations and Additions for Outdoor Lighting

Please refer to Chapter 6.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Outdoor Lighting Alterations – Increasing Connected Lighting Loads

Please refer to Chapter 6.6.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Outdoor Lighting Alterations – 10 Percent or More of Existing Luminaires are Replaced

Please refer to Chapter 6.6.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Outdoor Lighting Alterations – Half (50 Percent) or More of Existing Luminaires Are Replaced

Please refer to Chapter 6.6.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Outdoor Lighting Alterations – Less Than 10 Percent of Existing Luminaires Are Replaced

Please refer to Chapter 6.6.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Outdoor Lighting Additions – Mandatory Control Requirements and Lighting Power Requirements

Please refer to Chapter 6.6.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Outdoor Lighting Additions and Alterations – More Examples

Please refer to Chapter 6.6.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Outdoor Lighting Compliance Documents and Acceptance Tests

Please refer to Chapter 6.7 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Overview

Please refer to Chapter 6.7.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compliance Documentation and Numbering Scheme

Please refer to Chapter 6.7.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Certificate of Compliance Documents

Please refer to Chapter 6.7.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Certificate of Installation Documents

The certificate of installation is used primarily to declare that what was installed matches the plans and certificates of compliance. The certificate of installation is signed by a person with an approved license.

Even if the design has errors and has specified incorrect features and devices, the installer is responsible to meet all the applicable requirements that he or she installs.

A copy of the completed signed and dated installation certificate must be posted at the building site for review by the local enforcement agency in conjunction with requests for final inspection for the building. See Chapter 2 for more information about installation certificates.

Before a lighting control system, including an energy management control system (EMCS), can be recognized for compliance with the lighting control requirements in the Energy Code, 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 shall sign and submit an Installation Certificate (Section 130.4(b)1 and 2).

The nonresidential outdoor lighting certificate of installation includes the following:

- NRCI-LTO-E: Certificate of Installation, Outdoor Lighting

Certificate of Acceptance

Please refer to Chapter 6.7.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Acceptance Testing

Please refer to Chapter 6.7.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

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Sign Lighting

Overview

This chapter discusses the requirements for sign lighting (indoor signs and outdoor signs) in the Energy Code. There are requirements for controls, maximum allowable power, and minimum efficacy. These requirements conserve energy, reduce peak electric demand, and are both technically feasible and cost-effective. The Energy Code does not allow trade-offs between sign lighting power allowances and other end uses.

The 2025 Energy Code includes some updates to the lighting sources for signs – the changes reflect the ubiquitous and readily available of energy-efficient LED light sources as well as the banning of sales and distribution of linear fluorescent lamps and compact fluorescent lamps starting in 2024.

Scope and Application

Please refer to Chapter 7.1.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Summary of Requirements

Please refer to Chapter 7.1.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Measures

Please refer to Chapter 7.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Lighting Control Functionality

Please refer to Chapter 7.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Determining Luminaire Power

Please refer to Chapter 7.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Sign Lighting Controls

Indoor Sign Lighting Controls

Please refer to Chapter 7.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Outdoor Sign Lighting Controls

Please refer to Chapter 7.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Demand-Responsive Lighting Controls for Electronic Message Centers

Please refer to Chapter 7.3.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Sign Lighting Power Requirements

Please refer to Chapter 7.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Scope of Sign Lighting Power Requirements

Please refer to Chapter 7.4.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Applications Excluded From Sign Lighting Power Requirements

Please refer to Chapter 7.4.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Sign Lighting Power Compliance Options

Please refer to Chapter 7.4.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Maximum Allowed Lighting Power

Reference: Section 140.8(a)

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. Additional information on determining luminaire power is including in Determining Luminaire Power of this chapter.

This compliance approach may be used for any light source type except unfiltered LED and unfiltered neon lighting, which must comply with the alternate lighting source compliance method described in Alternate Lighting Sources.

The maximum allowed lighting power for internally and externally illuminated signs is calculated as follows:

Internally Illuminated Signs

Internally illuminated signs (see Figure 7-1: A picture of Illuminated Signs) 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. The maximum allowed lighting power shall not exceed the product of the illuminated sign area and 12 watts per square foot of illuminated sign area. For double-faced signs, only the area of a single face shall be used to determine the allowed lighting power.

Figure 7-1: A Picture of Illuminated Signs

Source: California Energy Commission

Figure 7-2: An Internally Illuminated Sign

Source: California Energy Commission

Externally Illuminated Signs

Externally illuminated signs (see Figure 7-3: An Externally Illuminated Sign with a Ground-Mounted Luminaire) 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.

The maximum allowed lighting power shall not exceed the product of the illuminated sign area and 2.3 watts per square foot of illuminated sign area. Only areas of an externally lighted sign that are illuminated without obstruction or interference, by one or more luminaires, shall be used.

Figure 7-3: An Externally Illuminated Sign With a Ground-Mounted Luminaire

Source: California Energy Commission

Alternate Lighting Sources

Reference: Section 140.8(b)

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 following light sources:

- Neon or cold cathode lamps with transformer or power supply efficiency greater than or equal to one of the following:
    - A minimum efficiency of 75 percent when the transformer or power supply rated output current is less than 50 mA.
    - A minimum efficiency of 68 percent when the transformer or power supply rated output current is 50 mA or greater.

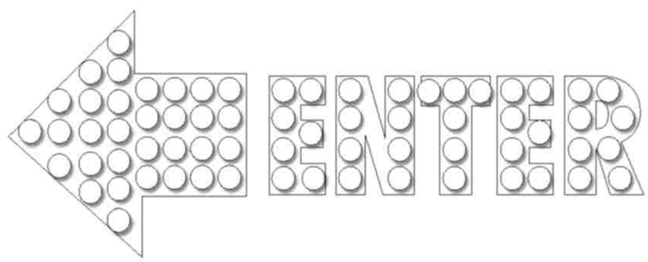
      The ratio of the output wattage to the input wattage is at 100 percent tubing load.
- LEDs with a power supply efficiency of 80 percent or greater.
    - Single-voltage external power supplies that are designed to convert 120 volt AC input into lower voltage DC or AC output and which have a nameplate output power less than or equal to 250 watts and must comply with the applicable requirements for external power supplies in the Appliance Efficiency Regulations.

Hybrid Signs

A sign may consist of components that are regulated and components that are not regulated. 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 7-4: 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 (§130.3) apply to the sign. This type of unfiltered incandescent sign is not regulated by §140.8.

Figure 7-4: Unfiltered Incandescent Sign



Source: California Statewide CASE Team

Example 7-1: Neon and Cold Cathode Lighting

Question:

Can I use neon or cold cathode lighting in my sign and comply with the Energy Code under Option 2 (compliant alternate lighting sources)?

Answer:

Yes, neon and cold cathode lighting are allowed under the alternate light source compliance option, provided that the transformers or power supplies have an efficiency of 75 percent or greater for output currents less than 50 mA and 68 percent or greater for output currents 50 mA or greater.

Example7-2: Indoor Sign Lighting in a Theater Lobby

Question:

Do signs inside a theater lobby or other indoor environments need to comply with the sign requirements?

Answer:

Yes, all illuminated signs must comply with either the maximum allowed lighting power or compliant alternate lighting sources compliance option.

Example 7-3: Alternate Lighting Sources – Incandescent Lamps

Question:

My sign is equipped with both hardwired compact fluorescent lamps and incandescent lamps. Can my sign comply under the alternate lighting sources approach?

Answer:

No. Because your sign is not exclusively equipped with energy efficient technologies allowed under the alternate lighting sources approach (incandescent sources are not allowed and fluorescent lamps are not available from sales in 2024), it must comply under the maximum-allowed lighting power compliance option. Your other option is to replace the incandescent sources and fluorescent lamps with an option allowed under the alternate lighting sources, such as compliant LED or cold cathode lamps.

Example 7-4: Alternate Lighting Sources – Multiple Light Source Types

Question:

My sign has an internally illuminated panel sign equipped with electronic ballasts and unfiltered 30 mA neon tubes above and below the panel sign having power supplies with 76 percent efficiency. Does this sign comply with the compliant alternate lighting sources option?

Figure 7-5: Unfiltered Neon Tube Sign

Source: California Statewide CASE Team

Answer:

Yes, as long as the internally illuminated panel portion is illuminated with a compliant technology. This sign is essentially made up of three different signs (the panel sign and the two neon tubes); the entire sign complies as long as each part complies.

Example 7-5: Sign Lighting and Outdoor Lighting Zones

Question:

Do outdoor lighting zone requirements apply to sign lighting?

Answer:

No. Lighting for signs must meet the sign lighting requirements and does not need to meet the outdoor lighting requirements.

Additions and Alterations

Please refer to Chapter 7.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Sign Alterations

Reference: Section 141.0(b)2M

Existing indoor and outdoor internally and externally illuminated signs that are altered as specified by §141.0(b)2M are required to meet the sign lighting power requirements in §140.8. Altered components of existing indoor and outdoor internally and externally illuminated signs must also meet the requirements in §130.0.

The sign lighting power requirements (either maximum-allowed power or alternate lighting sources) are triggered by alterations to existing internally or externally illuminated signs when any of the following occurs as result of the alteration, as specified in §141.0(b)2M:

- The connected lighting power is increased.
- More than 50 percent of the ballasts are replaced and rewired.
- The sign is relocated to a different location on the same site or on a different site.

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.

Example 7-6: Replacing More Than 50 Percent of Ballasts

Question:

We are replacing 60 percent of the ballasts in a sign. Must we replace the remaining ballasts in the sign to comply with the Energy Code?

Answer:

If more than 50 percent of the ballasts are being replaced, and the replacement involves rewiring the ballasts, then the requirements of §140.8 apply to the whole sign. If more than 50 percent of the ballasts are being replaced during regular maintenance, and the ballasts are not being rewired, then compliance with §140.8 is not required.

Example 7-7: Altering Existing Signs

Question:

I have a strip mall full of signs, and I will be altering some of them. Must I immediately bring all signs into compliance?

Figure 7-6: Example Strip Mall

Source: California Energy Commission

Answer:

No. Only those signs in which at least 50 percent of the ballasts are replaced and rewired or those signs that are moved to a new location (on the same property or a different property) must comply with the sign lighting power requirements. All newly installed signs must comply with sign lighting control requirements and sign lighting power requirements.

Energy Compliance Documentation

Overview

Please refer to Chapter 7.6.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Inspection

Please refer to Chapter 7.6.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Explanation of Compliance Document Numbering System

Please refer to Chapter 7.6.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Certificates of Compliance and Installation

The certificate of compliance documents demonstrate that the overall design of the regulated building or system complies with the Energy Code.

The plans examiner is responsible for verifying that these documents are submitted with the building plans and are complete when required. See Chapter 2 for more information about the certificate of compliance.

The NRCC-LTS-E is the nonresidential sign lighting certificate of compliance.

The certificates of installation primarily declare that what was installed matches the plans and certificates of compliance. The certificate of installation is signed by a person with an approved license.

Even if the design has errors and has specified incorrect features and devices, the installer is responsible to meet all the applicable requirements that he or she installs.

A copy of the completed, signed, and dated certificate of installation must be posted at the building site for review by the local enforcement agency in conjunction with requests for final inspection. See Chapter 2 for more information about certificates of installation.

The NRCI-LTS-E is the nonresidential sign lighting certificate of installation.

Lighting Control Systems Certificate of Installation

Please refer to Chapter 7.6.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

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Electrical Power Distribution

Overview

This chapter describes the Energy Code requirements in Section 130.5 for electrical power distribution systems of nonresidential and hotel/motel occupancy buildings.

Scope and Applications

Please refer to Chapter 8.1.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Service Electrical Metering Requirements

Please refer to Chapter 8.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Separation of Electrical Circuits for Electrical Energy Monitoring

Please refer to Chapter 8.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compliance Methods

Please refer to Chapter 8.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Application Considerations

Please refer to Chapter 8.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Voltage Drop Requirements

Please refer to Chapter 8.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Circuit Controls and Controlled Receptacles for 120-Volt Receptacles

Reference: Section 130.5(d)

Healthcare facilities are exempt from the controlled receptacle requirements.

“Office plug loads” are the loads with the largest power density (W/ft^2) in most office buildings. Controlled receptacles allow plug loads to be turned off automatically when the space is unoccupied, resulting in energy savings.

The Energy Code requires controlled and uncontrolled 120-volt receptacles in office areas, lobbies, conference rooms, kitchen areas in office spaces, copy rooms, and hotel/motel guest rooms. Healthcare facilities are exempt from the controlled receptacle requirements.

All controlled receptacles must be marked to differentiate them from uncontrolled receptacles.

Either circuit controls or controlled receptacles can be used for meeting the requirements of Section 130.5(d).

Either of the following is required for compliance:

- At least one controlled receptacle located within 6 feet of each uncontrolled receptacle
- A multiple receptacle outlet that provides at least one controlled and one uncontrolled receptacle

The controlled receptacle requirement does not require that there be one controlled receptacle for each uncontrolled receptacle.

In open office areas where receptacles are installed in modular furniture, at least one controlled receptacle must be provided for each workstation. Any controlled circuits already built into the building system can be used to meet the requirement.

Controlled receptacles or circuits must be capable of automatically switching off when the space is not occupied. See Application Considerations for example approaches of using automatic means for shutting off controlled receptacles. An automatic time switch with manual override may be used for meeting the requirement. Occupant sensing controls may also be used.

Plug-in strips and other plug-in devices shall not be used to comply with the requirement of Section 130.5(d).

Controlled receptacles are not required in the following situations:

- Receptacles in kitchen areas specifically for refrigerators and water dispensers
- Receptacles specifically for clocks. (The receptacle must be mounted 6' or more above the floor to meet this exception.)
- Receptacles in copy rooms specifically for network copiers, fax machines, audio-visual equipment, and data equipment other than personal computers
- Receptacles on circuits rated more than 20 amperes
- Receptacles connected to an uninterruptible power supply that are intended to be in use 24 hours per day, every day of the year, and are marked to distinguish them from other standard uncontrolled receptacles or circuits.

Application Considerations

Please refer to Chapter 8.5.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Demand Responsive Controlled Receptacles

Reference: Section 130.5(e), Section 110.12(e)

Demand responsive controlled receptacles must be installed in a space where it is required to have controlled receptacles per Section 130.5(d) and where demand responsive lighting controls are required for lighting systems. The controlled receptacles must be capable of automatically turning off all connected loads in response to a demand-response signal.

Spaces where health or life safety statute, ordinance, or regulation does not permit receptacles to be automatically controlled are exempt from this requirement.

See Appendix D of this manual for guidance on compliance with the demand-responsive control requirements.

The demand responsive controls for the installed controlled receptacles shall be tested in accordance with Nonresidential Appendix NA7.6.5. See Chapter 14 for information about the required acceptance tests.

Additions and Alterations

Please refer to Chapter 8.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Equipment Requirements – Electrical Power Distribution Systems

Please refer to Chapter 8.7 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Electrical Power Distribution Systems Compliance Documents

Overview

Please refer to Chapter 8.8.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compliance Documentation and Numbering

Please refer to Chapter 8.8.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

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Solar Photovoltaic, Community Shared Solar, Battery Energy Storage, and Solar-Ready Buildings

Overview

Chapter 9 describes the compliance requirements for solar photovoltaic (PV) systems, battery energy storage systems (BESS), and solar readiness for newly constructed nonresidential, and hotel/motel buildings. The prescriptive PV and battery energy storage requirements for specific nonresidential buildings determine the standard design energy budgets for the performance compliance method. Additional total long-term system cost (LSC) or hourly source energy compliance credit is available for installation of PV and BESS that exceed the energy performance of the prescriptive requirements. For both prescriptive and performance compliance, the PV system must meet the requirements of JA11 Qualification Requirements for Photovoltaic Systems, and the battery storage system must meet the requirements of JA12 Qualification Requirements for Battery Storage Systems.

The Energy Code allows the requirements for photovoltaics to be met by community-shared solar electric generation. The community-shared solar program must be approved by the Commission. For more information, please see Community Shared Solar Electric Generation and Storage Systems.

The requirements for solar-ready buildings are mandatory measures for newly constructed nonresidential and hotel/motel buildings that do not have a PV system because the building either qualifies for an exception in Section 140.10(a) or complies with the PV requirements using community shared solar as specified in Title 24, Part 1, Section 10-115.

For information about requirements and compliance options for solar water heating systems, please see Chapter 4.

What's New for 2025

Prescriptive Measures

Photovoltaic (PV) and battery storage systems are now required for additional nonresidential building categories. See Prescriptive Requirements for Photovoltaic System for specific building types and details.

Additionally, the BESS rated energy capacity calculation is based on the conditioned floor area of the building rather than the size of the PV system, and the power capacity calculation is now based on a 4-hour charging and discharging time.

Changes were also made to the PV exceptions for multitenant buildings.

Performance Compliance

PV and battery storage system requirements also can be met by using the performance approach. See Energy Budget Calculations. A community-shared solar electric generation system, or other renewable electric generation system, and/or community shared BESS can be used instead of onsite solar and/or BESS using either the performance compliance method. See Community Shared Solar Electric Generation and Storage Systems.

Prescriptive Requirements for Photovoltaic System

Photovoltaic System Size – Nonresidential and Hotel/Motel

Reference: Section 140.10(a)

To comply with the prescriptive requirements the following building types are required to have a PV system installed unless the building qualifies for an exception. Mixed-occupancy buildings, where 80 percent or more of the floor area is for one, or more, of these building types must comply. The PV system must meet the requirements of JA11 Qualification Requirements for Photovoltaic Systems.

Events & Exhibits Building is a Museum Building, Motion Picture or Performance Arts Theater Building, or other building that is comprised of Auditorium Area, Convention, Conference, Multipurpose and Meeting Area, or Civic Meeting Place Area.

Library Building is a building with building floor area used for repository of literary materials, and for reading reference such as books, periodicals, newspapers, pamphlets and prints.

Hotel/Motel is a building or buildings that has six or more guest rooms or a lobby serving six or more guest rooms, where the guest rooms are intended or designed to be used, or which are used, rented, or hired out to be occupied, or which are occupied for sleeping purposes by guests, and all conditioned spaces within the same building envelope.

Office Building is a building of CBC Group B Occupancy with building floor areas in which business, clerical or professional activities are conducted.

Financial Institution Building is a building with floor areas used by an institution which collects funds from the public and places them in financial assets, such as deposits, loans, and bonds.

Medical Office Building/Clinics is an occupancy Group B building or portion thereof used to provide medical care on less than 24 hour basis to persons who are not classified as nonambulatory or bedridden or rendered incapable of self-preservation of the services provided.

Restaurant Building is a building with building floor areas in which food and drink are prepared and served to customers in return for money.

Retail Store Building is a building with building floor areas used for the display and sale of merchandise except food.

Grocery Store Building is a building with building floor areas used for the display and sale of food.

School Building is a building used by an educational institution. The building floor area can include classrooms or educational laboratories, and may include an auditorium, gymnasium, kitchen, library, multipurpose room, cafeteria, student union, or workroom. A maintenance or storage building is not a school building.

Warehouse Building is a building that is constructed for storage or handling of products. This space may or may not be conditioned. Refrigerated warehouses is a space greater than or equal to 3,000 square feet constructed for storage of handling of products where mechanical refrigeration is sued to maintain the space temperature at 55 degree F or less.

Religious Worship Building is a building that is comprised of Religious Worship Area.

Sports & Recreation Building is a building that is comprised of Exercise/Fitness Center and Gymnasium Area, or other area where recreational sports are practiced.

For all building types specified in Table 140.10-A, the PV capacity in kW_{dc} shall not be less than the smaller of the minimum rated PV capacity determined by Equation 140.10-A for photovoltaic direct current capacity, or the total of all available Solar Access Roof Areas (SARAs) multiplied by 18 W/ft² for steep-sloped roofs or multiplied by 14 W/ft² for low-sloped roofs in the equations below.

SARAs include the area of the building roof, covered parking areas, carports, and all other newly constructed structures that are capable of structurally supporting a PV system as specified by Title 24, California Code of Regulations, Part 2, (California Building Code or CBC) Section 1511.2.

SARA does not include any roof area with less than 70 percent annual solar access. The percent of annual solar access is determined for each point on the roof by dividing the total solar insolation (accounting for shading obstructions) by the total solar insolation if the same point on the roof were unshaded by those obstructions. For all roofs, all solar obstructions including those that are external to the building, and solar obstructions that are part of the building design, including architectural features and roof mounted equipment may be considered for the annual solar access calculations.

SARA also excludes any roof area that is not available due to state building code requirements, such as HVAC equipment setback and access (on low sloped roofs only) and fire setback and access pathways. Occupied roof areas are also specifically excluded from SARA but must be defined consistent with California Building Code (CBC) Section 503.1.4.

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. The enforcement agency must apply to the CEC for that approval.

The minimum rated PV system capacity is normally determined using the following equation (Equation 140.10-A):

$$kkkk_{pppppppp} = \frac{(CCCCCC \times CC)}{1000}$$

Where,

- $kkkk_{PPPPPPPP}$ = Minimum rated PV system capacity in kW
- $CCCCCC$ = Conditioned floor area in square feet.
- CC = Capacity factor in W/ft² as specified in Table 140.10-A for the building type

When there is limited total Solar Access Roof Area, the minimum rated PV system capacity for the building may be reduced using the following equation.

$$kkkk_{PPPPPPPP,SSSSSSSS} = \frac{(SSCCSSCC \times BB)}{1000}$$

Where,

- $SSCCSSCC$ = Total kW of all available SARAs

BB = 18 W/ft² for steep-sloped roofs or 14 W/ft² for low-sloped roofs

The minimum rated PV system capacity for the building is the smaller value determined by the two equations.

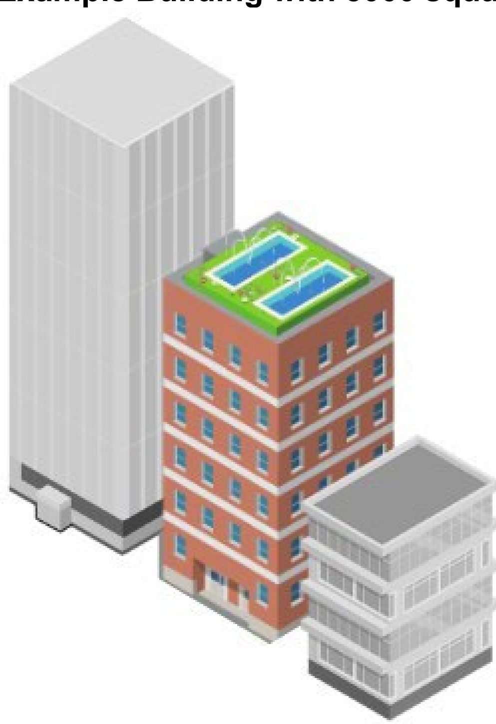
Photovoltaic System Exceptions – Nonresidential, Hotel/Motel

Reference: Section 140.10(a)

There are five allowable exceptions to the prescriptive PV requirements as listed below.

Exception 1 to 140.10(a): No PV system is required where the total of all available SARA is less than three percent of conditioned floor area.

Figure 9-1: Example Building with 5000 square feet CFA



Source: California Statewide CASE Team

The red building is determined to have a SARA of 30 square feet.

Exception 1: 3% × 5000 = 150 ft^2

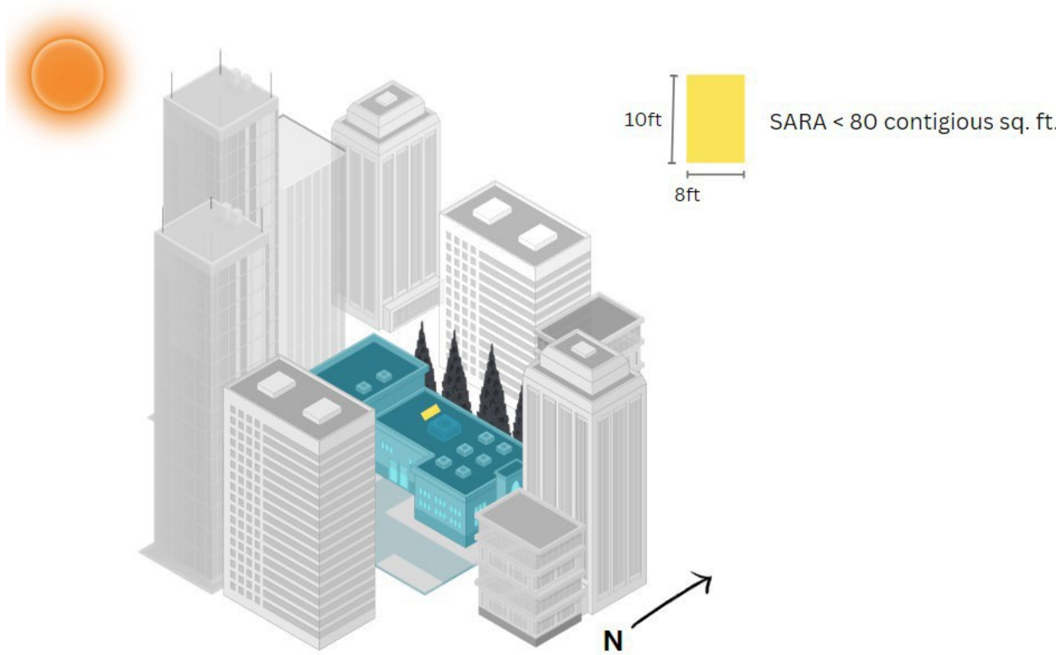
SARA = 30 ft^2 < 150 ft^2 → Exception 1 applies.

Exception 2 to 140.10(a): No PV system is required where the required PV system capacity is less than 4 $kWpv_{dc}$.

Exception 3 to 140.10(a): No PV system is required if the SARA contains less than 80 contiguous square feet.

The blue building is determined to have a SARA (indicated in yellow) that is less than 80 contiguous square feet. Exception 3 applies so that PV in this case is not required for the whole building. When the SARA for any individual roof area is less than 80 contiguous ft^2, that area is not included in determining PV kW sizing. When the SARA for any individual roof area is ≥ 80 contiguous ft^2, that roof area is included in determining PV kW sizing. If there is no SARA with ≥ 80 contiguous ft^2 on any portion of the roof, PV is not required for the building, and solar readiness will apply.

Figure 9-2: Example Building with SARA that is less than 80 contiguous square feet



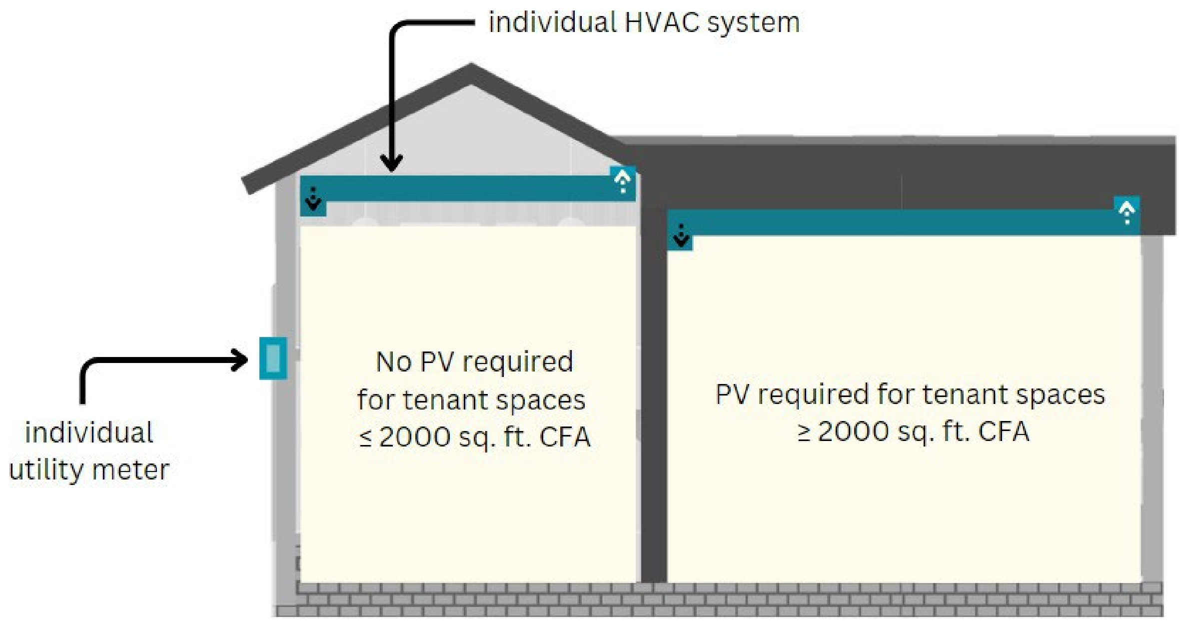
Source: California Statewide CASE Team

Exception 4 to 140.10(a): Buildings with enforcement-authority-approved roof designs, where the enforcement authority determines it isn't possible for the PV system, including panels, modules, components, supports, and attachments to the roof structure, to meet the snow load requirements of Ch. 7 in the American Society of Civil Engineers (ASCE) Standard 7-16.

Exception 5 to 140.10(a): For nonresidential and hotel/motel multitenant buildings, the PV capacity determined by the photovoltaic direct current capacity equation (Equation 140.10(a) shall be calculated without including tenant spaces meeting all of the following:

- The tenant space is less than or equal to 2,000 square feet of conditioned space;
- The tenant space is served by an HVAC system that does not serve other spaces in the building; and
- The tenant space has an individual utility meter to track electricity consumption that does not include the electricity consumption of other tenant spaces in the building.

Figure 9-3: Multitenant Space Qualifying for Exception 5 to Section 140.10(a)



Source: California Statewide CASE Team

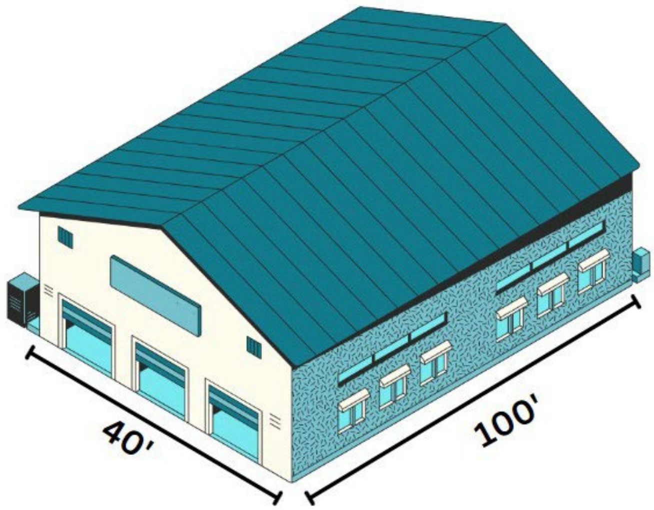
Multitenant buildings present a complication for PV systems to allocate the value provided by PV and BESS systems to each unit without wiring them separately and incurring added cost. Exception 5 allows for tenant spaces of 2,000 square feet or less of conditioned space to be excluded from the PV calculation if each of these units is served by its own HVAC system and its own electric meter. However, tenant spaces over 2,000 square feet (or otherwise not meeting the requirements for the exception) are required to comply with the solar and BESS requirements. Note that this exception does not apply in areas with approved community solar programs, because these programs allow for practical application of PV production to each tenant. Similarly, this exception also does not apply in areas where the electrical utility company or other load-serving entity provides a virtual net energy metering program that allows the owner of a multi-meter property to allocate portions of the energy credits calculated by the netting of the PV generation and onsite consumption from the property's PV generation meter to the property's tenants. Note that if the virtual net energy metering program provided by the load-serving entity does not allow energy bill credits from netting of energy generation and consumption, then compliance is required using Exception 5 provisions explained above for tenant spaces of greater than 2,000 square feet (or otherwise not meeting the requirements of the exception).

Example 9-1: PV Exception 2

Question:

I am designing a warehouse with 4,000 square feet of conditioned floor area in climate zone 12. Is PV required for my building?

Figure 9-4: Example Warehouse



Source: California Statewide CASE Team

Answer:

First determine the kWdc required by using the above equations Equation 140.10-A. From Table 140.10-A a warehouse in Climate Zone 12 has a PV capacity factor of 0.44.

kW_{PVdc} required = (CFA x A)/1000 = (4,000 x 0.44) / 1000 = 1.76 kWdc

Since the required PV is less than 4 kWdc, this warehouse qualifies for Exception 2, and a PV system is not required.

Example 9-2: PV Exception 5

Question:

I am designing a strip mall in Climate Zone 5 with a low-sloped roof and 30,000 square feet of conditioned floor area and SARA of 18,000 square feet. Each tenant space will be served by an individual HVAC system and utility meter. All tenant spaces, except one with 26,000 square feet CFA, will have less than 2,000 square feet of conditioned space each. What is the minimum rated PV system capacity required for my building?

Answer:

Under Exception 5, only the tenant space with the 26,000 square foot of conditioned space needs to be included when calculating PV capacity.

To determine the minimum required kW_{PVdc}, use the two equations shown in the Photovoltaic System Size – Nonresidential and Hotel/Motel section above, and select the smaller value. For a retail space in Climate Zone 5, the PV capacity factor is 3.05, and low-sloped roofs have a SARA multiplier of 14 W/ft².

Photovoltaic Direct Current Capacity:

- kW_{PVdc} required = (CFA x A)/1000 = (26,000 ft^2 x 3.05 W/ft^2)/1000 = 79.3 kW

If SARA is limited, PV System Capacity:

- $kW_{PVdc,SARA}$ required = (SARA x B)/1000 = (18,000 ft^2 x 14 W/ft^2)/1000 =252 kW

The minimum rated PV system capacity for the building is 79.3 kW.

Note: If the CEC has approved a community solar program , or if the load serving entity provides virtual energy bill credits calculated by the netting of PV generation and onsite consumption, the building does not qualify under Exception 5, and compliance will need to be determined for the PV capacity of all tenant spaces.

Example 9-3: PV Exception 5 - VNEM program applicable for Exception 5

Question:

I am designing a strip mall in climate zone 13 and there are 10 tenants in the building with 4 tenants that have their own HVAC system, electric meter, and conditioned floor areas less than 2,000 square feet. The load-serving entity provides a virtual net energy metering program. However, the program does not allow netting of energy generation and consumption. Can I apply Exception 5 and not include the 4 tenants for calculating kWpvdc that have conditioned floor areas of less than 2,000 square feet?

Answer:

Yes. Since the virtual net energy metering program does not allow the netting of building PV generation with onsite consumption of the tenants, Exception 5 will still apply and the PV will be calculated by adding the conditioned floor areas of the 6 tenants that have conditioned floor areas of more than 2,000 square feet.

Example 9-4: PV Exception 5 - VNEM program not applicable for Exception 5

Question:

I am designing a strip mall in climate zone 11 and there are 10 tenants in the building with 4 tenants that have their own HVAC system, electric meter, and conditioned floor areas less than 2,000 square feet. The load serving entity provides a virtual net energy metering program. The program applies bill credits from netting of the generation of the PV system with the consumption of the tenant spaces. Can I apply Exception 5 and not include the 4 tenants for calculating kWpvdc that have conditioned floor areas of less than 2,000 square feet?

Answer:

No. Since the virtual net energy metering program allows the netting of building PV generation with onsite consumption of the tenants, Exception 5 will not apply and the PV will be calculated by adding the conditioned floor areas of all tenants.

Joint Appendix 11 (JA11) Requirements

In addition to the discussion below, please refer to Chapter 9.2.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

System Orientation

For prescriptive path compliance, a PV system or strings with module pitches greater than 2:12, or 10 degrees, shall be oriented with an azimuth between 90 to 300 degrees measured clockwise from true north. Module pitches smaller than 2:12 or less than 10 degrees (low-slope) can be installed in any orientation since the azimuth of low-slope modules has an insignificant impact on array performance.

When using the performance approach, the array may be oriented in any direction, including due north; however, the more the orientation deviates from the optimum orientation of southwest, the worse the system performs, resulting in a larger PV system size to be needed to achieve compliance. It is best to orient the panels as close to southwest as possible to maximize the system performance with the smallest array size.

There are two options for using a California Flexible Installation approach to simplify performance approach compliance software modeling and installation in the field. To use the California Flexible Installation 1 (CFI1), the PV array shall be installed between 150 to 270 degrees from true north, with all modules at the same tilt as the roof for pitches up to 7:12. When the CFI2 option is selected in the performance calculation, the PV array can be installed in a larger azimuth range; the PV array shall be installed between 105 and 300 degrees from true north, with all modules at the same tilt as the roof for pitches up to 7:12. When selecting CFI2, the performance of the proposed system is derated by approximately 10 percent, which results in a larger PV size being necessary to comply.

If the PV array does not meet either CFI1 or CFI2, then the actual orientation and tilt of the PV array shall be described.

Shading

Shading from obstructions must be limited to meet the performance or prescriptive requirements. Any obstruction located north of the array does not need to be considered. 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. (The expected shading shall 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 feet from the nearest point of the array.

Example 9-5: Shading

Question:

What would be the impact of shading on the PV sizing requirement?

Answer:

Prescriptively, the PV array must have at least 98% annual solar access. Under the performance path, there is no minimum requirement for annual solar access; however, the increase in shading (lower annual solar access) will necessitate a larger PV size to meet the same LSC budget as a smaller unshaded PV system. In addition, shading may reduce annual solar access below 70% for some parts of the roof. Any roof sections with under 70% annual solar access may be excluded from SARA. If the SARA is low enough due to shading, a reduced PV size may be allowed. In extreme cases, the SARA will be so small that the building would require no solar system and thus no battery storage system, either.

Solar Access Verification

A certified solar assessment tool that is approved by the Executive Director, listed here https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/solar-assessment-tools, must be used to demonstrate the shading conditions modeled in the performance method as indicated on the CF1R-PRF-01 of the PV system or to claim an exception based on limited amount of solar access.

The installer must provide documentation that demonstrates the actual shading condition of the installed PV system using an approved solar assessment tool. To be certified by the executive director, the solar assessment tool:

- Must calculate the annual solar access percentage of each solar array and a weighted average of the PV system. The calculation must include all known obstructions, including any tree that is planted on the building lot or neighboring lots or planned to be planted as part of landscaping for the building.
- Must not include horizon shading in the calculation.
- Must 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 a weighted average of the PV system as a whole.
- Must ensure that annual solar access percentage values are comparable to on-site measurements if the model shading condition of the tool is based on satellite or aerial images. Documentation must be provided to the CEC as proof.

Remote Monitoring Capability

Please refer to Chapter 9.2.3.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additional Requirements

Please refer to Chapter 9.2.3.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Performance Approach Compliance for Photovoltaic Systems

Energy Budget Calculations

The performance approach allows for modeling of the PV system performance by taking into account the PV system size, climate, panel orientation, panel and inverter efficiency, and shading characteristics. As discussed earlier in the Photovoltaic System Size – Nonresidential and Hotel/Motel section, the minimum rated PV system capacity is normally determined using Equation 140.10-A as shown in Photovoltaic System Size – Nonresidential and Hotel/Motel. When there is limited total Solar Access Roof Area (SARA), the minimum rated PV system capacity may be reduced using the equation based on SARA. The standard design PV system size is the smaller of the two above calculations. The performance method allows for modeling different PV capacities, more energy efficiency measures, additional battery storage, and other demand-response measures. For showing compliance with the long-term system cost (LSC) energy budgets, the performance method allows for efficiency measures to substitute for PV and BESS but does not allow PV or BESS to substitute for efficiency measures. For showing compliance with the source energy budget, efficiency measures, PV, and BESS all can be considered, interchangeably.

Exceptions to PV Requirements

Please refer to the earlier Photovoltaic System Exceptions – Nonresidential, Hotel/Motel section. The same exceptions apply to the performance approach.

Additional Requirements

The installed PV system must meet the applicable requirements specified in JA11. See the earlier discussion of these requirements.

