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INTRODUCTION

Chapter 4 Introduction

This chapter covers heating, ventilation, and air conditioning (HVAC) system requirements for all dwelling units and common use areas in multifamily buildings for newly constructed buildings and additions or alterations to existing buildings.

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

Table 4-1: Excerpt from Table 100.0-A Application of Standards provides an overview of the location of the HVAC system requirements that apply to multifamily occupancies in the Energy Code.

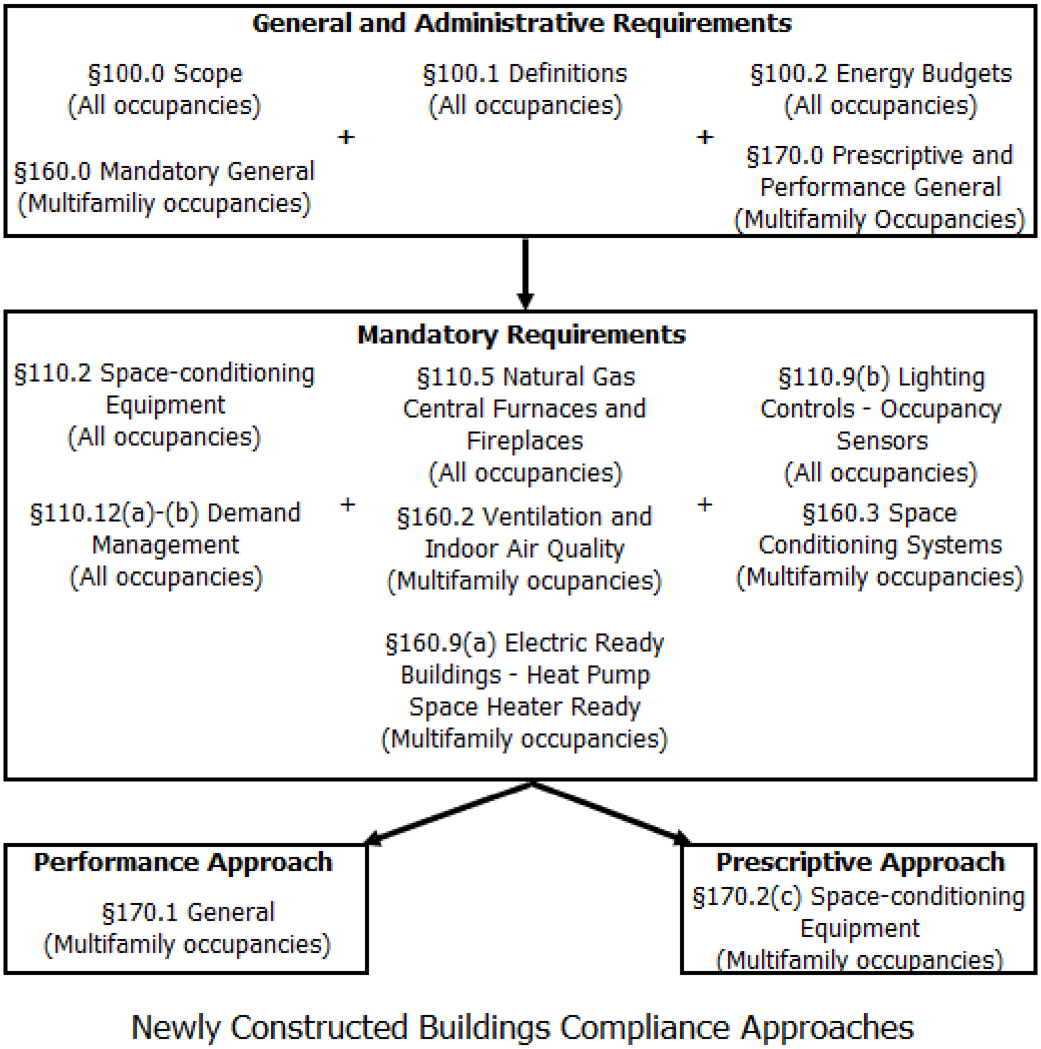
Table 4-1: Excerpt from Table 100.0-A Application of Standards