Example 9-6: Efficiency Tradeoff

Question:

Does the performance path allow tradeoffs between PV systems and energy efficiency measures? How about tradeoffs between a PV system that is coupled with a battery storage system and energy efficiency measures?

Answer:

The performance path does not allow installing a larger PV system in exchange for less energy efficiency measures for showing compliance with the LSC energy budget. However, compliance software does allow installing more energy efficiency, demand-responsive measures; and battery storage in exchange for a smaller PV system. Larger PV systems can gain compliance credit for meeting the hourly source energy .

Example 9-7 Solar Thermal System

Question:

Does a solar thermal water heating system still qualify for compliance credit in the performance path?

Answer:

Yes, although a solar water heating system cannot serve as a substitution for the prescriptively required PV system, it can still be installed along with a water heating system for optional compliance credit in the performance path. Solar water heating systems are modeled along with all of the other water heating and distribution systems and can be used for trading off efficiency measures or installing a smaller PV system. The requirements for solar thermal water heating systems are described in Chapter 4, Water Heating Requirements.

Community Shared Solar Electric Generation and Storage Systems

Photovoltaic and/or BESS System Size

Reference: Section 140.1(a)

The Energy Code allows for photovoltaics, which would otherwise be installed on the building site, to be offset by community-shared solar electric generation. "Community-shared solar electric generation" means solar electric generation 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 BESS that otherwise would be installed in combination with photovoltaics on the building site to comply with battery storage requirements could be offset by a community-shared BESS. Community-shared solar electric generation systems and community-shared BESS possibly can be combined or separate. All of these possibilities are hereinafter referred to as just "community-shared solar electric generation systems."

For these offsets to become available, entities who wish to serve as administrators of a proposed community-shared solar electric generation system or BESS must apply to the CEC for approval, demonstrating that all of the criteria specified in Section 10-115 of the regulations are met. The CEC will review these applications to determine if they meet these criteria. If approved, CEC-approved compliance software will be modified to enable users to take compliance credit for buildings participating in that CEC-approved community-shared solar electric generation system.

Any entity may apply to serve as administrator of a proposed community-shared solar electric generation system, including, but not limited to, utilities, builders, solar companies, or local governments. The entity will be responsible for ensuring that the criteria 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 CEC, and other parties who relied on these systems to offset compliance with the standards. Records demonstrating compliance with the criteria 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 criteria for approval specified in Section 10-115 and contact the CEC Building Standards Office for further discussion and explanation of the criteria as necessary.

Enforcement Agency

The community-shared solar electric generation system must exist and be available for enforcement agency review early in the permitting process and shall not cause delay in the enforcement agency review and approval of the building that will be served by the community-shared solar generation system. All documentation required to demonstrate compliance for the building and the compliance offset from the community-shared solar electric generation system must be completed and submitted to the enforcement agency with the permit application. The enforcement agency must be provided facilitated access to the community-shared solar generation system to verify the validity and accuracy of compliance documentation.

Energy Performance and Minimum Community-Shared PV Size

CEC-approved compliance software must be used to show that the energy performance of the shares of the community-shared solar electric generation system that is dedicated to the participating building results in an LSC that is equal to or greater than the LSC, which would be determined for the onsite solar electric generation system that otherwise would have been required for the building to comply with the standards.

The compliance software will determine a minimum kW size that will be the share of the community solar resource that is required to be dedicated to the building, based on the resource's PV system component performance characteristics, orientation (azimuth and tilt), inverter type, tracking versus fixed systems, climate zone and CEC weather files containing solar insolation data.

Participating Building Energy Savings and Bill Reduction Benefits

A specific share of the community-shared solar generation system, determined to comply with the energy performance requirement above, must be dedicated on an ongoing basis to the participating building. The energy savings benefits dedicated to the building shall be provided in one of the following ways:

A. Actual reductions in the energy consumption of the 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 that would result from one of the other two options above.

For all three options mentioned above, the reduction in energy bills resulting from the share of the community-shared solar generation system or community-shared battery storage system or both that is dedicated to the building must be greater than the cost that is charged to the building to obtain that share of the community-shared solar generation system or community-shared battery storage system or both.

Durability, Participation, and Building Opt-Out

Durability: The benefits from the specific share of the Community Shared Solar Generation System and/or community shared battery storage system must be provided to each participating building for a period of not less than 20 years.

Participation: Buildings using community shared solar and/or BESS to comply with the Energy Code requirements, must participate for at least 20 years, regardless of who owns or occupies the building, unless the building owner fulfills the opt-out requirements. The CEC-approved administrator(s) must require the builder to provide equitable servitude by recording a covenant, deed restriction or other legally binding method that runs with the land and obligates all owners/tenants to maintain the participation of the building in the community-shared solar and/or community shared battery storage system for at least 20 years or satisfy the opt-out requirements.

Compliance Documentation: The administrator must maintain record(s) of the compliance documentation that determined the requirements for the on-site solar electric generation system or battery storage system or both to comply with the standards in effect at the time the builder applied for the original building permit, and that 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 the title has transferred and to any participating building owner who requests to opt-out.

Building Opt-Out: During the 20-year participation period, a participating building owner has the option to opt out of participation in the community-shared solar electric generation system if the opt-out requirements are met.

- Before opting out, the building owner must demonstrate that they have installed an on-site solar electric generation system that meets or exceeds the annual LSC generation resulting from the on-site PV and battery storage system that would have been required by the Energy Code in effect at the time of the original building permit application for the building. The building owner must also provide documentation from the installer of the on-site solar system or an attestation of the building owner with supporting documentation confirming the installation of the required onsite systems. The building owner is responsible for all costs associated with documentation of the opt-out requirements.
- The administrator must review opt-out documentation and determine if the installed solar system meets the opt-out requirements. Within 30 days the administrator must provide written confirmation if the building meets the opt-out requirements.
- At the point in time that a building owner has completed all opt-out requirements, all costs and benefits associated with participation in the community-shared solar electric generation system shall cease. If any balance of costs or benefits is owed to either party at the time of opt-out, that balance shall be paid to that party.
- The administrator (or other approved entity) must not impose any penalty related to a participating building opting out or charge participants for recuperation of unrealized revenue that would have been expected to accrue beyond the end of participation. If the administrator plans to charge any other fees at the time of building opting out, the

application for commission approval of the community-shared solar electric generation system shall explain the purpose of those fees.

Additionality

The specific shares of the community-shared solar electric generation system must provide the benefits exclusively to the participating building. The benefits must in no way be attributed to any other building or transferred to other buildings or property. Renewable Energy Credits (RECs) that are unbundled from the community-shared solar electric generation system do not meet this additionality requirement.

The participating building(s) must be served primarily by renewable resources developed specifically for the community-solar electric generation system.

Other renewable resources meeting the requirements may be used for each participating building if the building(s) is permitted before the renewable resources developed for the program start operating or after they cease operating. For each renewable resource developed to serve participating buildings, bundled RECs, which satisfy the criteria of Portfolio Content Category 1 of the California Renewable Portfolio Standard regulations, shall be retired and tracked in the Western Renewable Energy Generation Information System (WREGIS) on behalf of program participants to ensure they will not be allocated to or used for any other mandatory or voluntary renewable electricity program requirement or claim.

Renewable resources that are 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 must be isolated from the generation serving participating buildings. This is not considered a violation of the additionality requirements.

Location

The community shared solar electric generation system must 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.

Size

The community shared solar electric generation system must not be served by any individual source larger than 20 MW.

Battery Energy Storage System (BESS)

The primary function of the BESS is daily cycling for the purpose of load shifting to harmonize the onsite PV system with the grid and to deliver benefits to the grid, environment, and the building occupants.

For the purpose of the Energy Code, “grid harmonization” is defined as strategies and measures that harmonize customer-owned distributed energy resources assets with the grid to maximize self-utilization of solar PV array output, and limit grid exports to periods beneficial to the grid and the ratepayer. This is done by charging the battery from the solar PV system when there is limited electrical load at the building and excess solar PV generation that would otherwise be exported directly to the grid in midday when the grid already has plenty of utility-owned solar PV, and the value of customer-owned generation has low value to the grid. By charging the battery with that excess solar PV generation, the battery can load shift by discharging to the building load in the late afternoon and early evening hours, when there is much less utility-owned solar PV generation available and loads at the house and on the grid are peaking for the day and when the customer-owned generation has much higher value to the grid.

BESS is a prescriptive requirement for specific nonresidential and hotel/motel buildings, as specified in Section 140.10(b). In the performance method, trade-offs are possible using different BESS sizes, but BESS only impacts the Total LSC and Source metrics, not the Efficiency LSC metric. In all cases, BESS must meet all applicable requirements in Joint Appendix JA12 and be self-certified to the CEC by the manufacturer as a qualified product.

Coupling a PV system with a BESS and appropriate control strategy, described in Prescriptive Requirements for BESS below, allow reaching specific Total LSC targets and source energy with a smaller PV system than otherwise would have been possible. This strategy is useful and cost-effective for meeting target LSCs that may be required by reach codes, with a smaller and grid-harmonized PV system.

The list of qualified JA12 products can be found at https://solarequipment.energy.ca.gov/Home/BatteryList and https://solarequipment.energy.ca.gov/Home/EnergyStorage.

Prescriptive Requirements for BESS

Reference: Section 140.10(b)

To comply with the prescriptive requirements for specific nonresidential and hotel/motel buildings that are required to have a PV system installed, a BESS must also be installed. The minimum qualifying energy capacity of the BESS is determined by the following equations. It is important to note that, if a building is not required to have a PV system, it is also not required to have a BESS.

The BESS Minimum Rated Usable Energy Capacity is calculated using the following equation (Equation 140.10-B).

$$kkkkh_{bbbbbbbb} = \frac{(CCCCCC \times BB)}{(1000 \times CC^{0.5})}$$

The BESS Minimum Rated Usable Energy Capacity, SARA-Adjusted is calculated using the following equation (Equation 140.10-C).

$$kkkkh_{bbbbbbbb} = \left[\frac{(CCCCCC \times BB)}{(1000 \times CC^{0.5})}\right] \times \frac{kkkk_{PPPPPPPP,SSSSSSSS}}{kkkk_{PPPPPPPP}}$$

Where,

kWh_{batt} = Minimum Rated Usable Energy Capacity of the BESS in kWh

CFA = Conditioned floor area that is subject to the PV system requirements of Section 140.10(a) in square foot.

kW_{PVdc} = Minimum Rated PV system Capacity in kW from Equation 140.10-A.

$kW_{PVdc,\ SARA}$ = Minimum Rated PV System Capacity in kW from the SARA calculation.

B = BESS Capacity Factor specified in Table 140.10-B for the building type (Wh per square foot).

C = Rated single charge-discharge cycle AC to AC (round-trip) efficiency of the BESS.

The BESS Minimum Rated Power Capacity is calculated using the following equation (Equation 140.10-D).

$$kW_{batt} = kWh_{batt} / 4kkkk_{bbbbbbbb} = \frac{kkkkh_{bbbbbbbb}}{4}$$

Where,

kW_{batt} = Minimum Rated Power Capacity of the BESS in kWdc

kWh_{batt} = Minimum Rated Usable Energy Capacity of the BESS in kWh

Where the building includes more than one of the building types specified in Table 140.10-B, the total BESS capacity for the building shall be determined by applying the above equations to each of the specified building types and summing up the capacities determined for each.

Exceptions to BESS Requirements

There are three allowable exceptions to the prescriptive BESS requirements as specified below for 140.10(b).

- Exception 1: No BESS is required if the installed PV system capacity is less than 15 percent of the capacity determined by Equation 140.10-A.
- Exception 2: No BESS is required if the rated usable energy capacity determined by Equation 140.10-B or Equation 140.10-C is less than 10 kWh.
- Exception 3: For multitenant buildings, the energy capacity of the BESS must be based on the tenant spaces with more than 5,000 square feet of conditioned floor area. For single-tenant buildings with less than 5,000 square feet of conditioned floor area, no BESS is required.

Example 9-11: BESS Exceptions

Question:

I am designing a library with a low-sloped roof, 12,000 square feet of conditioned floor area and SARA of 650 ft^2 in Climate Zone 3. Is PV or BESS required for my building?

Answer:

First determine the PV requirement by using Equation 140.10-A or the SARA multiplied by 18 for steep-sloped roofs or SARA multiplied by 14 for low-sloped roofs. The PV requirement is the smaller of these calculations.

A library in Climate Zone 3 has a PV capacity factor of 2.59.

kW_{PVdc} required = (CFA x A)/1000

= (12,000 ft^2 x 2.59 W/ft^2)/1000

= 31.08 kW

Using the SARA calculation referenced in Photovoltaic System Size – Nonresidential and Hotel/Motel:

$kW_{PVdc,SARA}$ required = (SARA x B)/1000

= (650 x 14)/1000 = 9.1 kW

The PV requirement is the smaller of the two numbers; therefore this building is required to have a minimum 9.1 kW PV system.

Now we can determine the battery requirement based on the equation in Prescriptive Requirements for BESS. A library in Climate Zone 3 has a BESS capacity factor of 5.97. A BESS with 90 percent roundtrip efficiency,

kWh_{batt} = ((CFA x B) / (1000 x $C^{0.5}$)) x ($kW_{PVdc,SARA}$ / kW_{PVdc})

= ((12,000 ft^2 x 5.97 Wh/ft^2) / (1000 x $0.9^{0.5}$)) x (9.1 kW / 31.08 kW)

= 22.11 kWh

Since the rated usable energy capacity is more than 10 kWh, this building does not qualify for Exception 2 and needs a battery energy storage system.

Now, to determine the BESS minimum rated power capacity, use Equation 140.10-D:

kW_{batt} = kWh_{batt} / 4

= 22.11 kWh / 4

= 5.53 kWh

Joint Appendix (JA12) Requirements

Minimum System Performance Requirements

JA12 specifies that the BESS must meet or exceed the following performance specifications:

- For performance compliance, Usable capacity of at least 5 kWh per building.
- For prescriptive compliance, single charge-discharge cycle AC to AC (round-trip) efficiency of at least 80 percent.
- For both performance and prescriptive compliance, energy capacity retention of 70 percent of nameplate capacity after 4,000 cycles covered by a warranty, or 70 percent of nameplate capacity under a 10-year warranty.

Controls Requirements

BESS that remain in backup mode indefinitely bring no grid benefits. 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. These requirements also enable the BESS to 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:

- The BESS must have the capability of being remotely programmed to change the charge and discharge periods and to remotely switch between control strategies.
- During charging, for a BESS that is 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. However, in anticipation of severe weather, Public Safety Power Shutoff events or a demand response signal, the BESS may charge from the grid at any time if allowed by the load serving entity.
- During discharge, the BESS shall be programmed to first meet the electrical load of the property. If during the discharge period the electrical load of the property 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.

Controls Strategies

JA12 includes four control strategies. BESS shall be commissioned to meet the requirements of one of the following control strategies. The installed BESS can follow any of the following control strategies. However, the compliance software will only simulate the "Time of Use" control strategy.

Basic Control

This control strategy is a simple control that accomplishes only limited load shifting. To qualify for the Basic Control, when combined with an on-site solar PV system, the BESS shall only allow charging when the PV system production is greater than the on-site electrical load. The BESS shall discharge whenever the PV system production is less than the on-site electrical load.

Time-of-Use (TOU) Control

This control strategy is designed to match load shifting with utility TOU rates. To qualify for the TOU Control, when combined with an on-site PV system, BESS shall discharge 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

This control strategy is designed to bring the maximum value to the PV system generations 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 allows discharging to the grid upon receiving a demand response signal from a grid operator. To qualify for the advanced demand flexibility control, when combined with an on-site solar PV system, the battery storage system shall be programmed as either basic control as specified in JA12.3.2.1 or TOU control as specified in

JA12.3.2.1. BESS control shall meet the demand flexibility control requirements specified in Section 110.12(a)1 and Section 110.12(a)2. Furthermore, 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 BESS

When BESS 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 the compliance credit, 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, BESS shall be operated in a manner that increases self-utilization of the photovoltaic array output, responds to load serving entity rates, responds to demand response signals, minimizes greenhouse gas emissions from buildings, and/or implements other strategies that achieve equal or greater benefits than those specified above. 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 UL1973 and UL9540. Inverters used with BESS shall be tested in accordance with the applicable requirements in UL1741 and UL1741 Supplement SA, or UL1741 Supplement SB.

Enforcement Agency

The local enforcement agency shall verify that all certificates of installation are valid. The BESS shall be verified as a model certified to the CEC as qualified for credit as a BESS. In addition, the enforcement agency shall verify that the BESS is commissioned and operational with one of the controls specified in Controls Strategies above. The control strategy and the compliance cycling capacity at system installation, commissioning and final inspection by enforcement agency shall be the control strategy and the compliance cycling capacity that was used in the certificate of compliance. 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.

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 the CEC for JA12 certification. In addition, a document showing the software operation of cycling control strategy, and a document or training materials describing the programming of the permanent 72 hour reset requirement during the commissioning of the BESS as specified in JA12.3.3.1(e) and JA12.3.3.1(e)(4), respectively shall be submitted to the Energy Commission for JA12 certification.

Example 9-12: Battery Storage Credit

Question:

Can you get compliance credit for battery storage?

Answer:

Battery storage is a prescriptive requirement for certain nonresidential building types. (See Table 140.10-B.) Additional compliance credit is available under the performance path if using a battery storage system larger than the prescriptive requirement. It can be used for compliance tradeoff for a smaller PV system and source energy.

The manufacturers must self-certify to CEC that the battery energy storage systems meet the requirements of JA12. JA12 specifies minimum performance requirements, communication requirements, control requirements, safety requirements, and interconnection requirements, among others, that must be complied with and certified to the CEC. The self-certification form may be downloaded from the Commission's website.

Example 9-13: Battery Storage Credit

Question:

When batteries are used there is a loss of electricity associated with the roundtrip charge and discharge resulting in fewer generated kWh. Why does the CEC require a BESS that is coupled with a PV system if there is a loss of energy?

Answer:

BESS store the PV generated electricity in the middle of the day when the solar resources are generally plentiful, and electricity prices are low. The BESS then discharges the stored electricity later in the day, during the peak hours when solar resources are diminished and electricity prices are high. BESS have a limited roundtrip charge and discharge loss of 5 to 15 percent, depending on the type of battery technology and the inverter efficiencies. The electricity price differential between the middle of the day and the peak hours is far greater than the battery charge and discharge losses.

To calculate the performance of a battery storage system coupled with a PV system, the CEC's compliance software on an hourly basis accounts for the PV generation, losses, storage capacity remaining, charge and discharge rates, cost of electricity, house loads, and hourly exports. Similar calculations are also performed to calculate the benefits of storage for CO2 emissions.

Not any BESS is eligible for compliance credit; it must comply with the requirements of Reference Joint Appendix 12 (JA12). The requirements ensure that the BESS remains in a dynamic mode that allows residents to take advantage of variable electricity costs associated with charge and discharge periods throughout the day. Static batteries that remain mostly in backup mode have little to no value for load shifting.

Example 9-14: Battery Storage TOU Schedule

Question:

How will the control requirement be enforced for customers that are not on a TOU schedule? How about customers on TOU rate who want to be in basic control?

Answer:

The BESS's cycling capacity must comply with JA12.3.3.1(e) whether the local utility does or does not currently have a TOU schedule. If the local utility currently does not have a TOU schedule, to comply with JA12.2.3, the BESS must perform a system check on 1 May and 1 November by default. A customer can set the control strategy to Basic Control, if a TOU rate is not currently available for the customer. However, this strategy will reduce the benefits of the battery storage for both the customer and the grid and, therefore, is not recommended. Load serving entities are expected to switch to TOU rates over time.

Performance Approach Compliance for Battery Storage System

Energy Budget Calculation

Please refer to Chapter 9.7.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Exceptions to Battery Storage Requirements

Please refer to Chapter 9.7.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additional Requirements

Please refer to Chapter 9.7.3 of the *2022 Nonresidential and Multifamily Compliance Manual.*

Solar-Ready Overview

Reference: Section 110.10

This chapter of the nonresidential compliance manual addresses solar-ready requirements for hotels/motels and nonresidential buildings. These requirements are in Section 110.10 and are only required if PV installation is not required. In these cases, solar-ready is mandatory for newly constructed buildings and additions where the total roof area is increased by at least 2,000 square feet.

The solar-ready requirements must be met when designing the roof and associated equipment of the building. 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.

Overview

The solar-ready provisions are mandatory. There are exceptions to the "solar zone" requirements, and these are described in the corresponding sections of this chapter.

Covered Occupancies

The nonresidential solar-ready requirements apply to:

- Hotel/motel occupancies with 10 habitable stories or fewer.
- All other nonresidential buildings with three or fewer habitable stories other than Group I-2 and I-2.1 buildings.

The Energy Code applies to mixed-occupancy buildings. Buildings with nonresidential space on the ground floor and multifamily residential floors above are common examples.

Solar Zone

Reference: Section 110.10(b)

The solar zone is a dedicated place where solar panels can be installed at a future date if the owner chooses to do so. A solar zone area must be designed to have no solar obstructions, such as vents, chimneys, architectural features and roof mounted equipment. The solar zone must comply with the access, pathway, smoke ventilation, and spacing requirements specified in the California Fire Code (Title 24), Part 9. Requirements from the other Parts of Title 24 and those adopted by a local jurisdiction should also be addressed in establishing the solar zone design.

The solar zone can be located at any of the following locations:

- Roof of building
- Overhang of the building
- Covered parking installed with the building project
- Roof of another structure located within 250 feet (75 meters) of the primary building
- Overhang of another structure within 250 feet (75 meters) of the primary building
- Other structures include, but are not limited to, trellises, arbors, patio covers, carports, gazebos, and similar accessory structures.

The solar zone must also adhere to size and azimuth requirements (Section 110.10(b)1A – Section 110.10(b)2). It must be free from solar obstructions, such as vents, chimneys, architectural features and roof mounted equipment. The solar zone must be clearly indicated on construction documents, which must also include the structural design loads of the roof. This documentation is required so that at the time of a future solar PV installation, the structural design loads at the time the building was permitted are known. The Energy Code does not require estimating the structural loads of possible future solar equipment.

Solar Zone Minimum Area

Total Area: The solar zone must have a total area of at least 15 percent of the total roof area, after subtracting any skylights.

Multiple areas: The solar zone may be composed of multiple subareas if they meet the following minimum size specifications:

1. Each subarea dimension must be at least 5 feet.
2. If the total roof area is equal to or less than 10,000 square feet, each subarea must be at least 80 square feet.
3. If the total roof area is greater than 10,000 square feet, each subarea must be at least 160 square feet.

Please refer to Chapter 9.8.4 of the *2022 Nonresidential and Multifamily Compliance Manual* for further information.

Solar Zone Exceptions

There are four exceptions, which are applicable to hotel/motel and nonresidential buildings, to the solar zone area requirement specified in Section 110.10(b)1B. Submit an NRCC-SRA-E, the "Solar Ready Areas" certificate of compliance to the enforcement agency for all building projects subject to solar ready, even if using a solar zone exception.

Exception 3 allows a reduced-size solar zone when the solar zone minimum area requirements cannot be achieved because solar access is limited due to shading obstructions exterior to the building.

Exceptions 1, 2, and 4 allow alternate efficiency measures instead of a solar zone. When these efficiency measures are installed, the solar zone requirements for zone shading, orientation, and design load; interconnection pathway; and owner documentation also do not apply. Any installations must be inspected and verified prior to final approval by the enforcement agency.

Exception 1: A compliant solar electric system is permanently installed on hotel/motel, and nonresidential buildings. The system must have 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. To verify compliance with this exception, submit NRCI-SPV-01-E Certificate of Installation: Solar Photovoltaic System.

Exception 2: A solar water heating system (SWH) is permanently installed on hotel/motel, and nonresidential buildings. The SWH system must comply with Section 150.1(c)8C. To verify compliance with this exception, submit NRCI-STH-01-E Certificate of Installation: Solar Water Heating System.

Exception 3: Obstructions that are not part of the building shade part of the roof where the potential solar zone would be, reducing the potential solar zone area to no more than 50% of the minimum solar zone area. The up to 50% reduced designated solar zone would become the required solar zone area.

How to Determine Annual Solar Access

Step 1: Determine the annual solar access: For the solar-ready requirements, solar access is the ratio of solar insolation including shading to the solar insolation without shading. Annual solar access is most easily determined using a CEC-certified solar assessment tool.

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First, evaluate whether there are any obstructions outside the building that will shade the rooftop (or other prospective solar zone areas such as overhangs or parking shade structures). If an existing obstruction outside of the building is located north of all potential solar zones, the obstruction o will not shade the solar zone. Similarly, if the horizontal distance ("D") from the obstruction to the solar zone is 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, then the obstruction will not shade the solar zone.

Step 2: Determine the potential solar zone area: On low-sloped roofs, the potential solar zone is the area where annual solar access is ≥ 70 percent.

On steep-sloped roofs the potential solar zone is the area where the annual solar access is

≥ 70 percent on the portion of the roof that is oriented between 90 and 300 degrees of true north.

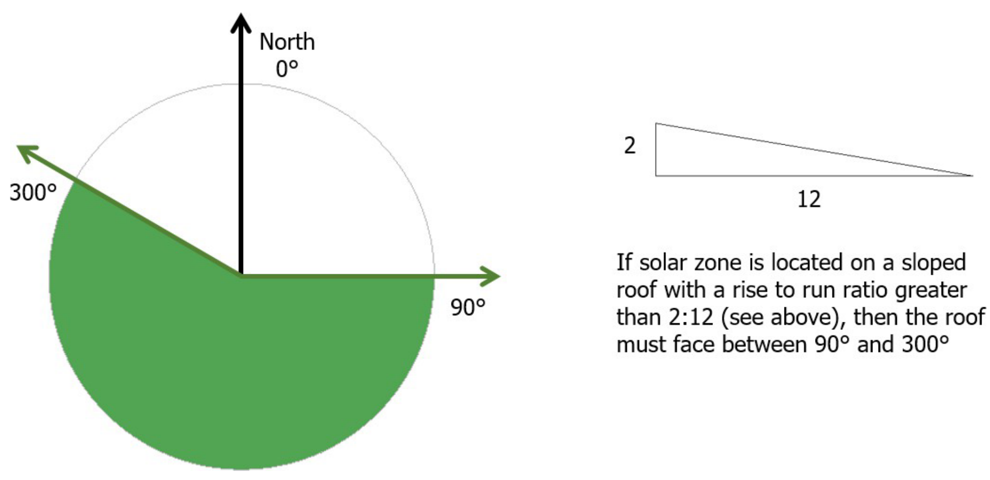
Exception 5: Applies to hotel/motel, and nonresidential buildings. If the roof is designed and approved to be a heliport, or used for vehicular traffic or parking, no solar zone is required. Therefore, interconnection pathway and documentation requirements do not apply.

Solar Zone Azimuth

Reference: Section 110.10(b)2

All sections of the solar zone on steep-sloped roofs (rise-to-run ratio greater than 2:12, or 10 degrees) must face between azimuths of 90 degrees and 300 degrees of true north. 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 9-5: Azimuth of Roof If Solar Zone Is Located on Steep-Sloped Roof



Source: California Energy Commission

Solar Zone Shading

Please refer to Chapter 9.8.5.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Solar Zone Structural Design Loads

The structural design load requirements apply if any portion of the solar zone is located on the roof of the building. For the areas of the roof designated as the solar zone, the structural design loads for roof dead load and roof live load shall be clearly indicated on the construction documents. This is required so that the structural loads are known if a solar energy system is installed in the future.

The Energy Code does not require estimating the loads of possible future solar equipment.

Interconnection Pathways

All buildings that include a solar zone must also include a plan for connecting a PV or SWH system to the electrical or plumbing system of the building. The construction documents must indicate:

1. 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.
2. 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.
3. 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.

Documentation for the Building Occupant

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-SRA-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 5 in lieu of a designated solar zone.

Main Electrical Service Panel

To anticipate the electrical loads of a future solar PV system, the main electrical service panel must have:

1. A minimum busbar rating of 200 amps; and
2. A reserved space to allow for the installation of a double pole circuit breaker. The reserved space shall be permanently marked as, “For Future Solar Electric.”

Additions

The solar-ready requirements for additions are specified in §141.0(a). Additions are not required to comply with the solar-ready requirements unless the addition increases the existing building roof area by more than 2,000 sq. ft.

California Fire Code Solar Access Requirements

The current versions of Title 24, Part 2, California Building Code, Section 3111, and Part 9, California Fire Code, Section 1205 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.

Compliance and Enforcement

At the time a building permit application is submitted to the enforcement agency, the applicant also submits plans and energy compliance documentation. This section describes the documents and procedures for documenting compliance with the solar-ready requirements of the Energy Code. The following discussion is addressed to the designer preparing construction and compliance documents and to enforcement agency plan checkers who are examining those documents for compliance with the Energy Code.

There are two documents to demonstrate compliance with the nonresidential solar ready requirements. Each document is briefly described below.

NRCC-SAB-E: Certificate of Compliance: Solar and Battery

> This document is required for every project where the solar-ready requirements apply: newly constructed hotel/motel buildings with 10 or fewer stories, high-rise multifamily buildings with 10 or fewer stories, all other newly constructed nonresidential buildings with 3 or fewer stories, and additions to the previously mentioned buildings that increase the roof area by more than 2,000 sq. ft. This form is required for all covered occupancies, including projects that use any of the solar zone exceptions.

NRCI-SAB-01-E: Certificate of Installation — Solar and Battery

> This document is required when using solar zone Exception 1 to achieve compliance.

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Covered Process

Overview

This chapter of the Nonresidential Compliance Manual addresses covered processes for the Energy Code (Section 110.2, Section 120.3, Section 120.6, Section 140.1, Section 140.9, and Section 141.1).

Organization and Content

This chapter is organized as follows:

- Overview
- Enclosed Parking Garages
- Commercial Kitchens
- Computer Rooms
- Commercial Refrigeration
- Refrigerated Warehouses
- Laboratory Systems
- Compressed Air Systems
- Process Boilers
- Elevators
- Escalators and Moving Walkways
- Controlled Environment Horticulture
- Steam Traps
- Process Pipe Insulation

Compliance Forms

Please refer to Chapter 10.1.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

What's New for 2025

Significant changes for covered process in the 2025 update to the Energy Code include both new processing loads being covered as well as additional requirements being applied to process loads that were covered by the Energy Code previously.

Newly covered process loads include:

- There are new mandatory pipe insulation requirements for process piping supported in Section 120.3. These new requirements are covered in Process Pipe Insulation.

Revisions to covered process loads previously regulated under the Energy Code:

- Commercial kitchens (mandatory measures)
    - Electrical panels for kitchens must be rated to serve a minimum of 800 connected amps.
    - Each cookline appliance must have a 50A branch circuit available to it.
- Refrigerated Warehouses

    - Minimum evaporator efficiency and maximum evaporator static pressure drop requirements were added to Section 120.6(a)3.
- Controlled environment horticulture (mandatory measures)
    - Electric lighting for growing plants have updated requirements for the photosynthetic photon efficacy (PPE) rating.
- Laboratory systems (prescriptive measures)
    - Added unoccupied setback guidelines.
    - Added an option for simplified exhaust controls.
    - Reduced exceptions to reheat limitations.
    - Added Occupancy L to laboratory requirements.

Enclosed Parking Garages

Overview

Please refer to Chapter 10.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Measures

Please refer to Chapter 10.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Minimum Fan Power Reduction

Please refer to Chapter 10.2.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

CO Sensor Number and Location

Please refer to Chapter 10.2.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

CO Sensor Minimum Requirements

Please refer to Chapter 10.2.2.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Measures

Please refer to Chapter 10.2.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions and Alterations

Please refer to Chapter 10.2.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Commercial Kitchens

Overview

There are mandatory requirements for commercial kitchens in Section 120.6(k) to ensure that kitchen infrastructure makes it easier to support electrification efforts. There are exceptions for healthcare facilities and kitchens that are already all-electric. Three types of commercial kitchen are defined in Section 100.1:

- A *full-service commercial kitchen* is defined as "a kitchen dedicated to an establishment that offers table service by waitstaff."

- An *institutional commercial kitchen* is defined as "a kitchen dedicated to a foodservice establishment that provides meals at institutions including schools, colleges and universities, hospitals, correctional facilities, private cafeterias, nursing homes, and other buildings or structures in which care or supervision is provided to occupants."
- A *quick-service commercial kitchen* is defined as "a kitchen dedicated to an establishment primarily engaged in providing fast food, fast casual, or limited services. Food and drink may be consumed on premises, taken out, or delivered to the customer's location."

There are four prescriptive energy-saving measures associated with commercial kitchen ventilation in Section 140.9(b). These four measures address:

- Direct replacement of exhaust air limitations.
- Type I exhaust hood airflow limitations.
- Makeup and transfer air requirements.
- Commercial kitchen system efficiency options.

Mandatory Measures

Reference: Section 120.6(k)

Installed appliances and equipment must meet the mandatory requirements of Section 110.1 and Section 110.2, respectively. Commercial kitchens must meet the mandatory requirements of Section 120.6(k).

Electric Commercial Kitchen Requirements

Section 120.6(k) sets mandatory requirements for commercial kitchens to have the proper electrical infrastructure to allow for an easier conversion to electrified cooklines in the future. The impacted kitchen types are quick-service commercial kitchens and institutional commercial kitchens. Kitchens in healthcare facilities and kitchens that are already planned to be all-electric are exceptions to 120.6(k).

Commercial kitchens shall meet the following mandatory requirements:

- Quick-service commercial kitchens and institutional commercial kitchens shall be serviced by a panel that has a minimum capacity of 800 connected amps.
- Quick-service commercial kitchens and institutional commercial kitchens shall have at least one dedicated branch circuit capable of supporting a 50A outlet in the kitchen.
- For commercial kitchens, the electrical service panel shall be sized to accommodate an additional 280 volt or 240 volt 50-amp breaker.

This outlet would be accessible to cookline appliances such as stoves, fryers, griddles ovens, etc. Thus, the outlet should be located so that it would be reasonably close to one of the cookline appliances. The location of the 50 Amp receptacle will typically be located directly behind the location of one of the current cookline appliances. This branch circuit wiring should be connected to overcurrent protection devices (circuit breakers) that are two-pole and sized to protect the branch circuit wiring.

The requirements for branch circuit conductors and electrical service panels are the expected requirements for an all-electric commercial kitchen. Insufficient electrical infrastructure is much more difficult to upgrade and can be costly. These requirements also cover the main electrical service panel to ensure that there will be enough power provided to the building, since this issue has been identified for all-electric retrofits.

Example 10-1

Question:

Can these facilities still install gas cooking equipment?

Answer:

Yes, quick-service commercial kitchens and institutional commercial kitchens are allowed to install gas cooking equipment as long as they meet the mandatory requirements to establish electric-ready infrastructure.

Prescriptive Measures

Kitchen Exhaust Systems

Reference: Section 140.9(b)1

This section addresses kitchen exhaust systems. There are two requirements for kitchen exhaust:

- A limitation on use of short-circuit hoods (Section 140.9(b)1A)
- Maximum exhaust ratings for Type I kitchen hoods (Section 140.9(b)1B)

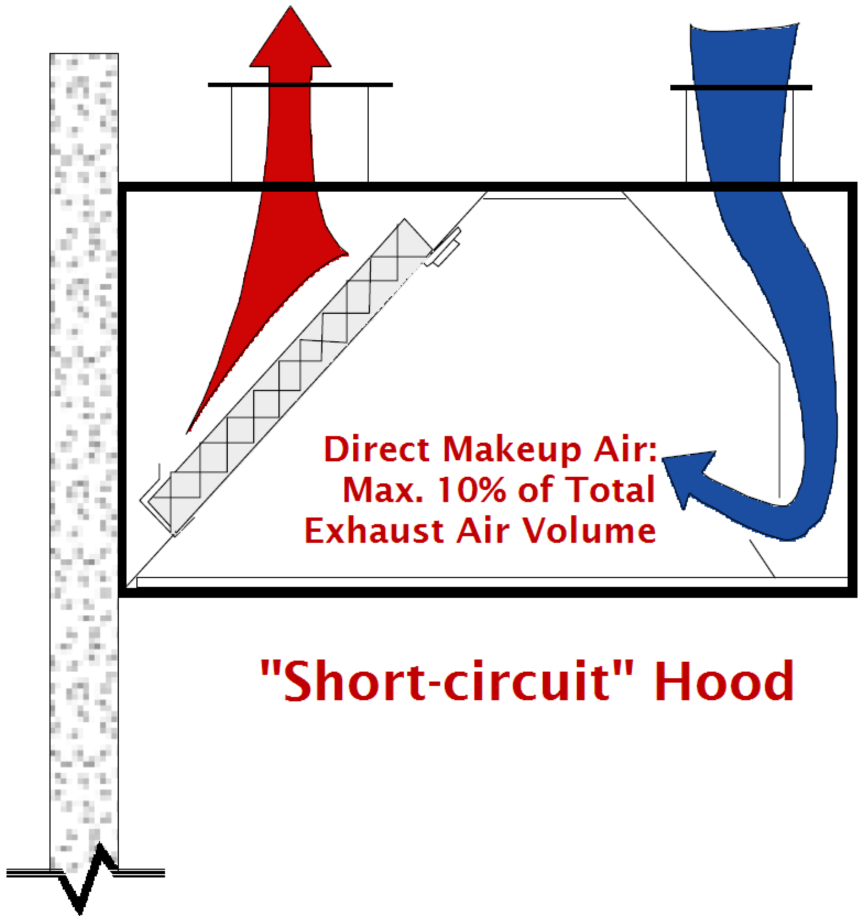
Limitation of Short-Circuit Hoods

Reference: Section 140.9(b)1A

Short-circuit hoods are limited to ≤10% replacement air as a percentage of hood exhaust airflow rate. The reasons for this include the following:

Studies by Pacific Gas and Electric (PG&E), the American Gas Association (AGA), and the California Energy Commission (CEC) have shown that in short-circuit hoods, direct supply greater than 10 percent of hood exhaust significantly reduces capture and containment. This reduces the extraction of cooking heat and smoke from the kitchen, forcing facilities to increase the hood exhaust rate. This reduction results in higher consumption of energy and conditioned makeup air.

Figure 10-1: Short-Circuit Hood



Source: California Energy Commission

Maximum Exhaust Ratings for Type I Kitchen Hoods

Reference: Section 140.9(b)1B

The Energy Code also limits the amount of exhaust for Type I kitchen hoods based on Table 140.9-C, when the total exhaust airflow for Type I and II hoods are greater than 5,000 cfm. Similar to the description regarding short-circuit hoods, excessive exhaust rates for Type I kitchen hoods increase energy consumption and increase energy use for conditioning of the makeup air.

There are two exceptions for this requirement:

- Exception 1 to Section 140.9(b)1B, where ≥75% of the total Type I and II exhaust makeup air is transfer air that would otherwise have been exhausted. This exception could be used when you have a large dining area adjacent to the kitchen, which would be exhausting air for ventilation even if the hoods were not running. The exception is satisfied if the air that would otherwise have been exhausted from the dining area (to meet ventilation requirements), is greater than 75 percent of the hood exhaust rate, and is transferred to the kitchen for use as hood makeup air.
- Exception 2 to Section 140.9(b)1B: Existing hoods that are not being replaced as part of an addition or alteration.

The values in Table 140.9-C are based on the type of hood (left column) and the rating of the equipment that it serves (light-duty through extra-heavy-duty). The values in this table are typically less than the minimum airflow rates for hoods that are not Underwriter Laboratories (UL) specification-listed products. These values are supported by ASHRAE research for use with UL-listed hoods. (For more detail see ASHRAE research project report RP-1202.) To comply with this requirement, the facility will likely have to use listed hoods. The threshold of 5,000 cfm of total exhaust was included in the Energy Code to exempt small restaurants.

The definitions for the types of hoods and the duty of cooking equipment are provided in ASHRAE Standard 154-2011.

Kitchen Ventilation

Reference: Section 140.9(b)2

This section covers two requirements:

- Limitations to the amount of mechanically heated or cooled airflow for kitchen hood makeup air (Section 140.9(b)2A)
- Additional efficiency measures for large kitchens (Section 140.9(b)2B)

For these requirements, it is important to understand the definition of mechanical cooling and mechanical heating, which the Energy Code defines as the following:

- *Mechanical cooling* is lowering the temperature within a space using refrigerant compressors or absorbers, desiccant dehumidifiers, or other systems that require energy from depletable sources to directly condition the space. In nonresidential, and hotel/motel buildings, cooling of a space by direct or indirect evaporation of water alone is not considered mechanical cooling.
- *Mechanical heating* is raising the temperature within a space using electric resistance heaters, fossil-fuel burners, heat pumps, or other systems that require energy from depletable sources to directly condition the space.

Direct and indirect evaporation of water alone is not considered mechanical cooling. Therefore, air cooled by the evaporation of water can be used as kitchen hood makeup air with no restrictions.

Limitations to the Amount of Mechanically Heated or Cooled Airflow for Kitchens

Reference: Section 140.9(b)2A

This section limits the amount of mechanically cooled or heated airflow to any space with a kitchen hood. The amount of mechanically cooled or heated airflow must not exceed the greater of:

- The supply flow required to meet the space heating or cooling load.
- The hood exhaust minus the available transfer air from adjacent spaces.

The supply flow required to meet the space heating or cooling loads can be documented by providing the load calculations.

To calculate the available transfer air:

- Calculate the minimum outside air (OA) needed for the spaces that are adjacent to the kitchen.
- From the amount calculated in the bullet point above, subtract the amount of air used by exhaust fans in the adjacent spaces. This amount includes toilet exhaust and any hood exhaust in adjacent spaces.
- From the amount calculated in the bullet point above, subtract the amount of air needed for space pressurization. The remaining air is available for transfer to the hoods.

An exception is provided for existing kitchen makeup air units (MAU) that are not being replaced as part of an addition or alternation.

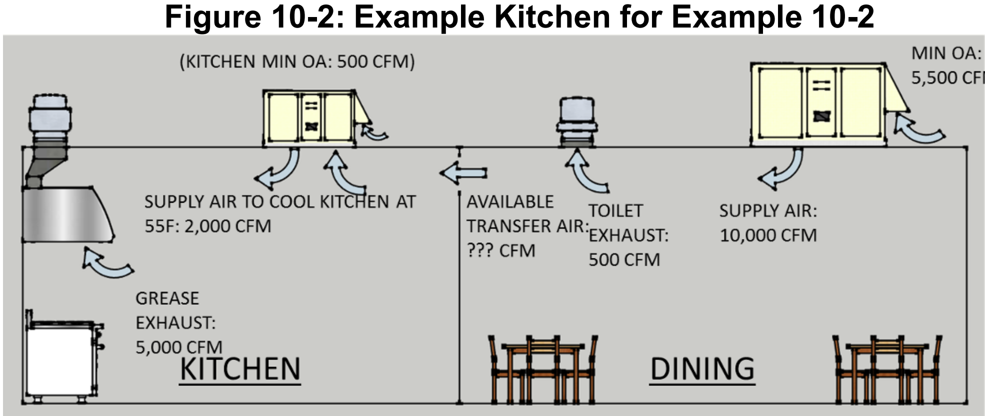
While the requirement to use available transfer air refers only to "adjacent spaces," available transfer air can come from any space in the same building as the kitchen. A kitchen on the ground floor of a large office building, for example, can draw transfer air from the return plenum and the return shaft. The entire minimum OA needed for the building, minus the other exhaust and pressurization needs, is available transfer air. If the return air path connecting the kitchen to the rest of the building is constricted, resulting in high transfer air velocities, then it may be necessary to install a transfer fan to assist the transfer air in making its way to the kitchen. The energy use of a transfer fan is small compared to the extra mechanical heating and cooling energy of an equivalent amount of OA.

Example 10-2

Question:

What is the available transfer air for the kitchen makeup in the scenario shown in the following figure?

Figure 10-2: Example Kitchen for Example 10-2



Source: California Energy Commission

Answer:

5,000 cfm calculated as follows.

The OA supplied to the dining room is 5,500 cfm. From this, subtract 500 cfm for the toilet exhaust and 0 cfm for building pressurization.

5,500 cfm – 500 cfm – 0 cfm = 5,000 cfm

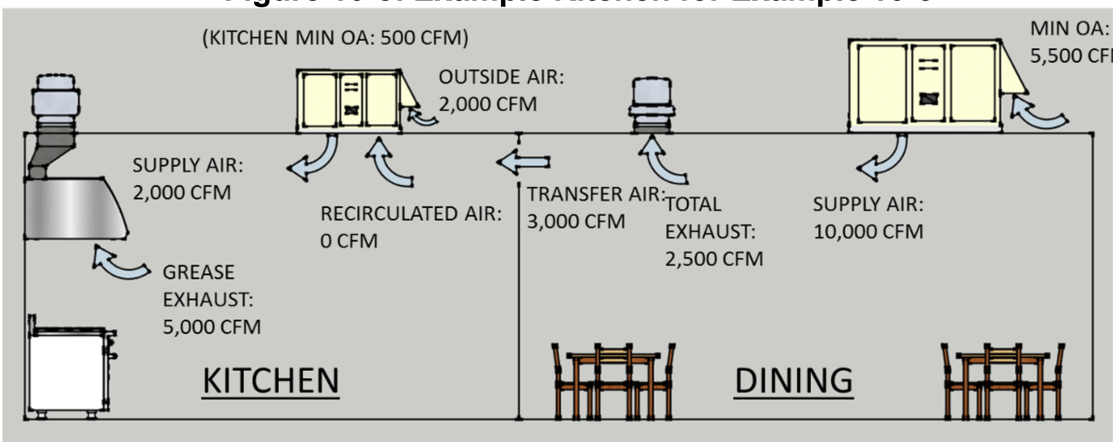
The remaining 5,000 cfm of air is available transfer air.

Example 10-3

Question:

Assuming that this kitchen needs 2,000 cfm of supply air to cool the kitchen with a design supply air temperature of 55°F, would the following design airflow meet the requirements of Section 140.9(b)2A?

Figure 10-3: Example Kitchen for Example 10-3



Source: California Energy Commission

Answer:

Yes. This example meets the first provision of Section 140.9(b)2A. The supply flow required to meet the cooling load is 2,000 cfm. Thus, up to 2,000 cfm of mechanically conditioned makeup air can be provided to the kitchen. The supply from the MAU, 2,000 cfm, is not as large as the hood exhaust, 5,000 cfm. This means that the remainder of the makeup air, 3,000 cfm, must be transferred from the dining room space.

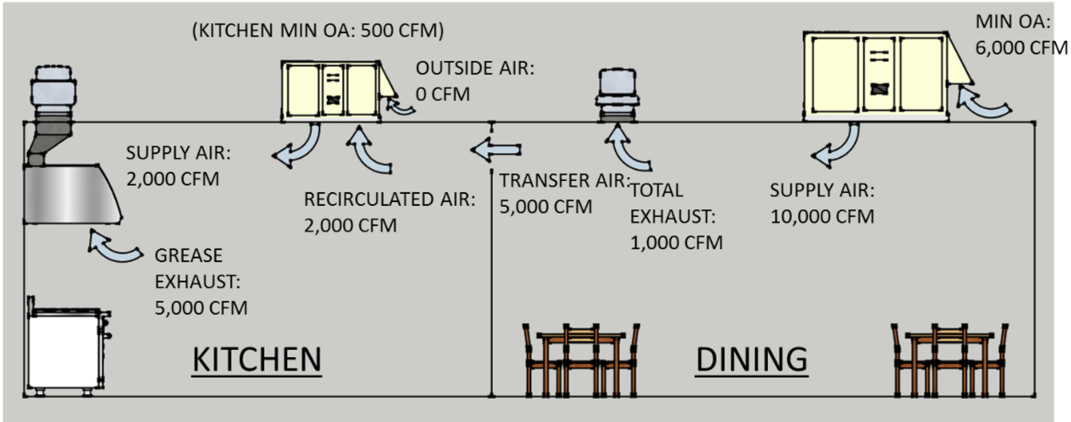
Although this is allowed under Section 140.9(b)2Ai, this is not the most efficient way to condition this kitchen, as demonstrated in the next example.

Example 10-4

Question:

Continuing with the same layout as the previous example, would the following design airflow meet the requirements of Section 140.9(b)2A?

Figure 10-4: Example Kitchen for Example 10-4



Source: California Energy Commission

Answer:

Yes. In this example, 100 percent of the makeup air, 5,000 cfm, is provided by transfer air from the adjacent dining room. The OA on the unit serving the dining room has been increased to 6,000 cfm to serve the ventilation for both the dining room and kitchen. Since the dining room has no sources of undesirable contaminants, we can ventilate the kitchen with the transfer air.

Comparing this image to the previous example you will see that this design is more efficient for the following reasons:

- The total outside airflow to be conditioned has been reduced from 7,500 cfm in the previous example (2,000 cfm at the MAU and 5,500 cfm at the dining room unit) to 6,000 cfm.
- The dining room exhaust fan has dropped from 2,500 cfm to 1,000 cfm reducing both fan energy and first cost of the fan.

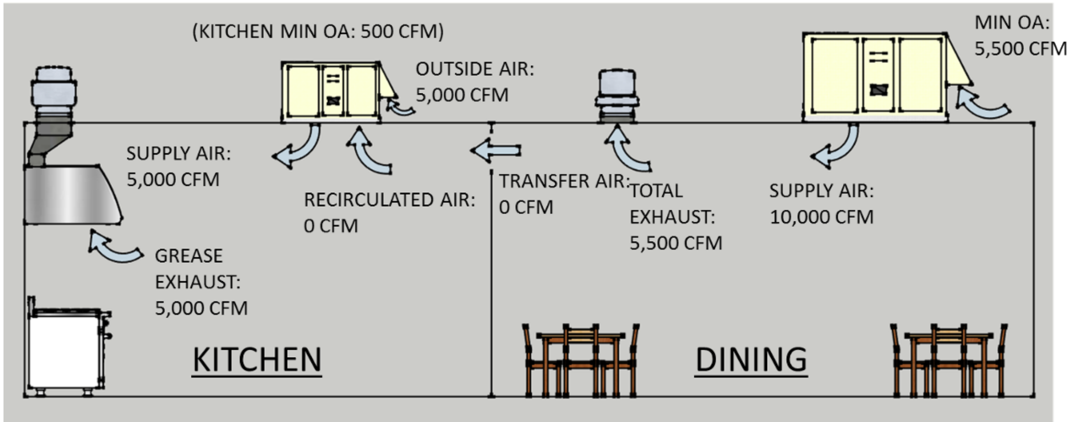
An even more efficient design would be if the kitchen MAU had a modulating OA damper that allowed it to provide up to 5,000 cfm of outside air directly to the kitchen when OA temperature < kitchen space temperature. When OA temperature > kitchen space temperature, then the OA damper on the MAU is shut, and replacement/ventilation air is transferred from the dining area. This design requires a variable-speed dining room exhaust fan controlled to maintain slight positive pressure in the dining area. This design is the baseline design modeled in the *Alternative Calculation Methods (ACM) Reference Manual* for performance compliance. The baseline model assumes that transfer air is available from the entire building, not just the adjacent spaces.

Example 10-5

Question:

Continuing with the same layout as the previous examples, would the following design airflow meet the requirements of Section 140.9(b)2A?

Figure 10-5: Example Kitchen for Example 10-5



Source: California Energy Commission

Answer:

Not if the kitchen is mechanically heated or cooled. Per Section 140.9(b)2A, the maximum amount of makeup air that can be mechanically heated or cooled cannot exceed the greater of:

- Per Section 140.9(b)2Ai: 2,000 cfm, the supply needed to cool the kitchen (from above example).
- Per Section 140.9(b)2Aii: 0 cfm, the amount of hood exhaust (5,000 cfm) minus the available transfer air (5,500 - 500 = 5000 cfm; from above example).

The 5,000 cfm of conditioned makeup air exceeds 2,000 cfm. This example assumes that the required exhaust for the dining space is 500 cfm of bathroom exhaust, and the remaining 5,000 cfm of dining outdoor air is available for transfer to the kitchen.

Additional Efficiency Measures for Large Kitchens

Reference: Section 140.9(b)2B

For kitchens or dining facilities that have more than 5,000 cfm of Type I and II hood exhaust, the mechanical system must meet one of the following requirements:

- At least 50% of all replacement air is transfer air that would have been exhausted.
- Demand ventilation control on at least 75% of the exhaust air.
- The listed energy recovery devices have a sensible heat recovery effectiveness ≥40% on ≥50% of the total exhaust flow.
- Seventy-five percent or more of the makeup air volume is:
  - Unheated or heated to no more than 60°F.
  - Uncooled or cooled without the use of mechanical cooling.

Exception to 140.9(b)2B: Existing hoods not being replaced as part of an addition or alteration.

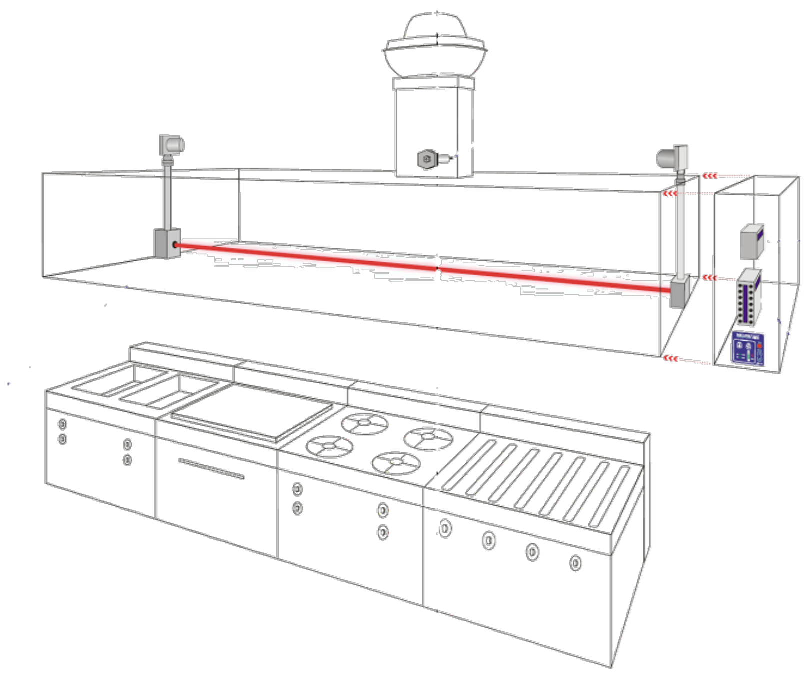
Transfer Air: The concept of transfer air was addressed in the discussion of Section 140.9(b)2A above.

Demand Ventilation Control: Per Section 140.9(b)2Bii, demand ventilation controls must have all the following characteristics:

- Include controls necessary to modulate airflow in response to appliance operation and to maintain full capture and containment of smoke, effluent, and combustion products during cooking and idle.
- Include failsafe controls that result in full flow upon cooking sensor failure.
- Include an adjustable timed override to allow occupants the ability to temporarily override the system to full flow.
- Be capable of reducing exhaust and replacement air system airflow rates to the larger of:
    - 50 percent of the total design exhaust and replacement air system airflow rates.
    - The ventilation rate required in Section 120.1.

There are several off-the-shelf technologies that use smoke detectors that can comply with all these requirements.

Figure 10-6: Demand Control Ventilation Using a Beam Smoke Detector



Source: California Energy Commission

Energy Recovery: Energy recovery is provided using air to air heat exchangers between the unit providing makeup air and the hood exhaust. This option is most effective for extreme climates (either hot or cold) and less commonly used in the mild climates of California.

Tempered Air With Evaporative Cooling: The final option is to control the heating (if there is heating) to a space by setting the temperature set point to 60°F and to use evaporative (non-compressor) cooling or no cooling at all for 75 percent of the makeup air.

Kitchen Exhaust Acceptance

Please refer to Chapter 10.3.3.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Healthcare Facilities

Please refer to Chapter 10.3.3.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions and Alterations

Prescriptive requirements for commercial kitchens covered in Section 140.9 shall apply to additions and alterations to existing kitchens.

Computer Rooms

Overview

Please refer to Chapter 10.4.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Measures

Please refer to Chapter 10.4.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Reheat

Please refer to Chapter 10.4.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Humidification

Please refer to Chapter 10.4.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Fan Control

Please refer to Chapter 10.4.2.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Measures

Please refer to Chapter 10.4.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Economizers

Please refer to Chapter 10.4.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Power Consumption of Fans

Please refer to Chapter 10.4.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Air Containment

Please refer to Chapter 10.4.3.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Minimum Uninterruptible Power Supply (UPS) Efficiency

Please refer to Chapter 10.4.3.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions and Alterations

Please refer to Chapter 10.4.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Economizers

Please refer to Chapter 10.4.5.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Commercial Refrigeration

Overview

This section addresses Section 120.6(b) of the Energy Code, which covers mandatory requirements for commercial refrigeration systems in retail food stores. This section explains the mandatory requirements for condensers, compressor systems, refrigerated display cases, and refrigeration heat recovery. All buildings under the Energy Code must also comply with the general provisions of the Energy Code (Section 100.0 – Section 100.2, Section 110.0 – Section 110.10, Section 120.0 – Section 120.9, Section 130.0 – Section 130.5) and additions and alterations requirements (Section 141.1).

All process piping operating at a temperature below 60°F such as refrigerant piping or chilled water piping shall comply with Section 120.3. New requirements for process pipe insulation are listed in Process Pipe Insulation.

Mandatory Measures and Compliance Approaches

Please refer to Chapter 10.5.1.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Scope and Application

Reference: Section 120.6(b)

Section 120.6(b) of the Energy Code applies to retail food or beverage stores that have 8,000 square feet or more of conditioned area and use either refrigerated display cases or walk-in coolers or freezers. The Energy Code has minimum requirements for the condensers, compressor systems, refrigerated display cases, and refrigeration heat-recovery systems associated with the refrigeration systems in these facilities.

The Energy Code does not have minimum efficiency requirements for walk-ins, as these are deemed appliances and are covered by the California Appliance Efficiency Regulations (Title 20). *Walk-ins* are defined as refrigerated spaces with less than 3,000 square feet of floor area that are designed to operate below 55°F (13°C). Furthermore, the Energy Code does not have minimum equipment efficiency requirements for refrigerated display cases, as the minimum efficiency for these units is established by federal law in the Commercial Refrigeration Equipment Final Rule, but there are requirements for display cases that do result in reduced energy consumption.

Example 10-6

Question:

The only refrigeration equipment in a retail food store with 10,000 square feet of conditioned area is self-contained refrigerated display cases. Does this store need to comply with the requirements for commercial refrigeration?

Answer:

No. Since the refrigerated display cases are not connected to remote compressor units or condensing units, the store does not need to comply with the Energy Code.

Example 10-7:

Question:

A new retail store with 25,000 square feet of conditioned area has two self-contained display cases. The store also has several display case lineups and walk-in boxes connected to remote compressors systems. Do all the refrigeration systems need to comply with the requirements for commercial refrigeration?

Answer:

There are no provisions in the Energy Code for the two self-contained display cases. The refrigeration systems serving the other fixtures must comply with the Energy Code.

Condenser Mandatory Requirements

Please refer to Chapter 10.5.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Condenser Fan Control

Please refer to Chapter 10.5.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Condenser-Specific Efficiency

Please refer to Chapter 10.5.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Condenser Fin Density

Please refer to Chapter 10.5.2.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Adiabatic Condenser Sizing

Please refer to Chapter 10.5.2.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compressor System Mandatory Requirements

Please refer to Chapter 10.5.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Floating Suction Pressure Controls

Please refer to Chapter 10.5.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Liquid Subcooling

Please refer to Chapter 10.5.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compressors for Transcritical CO_2 Refrigeration Systems

Reference: Section 120.6(b)2C

Floating head control is one of the largest energy savings measures applied to refrigeration systems. This control attempts to keep condensing temperatures as low as possible (while not consuming too much gas cooler fan energy) as this reduces compressor head pressure, which directly affects compressor energy.

When ambient temperatures are low, the primary constraint on how low the condensing temperature can be reset is the design requirements of the compressor and associated system components.

Section 120.6(b)2C addresses the compatibility of the compressor design and components with the requirements for floating head control. All compressors that discharge to the gas cooler(s) and all associated components (coalescing oil separators, expansion valves for liquid injection oil cooling, etc.) must be capable of operating at a condensing temperature of 60°F (16°C) or less. Oil separator sizing is often governed by the minimum condensing temperature, as well as other factors, such as the maximum suction temperature. Suction temperatures above the design value may occur under floating suction temperature control schemes.

The system designer should also keep in mind that other design parameters such as piping run lengths or evaporator defrost requirements must be considered to meet this requirement.

The exception to the minimum SCT of 60°F for transcritical CO_2 systems requirement is:

- Compressors with a design saturated suction temperature greater than or equal to 30°F shall be designed to operate at a minimum condensing temperature of 70°F or less.
- Existing compressor systems that are reused for an addition or alteration.

Refrigerated Display Case Lighting Control Requirements

Please refer to Chapter 10.5.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Refrigeration Heat Recovery

Please refer to Chapter 10.5.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Refrigeration Heat Recovery Design Configurations

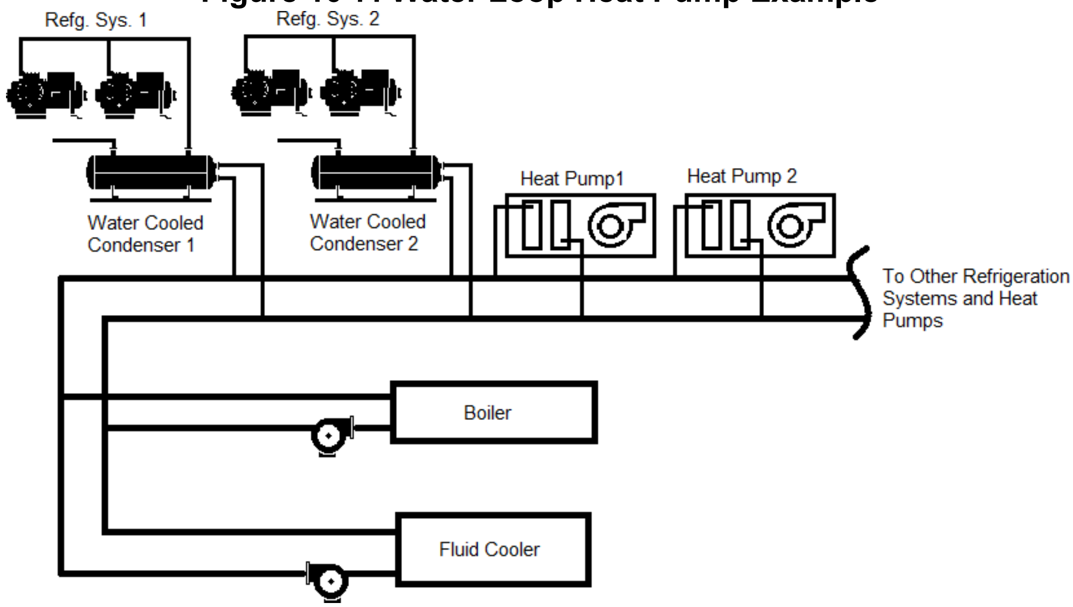
Please refer to Chapter 10.5.5.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Water Loop Heat Pump Heat Recovery

Water-source heat pumps (WLHP) can be used in conjunction with water cooled refrigeration systems, connected to a common water loop as shown in Figure 10-7: Water Loop Heat Pump Example. Refrigeration systems heat pumps serving various zones of the store reject heat into a water loop, which in turn is rejected to ambient by an evaporative fluid cooler. When the heat pumps are in heating mode, they extract the heat rejected by the refrigeration systems from the water loop. Additional heat, if required, is provided by a boiler connected to the water loop. A significant advantage of this design is low refrigerant charge, since the refrigeration systems use a compact water-cooled condenser, typically with less charge than an air-cooled condenser and no heat recovery condenser is required. Compared with other methods, however, the electric penalty is somewhat higher to utilize the available heat.

The floating pressure requirements in the standard would apply to the fluid coolers, i.e., controls to allow refrigeration systems to float to 70°F SCT and use of wet bulb following control logic.

Figure 10-7: Water Loop Heat Pump Example



Source: California Energy Commission

Control Considerations

Please refer to Chapter 10.5.5.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Recovery Coil Design Considerations

Please refer to Chapter 10.5.5.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Transcritical CO_2 Systems

Please refer to Chapter 10.5.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Transcritical CO_2 Gas Coolers

Reference: Section 120.6(b)5

New fan-powered gas coolers on all new transcritical CO_2 refrigeration systems must follow the gas cooler type, sizing, fan control, and efficiency requirements as described in Section 120.6(b)5.

Air-Cooled Gas Coolers Restrictions

Please refer to Chapter 10.5.6.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Gas Cooler Sizing

Please refer to Chapter 10.5.6.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Air-Cooled Gas Cooler Sizing

Please refer to Chapter 10.5.6.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Adiabatic Gas Cooler Sizing

Please refer to Chapter 10.5.6.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Fan Control

Please refer to Chapter 10.5.6.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Speed Control

Please refer to Chapter 10.5.6.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Subcritical Pressure Control

Please refer to Chapter 10.5.6.7 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Supercritical Pressure Control

Please refer to Chapter 10.5.6.8 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Minimum SCT Set Point

Please refer to Chapter 10.6.1.1.3.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Gas Cooler-Specific Efficiency

Please refer to Chapter 10.5.6.9 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions and Alterations

Please refer to Chapter 10.5.7 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Refrigerated Warehouses

Overview

This section of the manual focuses on the Energy Code provisions unique to refrigerated warehouses. The Energy Code described in this chapter of the manual address refrigerated space insulation levels, underslab heating requirements in freezers, infiltration barriers, evaporator fan controls and efficiency requirements, condenser sizing and efficiency requirements, condenser fan controls, and screw compressor variable-speed requirements.

All buildings regulated under Part 6 of the Energy Code must also comply with the general provisions of the Energy Code (Section 100.0–Section 100.2, Section 110.0–Section 110.10, Section 120.0–Section 120.9, Section 130.0–Section 130.5) and additions and alterations requirements (Section 141.1). These topics are generally addressed in Chapter 3 of this manual.

All process piping operating at a temperature below 60°F such as refrigerant piping or chilled water piping shall comply with Section 120.3. New requirements for process pipe insulation are listed in Process Pipe Insulation.

Mandatory Measures and Compliance Approaches

The energy efficiency requirements for refrigerated warehouses are all mandatory. There are no prescriptive requirements or performance compliance paths for refrigerated warehouses. Because the provisions are all mandatory, there are no trade-offs allowed between the various requirements. The application must demonstrate compliance with each of the mandatory measures. Exceptions to each mandatory requirement, when applicable, are described in each of the mandatory measure sections below.

Scope and Application

Reference: Section 120.6(a)

Section 120.6(a) of the Energy Code addresses the energy efficiency of refrigerated spaces within buildings, including coolers and freezers, as well as the refrigeration equipment that serves those spaces. Coolers are defined as refrigerated spaces designed to operate between 28°F (-2°C) and 55°F (13°C). Freezers are defined as refrigerated spaces designed to operate below 28°F (-2°C). The Energy Code does not address walk-in coolers and freezers, defined as refrigerated spaces less than 3,000 ft^2, as these are covered by the Appliance Efficiency Regulations (Title 20). Refrigerated warehouses and spaces with a total of 3,000 ft^2 or more and served by a common refrigeration system are covered by the Energy Code and required to comply with Section 120.6(a).

Areas within refrigerated warehouses designed solely for quick chilling or quick freezing of products have some exceptions for evaporators and compressor requirements. Quick chilling and freezing spaces are defined as spaces with a design refrigeration evaporator load of greater than 240 Btu/hr-ft^2 of floor space, which is equivalent to 2 tons per 100 ft^2 of floor space. A space used for quick chilling or freezing and used for refrigerated storage must still meet the requirements of Section 120.6(a).

The intent of the Energy Code is to regulate storage space, not quick chilling or freezing space or process equipment. Recognizing that there is often a variety of space types and equipment connected to a particular suction group in a refrigerated warehouse, it is not always possible to identify compressor plant equipment that serves the storage space only. It is not the intent of the Energy Code to apply compressor plant requirements to an industrial process that is not covered by the Energy Code simply because a small storage space is also attached to the suction group. Similarly, it is not the intent of the Energy Code to exclude a compressor plant connected to a suction group serving a large storage space covered by the Energy Code on the basis of a small process cooler or quick chill space also connected to the same suction group. As a result, the compressor plant requirements in Section 120.6(a)5C apply when 80 percent or more of the design refrigeration capacity connected to the suction group is from refrigerated storage space(s). A suction group refers to one or more compressors that are connected to one or more refrigeration loads whose suction inlets share a common suction header or manifold.

A variety of space types and processes may be served by a compressor plant at different suction pressures. When all these compressors share a common condensing loop, it is impossible to address only the equipment serving refrigerated storage spaces. The provisions addressing condensers, subsections 120.6(a)4A, 4B, and 4C, apply only to new condensers that are part of new refrigeration systems when the total design capacity of all refrigerated storage spaces served by compressors using a common condensing loop is greater than or equal to 80 percent of the total design capacity.

In addition to an all-new refrigerated facility, the Energy Code covers expansions and modifications to an existing facility and an existing refrigeration plant. The Energy Code does not require that all existing equipment must comply when a refrigerated warehouse is expanded or modified using existing refrigeration equipment. Exceptions are stated in the individual equipment requirements and an explanation of applicability to additions and alterations is included in Refrigerated Warehouses.

Ventilation

Section 120.1(a)1 of the Energy Code, concerning ventilation requirements, does not apply to "refrigerated warehouses and other spaces or buildings that are not normally used for human occupancy and work." The definition of refrigerated warehouses covers all refrigerated spaces greater than or equal to 3,000 ft,^{2} where mechanical refrigeration setpoint is at or below 55°F (13°C), which will in some instances include spaces with occupancy levels or durations, effect of stored product on space conditions, or other factors that may require ventilation for one or more reasons. Accordingly, while the Energy Code does not require ventilation for refrigerated warehouses, it is acknowledged that ventilation may be needed in some instances and is left to the determination of the owner and project engineer.

Example 10-8

Question:

A space that is part of a refrigerated facility is used solely to freeze meat products and not for storage. The design evaporator load is 310 Btu/hr-ft^2 at the applied conditions. Does the space have to comply with the space requirements in Section 120.1(a) of the Energy Code?

Answer:

Yes. If the warehouse is 3,000 ft^2 or larger or served by a refrigeration system serving 3,000 ft^2 or more, it must meet all the requirements in subsections 1, 2, 6, and 7. It also must meet the requirements of subsections 3A, 4D, 4E, 4F, 4G, 4H, 5A, 5B, and 5D. There are exceptions for 3B, 3C, 3D, 3E, 4A, 4B, 4C and 5C.

Example 10-9

Question:

A refrigerated warehouse space is used to cool and store melons received from the field. After the product temperature is lowered, the product is stored in the same space for a few days until being shipped or sent to packaging. The design evaporator capacity is 300 Btu/hr-ft^2 at the applied conditions. Does the space have to comply with all the space requirements of Section 120.1(a) of the Energy Code?

Answer:

Yes. While the design evaporator capacity is greater than 240 Btu/hr-ft² and the space is used for product pull down for part of the time, the space is also used for holding product after it has been cooled. Accordingly, the space has to comply with the space requirements of Section 120.1(a) of the Energy Code.

Comment: This measure does not define a specific time limit that a quick chill (which for clarity includes quick "freeze") space could operate as a holding space (i.e., at full speed and thus full fan power). The typical high fan power density in a quick chill space, particularly at full speed after the high cooling load has been removed, is very inefficient. Thus, a reasonable expectation for a dedicated quick chill space is to allow no more time (at full speed) than is appropriate to remove the product in a normal business cycle of loading, cooling/freezing, and removing product once it has been reduced to temperature. If product is to be held any longer, variable speed is required to reduce fan power. Variable-speed requirements are discussed in the mechanical system requirements of Chapter 10.

Example 10-10

Question:

A new refrigeration system serves both storage and quick chilling space. The design refrigeration capacity of the storage space is 500 tons. The design capacity of the quick chilling space is 50 tons. Is the refrigeration system required to meet all the requirements of Section 120.1(a) of the Energy Code?

Answer:

Yes. Since more than 80 percent of the design capacity of the system serves storage space, the refrigeration system requirements apply.

Example 10-11

Question:

A new refrigerated warehouse is being constructed, which will include a 1,500 ft² cooler space and a 2,500 ft² freezer space. Both the cooler and freezer are served by a common refrigeration system. Is the refrigeration system required to comply with this standard?

Answer:

Because the suction group serves a total 4,000 ft² of refrigerated floor area, the spaces must meet all the requirements of Section 120.6(a).

Building Envelope Mandatory Requirements

Please refer to Chapter 10.6.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Envelope Insulation

Please refer to Chapter 10.6.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Underslab Heating Controls

Please refer to Chapter 10.6.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Infiltration Barriers

Please refer to Chapter 10.6.2.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Automatic Door Closers

Please refer to Chapter 10.6.2.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Acceptance Requirements

Please refer to Chapter 10.6.2.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mechanical Systems Mandatory Requirements

Overview

Please refer to Chapter 10.6.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Evaporators

Please refer to Chapter 10.6.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Efficiency

Reference: Section 120.6(a)3D

Evaporators provide air cooling to spaces within refrigerated warehouses using refrigerants such as Ammonia (R-717), CO2 (R-744), and halocarbon refrigerants. Designers and engineers selecting evaporator equipment for a project typically have multiple models available from each manufacturer that meet all requirements. Evaporator specific efficiency requirements provide a consistent parameter for comparing evaporator models so the energy of the unit can be used in the decision process. The evaporator specific efficiency evaluates the capacity and power of the unit at a specific set of rating conditions for cooler and docks, as well as with freezers. Those rating conditions may vary from application design conditions, so multiple sets of ratings may be required for a project where specific efficiency is not directly published from the manufacturer.

Evaporator specific efficiency is the gross refrigeration capacity divided by the fan watts at full speed at the design conditions listed in Table 120.6-A-2 Fan-Powered Evaporators – Minimum Specific Efficiency Requirements and tested in accordance with AHRI 420-2023, Standard for Performance Rating of Forced Circulation Free-Delivery Unit Coolers. The rating conditions for all of the evaporators are at 0 inches static pressure, i.e., in free air and not ducted. The capacity rating for the specific efficiency calculation utilizes gross total refrigeration capacity in Btu/hr, including the capacity required to offset heat from operating the fan. The requirements are limited to evaporators which contain refrigerants which undergo a phase change (evaporation) and thus do not include evaporators where the heat transfer of the refrigerant is sensible only such as in glycol cooling coils.

Evaporator specific efficiency is not mandatory for spaces that are used solely for quick chilling or quick freezing of products. This includes, but is not limited to, spaces with design cooling capacities of greater than 240 Btu/hr-ft2 (2 tons per 100 square feet). Many units in quick applications require high airflow which as a result typically involves more fan power to achieve the cooling time requirements for the products.

Example 10-12

Question:

Evaporators for a new refrigerated warehouse space are being specified with the intent that the fan speed will be limited to a maximum 92% (55Hz) using a control system. Can the evaporator specific efficiency be rated at 95% fan speed since this is expected to give a closer representation of specific efficiency at the actual operating conditions?

Answer:

No, specific efficiency must be rated at 100% (60Hz) fan speed to reflect the worst case the fan may operate at, such as if the control system is modified at a later point in time.

Static Pressure Drop

Reference: Section 120.6(a)3E

Maximum requirements for evaporator static pressure drop provide a limit in the static pressure to prevent the need for larger horsepower evaporator motors when ducting is included in designs. The design pressure drop is limited to no more than 0.5 inches of water column. If pressure drop is too high, a redesign is warranted with consideration of duct cross-sectional areas, transitions, and fitting selection. There is no maximum static pressure drop for evaporators that are used solely for quick chilling or quick freezing of products.

Condensers

Reference: Section 120.6(a)4

New condensers on new refrigeration systems must follow the condenser sizing, fan control, and efficiency requirements as described in Section 120.6(a)4.

Condenser Sizing

Section 120.6(a)4A and Section 120.6(a)4B describe minimum sizing requirements for new condensers serving new refrigeration systems. Fan-powered evaporative condensers, as well as water-cooled condensers served by fluid coolers and cooling towers, are covered in Section 120.6(a)4A. Fan-powered air-cooled condensers are covered by Section 120.6(a)4B. Fan-powered adiabatic condensers are covered by Section 120.6(a)4C.

Condensers must be sized to provide sufficient heat rejection capacity under design conditions while maintaining a specified maximum temperature difference between the refrigeration system saturated condensing temperature (SCT) and ambient temperature. The design condenser capacity shall be greater than the calculated combined total heat of rejection (THR) of the dedicated compressors that are served by the condenser. If multiple condensers are specified, then the combined capacity of the installed condensers shall be greater than the calculated heat of rejection. When determining the design THR for this requirement, reserve or backup compressors may be excluded from the calculations.

There is no limitation on the type of condenser that may be used. The choice may be made by the system designer, considering the specific application, climate, water availability, etc.

The Energy Code includes an exception to Section 120.6(a)4A, 4B, and 4C for condensers serving refrigeration systems for which more than 20 percent of the design cooling load comes from quick chilling or freezing space, or process (nonspace) refrigeration cooling. The Energy Code defines quick chilling or freezing space as a space with a design refrigeration evaporator capacity greater than 240 Btu/hr-ft² of floor area, which is equivalent to 2 tons per 100 ft² of floor area, at system design conditions.

Another exception to Section 120.6(a)4A, 4B, 4C, 4G, and 4H for condenser sizing, efficiency, and fin density applies for equipment that must meet the Appliance Efficiency Requirements for walk-in cooler or walk-in freezers, which includes equipment serving spaces less than 3,000 square feet. Refrigeration equipment with condensers serving spaces of that size are commonly classified as a condensing unit, which is a unitary packaged equipment that includes compressor(s), condenser, liquid receiver, and control electronics in a single product.

Example 10-13

Question:

A new food processing plant is being constructed that will include an 800 ft² blast freezer, a holding freezer, and a loading dock. The design evaporator capacity of the blast freezer is 40 tons of refrigeration (TR). The combined evaporator capacity of the freezer and loading dock is 60 TR. Does the condenser group have to comply with the sizing requirements in Section 120.6(a)4A?