Application	Mandatory	Prescriptive	Performance	Additions/ Alterations
General[1]	160.0	170.0	170.0	180.0
HVAC	110.2, 110.5, 110.9, 110.12, 160.2, 160.3, 160.9	170.2	170.1	180.1, 180.2

Source: California Energy Commission

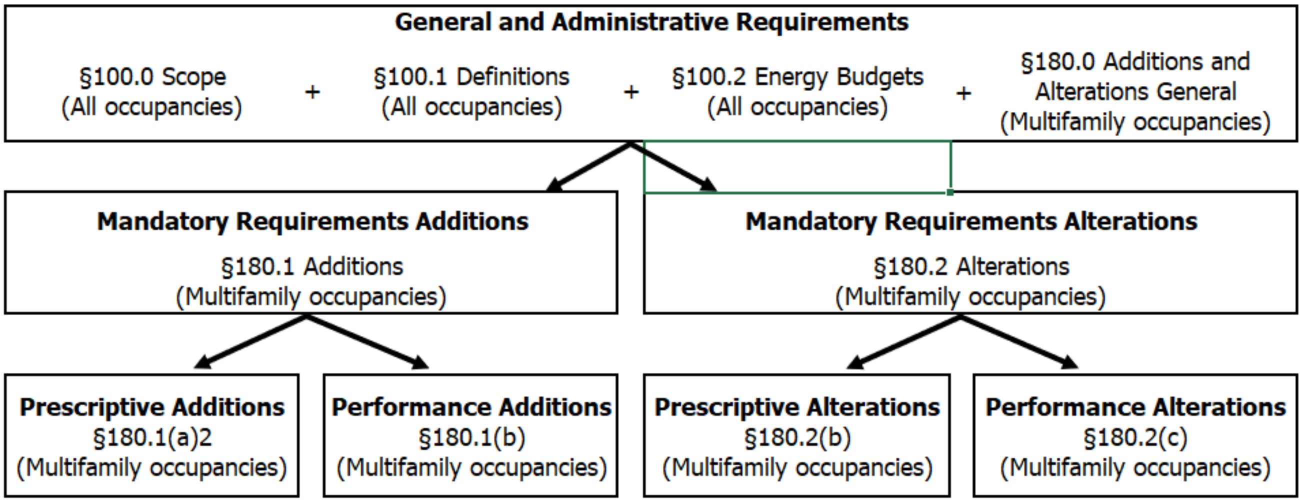
Figure 4-1: Flowchart Guidance for Application of New Construction Multifamily HVAC Requirements and Figure 4-2: Flowchart Guidance for Application of New Construction Multifamily HVAC Requirements below illustrate the applicable sections for newly constructed buildings and additions or alterations to existing buildings.

Figure 4-1: Flowchart Guidance for Application of New Construction Multifamily HVAC Requirements



Source: California Energy Commission

Figure 4-2: Flowchart Guidance for Application of New Construction Multifamily HVAC Requirements



Addition, Alteration Compliance Approaches

Source: California Energy Commission

SECTION 110.2 – MANDATORY REQUIREMENTS FOR SPACE-CONDITIONING EQUIPMENT

Certification by manufacturers. Any space-conditioning equipment listed in this section may be installed only if the manufacturer has certified to the Commission that the equipment complies with all the applicable requirements of this section.

(a) Efficiency. Equipment shall meet the applicable efficiency requirements in Tables 110.2-A through 110.2-L, subject to the following:

1. If more than one efficiency standard is listed for any equipment in Tables 110.2-A through 110.2-L, the equipment shall meet all the applicable standards that are listed; and
2. If more than one test method is listed in Tables 110.2-A through 110.2-L, the equipment shall comply with the applicable efficiency standard when tested with each listed test method; and
3. Where equipment serves more than one function, it shall comply with the efficiency standards applicable to each function; and
4. Where a requirement is for equipment rated at its "maximum rated capacity" or "minimum rated capacity," the capacity shall be as provided for and allowed by the controls, during steady-state operation.