Answer:

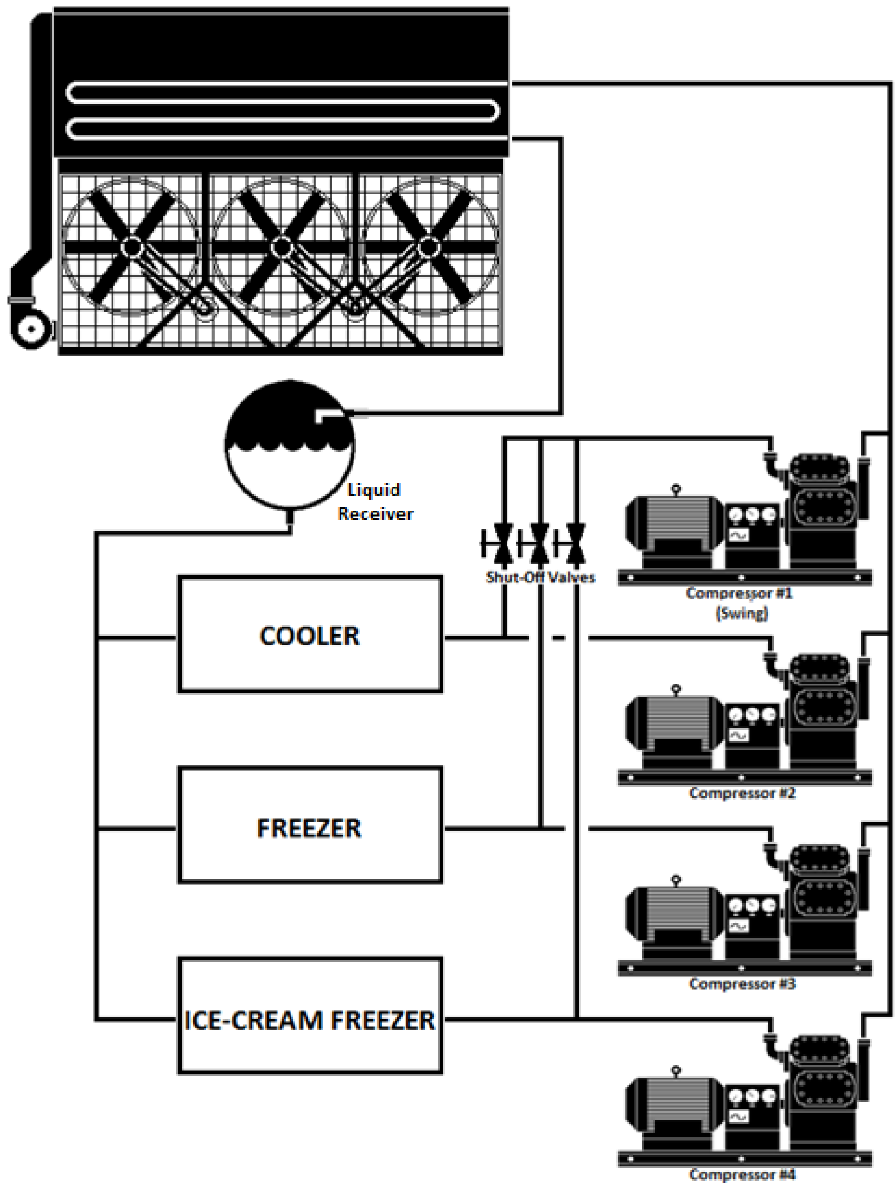
The blast freezer evaporator capacity divided by the floor area is 40 TR/800 ft², which is equal to 5 TR/100 ft². That means this particular blast freezer is deemed quick freezing space by the Energy Code. Therefore, the condenser group serving the refrigeration system does not have to comply with Section 120.6(a)4A, because 40% (i.e., greater than 20%) of the design refrigeration capacity is from quick freezing.

Example 10-14

Question:

The refrigerated warehouse system shown below has a backup or "swing" compressor. Does the heat rejection from this compressor need to be included in the condenser sizing calculations?

Figure 10- 8: Example Refrigerated Warehouse System for Example 10-14



Source: California Energy Commission

Answer:

It depends.

A swing compressor may be designed solely for backup of multiple suction groups, or it may be included in one suction group and necessary to meet the design load of that suction group, but in an emergency is also capable of providing backup for other compressors. If the compressor is solely for use as backup, it would be excluded from the heat rejection calculation for the purposes of the Energy Code. In this case, the calculations would include the heat of rejection from Compressors 2, 3, and 4 and would exclude Compressor 1.

Sizing of Evaporative Condensers, Fluid Coolers, and Cooling Towers

Reference: Section 120.6(a)4A

Section 120.6(a)4A provides maximum design SCT values for evaporative condensers as well as systems consisting of a water-cooled condenser served by a cooling tower or fluid cooler. For this section, designers should use the 0.5 percent design wet bulb temperature (WBT) from Table 2-3 – Design Day Data for California Cities in the Reference Joint Appendices JA2 to demonstrate compliance with this requirement. The maximum design SCT requirements are listed in Table 10-1: Maximum Design SCT Requirements for Evaporative Condensers and Water-Cooled Condensers Served by Cooling Towers and Fluid Coolers below.

Table 10-1: Maximum Design SCT Requirements for Evaporative Condensers and Water-Cooled Condensers Served by Cooling Towers and Fluid Coolers

0.5% DESIGN WET BULB TEMPERATURE	MAXIMUM DESIGN SCT
<= 76°F (24°C)	Design WBT plus 20°F (11°C)
Between 76°F (24°C) and 78°F (26°C)	Design WBT plus 19°F (10.5°C)
>= 78°F (26°C)	Design WBT plus 18°F (10°C)

Source: California Energy Commission

Example 10-15

Question:

A refrigerated warehouse is being constructed in Fresno. The refrigeration system will be served by an evaporative condenser. What is the sizing requirement for the condenser selected for this system?

Answer:

The 0.5% design wet bulb temperature (WBT) from Joint Appendix JA-2 for Fresno is 73°F. Therefore, the maximum design SCT for the refrigerant condenser is 73°F + 20°F = 93°F. The selected condenser for this system must be capable of rejecting the total system design THR at 93°F SCT and 73°F WBT.

Example 10-16

Question:

What is the minimum size for a condenser for a refrigeration system with the following parameters?

Located in Fresno

Design SST: 10°F

Suction group: Three equal-sized dedicated 100 hp screw compressors (none are backup units)

Evaporative condenser

240 TR cooling load

Answer:

From the previous example, it was determined that the design wet bulb temperature (WBT) to demonstrate compliance for Fresno is 73°F, and the maximum design SCT for the evaporative condenser is 93°F (73°F + 20°F). We will assume the system designer determined a 2°F loss between the compressors and condenser. The designer first calculates the THR for the suction group at the design conditions of 10°F SST and 95°F SCT. Each selected compressor has a rated capacity of 240 TR and will absorb 300 horsepower at the design conditions. Therefore, the calculated THR for one compressor is:

240 TR / compressor x 3 compressor x 12,000 Btuh/TR + 300HP x 2,545 Btuh/HP = 9,403,500 Btuh

To comply with the Energy Code, a condenser (or group of condensers) must be selected that is capable of rejecting at least 9,403,500 Btu/hr at 93°F SCT and 73°F WBT.

Sizing of Air-Cooled Condensers

Reference: Section 120.6(a)4B

Section 120.6(a)4B provides maximum design SCT values for air-cooled condensers. For this section, designers should use the 0.5 percent design dry bulb temperature (DBT) from Table 2-3 – Design Day Data for California Cities in the Reference Joint Appendices JA2 to demonstrate compliance with this requirement.

Standard practice is for published condenser ratings to assume the capacity of air-cooled condensers is proportional to the temperature difference (TD) between SCT and DBT, regardless of the actual ambient temperature entering the condenser. For example, the capacity of an air-cooled condenser operating at an SCT of 80°F with a DBT of 70°F is assumed to be equal to the same unit operating at 110°F SCT and 100°F DBT, since the TD across the condenser is 10°F in both examples. Thus, unlike evaporative condensers, the requirement for air-cooled condensers does not have varying sizing requirements for different design ambient temperatures.

However, the Energy Code has different requirements for air-cooled condensers depending on the space temperatures served by the refrigeration system. The maximum design SCT requirements are listed in Table 10-2: Maximum Design SCT Requirements for Air-Cooled Condensers:

Table 10-2: Maximum Design SCT Requirements for Air-Cooled Condensers

REFRIGERATED SPACE TYPE	SPACE TEMPERATURE	MAXIMUM SCT
Cooler	≥28°F (-2°C)	Design DBT plus 15°F (8.3°C)
Freezer	< 28°F (-2°C)	Design DBT plus 10°F (5.6°C)

Source: California Energy Commission

Often, a single refrigeration system and the associated condenser will serve a mix of cooler and freezer spaces. In this instance, the maximum design SCT shall be a weighted average of the requirements for cooler and freezer spaces, based on the design evaporator capacity of the spaces served.

Example 10-17

Question:

An air-cooled condenser is being sized for a system that has half of the associated installed capacity serving cooler space and the other half serving freezer space. What is the design TD to be added to the design dry bulb temperature?

Answer:

This measure specifies a design approach of 15°F (8.3°C) for coolers and 10°F (5.6°C) for freezers. When a system serves freezer and cooler spaces, a weighted average should be used based on the installed capacity. To calculate the weighted average, multiply the percentage of the total installed capacity dedicated to coolers by 15°F (8.3°C). Next, multiply the percentage of the total installed capacity dedicated to freezers by 10°F (5.6°C). The sum of the two results is the design condensing temperature approach. In this example, the installed capacity is evenly split between freezer and cooler space. As a result, the design approach for the air-cooled condenser is 12.5°F (6.9°C).

(50% x 15°F*) + (50% x 10*°F*) = 7.5*°F *+ 5*°F *= 12.5*°F

Adiabatic Condenser Sizing

Reference: Section 120.6(a)4C

Section 120.6(a)4C provides maximum design SCT values for adiabatic condensers. These requirements are the same as for Section 120.6(b)1E. See Condenser Mandatory Requirements for details.

Fan Control, Condensing Temperature Setpoint, and Condensing Temperature Reset

Reference: Section 120.6(a)4D, Section 120.6(a)4E, Section 120.6(a)4F

Condenser fans for new air-cooled, evaporative, or adiabatic condensers, or fans on cooling towers or fluid coolers used to reject heat on new refrigeration systems, must use continuously variable-speed. Variable-frequency drives are commonly used to provide continuously variable-speed control of condenser fans, although controllers designed to vary the speed of electronically commutated motors may be used to control these types of motors. All fans serving a common high side, or cooling water loop for cooling towers and fluid coolers, shall be controlled in unison. Thus, in normal operation, the fan speed of all fans within a single condenser or set of condensers serving a common high side should modulate together, rather than running fans at different speeds or staging fans off. However, when fan speed is at the minimum practical level usually no higher than 10-20%, the fans may be staged off to reduce condenser capacity. As load increases, fans should be turned back on before significantly increasing fan speed, recognizing a control band is necessary to avoid excessive fan cycling.

To minimize overall system energy consumption, the condensing temperature set point must be continuously reset in response to ambient temperatures, rather than using a fixed set point value. This strategy is also termed ambient-following control, ambient-reset, wet bulb following and dry bulb following—all referring to the control logic that changes the condensing temperature target in response to ambient conditions at the condenser. The control system calculates a target saturated condensing temperature that is higher than the ambient temperature by a predetermined temperature difference (i.e., the condenser control TD). Fan speed is then modulated according to the calculated target SCT. The target SCT for evaporative condensers or water-cooled condensers (via cooling towers or fluid coolers) must be reset according to ambient wet bulb temperature, the target SCT for air-cooled condensers must be reset according to ambient dry bulb temperature, and the target SCT for adiabatic condensers when operating in dry mode must be reset according to ambient dry bulb temperature. There is no requirement for SCT control during wet bulb (adiabatic) operation.

This requirement for the adiabatic condenser is applicable to all systems and is independent of the type of refrigerant used

The condenser control TD is not specified in the Energy Code. The nominal control value is often less than the condenser design TD; however, the value for a particular system is left up to the system designer. Since the intent is to use as much condenser capacity as possible without excessive fan power, a common practice for refrigerated warehouse systems is to optimize the control TD over a period such that the fan speed is between approximately 60 and 80% during normal operation (i.e., when not at minimum SCT). While not required, evaporative condensers and systems using fluid coolers and cooling towers may also vary the condenser control TD as a function of actual WBT to account for the properties of moist air, which reduce the effective condenser capacity at lower wet bulb temperatures.

The minimum saturated condensing temperature set point must be 70°F (21°C) or less. For systems using halocarbon refrigerants with glide, the SCT set point shall correlate with a midpoint temperature (between the refrigerant bubble-point and dew-point temperatures) of 70°F (21°C) or less. As a practical matter, a maximum SCT set point is also commonly employed to set an upper bound on the control set point in the event of a sensor failure and to force full condenser operation during peak ambient conditions. This value should be set high enough that it does not interfere with normal operation.

Split air-cooled condensers are sometimes used for separate refrigeration systems, with two circuits and two rows of condenser fans. Each condenser half would be controlled as a separate condenser. If a condenser has multiple circuits served by a common fan or set of fans, the control strategy may use the average condensing temperature or the highest condensing temperature of the individual circuits as the control variable for controlling fan speed.

Alternative control strategies are permitted to the condensing temperature reset control required in Section 120.6(a)4F. The alternative control strategy must be demonstrated to provide equal or better performance, as approved by the Executive Director.

Example 10-18

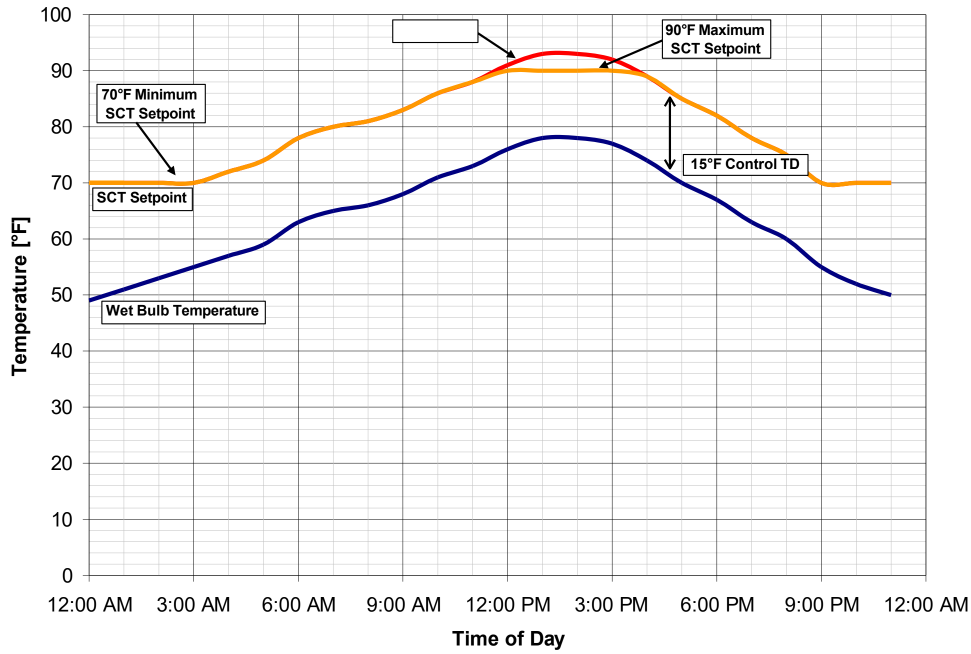
Question:

A refrigerated warehouse with evaporative condensers is being commissioned. The control system designer has used a wet bulb-following control strategy to reset the system saturated condensing temperature (SCT) set point. The refrigeration engineer has calculated that adding a TD of 15°F (8.3°C) above the ambient wet bulb temperature should provide a saturated condensing temperature set point that minimizes the combined compressor and condenser fan power usage throughout the year. What might the system SCT and SCT set point trends look like over an example day?

Answer:

The following figure illustrates what the actual saturated condensing temperature and SCT set points could be over an example day using the wet bulb-following control strategy with a 15°F (8.3°C) TD and observing the 70°F (21°C) minimum condensing temperature requirement. As the figure shows, the SCT set point is continuously reset to 15°F (8.3°C) above the ambient wet bulb temperature until the minimum SCT set point of 70°F is reached. The figure also shows a maximum SCT set point (in this example, 90°F (32.2°C) that may be used to limit the maximum control set point, regardless of the ambient temperature value or TD parameter.

Figure 10-9: SCT Setpoint and Wet-Bulb Temperature for Example 10-18



Source: California Energy Commission

Example 10-19

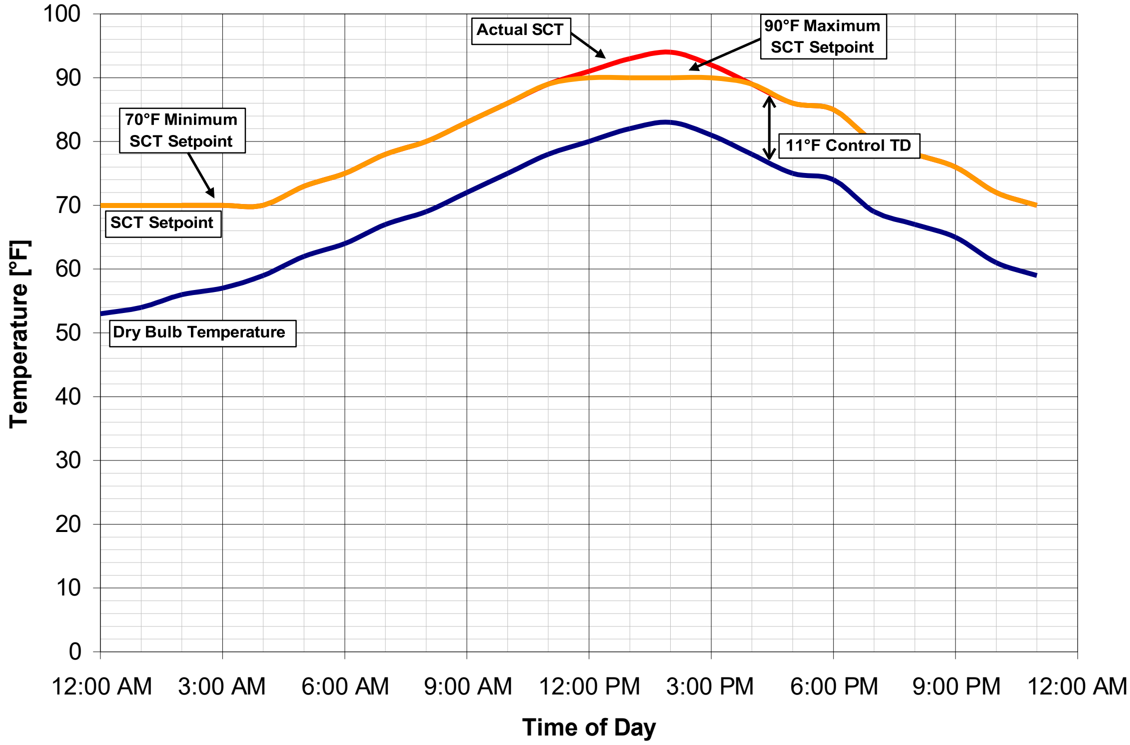
Question:

A cold storage facility with an air-cooled condenser is being commissioned. The control system designer has used a dry bulb-following control strategy to reset the system saturated condensing temperature (SCT) set point. The refrigeration engineer has calculated that adding a TD of 11°F (6.1°C) above the ambient dry bulb temperature should provide a saturated condensing temperature set point that minimizes the combined compressor and condenser fan power usage throughout the year. What might the system SCT and SCT set point trends look like over an example day?

Answer:

The following figure illustrates the actual saturated condensing temperature and SCT set points over an example day using the dry bulb-following control strategy with an 11°F (6.1°C) TD and observing the 70°F (21°C) minimum condensing temperature requirement. As the figure shows, the SCT set point is continuously reset 11°F (6.1°C) above the ambient dry bulb temperature but is bounded by the minimum and maximum SCT set points. The figure also shows a maximum SCT set point (in this example, 90°F (32.2°C) that may be used to limit the maximum control set point, regardless of the ambient temperature value or TD parameter.

Figure 10-10: SCT Setpoint and Wet-Bulb Temperature for Example 10-19



Source: California Energy Commission

Condenser Efficiency

Reference: Section 120.6(a)4G

Requirements for design condensing temperatures relative to design ambient temperatures, as described above for Section 120.6(a)4A, B, and C, help assure that there is enough condenser capacity to keeping condensing temperatures compressor head pressures at reasonable levels. However, the sizing requirements do not address condenser efficiency. For example, rather than providing amply sized condenser surface area, a condenser selection could consist of a small condenser area using a large motor to blow a large amount of air through the heat exchanger surface to achieve the design condenser TD. However, this would come at the expense of excessive fan motor horsepower. Also, relatively high fan power consumption can result from using condenser fans that have poor fan efficiency or low fan motor efficiency. Section 120.6(a)4G addresses these and other factors affecting condenser fan power by setting minimum specific efficiency requirements for condensers.

All newly installed indoor and outdoor evaporative condensers and outdoor air-cooled and adiabatic condensers to be installed on new refrigeration systems shall meet the minimum specific efficiency requirements shown in Table 120.6-B.

Condenser specific efficiency is defined as:

Condenser Specific Efficiency = Total Heat Rejection (THR) Capacity / Input Power

The total heat rejection capacity is at the rating conditions of 100°F saturated condensing temperature (SCT) and 70°F outdoor wet bulb temperature for evaporative condensers, and 105°F SCT and 95°F outdoor dry bulb temperature for air-cooled condensers. Input power is the electric input power draw of the condenser fan motors (at full speed), plus the electric input power of the spray pumps for evaporative condensers. The motor power is the manufacturer's published applied power for the subject equipment, which is not necessarily equal to the motor nameplate rating. Power input for secondary devices such as sump heaters shall not be included in the specific efficiency calculation.

As shown in Table 120.6-B, the Energy Code has different minimum efficiencies depending on the type of condenser that is being used. The different classifications of condenser are:

- Outdoor, evaporative, THR greater than 8,000 MBH at specific efficiency rating conditions.
- Outdoor, evaporative, THR less than 8,000 MBH at specific efficiency rating conditions.
- Indoor, evaporatively cooled.
- Outdoor, air-cooled, ammonia refrigerant.
- Outdoor, air-cooled, halocarbon refrigerant.
- Adiabatic (dry-mode operation), halocarbon refrigerant.
- Indoor, air-cooled.

The data published in the condenser manufacturer's published rating for capacity and power shall be used to calculate specific efficiency. For evaporative condensers, manufacturers typically provide nominal condenser capacity and tables of correction factors that are used to convert the nominal condenser capacity to the capacity at various applied condensing temperatures and wet bulb temperatures. Usually, the manufacturer publishes two sets of correction factors: one is a set of "heat rejection" capacity factors, while the others are "evaporator ton" capacity factors. Only the "heat rejection" capacity factors shall be used to calculate the condenser capacity at the efficiency rating conditions for determining compliance with this section.

For air-cooled and adiabatic condensers, manufacturers typically provide the capacity at a given temperature difference (TD) between SCT and dry bulb temperature. Manufacturers typically assume that condenser capacity is linearly proportional to TD; the catalog capacity at 20°F TD is typically twice as much as at 10°F TD. The condenser capacity for air-cooled condensers at a TD of 10°F shall be used to calculate efficiency. For adiabatic condensers, the dry mode capacity at a TD of 10°F shall be used to calculate efficiency. If the capacity at 10°F TD is not provided, the capacity shall be scaled linearly.

Depending on the type of condenser, the actual manufacturer's rated motor power may vary from motor nameplate in different ways. Air cooled condensers with direct-drive OEM motors may use far greater input power than the nominal motor horsepower would indicate. On the other hand, evaporative condenser fans may have a degree of safety factor to allow for higher motor load in cold weather (vs. the 100°F SCT/70°F WBT specific efficiency rating conditions). Thus, actual motor input power from the manufacturer must be used for direct-drive air-cooled condensers, while for large (i.e., > 8,000 MBH) evaporative condensers and other belt-drive condensers, the full load motor rating is generally conservative, but manufacturer's applied power should be used whenever possible to determine specific efficiency more accurately.

Example 10-20

Question:

An evaporative condenser is being considered for use in an outdoor application on a new refrigerated warehouse. The refrigerant is ammonia. The condenser manufacturer's catalog provides the following information:

Figure 10-11: Sample Condenser Properties for Example 10-20

Model Number	Base Heat Rejection (MBH)
A441	4410
B487	4866
C500	4998
D551	5513
E559	5586
F590	5895
G591	5909
H598	5983
I631	6306
J637	6365

Condensing Temperature (°F)	Entering Wetbulb Temperature (°F)					
	62	64	66	68	70	72
95	0.88	0.92	0.97	1.02	1.08	1.16
96.3	0.84	0.88	0.92	0.97	1.02	1.09
97	0.83	0.86	0.90	0.94	0.99	1.05
98	0.80	0.83	0.87	0.91	0.96	1.01
99	0.77	0.80	0.84	0.87	0.92	0.97
100	0.75	0.78	0.81	0.84	0.88	0.93

Source: California Energy Commission

For this example, model number D551 is being considered. Elsewhere in the catalog, it states that condenser model D551 has two 7.5 HP fan motors and one 5 HP pump motor. Fan motor efficiencies and motor loading factors are not provided. Does this condenser meet the minimum efficiency requirements?

Answer:

First, the condenser capacity must be calculated at the efficiency rating condition. From Table 120.6-B, we see that the rating conditions for an outdoor evaporative condenser are 100°F SCT, 70°F WBT. From the Base Heat Rejection table above, we see the nominal capacity for model D551 is 5,513 MBH. From the Heat Rejection Capacity Factors table, we see that the correction factor for 100°F SCT, 70°F WBT is 0.88. The capacity of this model at specific efficiency rating conditions is 5,513 MBH / 0.88 = 6,264 MBH. Since 6,264 MBH is less than 8,000 MBH, we can see from Table 120.6-B that the minimum specific efficiency requirement is 160 (Btu/hr)/watt.

To calculate input power, we will assume 100% fan and pump motor loading and minimum motor efficiency since the manufacturer has not yet published actual motor input power at the specific efficiency rating conditions. We look up the minimum motor efficiency from Nonresidential Appendix NA-3: Fan Motor Efficiencies. For a 7.5 HP four-pole open fan motor, the minimum efficiency is 91.0%. For a 5 HP six-pole open pump motor, the minimum efficiency is 89.5%. The fan motor input power is calculated to be:

- 2 motors x 7.5 HP/motor x 746 watts/HP x 100% assumed loading/ 91% efficiency = 12.297 watts

The pump motor input power is calculated to be:

- 1 motors x 5 HP/motor x 746 watts/HP x 100% assumed loading/ 89.5% efficiency = 4.168 watts

The combined input power is therefore:

- 12.297 watts + 4.168 watts = 16.464 watts

Note: Actual motor power should be used when available (see notes in text).

Finally, the efficiency of the condenser is:

- (6,264 MBH x 1000 Btuh/MBH) / 16.464 watts = 381 Btuh/watt

This condenser meets the minimum efficiency requirements because 381 Btu/hr per watt is higher than the 160 Btu/hr per watt requirement.

Condenser Fin Spacing

According to Section 120.6(a)4H, air-cooled condensers shall have a fin density no greater than 10 fins per inch. Condensers with higher fin densities have a higher risk of fouling with airborne debris. This requirement does not apply to air-cooled condensers that use a microchannel heat exchange surface, since this type of surface is not as susceptible to permanent fouling in the same manner as traditional tube-and-fin condensers with dense fin spacing.

Compressors

Please refer to Chapter 10.6.3.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Acceptance Requirements

Please refer to Chapter 10.6.3.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Transcritical CO_2 Systems

Please refer to Chapter 10.6.3.1 G and 10.6.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Transcritical CO_2 Gas Coolers

Please refer to Chapter 10.6.3.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions and Alterations

Requirements related to refrigerated warehouse additions and alterations are covered by the Energy Code in Section 141.1(a). The specific requirements for additions and alterations for commercial refrigeration are included in Section 120.6(a). Definitions relevant to refrigerated warehouses include the following:

An addition is a change to an existing refrigerated warehouse that increases refrigerated floor area and volume. Additions are treated like new construction.

When an unconditioned or conditioned building or an unconditioned or conditioned part of a building adds refrigeration equipment so that it becomes refrigerated, this area is treated as an addition.

An alteration is a change to an existing building that is not an addition or repair. An alteration could include installing new evaporators, a new lighting system, or a change to the building envelope, such as adding insulation.

A repair is the reconstruction or renewal of any part of an existing building or equipment for maintenance. For example, a repair could include the replacement of an existing evaporator or condenser.

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.

Example 10-21

Question:

The new construction is an addition to an existing refrigerated warehouse. The new space is served by an existing refrigeration plant. Does the refrigeration plant need to be updated to meet the Energy Code?

Answer:

No. The new construction must comply with the Energy Code; however, the existing refrigeration plant equipment is exempt from the Energy Code.

Example 10-22

Question:

The new construction includes an addition to refrigerated space and expansion of the existing refrigeration plant. Is the existing refrigeration equipment subject to the Energy Code?

Answer:

No. Only the new equipment installed in the added refrigerated space and any new compressors added to the existing plant are subject to the requirements of the Energy Code. If a new refrigeration system was installed with a new condenser for the addition, then the new condenser must also comply with the Energy Code.

Example 10-23

Question:

An upgrade to an existing refrigerated storage space includes replacing all of the existing evaporators with new evaporators. Do the new evaporators need to comply with the Energy Code?

Answer:

Yes. A complete renovation of the evaporators in the space is considered an alteration. The alteration requirements apply when all the evaporators in the space are changed.

Example 10-24

Question:

An existing refrigerated storage space is adding additional evaporators to meet an increase in the refrigeration load. Do the new evaporators need to comply with the Energy Code?

Answer:

Yes, the new evaporators must meet the single phase motor requirements in 120.6(a)3A, fan control for systems served by a single non-modulating compressor requirements in 120.6(a)3C, evaporator efficiency requirements in 120.6(a)3D, and maximum static pressure drop requirements in 120.6(a)3E.

Example 10-25

Question:

An existing evaporator is being replaced by a new evaporator as part of system maintenance. Does the new evaporator need to comply with the Energy Code?

Answer:

No. Replacement of an evaporator during system maintenance is considered a repair. The energy consumption of the new evaporator must not exceed that of the equipment it replaced.

Laboratory Systems

Overview

Section 140.9(c) sets the minimum requirements for laboratory and factory exhaust and space conditioning systems. Laboratories have an average annual energy intensity 10-20 times larger than offices when normalized by building area. The primary drivers of laboratory building energy are long operation hours, exhaust fan energy, and makeup air conditioning in addition to typically high internal loads.

To help reduce laboratory and factory energy use, there are six categories of energy saving measures:

- Exhaust and makeup air reduction
- Reduction of conditioned makeup air
- Exhaust fan power reduction
- Fume hood automated sash closures
- Exhaust air heat recovery
- Reheat limitations (4-Pipe VAV)

Laboratories in healthcare facilities are not required to meet the requirements of Section 140.9(c).

Note that as of 2025, laboratories in Group L Occupancies are required to meet the requirements of Section 140.9(c), as are laboratories in Occupancy Groups A, B, E, F, H, I, M, R, S, and U. Prior to 2025, Group L was exempt from the Energy Code.

Mandatory Measures

The mandatory equipment efficiencies in Section 110.1 and Section 110.2 apply to laboratories.

The lab system acceptance tests are also mandatory where applicable, including:

- NA7.16.1 Construction Inspection for VAV Lab Exhaust System with Occupancy Control, per 140.9(c)1 and 140.9(c)3
- NA7.16.2 Functional Testing for VAV Lab Exhaust System with Occupancy Control, per 140.9(c)1
- NA7.16.3 Construction Inspection for Simple Turndown Control, per 140.9(c)3D.v.a
- NA7.16.4 Functional Testing for Simple Turndown Control, per 140.9(c)3D.v.a
- NA7.16.5 Construction Inspection for Wind Speed/Direction Responsive Control, per 140.9(c)3D.v.b
- NA7.16.6 Functional Testing for Wind Speed/Direction Responsive Control, per 140.9(c)3D.v.b
- NA7.16.7 Construction Inspection for Monitored Contaminant Control, per 140.9(c)3D.v.c
- NA7.16.8 Functional Testing For Monitored Contaminant Control, per 140.9(c)3D.v.c

Prescriptive Measures

Summary of measures contained in this section:

- Airflow Reduction Requirements - Section 140.9(c)1
- Exhaust System Transfer Air - Section 140.9(c)2
- Fan System Power Consumption - Section 140.9(c)3
- Fume Hood Automatic Sash Closure - Section 140.9(c)4
- Reheat Limitation - Section 140.9(c)5
- Exhaust Air Heat Recovery - Section 140.9(c)6

Airflow Reduction Requirements

Reference: Section 140.9(c)1

Section 140.9(c)1 requires that all laboratory systems be designed for variable-volume control on the supply, fume exhaust, and general exhaust. The system must be capable of reducing the total zone exhaust and makeup airflow rates down to 1.0 cfm/ft2 or lower when occupancy sensor(s) indicate the space is occupied and down to 0.67 cfm/ft2 or lower when occupancy sensor(s) indicate the space is unoccupied.

The airflow rate can be higher if the cooling load or hood sash positions demand a higher flow rate but if the cooling load is low and the hood sash positions do not require higher flow then the system must reduce the total zone flows to these minimum values.

Higher minimum flow rates are allowed if a higher minimum is required to comply with code, accreditation, or facility environmental health and safety department requirements. The minimum cannot exceed that required to comply with code, accreditation, or facility environmental health and safety department requirements. Documentation is required if this clause is used.

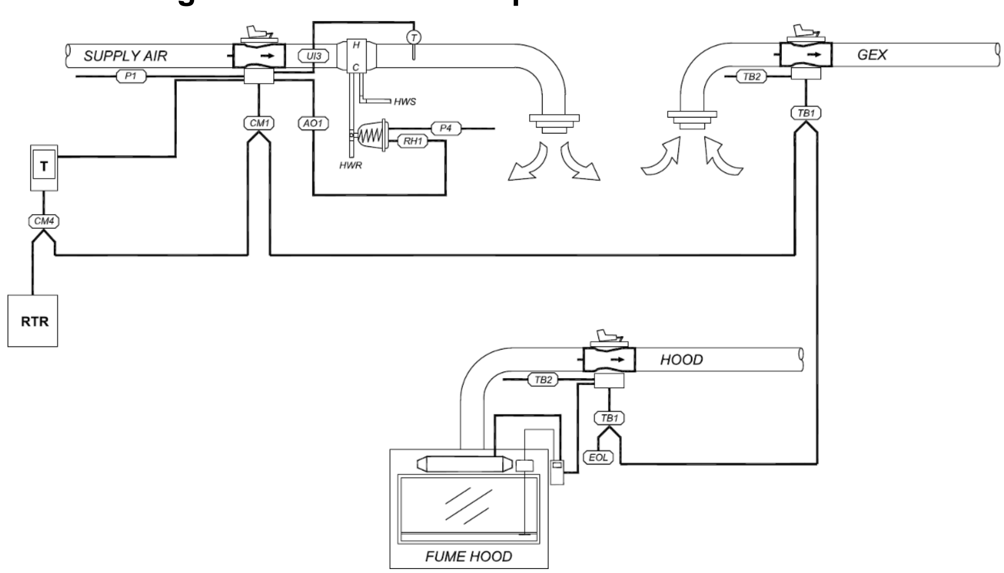
Higher minimum flow rates are also allowed if a higher minimum is required to maintain space pressurization. Typically, this would only be the case if there were many VAV fume hoods in a space and the total hood minimum flow with all the sashes closed still exceeded 0.67 or 1.0 cfm/ft2. A typical hood minimum flow rate with the sash closed is 50 cfm/ft of hood width or 25 cfm/ft2 of work surface.

The 1.0 cfm/ft2 occupied and 0.67 cfm/ft2 unoccupied are maximum minimums. Lower minimums are allowed. 1.0 cfm/ft2 is equivalent to 6 air changes per hour for a 10-foot-high ceiling. 0.67 cfm/ft2 is equivalent to 4 air changes per hour for a 10-foot-high ceiling. Many lab owners are comfortable with lower minimum air change rates, particularly when spaces are unoccupied.

Figure 10-12: Zone Components for a VAV Lab below shows the zone components for a VAV laboratory. There are three zone valves shown in this image: one each on the supply air to the zone, the fume hood (if one exists), and the general exhaust valve (GEX) if one is needed. These zone valves can be venturi type valves as shown in this image or standard dampers like those used for VAV boxes in offices. When used, the hood valve is controlled to automatically maintain the design sash face velocity (e.g., 100 ft/min) as the hood sash is opened or closed. The role of the supply valve is to maintain space pressurization by tracking the sum of the hood and general exhausts in the space. The GEX is typically used to control the cooling, on a call for cooling it opens, and the supply valve, in turn, opens to maintain space pressure. In some systems the supply modulates like a typical VAV box in response to the thermostat, and the GEX modulates to maintain space pressure.

All three valves can be designed for either variable volume or constant volume depending on the application. If the hood is a constant volume bypass hood then the hood valve must be constant volume. Even with a constant volume hood, you will need a pressure independent hood valve if the attached exhaust also serves variable-volume zones. The same rule applies for constant volume supply or general exhaust. If any zone on a supply or exhaust duct is variable volume, all zone ducts on it must have pressure independent controls.

Figure 10-12: Zone Components for a VAV Lab

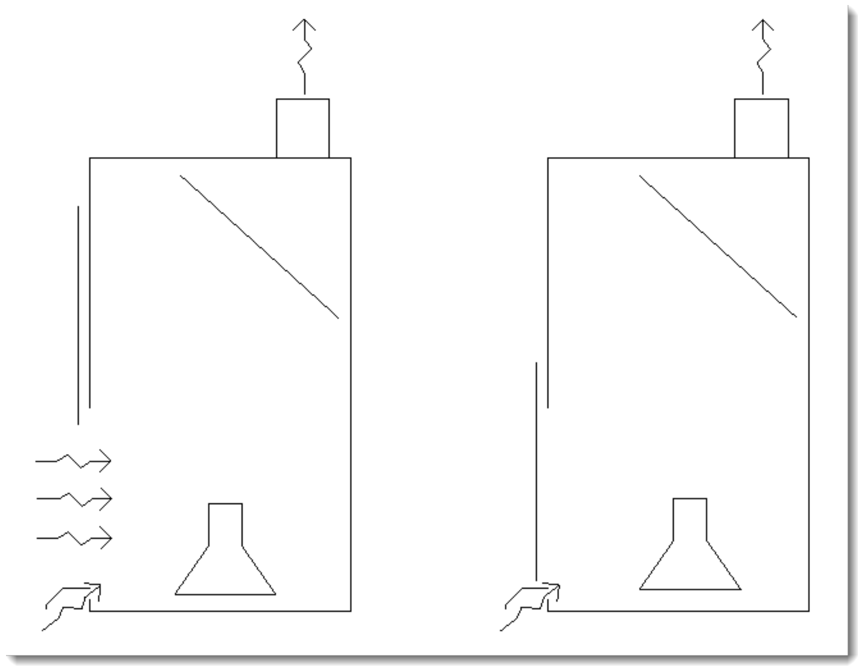


Source: California Energy Commission

Figure 10-13: Variable Air Volume Hood below illustrates a VAV hood. As the sash is moved the exhaust rate is modulated to maintain a fixed velocity (typically 100 ft/min) through the sash open area, with a minimum velocity when the sash is in the closed position (typically 50 cfm/ft of hood width or 25 cfm/ft2 of work surface).

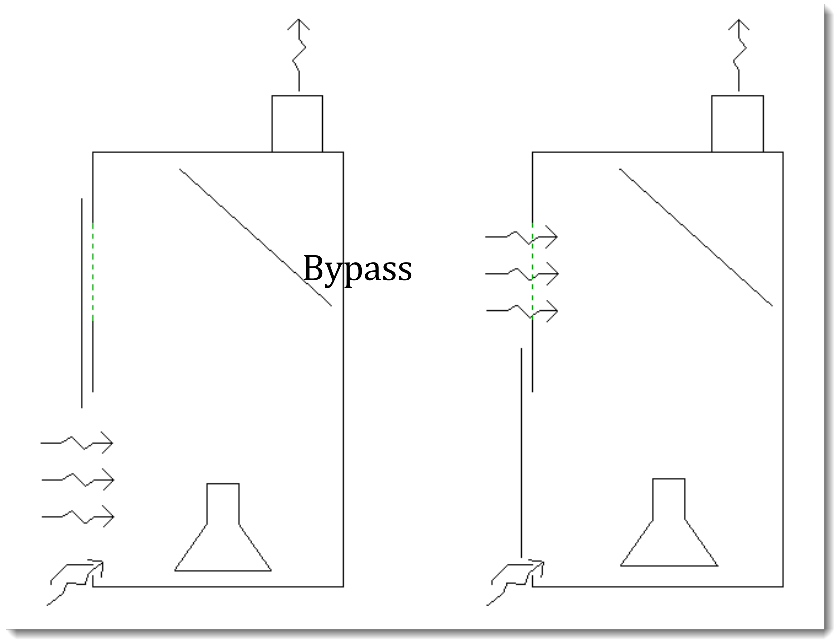
Figure 10-14: Contant Volume Hood illustrates a CAV hood. As the sash closes the bypass opens such that the sum of the flow rates through the sash and the bypass is constant.