«» Commentary for Section 110.2(a):

California Appliance Standards and Equipment Certification: Most heating and cooling equipment installed in California multifamily buildings is regulated by the National Appliance Efficiency Conservation Act (NAECA) and/or the California Appliance Efficiency Regulations (Title 20). Both the federal and state appliance standards apply to the manufacturing and sale of new equipment, whether for installation or replacement in newly constructed buildings, additions, or alterations. The Appliance Efficiency Regulations are enforced at the point of sale (except central split-system air conditioners and central single package air conditioners, see Title 20, Section 1605.1(c), Table C-3), while the Energy Code explained in this compliance manual is enforced by local enforcement agencies.

The equipment listed below is covered by the Appliance Efficiency Regulations. The manufacturer must certify that the equipment complies with the current Appliance Efficiency Regulations at the time of manufacture. The energy efficiency of other equipment, usually larger equipment, is regulated by the Energy Code Section 110.2(a).

Appliances covered by the Appliance Efficiency Regulations include:

1. Room air-conditioners
2. Room air-conditioning heat pumps
3. Central air conditioners with a cooling capacity of less than 135,000 British thermal units per hour (Btu/hr.)
4. Central air conditioning heat pumps
5. Gas-fired central furnaces
6. Gas-fired boilers
7. Gas-fired furnaces
8. Gas-fired floor furnaces
9. Gas-fired room heaters
10. Gas-fired duct furnaces
11. Gas-fired unit heaters

The Appliance Efficiency Regulations do not require certification for:

1. Electric resistance space heaters.
2. Oil-fired wall furnaces, floor furnaces, and room heaters. (Some are voluntarily listed with certified gas-fired furnaces.)

Equipment that does not meet the federal appliance efficiency standards may not be sold in California. Any equipment covered by the Appliance Efficiency Regulations and sold in California must have the date of manufacture permanently displayed in an accessible place on that equipment. This date is frequently included as part of the serial number.

Generally, equipment manufactured before the effective date of a new standard may be sold and installed in California indefinitely as long as the performance approach demonstrates energy compliance of the building using the lower efficiency of the relevant appliances. An exception is central split-system air conditioners and central single package air conditioners installed in California. The U.S. Department of Energy (DOE) requires compliance with the minimum efficiencies specified in Title 20, Section 1605.1(c), Table C-3 at the time of installation.

The compliance and enforcement processes should ensure that all installed HVAC equipment regulated by the Appliance Efficiency Regulations is certified by the California Energy Commission.

Equipment Efficiency

The efficiency of most dwelling unit heating and cooling equipment is regulated by the National Appliance Energy Conservation Act of 1987 (NAECA, the federal appliance standard) and California’s Appliance Efficiency Regulations. These regulations are not contained in the Energy Code but are published separately. These regulations are referenced in Section 110.1. The energy efficiency of larger equipment is regulated by Section 110.2(a). The Appliance Efficiency Regulations include definitions for all types of equipment and are regularly updated.

Note: The Appliance Efficiency Regulations that are in effect when the building permit is applied for will determine the minimum efficiency of the appliances identified in the compliance documentation. Because the Title 20 Appliance Efficiency Regulations are updated on a regular basis, it is important to confirm which version of Title 20 is in effect before permit submittal.

Central, Single-Phase Air Conditioners and Air Source Heat Pumps

Central, single-phase air conditioners and air source heat pumps commonly installed in multifamily dwelling units have a capacity less than 65,000 Btu/hr.

Air conditioner efficiencies are determined according to federal test procedures. The efficiencies are reported in terms of SEER and EER. The Appliance Efficiency Regulations for this equipment require minimum SEER. The SEER of all new central, single-phase air conditioners and air source heat pumps with an output less than 65,000 Btu/h must be certified to the Energy Commission to have values no less than the values listed in Title 20, Section 1605.1(c), Table C-3.

Heat Pumps and Electric Heating

Efficiency requirements for package terminal air conditioners, package terminal heat pumps, single-package vertical air conditioners, and single-package vertical heat pumps must meet federal minimum efficiency requirements.

Heat pumps must be certified to have a HSPF or coefficient of performance (COP) equal to or better than those listed in Title 20, Section 1605.1(c), Tables C-3 through C-6.

There are no minimum appliance efficiency standards for electric-resistance or electric-radiant heating systems.

Other Air Conditioners and Heat Pumps

The Appliance Efficiency Regulations contain minimum efficiency requirements for three-phase models, larger-capacity central air conditioners and heat pumps, and all room air conditioners and room air conditioner heat pumps. The efficiency for these types of equipment must be certified to the Energy Commission by the manufacturer. Title 20, Section 1605.1(b) and (c), Tables B-3, C-4, and C-5 include efficiency requirements for equipment with a cooling capacity less than 65,000 Btu/hour. Efficiency requirements for larger equipment are covered later in this chapter.

Gas and Oil-Fired Furnaces

The Appliance Efficiency Regulations require gas- and oil-fired central furnaces with outputs less than 225,000 Btu/hr to be rated according to the associated annual fuel utilization efficiency (AFUE). Gas- and oil-fired central furnaces with outputs greater than or equal to 225,000 Btu/hr are rated according to the respective thermal (or steady-state) efficiency.

Equipment with all output capacities are listed in Table E-6 of the Appliance Efficiency Regulations (Title 20, Section 1605.1(e)).

Noncentral gas furnaces and space heaters must be certified to have AFUE values greater than or equal to those listed in Title 20, Section 1605.1(e), Table E-2.

Gas- and Oil-Fired Central Boilers and Electric Boilers

Gas- and oil-fired central boilers must be certified to have an AFUE or combustion efficiency equal to or better than those listed in the Energy Code Table 110.2-J. **«»**

Exception 1 to Section 110.2(a): Water-cooled centrifugal water-chilling packages that are not designed for operation at ANSI/AHRI Standard 550/590 test conditions of 44°F leaving chilled water temperature and 85°F entering condenser water temperature with 3 gallons per minute per ton condenser water flow shall have a maximum full load kW/ton and NPLV ratings adjusted using the following equation:

Adjusted maximum full-load kW/ton rating = (full- load kW/ton from Table 110.2-D)/Kadj

Adjusted maximum NPLV rating = (IPLV from Table 110.2-D)/Kadj

Where:

Kadj = (A) × (B)

$A = 0.00000014592 \times (LIFT)^4 - 0.0000346496 \times (LIFT)^3 + 0.00314196 \times (LIFT)^2 - 0.147199 \times (LIFT) + 3.9302$

LIFT = LvgCond – LvgEvap (°F)

LvgCond = Full-load leaving condenser fluid temperature (°F)

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

B = (0.0015 × LvgEvap) + 0.934

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

- Minimum Leaving Evaporator Fluid Temperature: 36°F
- Maximum Leaving Condenser Fluid Temperature: 115°F
- LIFT ≥ 20°F and ≤ 80°F

Centrifugal chillers designed to operate outside of these ranges are not covered by this exception.

Exception 2 to Section 110.2(a): Positive displacement (air-cooled and water-cooled) chillers with a leaving evaporator fluid temperature higher than 32°F shall show compliance with Table 110.2-D when tested or certified with water at standard rating conditions, per the referenced test procedure.

Exception 3 to Section 110.2(a): Equipment primarily serving refrigerated warehouses or commercial refrigeration.

(b) Controls for heat pumps with supplementary heaters.

Control requirements for heat pumps with supplementary heaters in single-family residential buildings are specified in Section 150.0(h)7 and Section 150.0(i)2. Heat pumps with supplementary heaters in nonresidential and multifamily buildings shall have controls:

1. That prevent supplementary heater operation when the heating load can be met by the heat pump alone; and

2. In which the cut-on temperature for heat pump heating is higher than the cut-on temperature for supplementary heating, and the cut-off temperature for heat pump heating is higher than the cut-off temperature for supplementary heating.