Figure 10-13: Variable Air Volume Hood



Source: California Energy Commission

Figure 10-14: Contant Volume Hood



Source: California Energy Commission

The only exception to this requirement is for new zones on an existing constant volume exhaust system.

Example 10-26

Question:

Does Section 140.9(c)1 require VAV hoods?

Answer:

Not necessarily. Constant volume hoods are allowed if the total design exhaust rate of the hoods does not exceed 0.67 cfm/ft2 (or the regulated minimum unoccupied circulation rate documented to comply with code, accreditation, or facility environmental health and safety department requirements). However, if the total design exhaust rate of the hoods exceeds 0.67 cfm/ft2 then some or all hoods must be VAV. Only some hoods must be VAV as long as the total hood flow with the sashes closed does not exceed 0.67 cfm/ft2. If the total hood flow with the sashes closed exceeds 0.67 cfm/ft2 then all hoods must be VAV. The hood valve must follow the functionality of the hood, i.e., VAV hoods require VAV hood valves; CAV hoods require CAV hood valves.

Example 10-27

Question:

Does Section 140.9(c)1 require VAV supply valves?

Answer:

Typically, yes. A supply valve can only be CAV if its design flow rate does not exceed 0.67 cfm/ft2 (or the regulated minimum unoccupied circulation rate documented to comply with code, accreditation, or facility environmental health and safety department requirements).

Example 10-28

Question:

Does Section 140.9(c)1 require VAV GEX valves?

Answer:

Typically, yes. If the supply valve is VAV or the hood valve(s) are VAV then a VAV GEX is typically required.

Example 10-29

Question:

Our campus standard for lab minimums is 4 ACH occupied and 2 ACH unoccupied. The code language says, "shall be the greater of…user defined airflow not to exceed...6 ACH". So is 4 ACH / 2 ACH still ok?

Answer:

Yes. The user defined airflow can be any flow from 0 ACH up to 6 ACH occupied and 4 ACH unoccupied. So 4 ACH / 2 ACH is still allowed.

Example 10-30

Question:

Our EH&S Department requires at least 10 ACH for certain labs. Is this still allowed?

Answer:

Yes. The minimum may be set above 6 ACH if needed to meet EH&S minimum requirements. The AHJ may require documentation of the EH&S requirements.

Exhaust System Transfer Air

Reference: Section 140.9(c)2

This section limits the amount of conditioned air supplied to a space with mechanical exhaust. The benefit of this requirement is to take advantage of available transfer air. By doing so, the amount of air that needs to be conditioned is limited, thus saving energy. Conditioned supply air is limited to the greater of:

- The supply flow required to meet the space heating or cooling load.
- The ventilation rate required by the AHJ, facility EH&S department, or by Section 120.1(c)3.
- The mechanical exhaust flow minus the available transfer air.

The supply flow required to meet the space heating or cooling loads can be documented by providing load calculations.

Available transfer air can be from adjacent conditioned spaces or return air plenums that are on the same floor, same smoke or fire compartment, and within 15 feet. To calculate the available transfer air:

- Calculate the minimum outside air required by adjacent spaces.
- From the first bullet point, subtract the amount of air required by adjacent space exhaust.

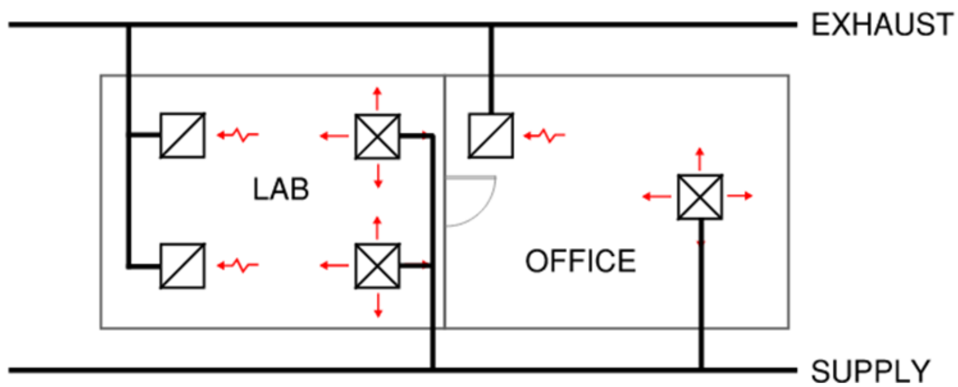
- From the second bullet point, subtract the amount of air required to maintain pressurization of adjacent spaces. This is your available transfer air.

Exceptions to Section 140.9(c)2 are provided for:

- Laboratories classified as biosafety level 3 or higher.
- Vivarium spaces.
- Spaces required to maintain positive pressure differential relative to adjacent spaces.
- Spaces that require a negative pressure relationship and the demand for transfer air may exceed the available transfer airflow rate.
- Healthcare facilities.

Figure 10-15: Does Not Comply with Transfer Air Requirement is a simple example of a system that does not comply with Section 140.9(c)2. It shows 100% of the lab space makeup air being conditioned outside air and an adjacent office that is also 100% outside air and 100% exhausted. The office space has available transfer air that can be transferred to the lab, rather than exhausted.

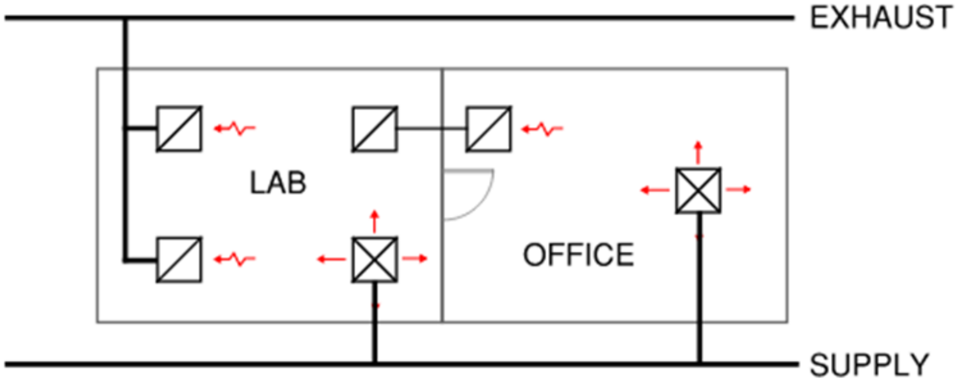
Figure 10-15: Does Not Comply with Transfer Air Requirement



Source: California Energy Commission

Figure 10-16: Complies with Transfer Air Requirement shows how the system in Figure 10-15 can be modified to comply with Section 140.9(c)2. Rather than exhausting the office space, its return air is transferred to the adjacent lab space (the pressure differential between the office and lab spaces is often sufficient to transfer the air without a fan, but a transfer fan can also be used). This reduces the amount of conditioned outside air / makeup air that must be supplied to the lab space.

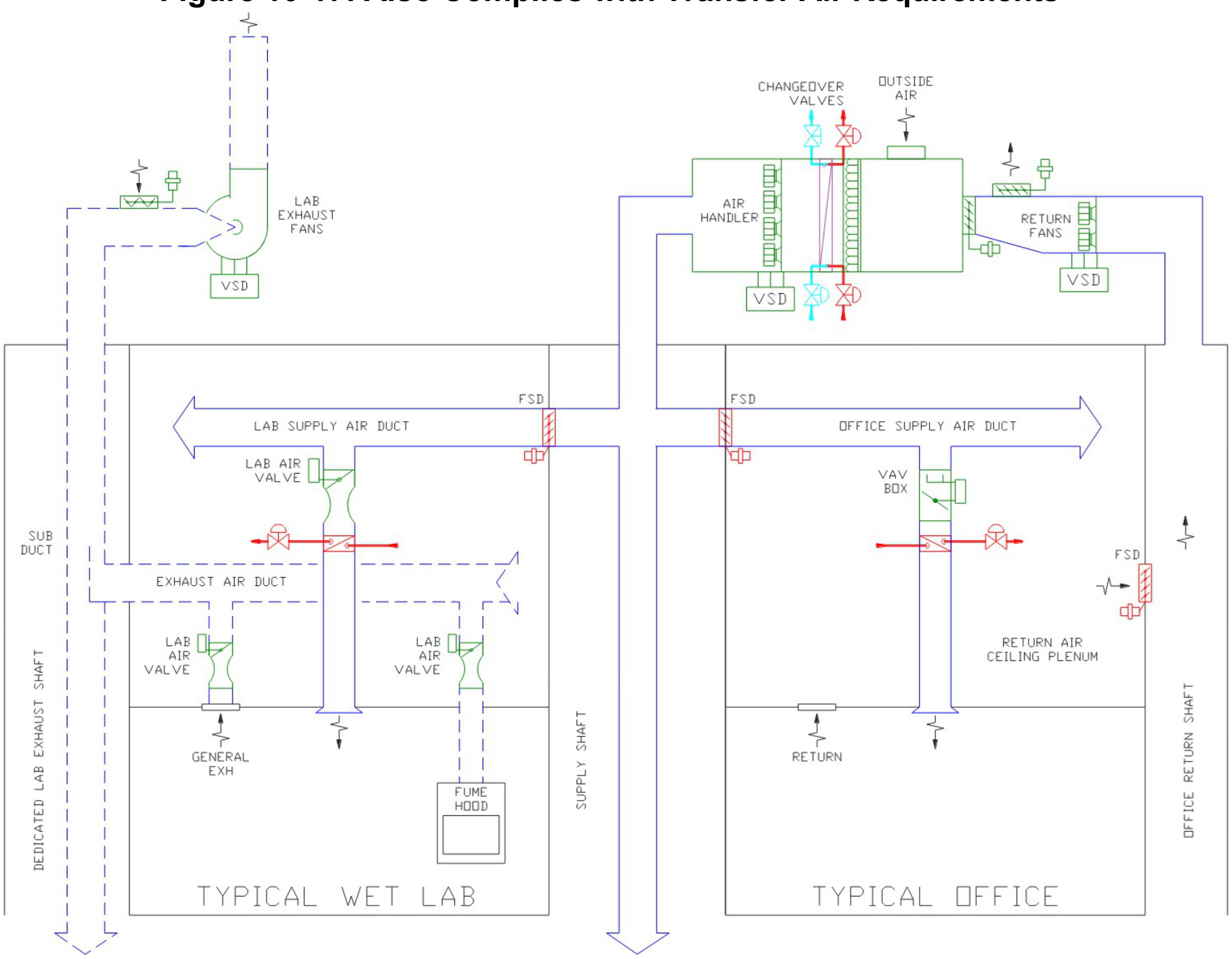
Figure 10-16: Complies with Transfer Air Requirement



Source: California Energy Commission

Figure 10-17: Also Complies with Transfer Air Requirements shows another option for complying with Section 140.9(c)2. Rather than directly transferring from office to lab spaces, the office spaces can be returned to the air handler, which can then transfer the office air to the lab spaces when the airside economizer is disabled.

Figure 10-17: Also Complies with Transfer Air Requirements



Source: California Energy Commission

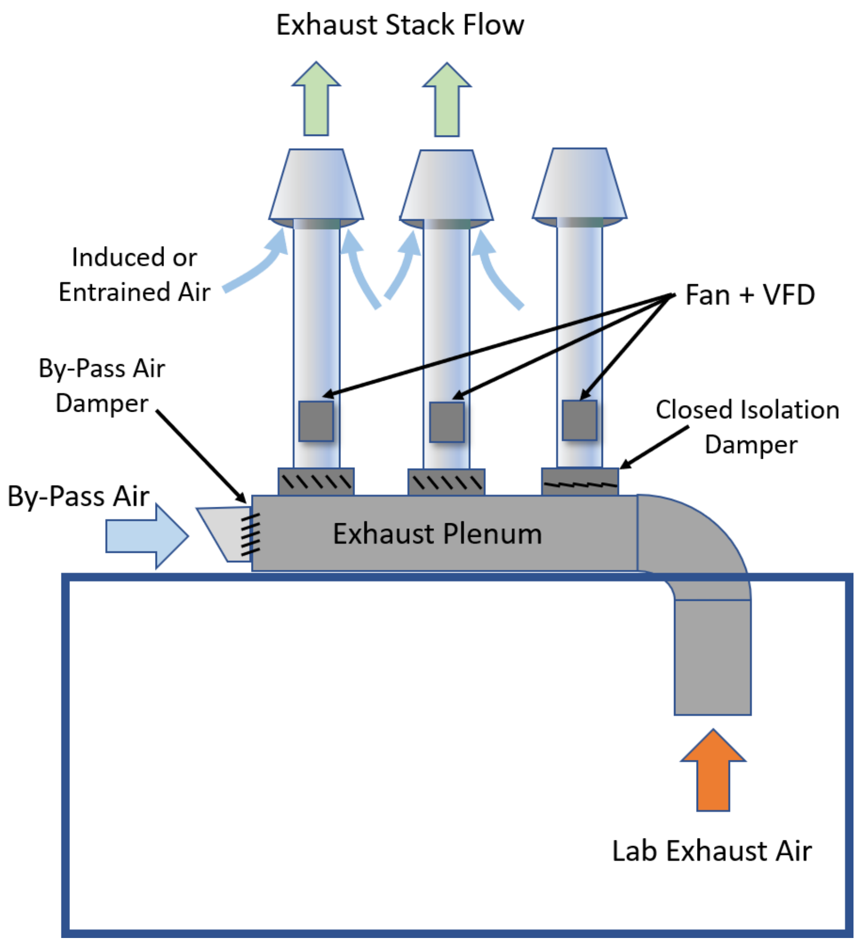
Exhaust Fan System Power Consumption

Reference: Section 140.9(c)3

Exhaust fan power consumption is a function of flowrate and pressure rise through the fan system. Because laboratory exhaust streams frequently have hazardous contaminants, there needs to be sufficient exhaust air to protect the occupants of labs by sufficiently diluting the laboratory space air. There also needs to be sufficient airflow to keep fumes generated in fume hoods from leaving through the face of the hood and instead pulled out through the exhaust ductwork to the outside. Additionally, the laboratory exhaust system must protect the general public from harmful concentrations of contaminants in the exhaust stream. This is accomplished by releasing the exhaust stream high in the air so that there is sufficient mixing and dilution before the air is at levels where people are present. This dilution and mixing are accomplished through a combination of exhaust stack height, mixing of airstreams, and exhaust velocity at the exit of the exhaust stack.

Variable air volume (VAV) exhaust systems reduce the amount of energy required to condition outside air. To keep velocities high enough to protect the general public, fans are staged so that the velocity per stack is maintained or a by-pass damper is opened so that unconditioned air can be mixed with the exhaust airstream. Some laboratory exhaust systems make use of induction fans which have openings downstream of the fan to induce or entrain air. Figure 10-18: Components of Exhaust Air Flow, illustrates lab exhaust air, bypass air, induced air, and total exhaust airflow.

Figure 10-18: Components of Exhaust Air Flow



Source: California Statewide CASE Team

The fan system air flow is the total exhaust system airflow minus induced or entrained airflow. The induction fan curves have fan inlet flow rates and higher fan exit flow rates for the same static pressure rise across the fan. This accounts for the difference between fan airflow and exiting stack airflow including induced flow. As a result, use the fan inlet flow rates for calculating exhaust fan system airflow.

Newly installed laboratory and factory exhaust systems greater than 10,000 CFM have five prescriptive options to show compliance with this section. Regardless of the path chosen, all exhaust systems must meet the discharge requirements of ANSI Z9.5-2022 Section 6.4.

Options 1 and 2 place relatively stringent fan power limitations but without the fan control requirements. Often times to meet these design fan power requirements, a relatively tall exhaust stack is needed.

Zoning or other constraints may limit the height of the exhaust stacks, and more design fan power is required to provide a higher exiting stack velocity. Options 3, 4, and 5 allow higher design fan power requirements but have fan control requirements.

The exhaust air flowrate from indoors varies due to the requirements in Section 140.9(c)1 that include different circulation air changes depending upon occupied versus unoccupied operation. Additionally, exhaust air flow rates must respond to exhaust airflow requirements from devices such as fume hoods, chemical storage cabinets, snorkels (point exhaust fixture), etc. and Section 140.9(c)4 which automates the fume hood sash opening. Reducing indoor exhaust flowrate with respect to device load and by occupancy status reduces the amount of outside air that is conditioned, brought into the space, and exhausted.

Options 1 and 2 are allowed to maintain a constant exhaust fan system airflow rate by adding unconditioned by-pass air when exhaust air flowrate from indoors drops. Thus, fan power is relatively constant while conditioned air requirements vary.

Options 3, 4, and 5 with higher design power allowances are based upon the controls descriptions in ANSI/ASSP Z9.5-2022 Laboratory Ventilation for simple turndown systems, wind responsive systems, and monitored systems. Under these control systems, the by-pass air is used less frequently, the fan speed is dropped, and fan energy is reduced most hours of the year.

Option 1: Fan Power Budget

Reference: Section 140.9(c)3B

Meet the fan power budget in Section 140.4(c)1. This option allows one to comply making use of the fan power limitations in 140.4(c)1. When using this path, one cannot make use of the process load exception to 140.4(c)1.

Option 2: 0.85/0.65 Watts/CF M

Reference: Section 140.9(c)3C

The exhaust system fan power does not exceed 0.85 w/cfm for systems with air treatment devices (e.g., scrubbers) or 0.65 w/cfm for systems without air treatment devices.

Option 3: Simple Turndown Control

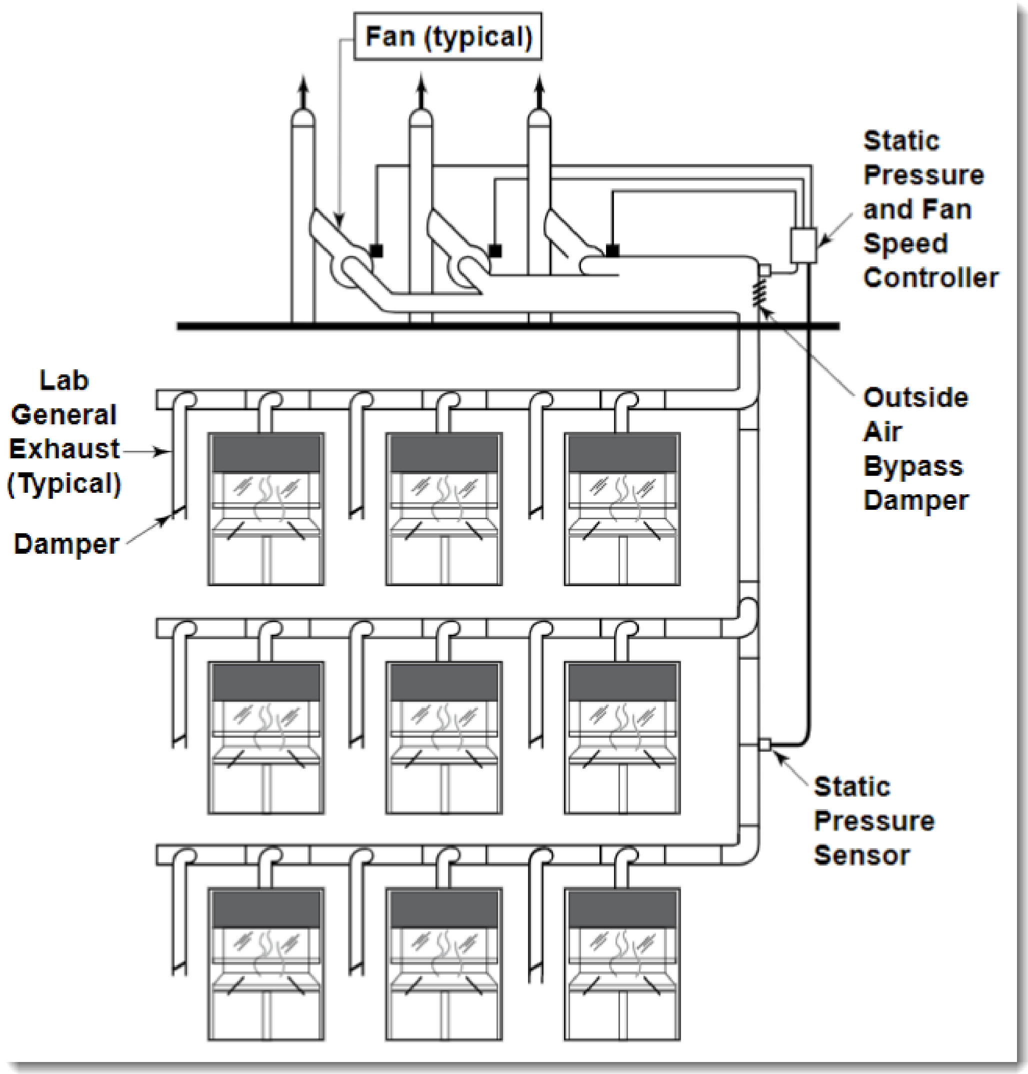
Reference: Section 140.9(c)3Dva

This option is only available if the minimum supply flow to the spaces served is less than 60% of the exhaust fan system design flow, i.e., the ability to turn down the exhaust flow to less than 60% at low load conditions. To meet this option, the exhaust system fan power cannot exceed 1.3 w/cfm, the exhaust fan must have a variable speed control, and the exhaust stack flow must track the supply flow to the spaces from 100% flow down to 60%, i.e., no bypass damper flow or strobic induction at the exhaust fan until the exhaust flow is less than 60% of design.

This option may require a very tall exhaust stack on the roof to meet the health and safety requirements in ANSI Z9.5 when the exhaust flow is less than 60% of the maximum exhaust flow.

Lab exhaust systems are often designed to maintain a stack discharge velocity at or above 3,000 feet/min. With VAV zone exhaust flows (as required by Section 140.9(c)1), there are a few options for maintaining near constant stack velocity. One option is staging exhaust fans on/off based on the load. Another option is an outside air bypass damper that supplements the exhaust from the spaces with outside air to maintain the stack velocity (see Figure 10-19: Typical Lab Exhaust Fan Control Schematic). Another option is to allow stack velocity below 3,000 fpm by analyzing hazards and providing equivalent hazard mitigation (e.g., a very tall stack). This is typically required in order to comply with Option 3. One might think that simply raising the design stack velocity to 5,000 fpm would be a simple option to allow 60% turndown while staying above 3,000 fpm. However, raising the design stack velocity to 5,000 fpm could result in exhaust system design fan power > 1.3 w/cfm or unacceptable acoustics.

Figure 10-19: Typical Lab Exhaust Fan Control Schematic



Source: California Statewide CASE Team

Option 4: Wind Responsive Control

Reference: Section 140.9(c)3Dvb

Similar to option 3, this option is only available if the minimum supply flow to the spaces served is less than 60% of the exhaust fan systems design flow. To meet this option the exhaust system fan power cannot exceed 1.3 w/cfm and the exhaust fan must have a variable speed control. The exhaust stack flow must track the supply flow to the spaces from 100% flow down to 60% for at least 70% of the hours of year. This prediction is based on dispersion model with a worst case emissions described in ANSI Z9.5. It is assumed that fan system airflow can be reduced to 60% of the design airflow for the predicted wind speeds and directions in a TMY (typical meteorological year) file 70% of the hours in a year. For the other 30% of the year with typically higher wind speeds, the bypass damper may be opened to keep exhaust fan system flowrates above 60%.

A wind responsive control system typically includes the following features:

- Anemometer Sensors:
    - Two anemometer sensors must be used to enable sensor fault detection.

    - Installation location must exhibit similar wind speed and direction to the free stream air above the exhaust stacks.
    - Sensors must be located high enough to be above the wake region created by nearby structures.
    - Sensors must be factory calibrated.
    - Sensors must be certified by the manufacturer to an accuracy of ± 40 feet per minute (fpm), ± 5.0 degrees, and to require calibration no more than every five years.
- Dispersion Modeling:
    - Wind dispersion analysis must be used to create a look-up table for exhaust volume flow rate versus wind speed/direction.
    - Look-up table must contain at least eight wind speeds and eight wind directions to define the safe exhaust volume flow rate.
    - Exhaust volume flow rate must be based on maintaining downwind chemical concentrations below health and odor limits as defined by the 2018 American Conference of Governmental Industrial Hygienists, Threshold Limit Values and Biological Indices, or more stringent, local, state, and federal limits if applicable.
- Sensor Fault Management:
    - Minimum sensor failure thresholds:
        - If any sensor has not been calibrated within the associated calibration period.
        - Any sensor that is greater than ±30% of the four-hour average reading for all sensors.
    - Upon sensor failure, the system must revert to a safe exhaust volume flow rate based on worst-case wind conditions. Furthermore, the system must report the fault to an Energy Management Control System or other application which notifies a remote system provider.

Option 5: Contaminant Monitored Control

Reference: Section 140.9(c)3Dvc

Similar to Options 3 and 4, this option is only available if the minimum supply flow to the spaces served is less than 60% of the exhaust fan systems design flow. To meet this option, the exhaust system fan power cannot exceed 1.3 w/cfm and the exhaust fan must have a variable speed control. The exhaust stack flow must track the supply flow to the spaces from 100% flow down to 60%, unless the current measured contaminant concentration in the exhaust plenum is above a defined threshold level, in which case higher exhaust flows are acceptable (e.g., the bypass damper may be opened at exhaust flows above 60%).

This option requires a real-time contaminant monitoring system capable of measuring the concentrations of all hazardous chemicals used in the building. This may place limitations on what chemicals can be used in the building.

A contaminant monitored control system typically includes the following features:

- Chemical Concentration Sensors:

  - Two contaminant concentration sensors must be used in each exhaust plenum to enable sensor fault detection.
  - Sensors must be photo ionization detectors.
  - Sensors must be factory calibrated.
  - Sensors must be certified by the manufacturer to an accuracy of ± 5% and require calibration no more than every six months.
- Dispersion Modeling:
  - Wind dispersion analysis must be used to determine contaminant-event thresholds (contaminant concentration levels), which control when the exhaust volume flow rate can be turned down during normally occupied hours.
  - Exhaust volume flow rate must be based on maintaining downwind chemical concentrations below health and odor limits as defined by the 2018 American Conference of Governmental Industrial Hygienists, Threshold Limit Values and Biological Indices, or more stringent, local, state, and federal limits, if applicable.
- Sensor Fault Management:
  - Minimum sensor failure thresholds:
    - If any sensor has not been calibrated within the associated calibration period.
    - Any sensor that is greater than ±30% of the four-hour average reading for all sensors.
  - Upon sensor failure, the system must revert to a safe exhaust volume flow rate based on worst-case wind conditions. Moreover, the system must report the fault to an energy management control system or other application that notifies a remote system provider.

Example 10-31

Question:

A laboratory space has 2,500 ft^2 of conditioned floor area, a drop ceiling for plenum space, and ceiling height of 10 feet. The lab has a design airflow rate of 2,500 cfm.

Is this laboratory required to have variable-volume exhaust and makeup air flow to comply with Section 140.9(c)1?

Answer:

In the absence of any other code or environmental health & safety requirement, Section 140.9(c)1 requires that laboratories have variable-volume exhaust and makeup airflow if the design cfm/ft2 > 0.67. The requirement is based on cfm/ft2, not air changes, so the ceiling height does not matter. For this laboratory space:

Design cfm/ft2 = 2,500 cfm / 2,500 ft^2 = 1.0 cfm/ft2

Thus, if there is no conflicting code or safety requirement, this space requires a variable-volume HVAC system.

Example 10-32

Question:

A variable-volume supply fan and a variable-volume exhaust fan serving a lab system has a fan system design supply airflow and design exhaust airflow of 8,000 cfm. The system consists of one supply fan operating at an input power of 5.0 bhp and one exhaust fan operating at an input power of 8.0 bhp. The exhaust system uses a 0.6 in. pressure drop filtration device, airflow control devices, and serves fume hoods.

Does this fan system comply with the fan power requirements in Title 24?

Answer:

For laboratory exhaust systems with total flow rates less than or equal to 10,000 cfm, the total fan energy of the space conditioning system and the laboratory exhaust system must comply with Section 140.4(c). First, the design fan power must be calculated in bhp, as shown below:

Design Fan Power = 5.0 bhp + 8.0 bhp = 13.0 bhp

Then, the fan power limit in section 140.4(c) is determined. From Table 140.4-A, the allowable system input power for the system is:

bhp = CFMs × 0.0013 + A

= 8,000 × 0.0013 + A = 10.4 + A

where A accounts for pressure drop adjustments.

From Table 140.4-B, the pressure drop adjustment for the exhaust flow control device (FC) is 0.5 in. of water, the pressure drop adjustment for fully ducted exhaust systems (DE) is 0.5 in. of water, and the pressure drop adjustment for the fume hoods (FH) is 0.35 in. of water. The pressure drop adjustment for fully ducted exhaust systems is included because laboratory exhaust systems are required under Title 8 to be fully ducted. An additional pressure drop adjustment is allowed to be equal to the design pressure drop of an exhaust filtration device (FD) which for this design is 0.6 in. of water column. The airflow through all these devices is 8,000 cfm, so the additional input power that is allowed is 3.8 bhp, as calculated below.

$A = [CFM_{FC} \times PD_{FC} + CFM_{DE} \times PD_{DE} + CFM_{FH} \times PD_{FH} + CFM_{FD} \times PD_{FD}] / 4{,}131$

A = [8,000 × 0.5 + 8,000 × 0.5 + 8,000 x 0.35 + 8,000 x 0.6] / 4131 = 3.8 bhp

The total allowed input power is 10.4 bhp plus 3.8 bhp, or 14.2 bhp. Because the design fan power of 13.0 bhp is less than 14.2 bhp, the system does comply using the procedure in section 140.4(c). If the system did not comply, one could evaluate several methods of dropping the design brake horsepower such as: lowering pressure drop though the system by increasing duct size or selecting low pressure drop valves or low pressure drop duct fittings. Alternatively, brake horsepower can be dropped by selecting a fan with higher fan efficiency at the design point.

Example 10-33

Question:

A variable-volume supply fan and a variable-volume exhaust fan serving a lab system has a fan system design supply airflow and design exhaust airflow of 12,000 cfm. The system consists of one supply fan operating at an input power of 10.0 bhp served by a nominal 15 hp motor and one exhaust fan operating at an input brake horsepower of 18.0 bhp served by a nominal 25 hp motor, which at design conditions draws 14.4 kW. The exhaust system uses a 0.6 in. pressure drop filtration device and airflow control devices and serves fume hoods.

Does this fan system comply with the fan power requirements in Title 24?

Answer:

For laboratory exhaust systems with total flow rates greater than 10,000 cfm, the fan energy of the space conditioning system is regulated by the requirements of Section 140.4(c) and the fan energy of the laboratory exhaust system is regulated by Section 140.9(c)3.

For laboratory exhaust systems with total flow rates greater than 10,000 cfm, the fan energy of the space conditioning system is regulated by the requirements of Section 140.4(c) and does NOT include the design exhaust fan power or the pressure drop adjustment credits for:

– Exhaust systems required by code or accreditation standards to be fully ducted.

– Exhaust airflow control devices.

– Exhaust filters, scrubbers, or other exhaust treatment.

– Exhaust systems serving fume hoods.

– Biosafety cabinets.

The fan power limit in Section 140.4(c) is determined. From Table 140.4-A, the allowable system input power for the system can be calculated for either the design motor horsepower for the fan or the brake horsepower supplied to the fan.

For the motor horsepower approach for a variable-volume system, with maximum design airflow rate, cfm_s, of 12,000 cfm, the nominal horsepower shall be no greater than:

$hp < cfm_s \times 0.0015 = 12{,}000 \times 0.0015 = 18$ hp

The supply fan had a nominal horsepower of 15 hp. The space conditioning system passes using this approach.

For the fan brake horsepower approach in Section 140.4(c), the allowable system input power for the space conditioning system is:

$bhp = CFMs \times 0.0013 + A$

where A accounts for pressure drop adjustments.

In this case, there are no fan pressure adjustments as all the exhaust system and fume hood credits are accounted for in the allowances to Section 140.9(c)3.

Allowable fan brake horsepower = $CFMs \times 0.0013 = 12{,}000 \times 0.0013 = 15.6$ bhp.

The supply fan had a design brake horsepower of 10.0 bhp, and since this design is less than 15.6 bhp, the space conditioning system passes using this approach.

The second half of this calculation is to determine whether the fan power of the laboratory exhaust systems complies with the requirements in Section 140.9(c)3. As given from the design documents, the exhaust fan draws 14.4 kW during design conditions while moving 12,000 cfm of air. The design fan watts per cfm is:

Design Exhaust Fan W/CFM = 14.4 kW x 1,000 W/kW / 12,000 CFM = 1.2 W/CFM

As described in Section 140.9(c)3B, an exhaust system with an air filtration device will have a maximum allowable exhaust fan power of 0.85 W/CFM. Therefore, the maximum allowable exhaust fan power for this system is 0.85 W/CFM. This is less than the fan system input power of 1.2 W/CFM. Therefore, the system does not comply with the fan power of Section 140.9(c)3B. The designer could redesign the system for lower design watts per cfm by increasing the height of the stack or alternatively design the system to vary the flow rate from the exhaust stack in response to wind speed in accordance with Section 140.9(c)3C or vary the flow rate from the exhaust stack in response to measured contaminant concentration in the exhaust plenum in accordance with Section 140.9(c)3D.

Fume Hood Automatic Sash Closure

Please refer to Chapter 10.7.3.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Reheat Limitation

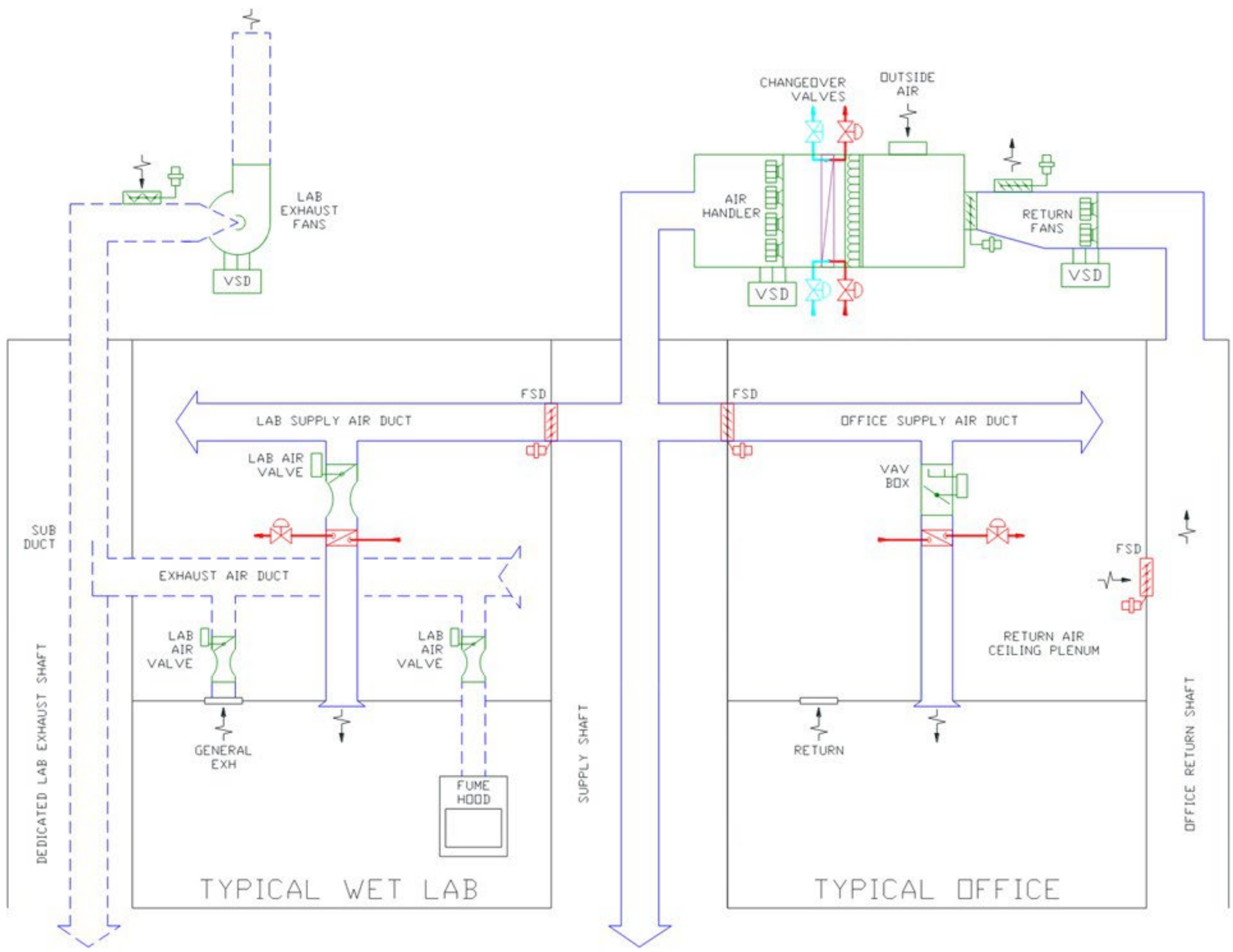
Reference: Section 140.9(c)5

Air handlers in buildings with greater than 20,000 cfm of laboratory exhaust that serve multiple space conditioning zones in laboratory spaces shall not mechanically cool air handler supply air below 80°F and shall not heat air handler supply air above 50°F, and each zone shall include heating and cooling capacity, to prevent cooling at the air handler and reheating at the zones. Most large labs use multizone AHUs.

The most common way for multizone air handlers to meet this requirement is with 4-pipe VAV, which is a VAV system with terminal units (VAV boxes) that have both hot water and chilled water coils or a single switchover coil that can be fed with hot water or chilled water. A 2-pipe VAV system (Figure 10-20: 2-Pipe VAV Does Not Comply with Section 140.9(c)5) only has hot water coils at the zones and can result in significant reheat because the air handler mechanically cools the supply air to satisfy zones with high cooling loads, and zones with low cooling loads must reheat the supply air to prevent overcooling. In a 4-pipe VAV system, reheat can be eliminated because cooling for zones with high cooling loads can be provided by the zone cooling coils.

4-pipe VAV is not the only system type that would meet this new requirement. Other systems include chilled beams, VRF, and separate cooling and heating coils at each zone, i.e., two 2-pipe coils, rather than one 4-pipe coil.