Exception 1 to Section 110.2(b): The controls may allow supplementary heater operation during:

A. Defrost; and

B. Transient periods such as start-ups and following room thermostat setpoint advance, if the controls provide preferential rate control, intelligent recovery, staging, ramping or another control mechanism designed to preclude the unnecessary operation of supplementary heating.

Exception 2 to Section 110.2(b): Room air-conditioner heat pumps.

«» Commentary for Section 110.2(b):

Heat Pump System Controls

Heat pump systems must be controlled by a central energy management control system (EMCS) or by a setback thermostat as described under Dwelling Units Controls.

Heat pumps with supplemental heaters must have controls that limit the operation of the supplemental heater to defrost and as a second stage of heating when the heat pump alone cannot satisfy the load. The most effective solution is to specify an electronic thermostat designed specifically for use with heat pumps. This “anticipatory” thermostat can detect if the heat pump is raising the space temperature during warm-up fast enough to warrant locking out the supplemental heater.

This requirement can also be met using conventional electronic controls with a two-stage thermostat and an outdoor lockout thermostat wired in series with the supplemental heater. The outdoor thermostat must be set to a temperature where the heat pump capacity is sufficient to warm up the space in a reasonable time (e.g., above 40 °F). This conventional control system is depicted schematically below in Figure 4-3: Heat Pump Auxiliary Heat Control, Two-Stage and Outdoor Air Thermostats.

The first required capability is to set the cut-on and cut-off temperatures for the heat pump and supplementary heating at different levels.

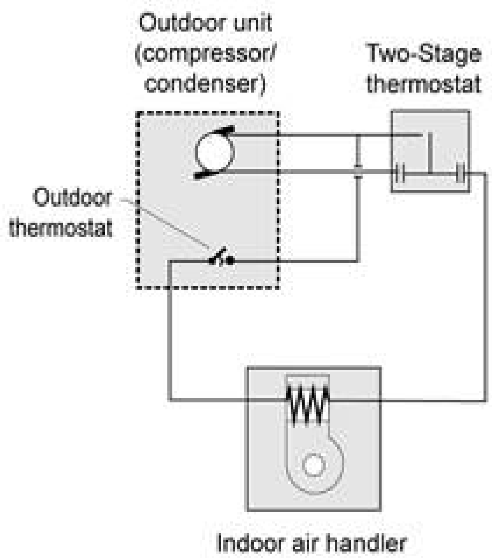
For example, if the heat pump begins heating when the inside temperature reaches 68°F, the supplementary heating may be set to come on if the temperature goes below 65°F if the heat pump alone could not maintain the set point of 68°F. Also, there must be an OFF mode that automatically shuts off the supplementary heating when the inside temperature reaches 68°F.

The second control capability must prevent the supplementary heater from operating if the heat pump alone can meet the heating load, except during defrost. There is a limited exception to this second function for “smart thermostats” that provide intelligent recovery, staging, ramping, or another control mechanism that prevents the unnecessary operation of supplementary heating when the heat pump alone can meet the heating load.

To meet the thermostat requirements, a thermostat for a heat pump with supplementary heating must be a thermostat that minimizes the use of supplementary heating during startup and recovery from setbacks.

Room air conditioner heat pumps are not required to comply with the thermostat requirements.

Figure 4-3: Heat Pump Auxiliary Heat Control, Two-Stage and Outdoor Air Thermostats



Source: California Energy Commission

«»

(c) Thermostats. All heating or cooling systems not controlled by a central energy management control system (EMCS) shall have a setback thermostat.

1. **Setback capabilities.** All thermostats shall have a clock mechanism that allows the building occupant to program the temperature setpoints for at least four periods within 24 hours. Thermostats for heat pumps shall meet the requirements of Section 110.2(b).

Exception to Section 110.2(c): Gravity gas wall heaters, gravity floor heaters, gravity room heaters, noncentral electric heaters, fireplaces or decorative gas appliances, wood stoves, room air conditioners and room air-conditioner heat pumps.