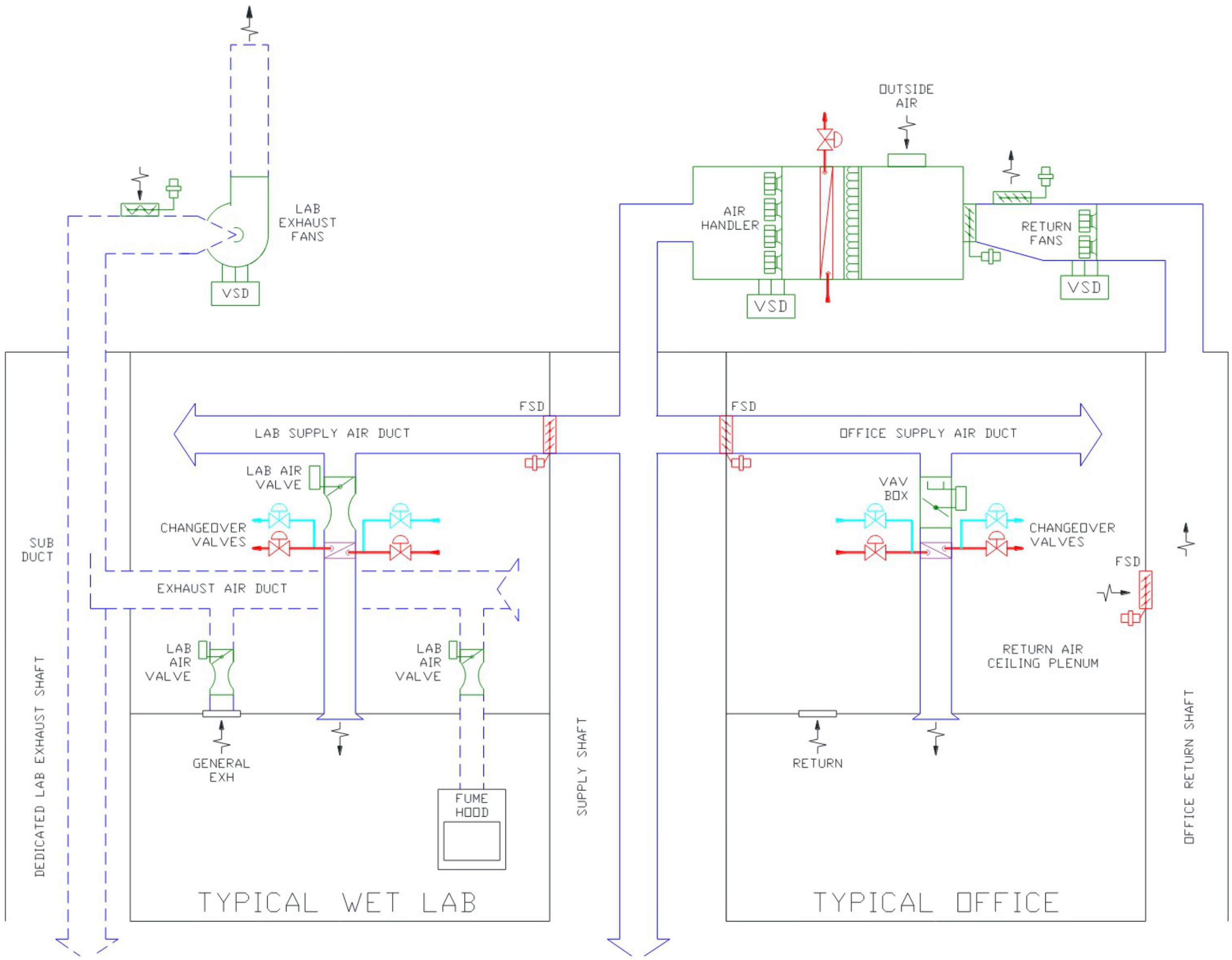
Figure 10-20: 2-Pipe VAV Does Not Comply with Section 140.9(c)5



Source: California Statewide CASE Team

Figure 10-21: 4-Pipe VAV Complies with Section 140.9(c)5 shows a 4-Pipe VAV system that meets the requirement. It shows a single changeover coil at each zone that has 4 pipes to it: chilled water supply/return and hot water supply/return. This figure shows only a hot water coil at the AHU. Cooling is not needed at the AHU if the zone cooling coil is designed to meet the design cooling load with the design outdoor air temperature (e.g., 100°F) entering the coil. Typically, this requires a deep coil (e.g., 8 rows deep). A cooling coil (or 4-pipe changeover coil) is permitted at the AHU but the AHU cannot cool the supply air below 80°F. Having cooling capacity at the AHU could reduce the overall project cost by allowing smaller zone coils (e.g., 4 rows deep).

Figure 10-21: 4-Pipe VAV Complies with Section 140.9(c)5



Source: California Statewide CASE Team

One consideration with a single zone coil used for both heating and cooling is that it is not possible to dehumidify the space by over-cooling with a cooling coil and then reheating with a downstream heating coil. Dehumidification is provided by the zone cooling coil in a 4-pipe VAV system (hence the need for condensate removal), but dehumidification will only occur if there is a space cooling load. This cannot be relied upon to maintain humidity if a cooling load is not present.

Fortunately, dehumidification is not required in most lab spaces in California. Per Addendum ASHRAE Standard 62.1-2022, active dehumidification is not required for climates where outdoor dewpoint is below 68°F at the ASHRAE 2 percent annual dehumidification design conditions. The proposed requirement includes an exception for these locations.

For the few lab spaces that require dehumidification for specific process requirements, active dehumidification can be provided by using separate cooling and heating coils at the zone level. This meets the proposed requirement. In fact, before 6-way control valves and changeover coils were common, it was common to minimize reheat in labs by installing separate cooling and heating coils at each lab zone. A lab can also meet the proposed requirement with a combination of changeover coils at most zones and dual coils at the few zones with strict humidity requirements.

There are three full exceptions to Section 140.9(c)5 and one partial exception.

Full Exceptions:

- Exception 1 to Section 140.9(c)5: Additions or alterations to existing air handling systems serving existing zones without heating and cooling capacity.
- Exception 2 to Section 140.9(c)5: Systems in climate zones 7 or 15 (these are the two most humid climate zones in California).
- Exception 3 to Section 140.9(c)5: Systems dedicated to vivarium spaces or to spaces classified as biosafety level 3 or higher.

Partial Exception:

- Exception 4 is only available in a handful of cities where the outdoor dew point temperature is greater than or equal to 64°F at the ASHRAE 2 percent annual dehumidification design condition. This ASHRAE website can be used to determine if this criteria is met, https://ashrae-meteo.info/v2.0/. Even in these locations, heating and cooling are required at the zone (e.g., 4-pipe VAV). The only difference is that the AHU can cool the supply air below 80ºF but only when the measured outside air dewpoint is above 60ºF. This allows the AHU to dehumidify in humid weather and can avoid the need to have separate cooling and heating coils at the zone level for dehumidification purposes.

Exhaust Air Heat Recovery

Reference: Section 140.9(c)6

Buildings with greater than 10,000 cfm of laboratory exhaust shall include an exhaust air heat recovery system. The heat recovery system must meet the following criteria:

- A sensible energy recovery ratio of at least 45 percent at heating design conditions and 25 percent at cooling design conditions.
    - The sensible energy recovery ratio is the ratio of the change in the outdoor air supply's dry-bulb temperature to the difference in dry-bulb temperature between the outdoor air and the entering exhaust airflow. For example, suppose the design winter outdoor temperature is 30ºF and the winter return/exhaust air temperature is 70ºF. The heat recovery system must be capable of raising the supply air temperature from 30ºF to at least 48ºF (= 0.45*(RAT-OAT)+OAT)
- Heat is recovered from at least 75 percent of all lab exhaust air volume.
    - Not every exhaust fan has to have a heat recovery coil as long as heat is recovered from 75% of the total exhaust volume.
- The system includes a run-around coil pump or other means to disable heat recovery.
    - Heat recovery is generally not beneficial when the outside air temperature is between the return air temperature and the desired AHU supply air temperature, i.e., airside economizer free cooling. For example, if RAT = 75ºF and OAT = 65ºF and desired SAT = 60ºF, then the heat recovery should be disabled to prevent inadvertently heating the air and creating a false cooling load. The term "desired AHU SAT" is used here instead of SAT setpoint because Section 140.9(c)5 generally prohibits controlling the AHU cooling coil below 80ºF but Section 140.9(c)5 does not prohibit economizer

free cooling to a desired supply air temperature that would reduce the total mechanical heating/cooling load.

- The system includes a bypass damper or other means so that the exhaust air pressure drop through the heat exchanger does not exceed 0.4 inch w.g. when heat recovery is disabled.
    - In California's mild climate there are many hours when heat recovery is not beneficial. Bypassing the heat exchanger saves fan energy.

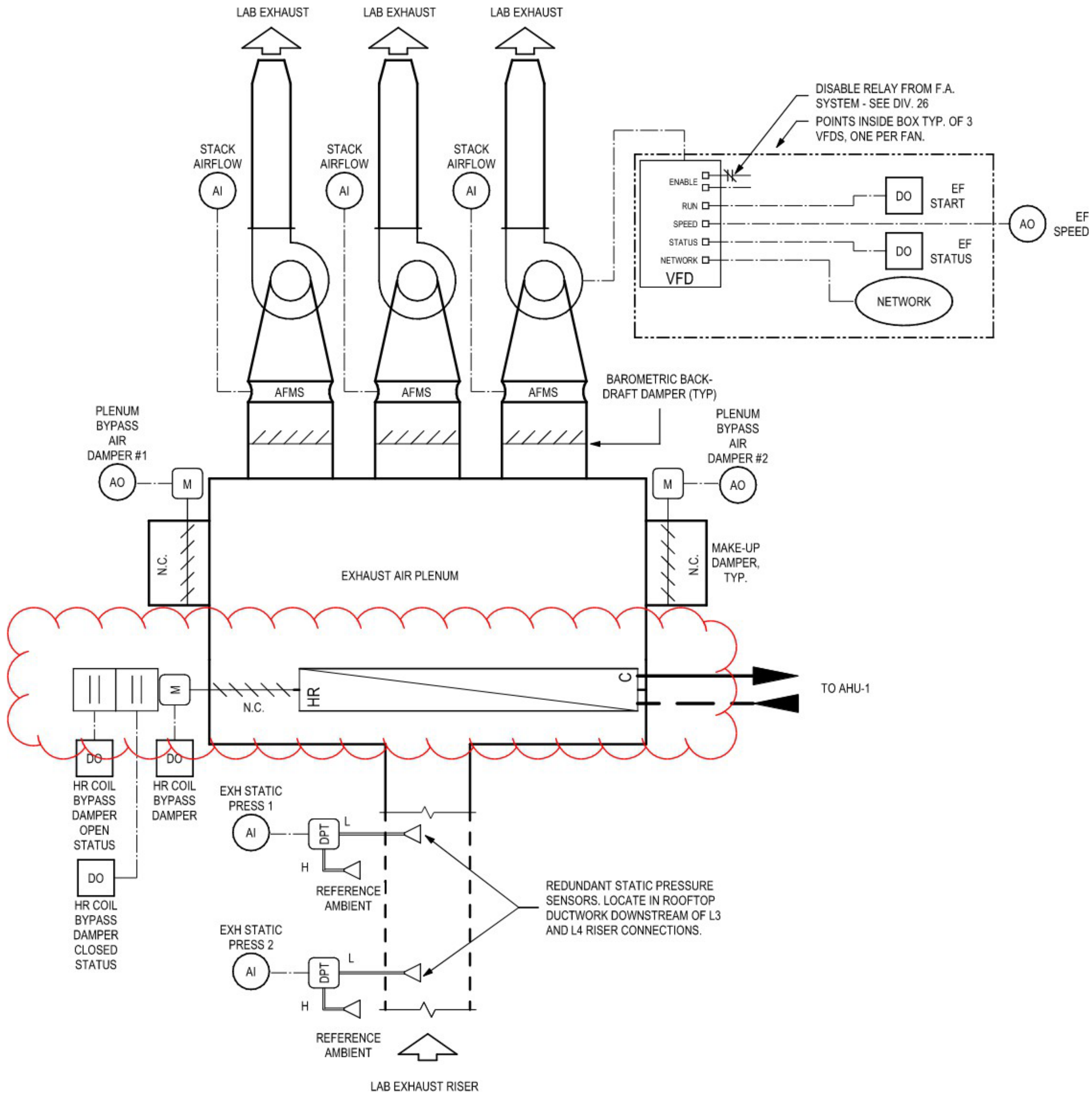
Lab exhaust heat recovery is typically achieved with a coil run-around system, as opposed to a plate-type or wheel-type air-to-air heat exchanger. This is to mitigate the risk of cross-contamination from the exhaust air stream to outside air stream.

With a run-around system, a fluid coil (water or glycol) is added into the exhaust airstream (see Figure 10-22: Typical Control Schematic of Lab Exhaust Fan System with Heat Recovery Coil). New pump(s) and piping are added to transfer heat from the exhaust coil to a coil in the supply air handler(s) (see Figure 10-23: Typical Schematic of Lab Exhaust Fan System). If the supply air handler has an existing heating coil, then that coil can also be used as the heat recovery coil. If the air handler does not have a heating coil, then a recovery coil must be added (see Figure 10-24: Typical Schematic of Lab Air Handler with Heat Recovery).

The control sequences for this type of lab exhaust heat recovery system are typically quite simple. For example:

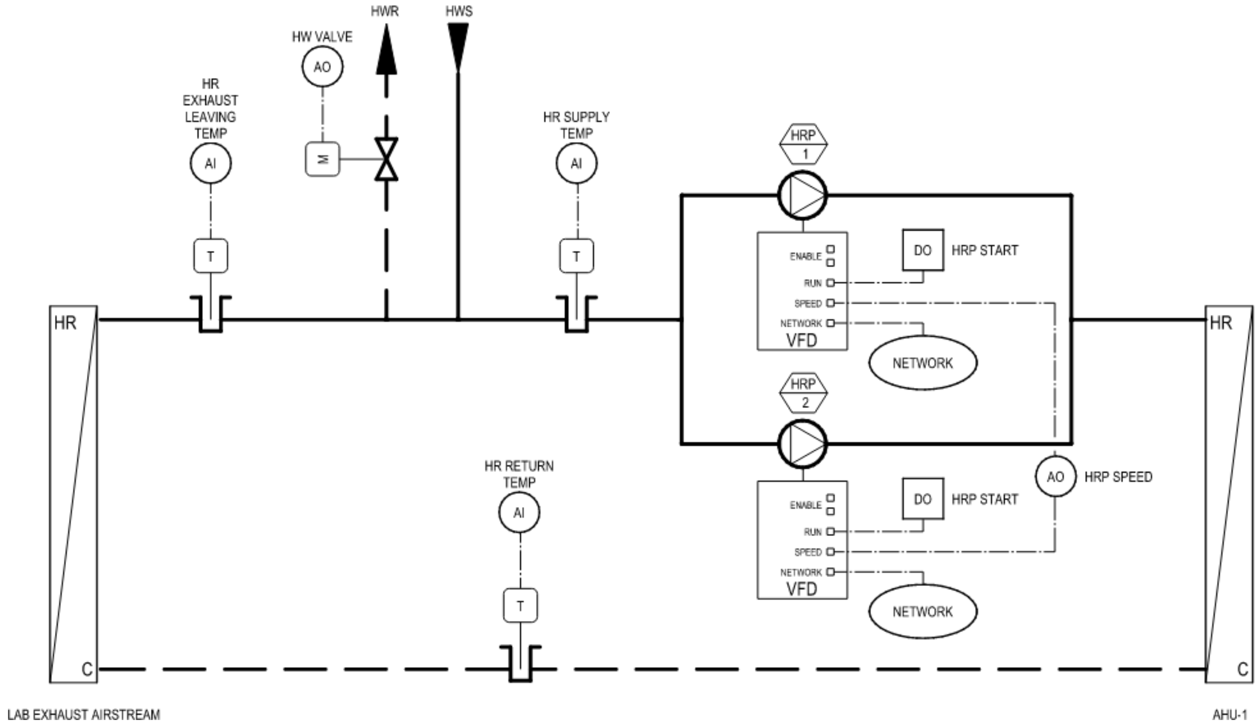
- Cooling: When the outside air temperature is above 83°F, command the lab exhaust heat recovery bypass damper zero percent open and enable the heat recovery pumps at design speed.
- Heating: A PID loop shall maintain the supply air temperature at the minimum SAT setpoint by first modulating the bypass damper from 100 percent to zero percent and then modulating the HW valve from 0 percent to 100 percent. Run the heat recovery pumps at design speed when the bypass damper is less than 100 percent.

Figure 10-22: Typical Control Schematic of Lab Exhaust Fan System with Heat Recovery Coil



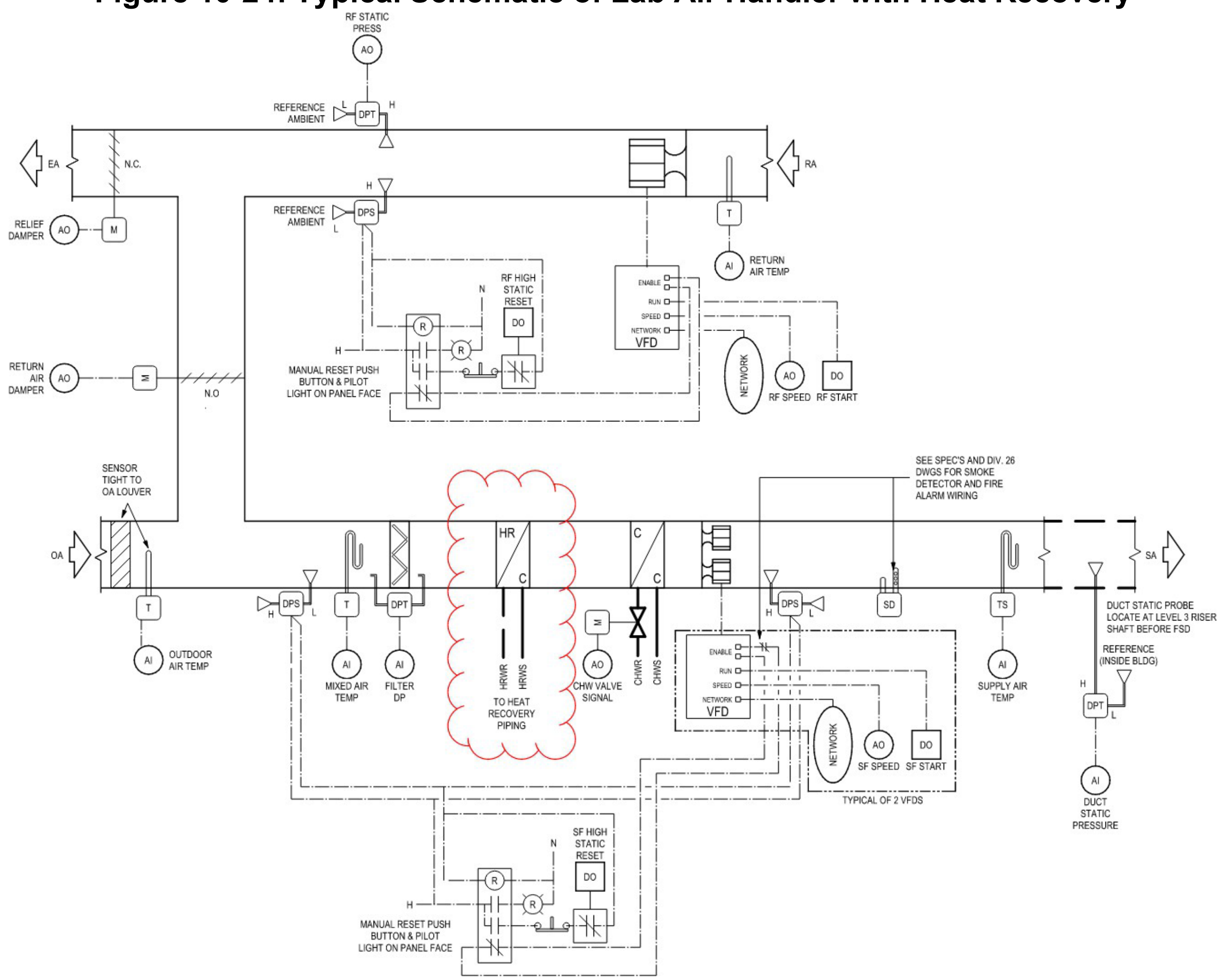
Source: California Statewide CASE Team

Figure 10-23: Typical Schematic of Lab Exhaust Fan System



Source: California Statewide CASE Team

Figure 10-24: Typical Schematic of Lab Air Handler with Heat Recovery



Source: California Statewide CASE Team

There are 4 full exceptions and one exception that requires an alternate compliance path.

Full Exceptions:

Exception 1 to Section 140.9(c)6: Additions or alterations to existing laboratory exhaust systems that do not include exhaust air heat recovery.

Exception 2 to Section 140.9(c)6: Buildings where the total laboratory exhaust rate exceeds 20 cfm/ft2 of roof area.

Heat recovery coils are typically designed for air velocities around 500 fpm. Without heat recovery coils, the exhaust plenum could be designed for velocities of 1000-2000 fpm. Adding an EAHR system can increase the size of the exhaust plenum. These plenums are typically located on the roof, near the exhaust fans. If the building is several stories tall and is packed with high load labs, then there may not be enough roof space to accommodate the larger exhaust plenums. Note that in many cases EAHR actually reduces the roof space requirements of the mechanical equipment. This is because EAHR reduces the peak heating and cooling loads. If heating is provided by air-source heat pumps (ASHPs), then fewer/small ASHPs are required on the roof. This reduction in ASHP footprint more than compensates for the increase in exhaust plenum footprint.

Exception 3 to Section 140.9(c)6: Locations that meet both of the following:

- In Climate Zone 6 or 7; and
- In a jurisdiction where gas heating is allowed. (Note: some jurisdictions do not allow gas heating)

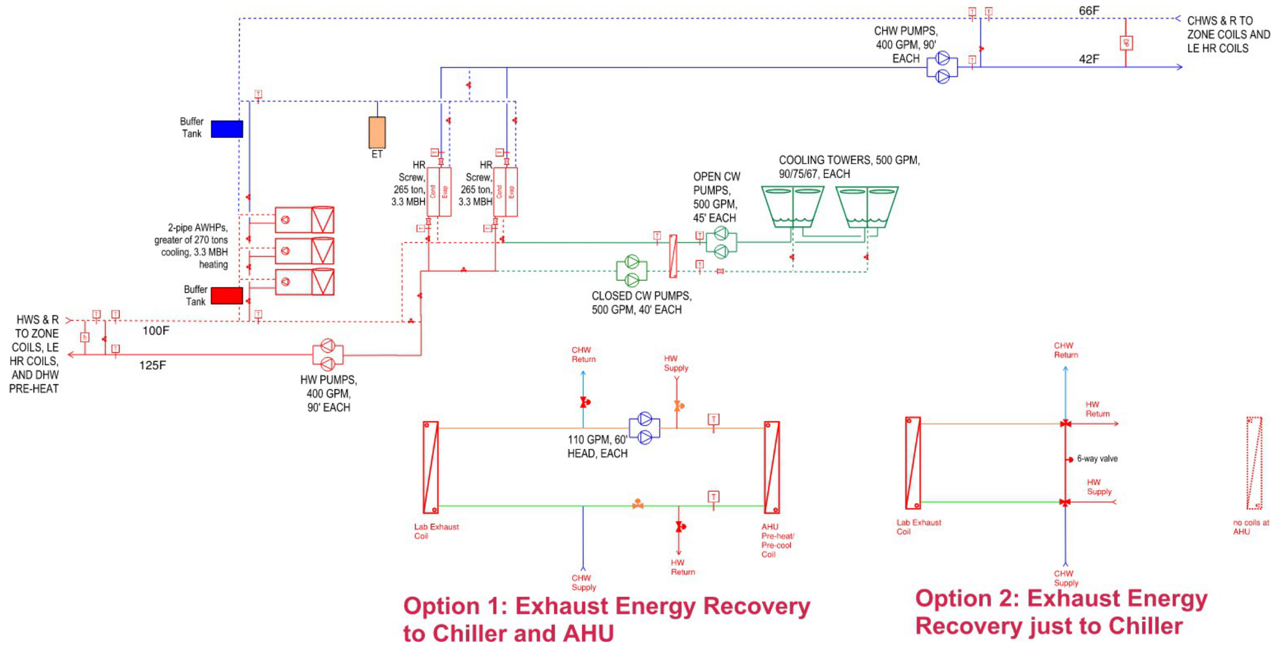
Exception 5 to Section 140.9(c)6: Exhaust systems requiring wash down systems such as exhaust systems dedicated to perchloric acid fume hoods.

Exception Requiring Alternate Compliance Path:

Exception 4 to Section 140.9(c)6: Buildings with an exhaust air heat recovery system and heat recovery chillers designed to provide at least 40% of the peak heating load from exhaust heat recovery.

Using the exhaust airstream for heat absorption/rejection by a heat recovery chiller system has similar energy savings to the proposed heat recovery requirement. Figure 10-25: Schematic of Lab Exhaust to Heat Recovery Chiller is a schematic of a lab system with options to recover heat to both the chiller and AHU or just to the chiller. When heat is recovered just to the chiller, a 6-way control valve is used at the heat recovery coil (like the changeover zone coils) so that the heat recovery coil can be used as a heat source (when there is a net heating load) or a heat sink (when there is a net cooling load).

Figure 10-25: Schematic of Lab Exhaust to Heat Recovery Chiller



Source: California Statewide CASE Team

Additions and Alterations

Variable Exhaust and Makeup Airflow

As noted in the previous section, variable volume controls are not required if you are adding zones to an existing constant volume system.

Exhaust System Transfer Air

Additions and alterations must comply with the requirements of this section. For alterations, this means that any additional exhaust and conditioned air resulting from an alteration must comply with this section.

Fan System Power Consumption

All newly installed exhaust systems greater than 10,000 cfm must meet the requirements of this section. Alterations and additions that increase an existing exhaust system's airflow rate over the 10,000 cfm threshold do not need to meet the requirements.

Fume Hood Automatic Sash Closure

Additions and alterations must meet the requirements of this section. The addition of fume hoods to a space resulting in a density above the values of Table 140.9-B requires compliance with this section for those newly installed fume hoods.

Reheat Limitations

Additions and alterations are exempt if the additions or alterations are to an existing air handling system serving existing-to-remain zones without both heating/cooling. If the addition or alteration is to an air handling system that does not already serve existing-to-remain zones without both heating/cooling, then the requirement applies.

Exhaust Air Heat Recovery

Additions and alterations are exempt if the addition or alteration is to an existing lab exhaust system that does not already have exhaust air heat recovery. If the existing exhaust system already includes exhaust air heat recovery or if the addition or alteration is a new lab exhaust system, then the requirement applies.

Compressed Air Systems

Overview

Section 120.6(e) applies to all new compressed air systems and all additions or alterations to a compressed air system with a total installed compressor capacity ≥ 25 hp. An exception is given for medical gas compressed air systems serving healthcare facilities.

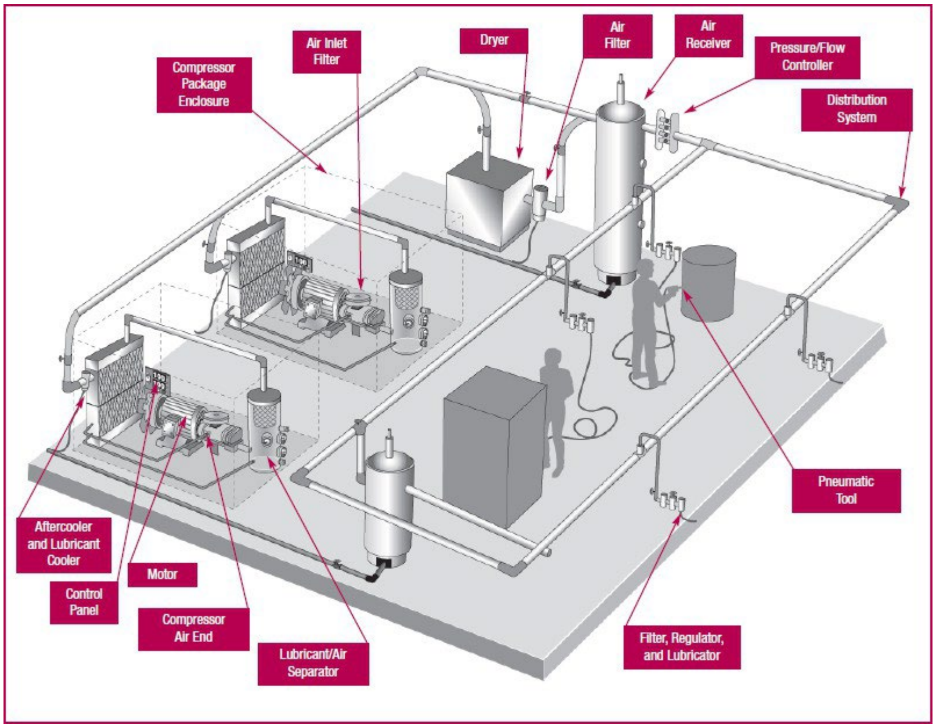
Key terms and definitions:

- Trim compressor: A compressor that is designated for part-load operation, handling the short-term variable trim load of end uses, in addition to the fully loaded base compressor. In general, the trim compressor will be controlled by a VSD, but it also can be a compressor with good part-load efficiency. If the trim compressor does not have good part load efficiency broadly across the operating range, then it will take more compressors to meet the Energy Code requirements.
- Base compressor: The opposite of a trim compressor, a base compressor is expected to be mostly loaded. If the compressed air system has only one compressor, the requirements of the Energy Code require that the single compressor be treated as a trim compressor.
- Specific power: The ratio of power to compressed air flow rate at a given pressure typically given in units of kW/100 acfm. The lower the specific power, the more efficient the compressor is at a given compressed air load.
- Total effective trim capacity: The combined effective trim capacity of all trim compressors where effective trim capacity for each compressor is the range of capacities in acfm, which are within 15 percent of the specific power at the most efficient operating point.
- Largest net capacity increment: The largest increase in capacity when switching between combinations of base compressors that is expected to occur under the compressed air system control scheme.
- Primary Storage: Tanks or other devices that store compressed air. Also known as an air receiver, they reduce peak air demand on the compressor system and reduce the rate of pressure change in a system. As primary storage, these devices are near the air compressors and are differentiated from remote storage that might be near an end-use device.
- Interconnection Piping: Interconnection piping is considered to be the piping between compressor discharge outlets, conditioning equipment such as dryers and aftercoolers, and often the primary storage receiver prior to delivery to the main header. Interconnection piping often connects multiple compressors, as well.
- Main Header Piping: Main header piping is the piping that delivers air from the interconnection piping to any distribution piping or sub-headers. This piping often begins at the outlet of a storage receiver or flow controller and terminates at distribution piping out to different areas of a facility. In some cases, there may not be main header piping if the

distribution piping is simple enough to contain only a single diameter distribution loop or loops.

- Distribution Piping: Distribution piping includes all piping after the main header and transports air to service lines.
- Service Line Piping: Service lines, often called drops, are typically the smallest diameter piping that delivers air from distribution piping to individual or groups of end-uses. Any tubing such as flexible hoses or plastic tubing within end-uses is not considered service line piping and is not covered by the compressed air pipe sizing or leak testing requirements.

Figure 10-26: Typical Compressed Air System Components



Source: Improving Compressed Air System Performance: A Sourcebook for Industry, USDOE 2003

Mandatory Measures

Please refer to Chapter 10.8.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Trim Compressor and Storage

Please refer to Chapter 10.8.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Controls

Please refer to Chapter 10.8.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Monitoring

Please refer to Chapter 10.8.2.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Leak Testing

Please refer to Chapter 10.8.2.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Pipe Sizing

Please refer to Chapter 10.8.2.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compressed Air System Acceptance

Please refer to Chapter 10.8.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Measures

Please refer to Chapter 10.8.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions and Alterations

Please refer to Chapter 10.8.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Process Boilers

Overview

A *process boiler* is a type of boiler with a capacity (rated maximum input) of 300,000 Btu/h or more that serves a process. A *process* is an activity or treatment that is not related to the space conditioning, service water heating, or ventilating of a building as it relates to human occupancy.

All process piping operating at 105°F or higher shall comply with Section 120.3. Steam pipes, hot water pipes, heated tanks, and vessels shall be insulated in accordance with Section 120.3. New requirements for process pipe insulation are listed in Process Pipe Insulation.

Mandatory Measures

Combustion Air

Please refer to Chapter 10.9.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Combustion Air Fans

Please refer to Chapter 10.9.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Excess Oxygen ≥ 5 MMbtu/h

Please refer to Chapter 10.9.2.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Measures

Please refer to Chapter 10.9.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Elevators

Please refer to Chapter 10.10.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Measures

Reference: Section 120.6(f)

Elevator Lighting Power Density

Please refer to Chapter 10.10.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Elevator Ventilation CFM Fan Performance

Please refer to Chapter 10.10.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Elevator Lighting and Fan Shutoff Control

Please refer to Chapter 10.10.2.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Measures

Please refer to Chapter 10.10.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions and Alterations

Please refer to Chapter 10.10.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Escalators and Moving Walkways

Overview

Please refer to Chapter 10.11.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Measures

Reference: Section 120.6(g)

Escalator and Moving Walkway Speed Control

Please refer to Chapter 10.11.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Measures

Please refer to Chapter 10.11.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions and Alterations

Please refer to Chapter 10.11.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Controlled Environment Horticulture

Overview

Section 120.6(h) sets efficiency standards for controlled environment horticulture (CEH) spaces. These standards are divided into two groups: indoor growing facilities, with a skylight area to roof areas ratio less than 50 percent, and greenhouse CEH facilities with 50 percent or more of the roof is glazed. For indoor growing facilities, requirements exist for lighting technology and dehumidification. For greenhouses, there are requirements for lighting and building envelope materials. These requirements impact all newly constructed CEH spaces.

These requirements help reduce the energy usage of horticulture facilities. These requirements are not dependent on the type of crop being grown in the facility.

Mandatory Measures

Reference: Section 120.6(h)

There are three main mandatory requirements in this section:

- Indoor horticultural growing facilities - Section 120.6(h)1 - 2,
- Greenhouse facilities - Section 120.6(h)3 - 4, and
- Horticultural lighting - Section 120.6(h)5

Indoor Growing Dehumidification

Reference: Section 120.6(h)1

Section 120.6(h)1 sets efficiency standards for dehumidification equipment for indoor facilities. Compliance can be reached by one of the four following pathways:

- Dehumidifiers that comply with the federal performance and testing requirements; or
- Integrated HVAC system with on-site heat recovery designed to fulfill at least 75 percent of the annual energy for dehumidification reheat; or
- Chilled water system with on-site heat recovery designed to fulfill at least 75 percent of the annual energy for dehumidification reheat; or
- Solid or liquid desiccant dehumidification system for system designs that require dewpoint of 50°F or less.

Example 10-33

Question:

How do I find a dehumidifier that meets the federal regulations?

Answer:

The Department of Energy's Compliance Certification Management System, https://www.regulations.doe.gov/certification-data/CCMS-4-Dehumidifiers.html#q=Product_Group_s%3A%22Dehumidifiers%22, maintains a database of products that have been certified to meet the federal requirements.

Indoor Growing Electrical Power Distribution

Reference: Section 120.6(h)2

Electrical power distribution systems servicing indoor CEH spaces must be designed so that a measurement device is capable of monitoring the electric energy usage of aggregate horticultural lighting load.

For compliance with existing California Department of Food & Agriculture CalCannabis regulations, growers must submit canopy size calculations and a lighting diagram for indoor and mixed-light licensing types. The lighting diagram includes the maximum wattage for each light so through this diagram one can determine total horticulture lighting load.

Luminaires are required to have a photosynthetic photon efficacy (PPE) of 2.3 micromoles per joule. This required efficacy level is currently only provided by high efficacy light emitting diodes (LEDs) as legacy high pressure sodium and other sources have lower PPEs and would not comply. Some LED sources, especially those not specifically designed for horticultural use, also have PPEs that are lower than the required 2.3 μm/J. Often the PPE of horticultural luminaires is published. Otherwise, divide the full output photosynthetic photon flux by the rated input watts at full light output. Note that some manufacturers publish the total photon flux from their fixtures; this is not photosynthetic photon flux. Photosynthetic photon flux, as defined by ANSI/ASABE S640, is measured only for the wavelengths between 400 and 700 nanometers. LEDs have become a standard choice as growers have become familiar with their impacts on plant quality and yield while saving energy and reducing internal gains and cooling loads.

Example 10-34

Question:

How do I find the photosynthetic photon efficacy of a particular lighting fixture or lamp?

Answer:

A variety of options exist to determine the PPE of a given product. The DesignLights Consortium (DLC) Qualified Products List notes the PPE level of over 415 products from popular lighting manufacturers. If your product is not found in this listing, your manufacturer's product specification may list PPE. Additionally, there are industry test procedures that can assist in the determination of a PPE level. IES LM-46-04: IESNA Approved Method for Photometric Testing of Indoor Luminaires Using High Intensity Discharge or Incandescent Filament Lamps is the most appropriate test standard for lamps and can be used to report PPE when certain data gaps are filled. The information needed to conduct the test procedure for PPE is found in existing IES standards, LM-51 and LM-79.

Conditioned Greenhouse Building Envelope

Reference: Section 120.6(h)3

Section 120.6(h)3 provides separate building envelope requirements for conditioned greenhouses. Roof/ceiling and wall insulation must meet assembly requirements of Section 120.7. Buildings have different U-factor requirements for roof/ceiling and wall insulation depending on whether they are constructed with metal or wood products and their climate zones.

Non-opaque wall and non-opaque roof assemblies shall have greenhouse glazing with two or more glazing layers separated by air or gas fill.

Examples of non-opaque glazing products that meet these requirements include double pane glass, double and triple wall polycarbonate, and double film polyethylene.

Conditioned Greenhouse Space-Conditioning Systems

Reference: Section 120.6(h)4

Section 120.6(h)4 requires that space-conditioning systems used in conditioned greenhouses for plant production must meet requirements applicable to the systems

Horticultural Lighting

Reference: Section 120.6(h)5

Pertaining to Section 120.6(h)5, greenhouse growing spaces with more than 40 kW of horticultural lighting load shall have electric lighting systems used for plant growth and maintenance that meet all of the below requirements:

- Luminaires with removable lamps shall contain lamps with a lamp photosynthetic photon efficacy (PPE) of at least 2.3 micromoles per joule (µm/J); all other luminaires shall have a luminaire photosynthetic photon efficacy of at least 2.3 µm/J.
- Time-switch lighting controls shall be installed and comply with Section 110.9(b)1, Section 130.4(a)4, and applicable sections of NA 7.6.2.
- Multilevel lighting controls shall be installed and comply with Section 130.1(b).

A lamp and luminaire PPE of 2.3 µm/J will require the use of high efficacy light emitting diodes (LEDs) as legacy high pressure sodium and other sources have lower PPEs and would not comply.

Example 10-34

Question:

How do these Energy Code requirements interact with any CalCannabis requirements?

Answer:

Energy Code requirements for CEH greenhouses and indoor growing spaces apply to all building spaces that "are dedicated to plant production by manipulating indoor environmental conditions, such as through electric lighting, mechanical heating, mechanical cooling, or dehumidification." Energy Code requirements apply regardless of the type of crop grown in these spaces. The Energy Code defines a CEH indoor growing space as having a skylight area to roof area ratio less than 50 percent. A CEH greenhouse has a skylight area to roof area ratio of 50 percent or greater. Thus, the Energy Code definitions of greenhouse and indoor growing space are solely determined by the fraction of roof area that has glazing and is not affected by how much electric lighting is used in the space.

CalCannabis (operated by the Department of Cannabis Control) grants licenses for cannabis growing. Different types of licenses are based on factors such as lighting density and light deprivation. As of 2021, CalCannabis defines Indoor Cultivation as, "Cultivation of cannabis within a permanent structure using artificial light exclusively, or within any type of structure using artificial light at a rate above 25 watts per square foot." Therefore, a CalCannabis indoor cultivation license applies to indoor spaces with no skylights and any space, even greenhouses, with more than 25 watts of electric lighting per square foot of growing area. A CalCannabis mixed light cultivation license makes use of some amount of sunlight and must have no more than 25 watts of electric lighting power installed per square foot of growing area.

The CalCannabis definitions of "indoor growing" and "mixed light" for licensure are not equivalent to the "indoor growing" and "conditioned greenhouse" definitions used for obtaining building permits under the Energy Code and are not relevant to Energy Code compliance.

Prescriptive Measures

Please refer to Chapter 10.12.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions and Alterations

Section 141.1(c) applies to major retrofits of all CEH spaces. Alterations to indoor or greenhouse horticulture lighting systems that increase lighting wattage or that include adding, replacing, or altering 10 percent or more of the horticulture luminaires servicing an enclosed space must meet the applicable requirements of Section 120.6(h).

Greenhouses being converted into conditioned greenhouses or additions to conditioned greenhouses must meet the requirements of 120.6(h)3 and 120.6(h)4. A conditioned greenhouse is an enclosed space that is provided with wood heating, mechanical heating that has a capacity exceeding 10 Btu/hr-ft2 or mechanical cooling with capacity exceeding 5 Btu/hr-ft2. In conditioned greenhouses, space-conditioning systems used for plant production shall comply with all applicable Energy Code requirements.

Example 10-35

Question:

Alterations that change the occupancy group of a building do trigger the CEH requirements. Occupancy groups are defined in Chapter 3 of Title 24, Part 2. One common change of building type that would trigger the requirements is converting an indoor warehouse into a CEH grow facility of over 10 percent of the luminaires in my greenhouse or indoor CEH facility. Do I need to meet the lighting efficiency standards in 120.6(h)5?

Answer:

Lamp replacements do not trigger the horticulture lighting efficacy alteration requirements. Only replacements of 10 percent or more of the horticulture luminaires serving an enclosed space trigger the lighting efficacy requirement. When replacing 10 percent or more of the luminaires in an enclosed space, only the replacement luminaires need to meet the applicable requirements.

Example 10-36

Question:

If I replace the lamps of over 10 percent of the luminaires in my greenhouse or indoor CEH facility, do I need to meet the lighting efficiency standards in 120.6(h)5?

Answer:

Lamp replacements do not trigger the horticulture lighting efficacy alteration requirements. Only replacements of 10 percent or more of the horticulture luminaires serving an enclosed space trigger the lighting efficacy requirement. When replacing 10 percent or more of the luminaires in an enclosed space, only the replacement luminaires need to meet the applicable requirements.

Steam Traps

Overview

Please refer to Chapter 10.13.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Mandatory Measures

Please refer to Chapter 10.13.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Central Steam Trap Fault Detection and Diagnostic Monitoring

Please refer to Chapter 10.13.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Steam Trap Fault Detection

Please refer to Chapter 10.13.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Steam Trap Strainer Installation

Please refer to Chapter 10.13.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Steam Trap System Acceptance

Please refer to Chapter 10.13.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Prescriptive Measures

Please refer to Chapter 10.13.7 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions and Alterations

Please refer to Chapter 10.13.8 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Process Pipe Insulation

Overview

Section 120.3 applies to a covered process requirement for process piping where the fluid inside the pipe is heated to 105°F or above or chilled to 60°F or below. In addition to space cooling, space heating, and service water-heater systems covered in Section 120.3, all process heating and process cooling piping has been added to pipes requiring insulation as stated in Tables 120.3-A-1 and 120.3-A-2.

Mandatory Measures

Reference: Section 120.3

There are three main mandatory requirements in this section:

- General requirements - Section 120.3(a),
- Insulation protection - Section 120.3(b),
- Insulation thickness - Section 120.3(c)

There are several exceptions to the general and mandatory insulation requirements:

- Factory-installed piping for appliances or space-conditioning equipment.
- Piping that conveys fluids with a design operating temperature range between 60°F and 105°F.
- Where the energy loss from the un-insulated pipe will not increase the building's energy use.
- Piping that penetrates framing members for the distance of the framing penetration.
- Equipment such as pumps, steam traps, blow-off valves, and piping within process equipment.
- Valves, strainers, coil u-bends, and air separators with at least 0.5 inches of insulation.

General Requirements

Reference: Section 120.3(a)4, Section 120.3(a)5

There are two new requirements for pipe insulation:

- Process heating system piping where the fluid is heated above 105°F. This includes steam, steam condensate and hot water fluid distribution systems for heating a process unrelated to space conditioning or service water-heating.
- Process cooling system piping where the fluid is cooled below 60°F. This includes refrigerant suction, chilled water, and brine fluid distribution systems for cooling a process unrelated to space conditioning.

Insulation Protection

Reference: Section 120.3(b)

Pipe insulation shall be protected from damage to maintain its integrity and its ability to reduce energy loss. The insulation should be protected against weather damage, water, and mechanical damage. Protection, at minimum, should include the following:

- Pipe insulation located outdoors should be protected by outdoor rated insulation cover that is resistant to rain, wind, and solar radiation.
- Cold pipes located outside should be protected by a vapor retarder. All penetrations and joints shall be sealed.
- Underground piping should be mechanically protected against physical damage or getting crushed by providing adequate clearance around the pipe and using physical barriers such as non-crushable casing or sleeves.

Insulation Thickness

Reference: Section 120.3(c)

Pipes should be insulated with a minimum thickness listed in Table 120.3-A-1 and Table 120.3-A-2 for the corresponding pipe diameters and fluid temperatures if insulation conductivity is provided in the relevant temperature range. If the conductivity value is greater than the range given for your application, you must calculate an adjusted required thickness to achieve the minimum required R-value using the following equation.

The following equation is used to calculate the minimum thickness.

$$TT = PPPP[(1 + \frac{tt}{PPPP})^{\frac{KK}{kk}} - 1]$$

Where,

- T = insulation thickness for material with conductivity K, inches.
- PR = actual outside radius, inches.
- t = Insulation thickness from Table 120.3-A-1 and Table 120.3-A-2, inches.
- K = Conductivity of alternate material at the mean rating temperature indicated in Table 120.3-A-1 and Table 120.3-A-2 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 120.3-A-1 and Table 120.3-A-2 for the applicable fluid temperature range, Btu-inch per hour per square foot per °F.

Prescriptive Measures

There are no prescriptive measures for pipe insulation.

Additions and Alterations

All newly installed pipes for process heating or cooling as part of process equipment additions or pipes that are relocated or added as part of an alteration must be insulated with a minimum insulation thickness or R value shown in Table 120.3-A-1 and Table 120.3-A-2.

Example 10-37

A manufacturing facility has newly installed 2” hot water pipe as part of their new Clean in Place (CIP) system. The water is heated to 180°F.

Question 1:

What is the minimum insulation thickness required?

Answer:

The minimum insulation thickness must be 2” or greater.

Question 2:

For the previously described facility, most of the piping is located indoors but some are located outdoors and exposed to the weather. They have installed standard insulation cover that is not outdoor rated. Are they in compliance with the code?

Answer:

No. The sections of the pipe that are located outdoors must have an insulation jacket that is outdoor rated with a water retardant cover and shielding from solar radiation.

Example 10-38

A manufacturing facility operates a boiler at 100 psig. The steam condensate piping passes through the warehouse then goes down the drain. The warehouse is not conditioned. The steam condensate is at 205°F.

Question:

Does the condensate piping need to be insulated?

Answer:

Per Exception 2 above, because the condensate is not recovered and the building is not conditioned, the heat loss of the condensate piping does not increase the building energy use.

Example 10-39

A refrigerated warehouse has 0.75” refrigerated line with refrigerant at -10°F.

Question:

What is the minimum insulation thickness required?

Answer:

The minimum insulation thickness must be 1.0”.

Example 10-40

A facility uses 20°F chilled water to cool their product after it exits the oven. The chilled water pipe is 4” in diameter.

Question:

What is the minimum insulation thickness required?

Answer:

The minimum insulation thickness must be 1.5”.

Example 10-41

A facility uses steam at 265°F. They have 200’ of bare steam pipe that needs to be insulated. The outside pipe diameter is 1.5”. They have an insulation material that they want to use with a thermal conductivity of 0.44.

Question:

What is the insulation thickness required?

Answer:

The conductivity is outside the range shown in Table 120.3-A-1 and Table 120.3-A-2; therefore, the insulation thickness must be calculated.

$$TT = 0.75\left[\left(1 + \frac{4.5}{0.75}\right)^{\frac{0.44}{0.29}} - 1\right] = 13.6"$$

The minimum required insulation thickness is 13.6.”

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Performance Approach

Overview

This chapter summarizes the building performance approach to be used for compliance. It includes a discussion of the alternative calculation methods, the procedures involved in determining the energy budget of the Standard Design and the energy use of the proposed design building, and how to plan check performance compliance documentation. The basic procedure is to show that the long-term system costs (LSC) and source energy use of the proposed design are less than or equal to the LSC and source energy budget of the standard design. The standard design is a building with the same geometry as the proposed design, but the envelope, lighting, and mechanical features are defined by the mandatory and prescriptive requirements of the Energy Code. The standard design features are defined in detail in the Nonresidential and Multifamily Alternative Calculation Method (ACM) Reference Manual.

The performance method is the most detailed and flexible compliance path. The energy performance of a proposed building can be calculated according to actual building geometry and site placement. Credit for certain energy features, such as a high-efficiency mechanical system, cannot be taken in the prescriptive approach but can be evaluated with an approved compliance software program using the performance approach.

Performance Method Description

The ACM Approval Manual describes the application and approval process for submitted compliance software. The Nonresidential and Multifamily ACM (NRMFACM) Reference Manual is approved by the California Energy Commission (Energy Commission) and includes explanations of the instructions that all compliance software programs must use to model the energy performance of the proposed design building and the standard design building. The reference manual also includes an explanation of the reference method and certification tests used by the Energy Commission to approve compliance software tools. Since the NRMFACM Reference Manual is approved by the Energy Commission (just like the residential and nonresidential compliance manuals), it can be updated from time to time to allow for corrections and enhancements during the 2025 Energy Code cycle.

Performance Concepts

Please refer to Chapter 12.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Minimum Capabilities

Please refer to Chapter 12.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

California Energy Commission Approval

Alternative Calculation Methods (Compliance Software)

Please refer to Chapter 12.2.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Input and Output Requirements

Please refer to Chapter 12.2.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Building Performance Metrics

Beginning with the 2005 Energy Code, the metric or "currency" for assessing building performance has been time-dependent valued (TDV) energy. TDV energy replaced annual source energy that had been the compliance metric since the Energy Commission first adopted the Energy Code in 1978. Starting with the 2025 code cycle, compliance will be based on both LSC and hourly source energy. For a proposed building to comply, both its LSC and source energy use must be less than or equal to the standard design energy budgets. More details on how proposed design energy use and the standard design energy budgets are calculated and how compliance is determined can be found in the NRMFACM Reference Manual and the CBECC or third-party compliance software user's manuals.

Long-Term System Cost (LSC)

While TDV focuses on short-term variations in energy value, LSC provides a long-term perspective, considering the lifespan of a building. This can be especially useful in assessing the true value of investments in energy efficiency or renewable energy systems.

Since when people use energy is as important as how much we use, these calculations are done for each hour throughout a typical year. They are also created for each of the 16 climate zones in California.

Source Energy

Please refer to Chapter 12.2.3.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Professional Judgment

Certain modeling techniques and compliance assumptions applied to the proposed design are fixed or restricted. That is, there is little or no freedom to choose input values for energy compliance modeling. However, there are other aspects of energy modeling where some professional judgment may be necessary. In those instances, the compliance software user must decide whether a given input is appropriate and will be matched by the actual installation.

Enforcement agencies have discretion to question a particular input if the permit applicant cannot substantiate the value with supporting documentation, cannot demonstrate that appropriate judgment has been applied, or cannot demonstrate that the actual installation matches the input.

Simplified modeling approaches can be used if the predicted energy use of the proposed building is not affected or if the proposed energy use increases, reducing the compliance margin when compared to a more explicit and detailed modeling assumption. That is, simplification must reflect the same or higher energy use than a more detailed model and reflect the same or lower compliance margin when comparing the standard and proposed LSC and source energy.

Any unusual modeling approach, assumption, or input value should be documented with published data and, when applicable, should conform to standard engineering practice.

Example 12-1

Question:

Three different-sized windows in the same wall of a new one-story office building are designed without exterior shading, and they have the exact same NFRC-rated U-factors and SHGC values. Is it acceptable professional judgment to simplify the computer model by adding the areas of the three windows together and inputting them as a single fenestration area?

Answer:

Yes. For a simplified, two-dimensional, geometry model, the compliance software will produce about the same energy results whether the windows are modeled individually or together as one area because the orientation, fenestration U-factors, and SHGC values of the windows are identical.

However, if overhangs and side-fins are modeled, the correct geometry of fixed shades must be modeled for each window.

For detailed, three-dimensional, geometry models, the location of windows on walls affects the daylighting energy calculation, and this effect must be considered before making the simplification in the example.

For reference, to help determine if you're using a detailed or simplified approach, a wall in a simplified model will be entered as an area, orientation (i.e., North, South, East, West), height, and width. In a detailed model a wall is entered as a series of points (i.e., x, y, z coordinates) to place the wall in three-dimensional space relative to other surfaces in the building.

Analysis Procedure

Reference: Section 140.1

This section summarizes the analysis procedures used to demonstrate building compliance when using approved compliance software programs. Software users and those checking for enforcement should consult the most current version of the compliance software user's manual, on-line help and associated compliance supplements, or a combination for specific instructions on the operation of the compliance software. Although there are numerous requirements for each software input, the data entered into each software version may be organized differently from one vendor to the next. As a result, it is not possible in this summary to present all variables in the correct order or hierarchy for any one software version. The aim is to identify the procedures used to calculate the standard and proposed design LSC and source energy budgets.

General Procedure

Please refer to Chapter 12.4.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Computer Input Files

Please refer to Chapter 12.4.1.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Basic Data Entry

Elements Used in Compliance Software

Please refer to Chapter 12.4.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Calculating Building Energy Use

The LSC and source energy proposed design energy use and standard design energy budgets are separated into compliance totals, which are the basis for building compliance with the performance method, and total building energy use, which adds receptacle, process and other nonregulated energy usage.

The compliance total energy can be summarized into several components:

- The space-conditioning energy use
- The service water heating energy use
- The mechanical ventilation energy use
- The lighting energy use
- The photovoltaic system energy impact
- The battery energy storage system energy impact
- The demand flexibility energy impact

Nonregulated energy such as process, receptacle, other lighting, and process motors is treated as compliance neutral. The standard design will always match the proposed energy usage for these categories.

The proposed building energy use is defined by Section 140.1(b) and includes the envelope, space conditioning and ventilation, indoor lighting, and water-heating systems assigned to the building. The key component of calculating the LSC energy and source energy use of the proposed building is that if a feature of the building is not included in the building permit application, the energy use of that feature is equal to that of the standard design energy budget defined in Section 140.1(a). That means that if a permit is submitted for a building shell (envelope only), and the performance approach is used to demonstrate compliance, trade-offs cannot be made between the envelope and the mechanical or lighting system.

The standard design budget is defined by replacing all of the energy features of the proposed building with the prescriptive requirements in Section 140.3 of the Energy Code. Details of the standard design features are documented in the NRMFACM Reference Manual.

Space-Conditioning Energy Budget

Please refer to Chapter 12.4.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Lighting Energy Budget

The indoor lighting energy budget consists of the lighting power used by a building based on one of the following criteria:

- When no lighting plans or specifications are submitted for permit and the occupancy of the space is not known, the standard lighting power density is 0.40 W/ft².
- When no lighting plans or specifications are submitted for permit and the occupancy of the space is known, the standard lighting power is equal to the corresponding watt per ft² value derived in the Area Category Method of Section 140.6(c)2.
- When lighting plans and specifications are submitted for permit, the standard lighting power is equal to the corresponding total allowed lighting power (in watts) that was used in calculating the proposed lighting level that can be based on the Area Category Method in Section 140.6(c)2. The standard design building uses the lesser of allowed watts or actual lighting power to be installed in the building. The proposed design building uses the actual lighting power to be installed as detailed on the lighting plans. This value must be equal to or less than the allowed watts.

For all occupancies except hotel guest rooms and multifamily dwelling units, the proposed lighting power is input into the software. For hotel guest rooms or multifamily dwelling units, the compliance software will automatically set the proposed lighting power and the standard design lighting power at the same value as specified in the NRMFACM Reference Manual.

Water-Heating Energy

Please refer to Chapter 12.4.3.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Application Scenarios

Please refer to Chapter 12.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Whole-Building Compliance

Please refer to Chapter 12.5.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compliance by Permit Stage

Please refer to Chapter 12.5.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Modeling Future Construction by Permit Stage

Please refer to Chapter 12.5.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Modeling Existing Construction by Permit Stage

Please refer to Chapter 12.5.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Additions Performance Compliance

An addition that consists of new conditioned floor area and added volume will either need to comply as an addition alone or as an existing plus addition plus alteration. For the addition-alone path, the same requirements for a newly constructed building will apply to the addition.

All systems serving the addition will require compliance to be demonstrated, and either the prescriptive or performance approach can be used for each stage of the construction of the addition. Existing plus addition plus alteration requires modeling of the existing, altered, and new components but gives the opportunity for compliance tradeoffs between the new and altered components in the addition and existing building.

When existing space conditioning or water heating is extended from the existing building to serve the addition, the existing components of these systems should be modeled as existing, and the new components of these systems must be modeled as new (e.g., new ducts extended to the addition) so that the software can determine the correct standard design based on Section 141.0(a).

Addition Only

Additions that show compliance with the performance approach independent of the existing building must meet the requirements for newly constructed buildings. Section 141.0(a) states that the envelope and indoor lighting of the addition, and any newly installed space conditioning, electrical power distribution system, or water-heating system, must meet mandatory measures and the applicable energy budget:

- If the permit is done in stages, the rules for each permit stage apply to the performance run of the addition.
- If the whole addition (envelope, lighting, and mechanical) is included in the permit application, the rules for whole buildings apply.

Existing Plus Addition Plus Alteration

Additions may also show compliance by either:

- Demonstrating that efficiency improvements to the envelope component of the existing building, as well as certain indoor lighting and mechanical improvements, offset addition performance that would otherwise not meet the energy budgets for the addition alone. (See Section 141.0(a)2Bii.
- Showing that the existing building combined with the addition meet the requirements of Section 141.0(b) for newly constructed buildings.

For additions, the most flexible compliance method is to consider the entire existing building along with the addition (Existing + Addition + Alteration).[1] The combination of additions and alterations to the existing building may be shown to comply by demonstrating that the proposed design energy use is equal to or less than the standard design energy budget based on the alterations meeting the requirements of Section 141.0(b)3 and additions meeting the requirements of Section 141.0(a)2. Furthermore, Section 141.0(a)2 states that the envelope and indoor lighting in the conditioned space of the addition, and any newly installed space conditioning, electrical power distribution system or service water heating system, must meet the mandatory measures.

1This method may also be used whenever an alteration is made to existing buildings, whether or not there is an addition to the building at the same time.

This approach allows the applicant to improve the energy efficiency of the existing building so that the entire building meets the energy budget that would apply if the existing building were unchanged, and the addition complied on its own. Changes to features in the existing building are considered alterations.

For a full description of when and how altered components in the existing building are counted in the performance calculation, as well as basic energy modeling rules for alterations, see the Alterations Performance Compliance below.

Example 12-2

Question:

Three thousand square feet (3,000 ft²) of conditioned space is being added to an existing office building. Twenty-five percent of the lighting fixtures in the existing office space are being replaced with more efficient fixtures. Can credit be taken for the improved lights in the existing building to comply through the existing-plus-addition performance approach?

Answer:

Since 10 percent or more of the lighting fixtures are replaced, all prescriptive lighting alteration requirements must be met. Credit can be taken only for lighting efficiency improvements, resulting in a lower lighting power than is required to meet Section 140.6.

Alterations Performance Compliance

Please refer to Chapter 12.5.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Alterations of the Permitted Space

Altered spaces can show compliance with the performance approach independent of the remainder of the existing building but must still meet the requirements for the altered components of the building as specified in Section 141.0(b)2. These require that envelope and lighting alterations, as well as any new or replacement space-conditioning or service water-heating system serving the alteration, meet the mandatory measures. The permitted space alone may comply with the energy budget determined using approved compliance software.

If the permit is done in stages, the rules for each permit stage apply to the alteration performance run.

Alterations in Existing Buildings Without an Addition

Alterations may also show compliance by demonstrating that the energy use of the proposed design — including all energy efficiency improvements to the existing building — is equal to or less than the standard design energy budget that is based on the alterations meeting the requirements of Section 141.0(b)2 and Table 141.0-E of the Energy Code. Section 141.0(b)1 also requires that envelope, lighting, space-conditioning, and service water-heating system alterations meet the applicable mandatory measures.

This approach allows the applicant to improve the energy efficiency of the existing building so that it meets the energy budget that would apply to the entire building if the existing building other than the portion being altered was unchanged. Changes to features in the existing building are considered alterations.

Altered components that do not meet or exceed the requirements of Section 141.0(b)2 are considered when the complying through the performance pathway. A credit is assigned to an alteration (improvement) that exceeds the requirements in Section 141(b)2 as summarized in Table 141.0-E of the Energy Code and further detailed in the NRMFACM Reference Manual. The compliance software sets the standard design for the altered component, as listed in Table 141.0-E of the Energy Code.

This compliance approach includes the entire building, which means the ensemble of all enclosed space in a building, including the space for which a permit is sought, plus all conditioned and unconditioned space within the structure. The inclusion of the characteristics of unconditioned spaces has an effect on the overall performance budget of the building due to the loads of the unconditioned spaces adjacent to the conditioned spaces, which can be beneficial or detrimental to the overall compliance margin.

When using this compliance approach, it is important to take into account all the changes in the features of the building that are:

- Existing (that remain unchanged).
- Altered (improved or replaced).
- New (all new).

Surfaces that are being completely removed from the existing building — roofs/ceilings, exterior walls and floors, and all glazing removed with those removed surfaces — are not modeled.

To show compliance with this approach, you need to follow the instructions in the compliance software user's manual. Documentation of the existing building's glazing areas is required to be submitted with the permit application if this method is used for replacement fenestration credit.

Example 12-3

Question:

Alterations to an existing office building in Climate Zone 12 include replacing all single clear metal frame-operable windows with new NFRC-rated windows (U-factor =0.45, SHGC=0.31.) What standard design values will the compliance software use for the replacement fenestration area?

Answer:

The standard design will use the values in Table 141.0-A (U=0.47, SHGC=0.31 and VT=0.32) of the Energy Code regardless of whether the replacement windows' values exceed those Table 141.0-A values.

Alterations in Existing Building With an Addition

Please refer to Chapter 12.5.4.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Alternate Performance Compliance Approach

Please refer to Chapter 12.5.4.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Enforcement and Compliance

Please refer to Chapter 12.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Performance Inspection

Please refer to Chapter 12.6.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

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Building Commissioning Guide

Commissioning is included in the design and construction process of newly constructed nonresidential buildings to verify that the energy systems and components of a building meet the owner's or owner representative's project requirements.

Commissioning under Part 6 is required for nonresidential buildings of 10,000 square feet and larger, excluding healthcare facilities (which instead follow a procedure specified in Chapter 7 of the California Administrative Code, Title 24, Part 1). Commissioning is also required for nonresidential portions of hotel/motel buildings when the total space of the nonresidential spaces is 10,000 square feet or larger.

Newly constructed buildings with less than 10,000 square feet of nonresidential area are only required to perform a design review, though they may elect to perform a more complete commissioning process. Design review is discussed in Chapter 12.

Part 6 does not require retrocommissioning of existing buildings; neither commissioning nor design review is required for building additions or alterations. That said, this guide may still be useful for projects engaging in retrocommissioning.

Overview

Please refer to Chapter 13.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Selecting Trained Personnel for Commissioning

Please refer to Chapter 13.1.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Owner's Project Requirements (OPR)

Please refer to Chapter 13.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Intent

Please refer to Chapter 13.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compliance

Please refer to Chapter 13.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Basis of Design (BOD)

Please refer to Chapter 13.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Intent

Please refer to Chapter 13.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compliance Method

Please refer to Chapter 13.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Enforcement

Please refer to Chapter 13.3.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Design Phase Review

Please refer to Chapter 13.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Intent

Please refer to Chapter 13.4.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compliance Method

Please refer to Chapter 13.4.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Enforcement

Please refer to Chapter 13.4.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Commissioning Measures

Please refer to Chapter 13.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Intent

Please refer to Chapter 13.5.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Existing Law or Regulation

Please refer to Chapter 13.5.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compliance

Please refer to Chapter 13.5.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Enforcement

Please refer to Chapter 13.5.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Commissioning Plan

Please refer to Chapter 13.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Intent

Please refer to Chapter 13.6.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Existing Law or Regulation

Please refer to Chapter 13.6.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compliance

Please refer to Chapter 13.6.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Enforcement

Please refer to Chapter 13.6.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Functional Performance Testing

Please refer to Chapter 13.7 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Intent

Please refer to Chapter 13.7.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Existing Law or Regulation

Please refer to Chapter 13.7.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compliance

Please refer to Chapter 13.7.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Enforcement

Please refer to Chapter 13.7.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Documents and Training

Please refer to Chapter 13.8 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Intent

Please refer to Chapter 13.8.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compliance Method

Please refer to Chapter 13.8.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Enforcement

Please refer to Chapter 13.8.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Systems Operations Training

Please refer to Chapter 13.9 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compliance

Please refer to Chapter 13.9.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Enforcement

Please refer to Chapter 13.9.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Commissioning Report

Please refer to Chapter 13.10 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Intent

Please refer to Chapter 13.10.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compliance Method

Please refer to Chapter 13.10.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Enforcement

Please refer to Chapter 13.10.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

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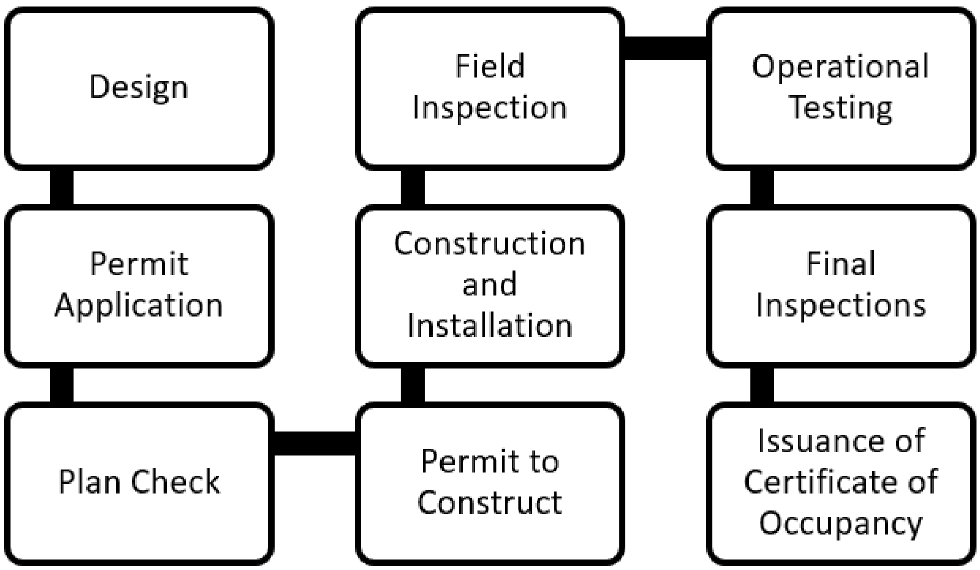
Acceptance Test Requirements

Overview

Acceptance testing is performed during the operational testing phase of project permitting (shown in Figure 14-1: Idealized International Code Council Permitting Process for Building Permit Applications) and before final inspections and the issuance of the certificate of occupancy. See Nonresidential Compliance Manual Chapter 2 for more information regarding the phase of project permitting.

Figure 14-1: Idealized International Code Council Permitting Process for Building Permit Applications



Source: California Energy Commission staff

However, it is advisable (although not required) to include professionals who are knowledgeable regarding the acceptance test procedures and requirements in the design phase as well.

What's New for 2025

Mechanical Systems and Equipment - Section 120.5

New Acceptance Test:

- Cooling Tower Conductivity Controls

Lighting Controls

Minor Clarifications:

- Changed all occurrences of "automatic daylighting controls" to "daylight responsive controls" to be consistent with the terminology change in the standards.
- Improved the construction inspection specification for verifying the communication protocols used in controlled receptacles demand responsive controls.

Covered Process Systems and Equipment

Major Modifications:

- A new table would be added to the compliance form to allow the design team to add information regarding evaporators for the calculation of evaporator specific efficiency to test for compliance to code requirements (NRCC-PRC-E).
- Pipe insulation verification must be added to compliance documents (NRCC-PRC-E, NRCC-PRC-01-E, NRCI-PRC-E).
- Lab Exhaust Ventilation System Acceptance Test must be updated to include procedures on testing the new requirement for occupancy based VAV and for updated fan power and simple turndown controls requirements, and compliance forms must be updated to include detail on the configuration of lab air equipment (NA7.16, NRCC-PRC-E, NRCA-PRC-14-F).

Minor Clarifications:

- Minimum efficacy for indoor and greenhouse CEH lighting must be updated (NRCC-PRC-E).

What Is Acceptance Testing

From simple thermostats and manual light switches to complex building automation systems, controls are integral to building health, safety, comfort, and energy efficiency.

Acceptance test requirements specify targeted inspections and functional performance tests that demonstrate that the building components, equipment, systems, and interfaces conform to the Energy Code, inclusive of Reference Nonresidential Appendix NA7, as specified on applicable construction documents.

This helps ensure that the building achieves the energy savings potential specified in the design and protects installing technicians by providing demonstrable proof that the system functioned as required by code when it was installed.

Roles and Responsibilities

Please see Chapter 2 for a complete discussion concerning the roles and responsibilities of all parties.

Field Technician

Please refer to Chapter 14.1.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Acceptance Test Technician

An Acceptance Test Technician (ATT) is a certification standard for technicians, contractors, engineers, architects, and commission agents that design, install, and commission (perform acceptance testing for) lighting controls and mechanical system in newly constructed or existing nonresidential buildings or spaces.

The certification is restricted to applicants with a minimum of three years of professional experience and expertise in either lighting or mechanical controls. Qualifying experience for certification is provided by verifiable employment as an electrical contractor, certified general electrician, licensed architect, professional engineer, controls installation and startup contractor, HVAC installer, mechanical contractor, testing and balancing certified technician, or certified commissioning professional with verifiable experience in lighting controls or HVAC installations. ATTs are provided classroom and laboratory training to perform acceptance testing. ATTs must pass classroom and laboratory testing to gain their certification. The ATT is required to work with the California Energy Commission (CEC) -approved acceptance test technician certification provider (ATTCP) to track and verify quality assurance of their acceptance test performance.

- A certified lighting controls ATT is required to perform the lighting controls acceptance tests referenced by Section 130.4 and sign the certificate(s) of acceptance (NRCAs).
- A certified mechanical ATT is required to perform the mechanical acceptance tests referenced by Section 120.5 and sign the certificate(s) of acceptance.
- Other acceptance tests, such as those for covered processes and building envelope, do not require a certified ATT.

More information on becoming certified and other information on ATTs can be found at https://www.energy.ca.gov/programs-and-topics/programs/acceptance-test-technician-certification-provider-program.

Responsible Person

Please refer to Chapter 14.1.2.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Commissioning Provider

A commissioning provider (also referred to as a commissioning agent) is not defined by the Energy Code but is an industry term for a person who may be contracted by the owner to verify functional performance testing is conducted (among other responsibilities) to ensure proper performance at building turnover. Commissioning during construction is required by Section 120.8. In general, newly constructed nonresidential buildings with more than 10,000 square feet of conditioned floor area must comply with all the requirements in Section 120.8 (full commissioning). Smaller buildings are required to complete just the design review phase of commissioning. The commissioning requirements in Section 120.8 do not apply to healthcare facilities, which have parallel requirements in Chapter 7 of the California Administrative Code (Title 24, Part 1), and do not apply to additions or alterations to existing buildings.

Although system commissioning and acceptance testing are related, not all projects that require acceptance testing will also require full commissioning. If a commissioning agent is part of the project team, they will often be present for functional performance testing of major building systems to verify the tests were completed and passed on behalf of the building owner. (Commissioning agents may instead perform acceptance testing themselves, and if this is the case, they may also need to be a certified ATT.) See Chapter 2 for more information regarding commissioning and commissioning agents.

Enforcement Agency

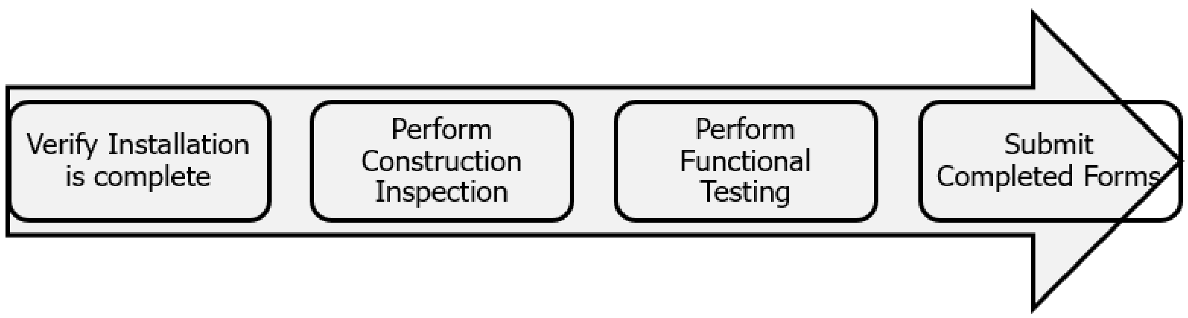
The certificate of acceptance must be provided on site for the enforcement agency, typically at final inspection, to receive the certificate of occupancy. Many enforcement agencies will issue a provisional certificate of occupancy and allow the builder to fix or complete specific elements within a specified time frame. Enforcement agencies may not release a *final* certificate of occupancy unless the submitted certificate of acceptance demonstrates that the specified systems and equipment have been shown to perform in accordance with the applicable acceptance requirements.

The enforcement agency has the authority to require the field technician or responsible person to demonstrate competence to its satisfaction. When a certified ATT is required to complete an acceptance test, the enforcement agency may verify the ATT certification status through the ATTCP before issuing a certificate of occupancy or confirm that the NRCA form was completed via an approved ATTCP by the certified ATT in which the provider name and logo will be included within the electronic NRCA form and is not completed by hand. For details on how to do this most efficiently, see the Acceptance Testing Process below. Please see Chapter 2 for more information regarding enforcement agencies' roles and responsibilities.

Acceptance Testing Process

See Chapter 2 for a more complete discussion of the permitting process. As was shown in Figure 14-1: Idealized International Code Council Permitting Process for Building Permit Applications, the acceptance testing is performed during the operational testing phase of permitted construction. The acceptance process itself follows four major steps as shown in Figure 14-2: Steps in the Acceptance Testing Process.

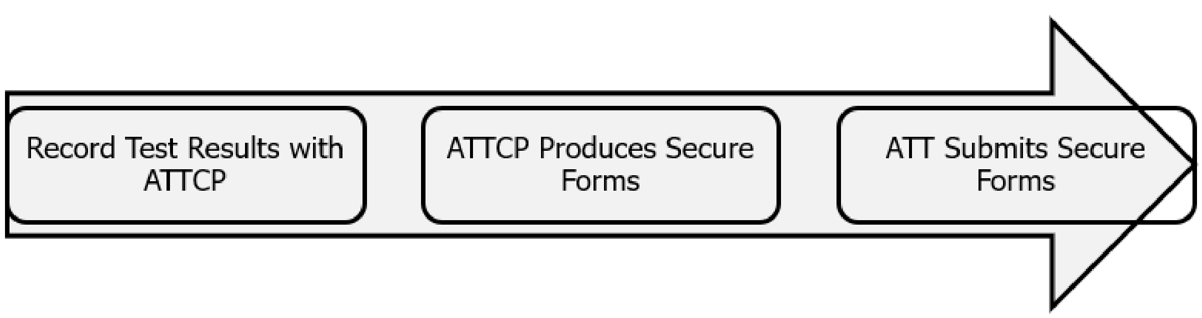
Figure 14-2: Steps in the Acceptance Testing Process



Source: California Energy Commission

The acceptance test process is slightly different when an ATT is required. As shown in Figure 14-3: Final Step to Submit Completed Forms for the ATT Acceptance Testing Process, the difference is in the use of the ATTCP when completing and submitting the completed forms (the final step in the general acceptance test process shown in Figure 14-2: Steps in the Acceptance Testing Process).

Figure 14-3: Final Step to Submit Completed Forms for the ATT Acceptance Testing Process



Source: California Energy Commission

Reviewing the acceptance requirements with the contractor before installation may help the process run smoothly. In some cases, performing tests immediately after installation is most economical, though this requires the complete installation of any associated systems and equipment necessary for proper system operation. Awareness of the acceptance test requirements can allow the contractor to identify a design or construction practice that would not comply with the Energy Code before equipment installation.

A technician or ATT assumes the responsibility for performing the required acceptance test requirement procedures in NA7 and reproduced on the certificates of acceptance for convenience. The CEC expects that the same technician or ATT that installed the efficiency feature will perform all the required acceptance tests for that feature, but this is not required. The technician or ATT who performs the acceptance test is responsible for identifying and remediating all performance deficiencies, repeating the test (if necessary) until the specified efficiency feature is performing in accordance with the acceptance test requirements.

In addition, the CEC makes the following recommendations as good industry practice but are not required:

- When planning construction, consider costs of testing within subcontractor bids, scheduling time within the overall construction schedule and coordination with commissioning if required on the project.
- Purchasing sensors and equipment with calibration certificates often reduces the amount of time required for site calibration, which can lower overall costs.
- In some cases, performing tests immediately after installation or during set-up and commissioning is most economical, though this requires the complete installation of any associated systems and equipment necessary for proper system operation.

Verify Installation is Complete

The technician or ATT is responsible for verifying that the efficiency feature is installed as indicated by the approved plans, including the certificate of compliance. These plans, including the certificates of compliance, are approved by the enforcement agency during the permit application phase. (See Figure 14-1: Idealized International Code Council Permitting Process for Building Permit Applications). See Chapter 2 for a detailed explanation of the permitting process and roles and responsibilities. The prescriptive Certificates of Compliance can be completed by using the Virtual Compliance Assistant (VCA) Tool from Energy Code Ace, or via the Performance Approach. The VCA Tool or approved compliance software will indicate what acceptance tests are to be completed for each efficiency features at permit application phase. The technician or ATT must verify with the help of the responsible person what acceptances are to be performed and on what efficiency features. The technician or ATT is then to install the efficiency feature and ensure that it is operational and ready for acceptance testing.

Perform Construction Inspection

Please refer to Chapter 14.1.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Perform Functional Testing

Please refer to Chapter 14.1.3.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Complete and Submit Certificate of Acceptance Forms

Once the efficiency feature passes the acceptance test requirements, the technician or ATT who performed the acceptance test completes the respective certificate of acceptance form and signs it to assert that the information recorded on the certificate is true and correct. In some instances, it may be beneficial for the technician or ATT to complete the certificate of acceptance form when the efficiency feature does not pass acceptance testing to support the feature being improved to that it can pass. This may help the technician or ATT identify the issues or errors that the efficiency feature is having that prevent it from passing. This information can be used to convey these issues to the responsible person for the project for remedy. A responsible person for the project must also sign the form to ensure that the performance of the scope of work specified by the certificate of acceptance and the test results provided by the field technician are complete.

As noted previously, the responsible person may also perform the field technician's responsibilities and, if so, must sign the field technician declaration on the certificate of acceptance. If the acceptance test requires a certified ATT, the responsible person must be a certified ATT to perform the acceptance test.

The completed and signed certificate of acceptance form must be submitted to the enforcement agency in accordance with the local laws, ordinances, regulations, or customs.

Building inspectors may review the forms during inspection. Inspectors can also verify the ATT certification status through the ATTCP online certification lists. Finally, the inspector can verify that the completed form is valid by relying on the watermark provided by the ATTCP or by contacting the ATTCP to verify the form over the phone or via internet. Some ATTCPs provide a QR-Code for a quick and simple verification. ATTCP documents should not be accepted if completed by hand, completed electronically outside the ATTCP online interface, or fails to show the ATTCP logo and watermark.

Certificate of Acceptance

Certificate of acceptance (NRCA) forms consist of worksheets to document the results of construction inspections and functional testing, as well as a signatory page. Appendix A provides a list of NRCA documents.

The name of the compliance document can give you clues about the documents use. The NRCA prefix indicates a nonresidential certificate of acceptance which is used for nonresidential buildings. The next set of letters specifies the building component; for example, "LTI" indicates indoor lighting. The suffix will tell you whether a certified acceptance test technician "-A" or field technician "-F" is appropriate to perform the functional performance test. Remember that an ATT can act as a field technician, but a current ATT certification is required for someone to sign as an ATT.

Acceptance Testing Requirements

The following provides a summary of the acceptance testing requirements and testing procedures in the Energy Code for mechanical systems, lighting controls, building envelope, and covered processes.

Separate files providing detailed instructions on how to conduct acceptance tests are located on the Energy Commission website, https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency.

Building Envelope Acceptance Testing Requirements

Envelope acceptance testing may be performed by any field technician; however, the installing contractor typically performs this testing.

Envelope acceptance testing is required for all buildings except fenestration products removed and reinstalled as part of alteration or addition to buildings per Section 110.6(a). These requirements apply to newly constructed buildings and to alterations.

The building envelope acceptance testing procedures are specified in Reference Nonresidential Appendix NA7.4.

The building envelope features that require acceptance testing include:

- NA7.4.1 Fenestration.
- NA7.4.2 Window Films.
- NA7.4.3 Dynamic Glazing.
- NA7.4.4 Clerestories for Power Adjustment Factor.
- NA7.4.5 Interior and Exterior Horizonal Slats for Power Adjustment Factor.
- NA7.4.6 Interior and Exterior Light Shelves for Power Adjustment Factor.

Fenestration, Window Films, and Dynamic Glazing Acceptance Testing - NA7.4.1, NA7.4.2, and NA7.4.3

These tests are required for newly installed fenestration, window film, and dynamic glazing in new construction, additions, and alterations for all buildings per Section 110.6(a).

These fenestration products must be tested according to NA7.4 to verify that the National Fenestration Rating Council (NFRC) Label Certificate, or Certificate of Installation NRCI-ENV-E for fenestration using default values of Tables 110.6-A and 110.6-B or per NA6, is provided for each fenestration product being installed. These certificates identify the thermal performance of the fenestration product (e.g., U-factor, solar heat gain coefficient, and visible transmittance).

This test also verifies that the thermal performance of installed fenestration products matches the label certificate, certificate of compliance, and plan specifications.

Daylighting Design Power Adjustment Factors Acceptance Testing - NA7.4.4, NA7.4.5, and NA7.4.6

These tests are required to qualify for power adjustment factors for clearstory fenestration, interior and exterior horizontal slats, and interior and exterior light shelves in nonresidential and hotel/motel areas per Section 140.3(d), Section 140.6(a)2L, and Section 110.6(a)6.

These daylighting design features must be tested according to NA7.4 to verify that clerestory windows, interior and exterior horizontal slats, and interior and exterior light shelves meet the daylighting design requirements in the Energy Code when claiming a power adjustment factor (PAF) for lighting systems in nonresidential and hotel/motel buildings.

Spaces that have clerestory windows, horizontal slats, or light shelves, and compliant automatic daylighting controls may receive a power adjustment factor if the daylighting feature meets the design criteria in Energy Code.

Mechanical Systems Acceptance Testing Requirements

Outdoor Air

This test (NA7.5.1.2) ensures the constant-volume air-handling unit provides adequate outdoor air ventilation to the spaces served under all operating conditions, while NA7.5.1.1 supports variable-air-volume systems. Systems requiring demand ventilation controls per Section 120.1(c)3 must conform to Section 120.1(c)4E regarding the minimum ventilation rate when the system is in occupied mode. Related acceptance tests for these systems include the following:

- NA7.5.2 Constant-Volume, Single-Zone, Unitary Air Conditioners and Heat Pump Systems Acceptance
- NA7.5.4 Air Economizer Controls Acceptance (if applicable)
- NA7.5.5 Demand-Controlled Ventilation Systems Acceptance (if applicable)

This test is restricted to certified mechanical ATTs using Certificate of Acceptance NRCA-MCH-02-A.

HVAC and Heat Pumps

Please refer to Chapter 14.3.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Duct Leakage

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 120.4(a) and leakage requirements outlined either in Section 120.4(g)1 for new duct systems or Section 141.0(b)2D and Section 141.0(b)2Eii for existing duct systems.

Economizer, DOAS, HRV, or ERV

This test (NA7.5.4) is restricted to certified mechanical ATTs and is intended to verify Energy Code compliance for nonresidential and hotel/motel buildings with newly installed economizers, dedicated outdoor air system (DOAS), heat recovery ventilation (HRV) systems, and energy recovery ventilation (ERV) system. Economizers must be certified to the CEC in compliance with JA6.3.

Submit one Certificate of Acceptance (NRCA-MCH-05-A) for each economizer, DOAS, HRV, or ERV system that must demonstrate compliance with the Energy Code. For direct Energy Code reference, see JA6.3, NA7.5.4, Section 140.4(e), Section 120.5(a)4.

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 in Section 140.4(e). 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.

Demand Ventilation Control

Please refer to Chapter 14.3.2.5 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Supply Fan Controls

Please refer to Chapter 14.3.2.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Valve Leakage Test

Please refer to Chapter 14.3.2.7 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Water Temperature Reset

Please refer to Chapter 14.3.2.8 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Variable-Flow Control

Please refer to Chapter 14.3.2.9 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Automatic Demand Shed Control

Please refer to Chapter 14.3.2.10 of the *2022 Nonresidential and Multifamily Compliance Manual*.

FDD — Packaged Units

Please refer to Chapter 14.3.2.11 of the *2022 Nonresidential and Multifamily Compliance Manual*.

AHU and Zone Terminal FDD

Please refer to Chapter 14.3.2.12 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Energy Storage for HVAC

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) systems 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 test is restricted to certified mechanical ATTs using NRCA-MCH-14-A to verify that the system conforms with the Energy Code requirements.

Thermal Energy Storage

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.

Supply Air Temperature Reset Controls

Please refer to Chapter 14.3.2.15 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Condenser Reset Controls

Please refer to Chapter 14.3.2.16 of the *2022 Nonresidential and Multifamily Compliance Manual*.

EMCS System Acceptance

This acceptance test (Section 120.5[a]17) ensures that when an energy management control system (EMCS) is installed for compliance with the Energy Code, it is properly installed, is operational, and is in compliance with each relevant requirement in the standards.

This test is restricted to certified mechanical ATTs using NRCA-MCH-18-A to ensure that when an EMCS is installed for compliance with the Energy Code, it is properly installed, is operational, and is in compliance with each relevant requirement in the standards.

Occupancy Sensor/Occupied Standby

Please refer to Chapter 14.3.2.18 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Cooling Tower Conductivity Controls

This test (NA7.5.18) verifies that the open or closed-circuit cooling tower conductivity controls, makeup water, and overflow alarms are installed per the specifications in the plan and certificate of compliance (NRCC-MCH-E or NRCC-PRF-01-E) via the testing protocols of NA7.5.18.2.

This test is restricted to certified mechanical ATTs using the NRCA-MCH-24-A to ensure that the system is functional and complies with the design and with the Energy Code requirements in Section 110.2(e)7.

Lighting Controls Acceptance Testing Requirements

Lighting controls acceptance testing must be performed by a certified lighting controls ATT to certify the indoor and outdoor lighting controls serving the building, area, or site meet the acceptance requirements.

Lighting controls acceptance testing is required for all installed lighting controls in nonresidential buildings and hotel/motel buildings per Section 130.4(a). These requirements apply to newly constructed buildings and alterations. For alterations where lighting controls are added to control 20 or fewer luminaires, acceptance testing is not required.

The lighting controls acceptance testing procedures are specified in Reference Nonresidential Appendix NA7.6.

The lighting controls that require acceptance testing include:

- NA7.6.1 Automatic daylighting controls.
- NA7.6.2 Shutoff controls.
- NA7.6.3 Demand-responsive lighting controls.
- NA7.6.4 Lighting systems receiving institutional tuning power adjustment factor.
- NA7.6.5 Demand responsive controls for controlled receptacles.
- NA7.8 Outdoor lighting controls.

Automatic Daylighting Controls Acceptance Testing - NA7.6.1

This test is required when automatic daylighting controls are installed in nonresidential and hotel/motel buildings. General lighting within a daylit zone must be controlled by automatic daylighting controls per the requirements of Section 130.1(d).

Automatic daylighting controls must be tested according to NA7.6.1 and is restricted to certified lighting ATTs using the NRCA-LTI-03-A. This is to verify that the automatic daylighting controls are installed and that they automatically adjust electric lighting power in response to available daylighting in the space.

Shutoff Controls Acceptance Testing - NA7.6.2

All installed indoor lighting must be controlled by shutoff controls per Section 130.1(c). Shutoff controls acceptance testing ensures that occupant-sensing controls and automatic time-switch controls that are installed are functioning according to these requirements.

Automatic shutoff controls must be tested according to NA7.6.2 and is restricted to certified lighting ATTs using the NRCA-LTI-02-A 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.

Demand-Responsive Lighting Controls Acceptance Testing - NA7.6.3

This test is required when demand-responsive lighting controls are installed in nonresidential and hotel/motel buildings per the requirements of Section 130.1(e) and Section 110.12. Demand-responsive lighting controls are required for:

- Newly constructed buildings with general lighting power of 4,000 watts or greater.
- Lighting alterations and additions with general lighting power of 4,000 watts or greater.

Demand-responsive lighting controls must be tested according to NA7.6.2 and is restricted to certified lighting ATTs using the NRCA-LTI-04-A to verify that demand responsive controls can reduce lighting power of the building to at least 85 percent of full power. The test also confirms that the lighting system produces a uniform level of illumination during a demand response event.

Institutional Tuning Power Adjustment Factor Acceptance Testing - NA7.6.4

This test is required when institutional tuning controls are installed to qualify for a power adjustment factor in nonresidential lighting systems per Section 140.6(a)2J. Institutional tuning is the adjustment of 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 at the institutional rather than the individual user level, and maximum light-level adjustments are available only to authorized personnel.

Institutional tuning must be tested according to NA7.6.4 and is restricted to certified lighting ATTs using the NRCA-LTI-05-A 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.

Completion of this acceptance test certifies that lighting systems receiving the institutional tuning power adjustment factor (PAF) comply with Section 140.6(a)2J and NA7.6.4.

Demand-Responsive Controls for Controlled Receptacles - NA7.6.5

This test is required when demand-responsive controls for controlled receptacles are installed in nonresidential and hotel/motel buildings per the requirements in Section 130.5(d) and Section 110.12(e). Demand-responsive controls for controlled receptacles are required when the following conditions are met:

- Controlled receptacles are required per Section 130.5(d)
- The building is required to have demand-responsive lighting controls per Section 110.12(c)

Demand-responsive controls for controlled receptacles must be tested according to NA7.6.5 and is restricted to certified lighting ATTs using the NRCA-LTI-04-A to verify that demand-responsive controls can turn off all loads connected to controlled receptacles when a demand response signal is received.

Outdoor Lighting Controls Acceptance Testing - NA7.8

This test applies to outdoor lighting controls that include photocontrols, motion sensors, astronomical time-switch controls, and scheduling controls for outdoor lighting systems per the requirements of Section 130.2. These controls are required for nonresidential and hotel/motel buildings.

Outdoor lighting controls must be tested according to NA7.8 and is restricted to certified lighting ATTs using the NRCA-LTO-02-A to verify that all outdoor lighting regulated by Section 130.2(c) is controlled by a motion sensor, photocontrol, astronomical time-switch control, and automatic scheduling control, as required.

Covered Process Acceptance Testing Requirements

Please refer to Chapter 14.3.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Refrigerated Warehouse Acceptance Testing - NA7.10

Please refer to Chapter 14.3.4.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Commercial Kitchen Exhaust System Acceptance Testing - NA7.11

Please refer to Chapter 14.3.4.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Parking Garage Ventilation Acceptance Testing - NA7.12

Please refer to Chapter 14.3.4.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Compressed Air System Acceptance Testing - NA7.12

Please refer to Chapter 14.3.4.4 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Elevator Lighting and Ventilation Controls Acceptance Testing - NA7.14

This test is required for newly installed elevators in nonresidential and hotel/motel buildings per Section 120.6(f).

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 also 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.

Escalator and Moving Walkway Controls Acceptance Testing - NA7.15

Please refer to Chapter 14.3.4.6 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Lab Exhaust Ventilation System Acceptance Testing - NA7.16

This test is required for newly installed laboratory and factory exhaust systems with airflow greater than 10,000 cfm per Section 140.9(c) for compliance with the Energy Code requirements on laboratory heat recovery and exhaust fan power consumption.

For all laboratory exhaust systems with a VAV control controlled by occupancy sensors, the controls and turndown settings must be tested according to NA7.16 to verify that the occupied and unoccupied setpoints are in operation and correctly configured to limit excessive energy use, without sacrificing operator safety.

Fume Hood Automatic Sash Closure Acceptance Testing - NA7.17

Please refer to Chapter 14.3.4.8 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Steam Trap Fault Detection Acceptance Testing - NA7.19

Please refer to Chapter 14.3.4.9 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Transcritical CO_2 Systems Acceptance Testing - NA7.20

Please refer to Chapter 14.3.4.10 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Acceptance Test Technician Certification Provider (ATTCP)

Provider Qualifications

Please refer to Chapter 14.5.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Organizational Structure

Please refer to Chapter 14.5.1.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Certification of Acceptance Test Employers (ATE)

Please refer to Chapter 14.5.1.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Training and Certification Procedures

These requirements are the most significant of the ATTCP regulations. They encapsulate all the required training, testing, certification, and oversight for the ATTs and ATEs that the ATTCP must provide. These requirements describe the level of experience, education, professionalism, and accountability of the ATT that the CEC is seeking and that the ATTCP must enforce.

ATTCPs shall include with their application a complete copy of all training and testing procedures, manuals, handbooks, and materials. ATTCPs shall explain in writing how their training and certification procedures include, but are not limited to, the following (Section 10-103.1(c)3 et seq. and Section 10-103.2(c)3 et seq.):

Training Scope

The ATT training must include both classroom and laboratory training. In essence, the ATT must be instructed on all acceptance tests and then practice those instructions in a laboratory setting. Furthermore, the ATT must be educated on the general science regarding acceptance testing, as well as the procedure to complete and submit the correct acceptance test documents.

ATT Training

Curricula. ATTCP training curricula for lighting controls and mechanical ATTs shall include, but not be limited to, the analysis, theory, and practical application of the items listed in Section 10-103.1(c)3Bi and Section 10-103.2(c)3Bi, respectively. These include training on the acceptance tests themselves.

Several approved ATTCPs require extensive classroom training to accomplish this educational requirement. One approved ATTCP requires that each ATT applicant hold a third-party certificate of training that the CEC found to be equivalent to the curricula required.

Hands-On Training. The ATTCP shall describe in its application the design and technical specifications of the laboratory boards, equipment, and other elements that will be used to meet the hands-on requirements of the training and certification.

Prequalification. Participation in the certification program shall be limited to persons who have at least three years of professional experience and expertise in either lighting controls and electrical systems or mechanical systems, as determined by the ATTCP.

Professional experience is defined by the ATTCP but generally means experience in a professional occupation that provides training and work experience related to the systems subject to lighting controls or mechanical acceptance testing. The ATTCP must clarify the process that it will use to determine what experience is considered professional and relevant to either lighting controls or mechanical acceptance testing, as well as to what extent the ATTCP will verify that experience. The following are some relevant questions that the ATTCP should consider when establishing an ATT applicant's prequalified experience, though not specifically required by regulation:

- How is the experience documented (for example, letters from employers or other written evidence), and how is it related to lighting controls or mechanical acceptance testing requirements?
- Should professional experience be demonstrated by requiring applicants to be certified in specifically identified professions, such as:
    - California licensed electrical contractors.
    - California licensed mechanical or HVAC contractors.
    - California certified general electricians.
    - California licensed air conditioning repair contractors.
    - California licensed professional engineers.
    - Lighting control manufacturer representative.
    - Certified commissioning professionals.

- Other professional occupations that are demonstrated to provide industry-accepted training and work experience relevant to the systems subject to lighting control or mechanical acceptance testing.

ATTCPs may adopt additional prequalification requirements for ATT applicants. For example, an ATTCP may restrict applicants from participating in the training program if the applicant is decertified by other ATTCPs. Any such additional requirements are at the ATTCP's discretion and not required by the CEC.

Instructor-to-Trainee Ratio. The ATTCP shall document in its application to the CEC why its instructor-to-trainee ratio is sufficient to ensure the integrity and efficacy of the curriculum and program based on industry standards and other relevant information.

Typically, the instructor-to-student ratio for classroom training is much higher than for laboratory training. In the applications that the CEC has approved, classroom instructor to student ratios were between 1:25 and 1:35. For laboratory training, the ratios were between 1:6 and 1:12. Most important, each ATTCP application included a discussion of the basis for each ratio.

Tests. The ATTCP shall describe the written and practical tests used to demonstrate each certification applicant's competence in all specified subjects. The ATTCPs shall retain all results of these tests for five years from the date of the test.

When developing and implementing both written and practical tests, the ATTCP may consider the following issues:

- Subject matter experts should validate contents of the exams.
- Pilot testing and statistical analysis by qualified psychometricians can identify poor quality questions and bias, as well as validating a passing score.
- Checking exam question response option frequency and other measurements of consistency may help validate the exam rigor and justify passing scores and performance standards.
- Exam questions should be evaluated annually to confirm reliability, rigor, and lack of bias.
- Lack of bias should be validated consistent with the Uniform Guidelines on Employee Selection Procedures (1978) (Federal Register, 43(166), 38290-38315).

Measures should be adopted to ensure exam security, such as having multiple versions of exams with random question generation and at least twice the number of questions in a validated question bank than are scored on any given test.

Recertification. The ATTCP shall recertify all ATTs before implementing each adopted update to the Energy Code when these updates affect the acceptance test requirements. Recertification requirements and procedures shall apply only to those specific elements that are new or modified in future updates to the Energy Code.

The ATTCP shall develop recertification training curricula for ATTs consistent with training requirements in Section 10-103.1(c)3A and Section 10-103.1(c)3B (or Section 10-103.2(c)3A and Section 10-103.2(c)3B) and shall submit the proposed recertification training curricula to the CEC for review and approval in the update report required under Section 10-103.1(d)2 (or Section 10-103.2(d)2). Once approved, the ATTCP will implement the recertification process.

ATE Training

Training for ATEs shall consist of at least a single class or webinar consisting of at least four hours of instruction that covers the scope and process of the lighting controls or mechanical systems acceptance tests in the Energy Code.

Complaint Procedures

The ATTCPs shall describe in their applications to the CEC procedures for accepting and addressing complaints regarding the performance of any ATT or ATE certified by the ATTCP and explain how building departments and the public will be notified of these proceedings.

Decertification Procedures

The ATTCPs shall describe in their applications to the CEC procedures for revoking their certification of ATTs and ATEs based upon poor quality or ineffective work, failure to perform acceptance tests, falsification of documents, failure to comply with the documentation requirements of these regulations, or other specified actions that justify decertification. The ATTCP shall also describe its general procedures for decertified ATTs or ATEs seeking to regain their certification status, including eligibility requirements for recertification (if any).

Quality Assurance and Accountability

The quality assurance and accountability requirements for lighting controls and mechanical ATTCPs vary significantly for the Energy Code, so they will be discussed separately.

- Lighting Controls

  The ATTCP shall describe in its application to the CEC its procedures for conducting quality assurance and accountability activities, including, but not limited to, the following:

- The ATTCP shall include quality assurance and accountability measures, including, but not limited to, independent oversight of the certification materials, processes, and procedures; visits to building sites where certified technicians are completing acceptance tests; certification process evaluations; and expert review of the training curricula developed for Energy Code Section 130.4 and Section 160.5(e). Independent oversight may be demonstrated by accreditation under the ISO/IEC 17024 standard.
    - The ATTCP shall review a random sample of no fewer than 1 percent of each ATT's completed compliance forms.
    - The ATTCP shall perform shadow audits by meeting either of the following:
        - The ATTCP shall randomly select and shadow audit no less than 1 percent of each ATE's overseen projects, following the assigned ATT and observing their performance on the job site.
        - The ATTCP shall shadow audit each ATT at an ATTCP training facility at least once per code cycle where the ATTCP shall observe the performance of the ATT on at least five functional tests for which the ATT is certified. The shadow audit must replicate field conditions for installed equipment and controls in a building. The ATTCP training facility shall be set up to allow auditing of all functional tests for which

the ATT is certified. The shadow audits must be in addition to any testing used for ATT recertification.

The consequences of failed audits should be fully described by the ATTCP. ATTCPs might consider whether to require a higher percentage of document and on-site audits the first few years of operation to ensure that any initial issues with training or compliance are identified and addressed.

For example, one ATTCP proposed the following:

- For the first three years of operation, review a random sample of 6 percent of each technician's completed documents and perform on-site audits of 6 percent of acceptance tests.
- For years 4 and 5 of the ATTCP operation, review a random sample of 4 percent of each technician's completed documents and perform on-site audits of 4 percent of acceptance tests.
- After five years of operation, reduce a random sample of 2 percent of each ATT's completed compliance documents and perform on-site audits of 2 percent of acceptance tests.

- Mechanical Systems

  The ATTCP shall describe in its applications to the CEC procedures for conducting quality assurance and accountability activities, including, but not limited to, the following:

  - The ATTCPs shall include quality assurance and accountability measures, including, but not limited to, independent oversight of the certification materials, processes, and procedures; visits to building sites where ATTs are completing acceptance tests; certification process evaluations; building department surveys to determine acceptance testing effectiveness; and expert review of the training curricula developed for Energy Code Section 120.5 and Section 160.3(d).
  - The ATTCP shall review a random sample of no fewer than 1 percent of each ATT’s completed compliance forms. The ATTCP shall also randomly select and shadow audit no fewer than 1 percent of each ATE’s overseen projects, following the assigned ATT and observing his or her performance on the job site. Independent oversight may be demonstrated by accreditation under the ISO/IEC 17024 standard.

  The mechanical regulation generally follows the same requirements as lighting controls, except the focus for on-site audits is on the ATEs rather than the ATTs.

Certification Identification Number and Verification of ATT and ATE Certification Status

The ATTCP shall describe in its applications to the CEC procedures for recording, tracking, and communicating certification status, including but not limited to the following:

- Upon certification of an ATT or ATE, the ATTCP shall issue a unique certification identification number to the ATT or ATE.
- The ATTCP shall maintain an accurate public record of the certification status for all ATTs and ATEs that the ATTCP has certified, including any ATTs or ATEs who have been decertified as specified in Section 10-103.1(c)3E or Section 10-103.2(c)3E.

- The ATTCP shall provide verification of current ATT certification status upon request to authorized document registration provider personnel or enforcement agency personnel to determine the ATT's eligibility to sign certificate of acceptance documentation.

Energy Code compliance will also be simplified by requiring the ATT to include its assigned certification number on the compliance documentation, thereby allowing the enforcement agency and the CEC to track the effectiveness of this certification program.

The ATTCP is not required to implement an on-line presence of any kind for compliance with these regulations. However, the applications that the CEC has approved all include the implementation of an online presence to contend with the ATT/ATE application processing, complaints process, certification status, and ATT/ATE contact information.

Electronic Database System

The ATTCP shall maintain, or by suitable contractual requirements cause to be maintained, an electronic database system approved by the CEC. The electronic database system shall be capable of all the following:

- Support all activities for the ATTCP to comply with its quality assurance program as required by Section 10-103.1(c)3F.
- For no less than five years, record and preserve all certificates of acceptance offered for certification by the ATTCP and as performed by its own certified ATTs.
- Allow the transmission of electronic copies of each completed certificate of acceptance to the ATT that performed the test, the ATE associated with that ATT, or both.
    - Each page of each certificate of acceptance shall bear the logo of the ATTCP or other identifying insignia as approved by the CEC.
    - The electronic copy shall be capable of being printed.
    - The ATTCP may apply to the CEC for approval to use alternative compliance documents that differ from those approved for use by the CEC but must demonstrate that these alternative compliance documents do not differ in format, informational order, or content from approved compliance documents.
- Provide a means of verifying any certificate of acceptance to the enforcement agency having jurisdiction as identified on the certificate of acceptance.
- Provide the CEC with any of the following project data or documents upon request: project address, permit numbers, ATT and ATE certification numbers, certificates of acceptance, compliance forms, installation forms, and record of quality assurance review. The CEC may adopt an Application Programming Interface (API) for providing data electronically. Within one year of development of an API, the ATTCP’s electronic database system shall have the ability to transfer project data to the CEC through the API upon completion of the project or at established intervals no longer than monthly.

Compliance Document Recording and Repository Reporting Requirement

- The ATTCP shall record all certificates of compliance (Section 10-103(a)1), certificates of installation (Section 10-103(a)3), and certificates of acceptance (Section 10-103(a)4) associated with any acceptance test specified in Section 130.4, Section 160.5(e), Section 120.5, and 160.3(d).

- Contingent upon CEC approval of the threshold (Section 10-103.1(b) or Section 10-103.2(b)) and upon availability and approval of an electronic document repository by the Executive Director, the ATTCP shall submit monthly data transfer packets to the CEC to an electronic document repository for retention consistent with CEC instructions.

Requirements for ATTCPs to Provide Regular Reports

Please refer to Chapter 14.5.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Annual Report

Please refer to Chapter 14.5.2.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Update Report

Please refer to Chapter 14.5.2.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Amendment of ATTCP Applications

Please refer to Chapter 14.5.3 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Amendment Scope

Please refer to Chapter 14.5.3.1 of the *2022 Nonresidential and Multifamily Compliance Manual*.

Amendment Review

Please refer to Chapter 14.5.3.2 of the *2022 Nonresidential and Multifamily Compliance Manual*.

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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 (NRCC) Documents

Title	Category	Document Description
NRCC-CXR-E	Commissioning	Nonresidential Building Commissioning
NRCC-ELC-E	Electrical	Electrical Power Distribution
NRCC-ENV-E	Envelope	Envelope Component Approach
NRCC-LTI-E	Lighting	Indoor Lighting
NRCC-LTO-E	Lighting	Outdoor Lighting
NRCC-LTS-E	Lighting	Sign Lighting
NRCC-MCH-E	Mechanical	Mechanical System
NRCC-PLB-E	Plumbing	Domestic Water Heating System
NRCC-PRC-E	Process	Process Systems
NRCC-SAB-E	Solar and Battery	Solar and Battery
NRCC-PRF-01	Performance	Nonresidential Performance Compliance Method

Source: California Energy Commission

Table A-2: Certificate of Installation (NRCI) Documents

Type	Category	Document Description
NRCI-ELC-E	Electrical	Electrical Ready Requirements
NRCI-ENV-E	Envelope	Envelope Component Approach
NRCI-LTI-E	Lighting	Indoor Lighting
NRCI-LTO-E	Lighting	Outdoor Lighting
NRCI-LTS-E	Lighting	Sign Lighting
NRCI-MCH-E	Mechanical	Mechanical Systems
NRCI-PLB-E	Plumbing	Domestic Water Heating System
NRCI-PRC-E	Process	Process System

Type	Category	Document Description
NRCI-SAB-E	Solar and Battery	Solar and Battery
NRCI-MCH-20-H	Mechanical	Duct Leakage Diagnostic Test
NRCI-MCH-22-H	Mechanical	Space Conditioning System Fan Efficacy
NRCI-MCH-23-H	Mechanical	Space Conditioning System Airflow Rate
NRCI-MCH-25-H	Mechanical	Refrigerant Charge Verification

Source: California Energy Commission

Table A-3: Certificate of Accepting (NRCA) Documents

Title	Category	Document Description
NRCA-ENV-02-F	Envelope	Fenestration Acceptance
NRCA-ENV-03-F	Envelope	Daylighting Design PAFs
NRCA-LTI-02-A	Lighting	Shut Off Lighting Control
NRCA-LTI-03-A	Lighting	Automatic Daylighting Control
NRCA-LTI-04-A	Lighting	Demand Response Controls
NRCA-LTI-05-A	Lighting	Institutional Tuning PAF
NRCA-LTO-02-A	Lighting	Outdoor Lighting Controls
NRCA-MCH-02-A	Mechanical	Outdoor Air
NRCA-MCH-03-A	Mechanical	Constant Volume Single Zone HVAC
NRCA-MCH-04-A	Mechanical	Duct Leakage
NRCA-MCH-05-A	Mechanical	Economizer DOAS HRV ERV
NRCA-MCH-06-A	Mechanical	Demand Control Ventilation
NRCA-MCH-07-A	Mechanical	Supply Fan Variable Controls Acceptance
NRCA-MCH-08-A	Mechanical	Valve Leakage Test
NRCA-MCH-09-A	Mechanical	Water Temp Reset
NRCA-MCH-10-A	Mechanical	Hydronic System Variable Flow Control Acceptance
NRCA-MCH-11-A	Mechanical	Automatic Demand Shed Controls
NRCA-MCH-12-A	Mechanical	FDD - Packaged Units
NRCA-MCH-13-A	Mechanical	AHU and Zone Terminal FDD
NRCA-MCH-14-A	Mechanical	Distributed Energy Storage DX AX Systems
NRCA-MCH-15-A	Mechanical	Thermal Energy Storage

Title	Category	Document Description
NRCA-MCH-16-A	Mechanical	Supply Air Temperature Reset Controls
NRCA-MCH-17-A	Mechanical	Condenser Water Temperature Reset Controls
NRCA-MCH-18-A	Mechanical	EMS System Acceptance
NRCA-MCH-19-A	Mechanical	Occupied Standby
NRCA-MCH-20a-H	Mechanical	MF Dwelling Ventilation
NRCA-MCH-20b-H	Mechanical	MF Dwelling Kitchen Exhaust
NRCA-MCH-20c-H	Mechanical	MF IAQ Ventilation System
NRCA-MCH-20d-H	Mechanical	MF Dwelling Ventilation – HRV-ERV
NRCA-MCH-21-H	Mechanical	MF Enclosure Leakage
NRCA-MCH-22-A	Mechanical	MF System Duct Leakage
NRCA-MCH-23-A	Mechanical	HRV ERV Verification
NRCA-MCH-24-A	Mechanical	Cooling Tower Conductivity Controls
NRCA-PRC-01a-F	Process	Compressed Air System Controls
NRCA-PRC-01b-F	Process	Compressed Air System Controls
NRCA-PRC-02-F	Process	Commercial Kitchen Exhaust
NRCA-PRC-03-F	Process	Parking Garage Ventilation
NRCA-PRC-04-F	Process	Refrigerated Warehouse Evap & Fan Ctrl
NRCA-PRC-05-F	Process	Evaporative Condenser Controls
NRCA-PRC-06-F	Process	Air Cooled Condensers
NRCA-PRC-07-F	Process	Variable Speed Compressors
NRCA-PRC-08-F	Process	Refrigerated Warehouse Underslab Heating
NRCA-PRC-12-F	Process	Elevator Light & Vent Ctrl
NRCA-PRC-13-F	Process	Escalator and Moving Walkways Speed Control
NRCA-PRC-14a-F	Process	Lab Exhaust - Summary
NRCA-PRC-14b-F	Process	Lab Exhaust - Test and Balance
NRCA-PRC-14c1-F	Process	Lab Exhaust - Simple
NRCA-PRC-14c2-F	Process	Lab Exhaust - Wind Responsive
NRCA-PRC-14c3-F	Process	Lab Exhaust - Contaminant Monitoring
NRCA-PRC-15-F	Process	Fume Hood

Title	Category	Document Description
NRCA-PRC-16-F	Process	Adiabatic Condenser
NRCA-PRC-17-F	Process	Transcritical Refrigeration
NRCA-PRC-18a-F	Process	Steam Traps Fault Summary
NRCA-PRC-18b-F	Process	Steam Traps Fault Individual
NRCA-PRC-18b-F	Process	Steam Traps Fault Group

Source: California Energy Commission

Table A-4: Certificate of Verification (NRCV) Documents

Title	Category	Document Description
NRCV-MCH-24	Mechanical	Enclosure Air Leakage Worksheet
NRCV-MCH-27	Mechanical	Indoor Air Quality and Mechanical Ventilation - Highrise Residential
NRCV-MCH-32	Mechanical	Local Mechanical Exhaust
NRCV-PLB-21	Plumbing	Multifamily Central Hot Water System Distribution
NRCV-PLB-22	Plumbing	Individual Dwelling Unit Hot Water System Distribution

Source: California Energy Commission

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Appendix B Excerpts from the Appliance Efficiency Regulations

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
NONCOMMERCIAL 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	ANSI/ASHRAE 127-2001
evaporatively-cooled	10 C.F.R. sections 431.95 and 431.96
air-cooled, glycol-cooled, water-cooled	
Other electric-powered unitary air-conditioners and electric-powered heat pumps	10 C.F.R. section 430.23(m) (Appendix M to Subpart B of part 430)
air-cooled air conditioners and air-source heat pumps	10 C.F.R. sections 431.95 and 431.96
< 65,000 Btu/hr, single-phase	10 C.F.R. sections 431.95 and 431.96
< 65,000 Btu/hr, three-phase	10 C.F.R. sections 431.95 and 431.96
≥ 65,000 and < 760,000 Btu/hr	
evaporatively-cooled air conditioners < 240,000 Btu/hr	10 C.F.R. sections 431.95 and 431.96
water-cooled air conditioners and water-source heat pumps	ARI/ISO-13256-1:1998
< 240,000 Btu/hr	ARI/ISO-13256-1:1998
ground water-source heat pumps	
ground-source closed-loop heat pumps	
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, 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 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 ft^3.	

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 ft^3, which is 1.73 x freezer volume (ft^3).	

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 (ft^3) AV = Adjusted Volume = [1.63 x freezer volume (ft^3)] + refrigerator volume (ft^3) 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	$P \le 0.20 \times A + 32$	0.9
January 1, 2013	$A < 1400$	1 W	$P \le 0.12 \times A + 25$	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	$CRF \le 1.10$
	40 percent Depth of discharge	$CRF \le 1.15$
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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Figure C- 1 – California Climate Zones 1

APPENDIX C: California Climate Zones

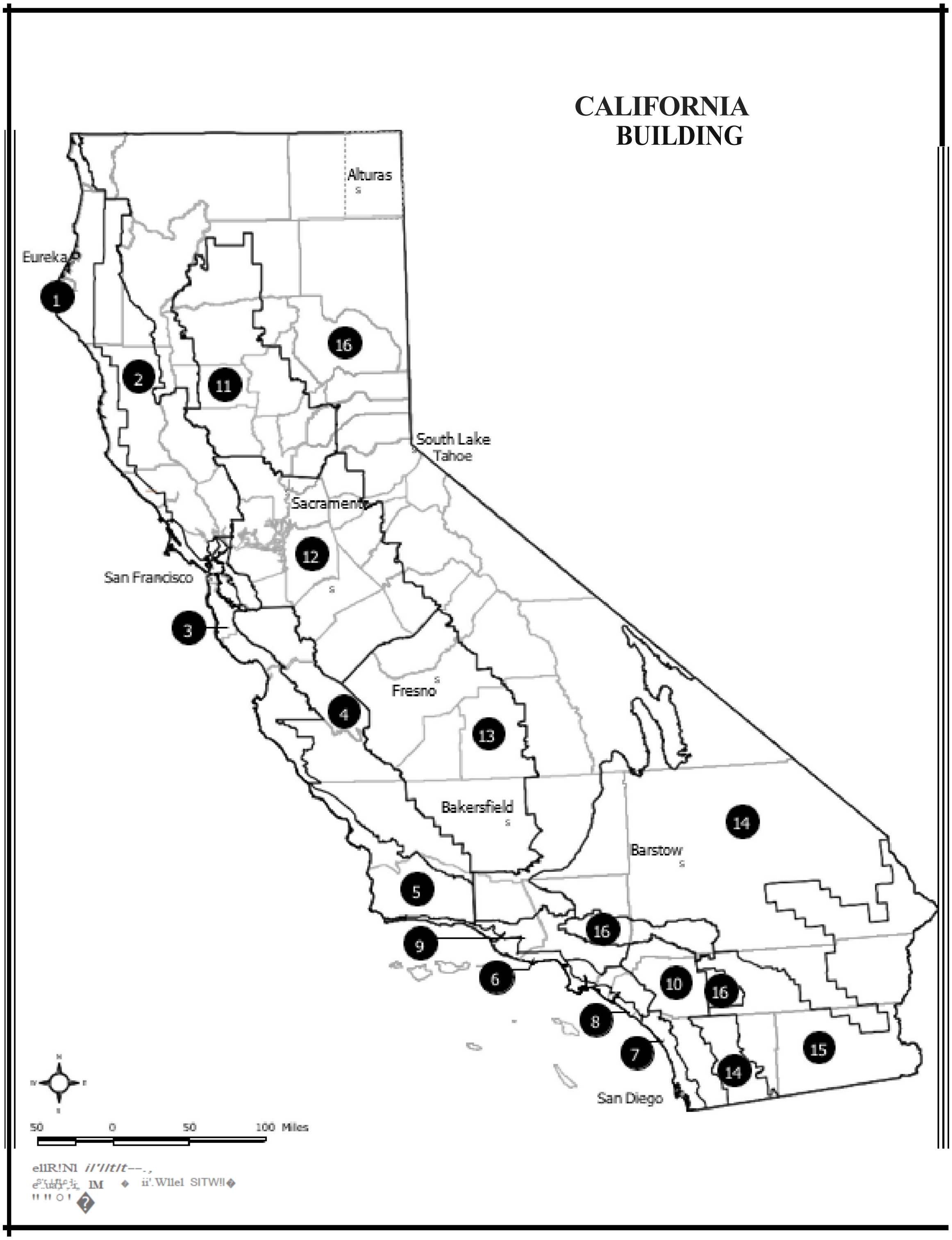
All energy calculations used for compliance with the Energy Code must use the climate zone applicable to a building project. The climate zone is determined based on its physical location as it relates to the determinations of climate regions found in the California Energy Commission's publication, *California Climate Zone Descriptions,* which contains detailed survey definitions of the 16 climate zones.

The list of climate zones 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.

The CEC has also developed an interactive climate zone lookup tool that allows users to locate climate zone by address or ZIP code. The lookup tool is located here, https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/climate-zone-tool-maps-and.

Figure C-1: California Climate Zones



Source: California Energy Commission

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APPENDIX D: Demand-Responsive Controls

This appendix to the nonresidential compliance manual addresses the demand-responsive (DR) control requirements in the 2025 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 Code. 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:** The DR of a building 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 apply only if the controls are used to comply with the building standards (i.e., DR thermostats or a heat pump water heater). If DR controls 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 identified in Section 110.10 of the Energy Code.

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.
- The control must, at a minimum, be able to communicate with the virtual end node using a wired or wireless bidirectional 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 to 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 Code requires certain buildings to have direct digital control (DDC) to the zone level. (See Chapter 4 Direct Digital Controls section of the nonresidential compliance manual.) When the building has DDC to the zone level, either to comply with the Energy Code 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 that 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 Code is simply a test to confirm the DR control system is installed correctly and can perform the function while 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 setpoints by 4°F or more in all noncritical zones and maintain the setpoints throughout the DR period.
- When in heating mode, decrease the operating heating temperature setpoints by 4°F or more in all noncritical zones and maintain the setpoints throughout the DR period.
- Maintain the temperature and ventilation setpoints 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 setpoints in noncritical 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 noncritical zones while maintaining setpoints in critical zones. The Energy Code defines 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." Noncritical zones are defined as "a zone that is not a critical zone."

(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

Reference: 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)
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 Code 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 Code).

(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 15 kW 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) 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) in nonresidential buildings and hotel/motel buildings. 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), 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).

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.