«» Commentary for Section 110.2(c):

Dwelling Unit Controls

The Energy Code includes a mandatory requirement for thermostat controls. Unless controlled by a central energy management control system the thermostat must have setback capabilities.

When it is required, the setback thermostat must have a clock or other mechanism that allows the resident to schedule the heating and/or cooling set points for at least four periods over 24 hours.

If more than one piece of heating or cooling equipment is installed in a dwelling unit, the setback requirement may be met by controlling all heating or cooling units by one thermostat or by controlling each unit with a separate thermostat. Separate heating or cooling units may be provided with a separate on/off control capable of overriding the thermostat.

Thermostats for heat pumps equipped with supplementary heating must be thermostats that minimize the use of supplementary heating during startup and recovery from setback. **«»**

(d) Gas-fired and oil-fired furnace standby loss controls. Gas-fired and oil-fired forced-air furnaces with input ratings ≥ 225,000 Btu/hr shall also have an intermittent ignition or interrupted device (IID), and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for furnaces where combustion air is drawn from the conditioned space. All furnaces with input ratings ≥ 225,000 Btu/hr, including electric furnaces, that are not located within the conditioned space shall have jacket losses not exceeding 0.75 percent of the input rating.

«» Commentary for Section 110.2(d):

Standby Losses and Pilot Lights

Per Section 110.5, fan-type central furnaces may not have a continuously burning pilot light. This requirement does not apply to wall furnaces, floor furnaces, or any gravity-type furnace. Household cooking appliances also must not have a continuously burning pilot light, except for those without an electrical supply voltage connection and in which each pilot consumes less than 150 Btu/h.

Per Section 110.2(d), larger gas-fired and oil-fired forced air furnaces with input ratings equal to or greater than 225,000 Btu/h must also have an intermittent ignition device and either power venting or a flue damper.

A vent damper is an acceptable alternative to a flue damper for furnaces where combustion air is drawn from the conditioned space. All furnaces with input ratings equal to or greater than 225,000 Btu/h, including electric furnaces, that are not within the conditioned space must have jacket losses not exceeding 0.75 percent of the input rating. **«»**

(e) Open and closed-circuit cooling towers. All open and closed-circuit cooling tower installations shall comply with the following:

1. Be equipped with conductivity controls that maximize cycles of concentration based on local water quality conditions. Controls shall automate system bleed and chemical feed based on conductivity. Conductivity controllers shall be installed in accordance with manufacturer's specifications in order to maximize accuracy.
2. Documentation of maximum achievable cycles of concentration. Building owners shall document the cycles of concentration achievable based on local water supply conditions as reported annually by the local water supplier, and using the calculations below. The calculations are intended to determine maximum achievable cycles of concentration based on the parameters identified in Table 110.2-A-1. Building owner shall document maximum achievable cycles of concentration on the mechanical compliance form which shall be reviewed and signed by the Professional Engineer (P.E.) of Record.

The maximum achievable cycles of concentrations are based on the local water supply quality as reported by the local water supplier, and shall be the minimum of:

A. 2970 divided by the conductivity of the entering make-up water

B. 1845 divided by the total dissolved solids of the entering make-up water

C. 540 divided by the M-alkalinity excluding galvanized steel of the entering make-up water

D. 450 divided by the M-alkalinity including galvanized steel of the entering make-up water

E. 540 divided by the calcium hardness of the entering make-up water

F. 270 divided by the chlorides of the entering make-up water

G. 225 divided by the sulfates of the entering make-up water

H. 135 divided by the silica of the entering make-up water

I.

Langelier Saturation Index =

$$10^{(-12.038895*[\mathrm{Log}(M*0.9*1.219)-0.061105*\mathrm{Log}(C*0.8)+0.55*\mathrm{Log}(H*M)+0.0050325*T-5.95])}$$

Langelier Saturation Index = 10−12.038895∗LogM∗0.9∗1.219−0.061105∗LogC∗0.8+0.55∗LogH∗M+0.0050325∗T−5.95

Where:

C = Conductivity of the entering make-up water.

H = Calcium hardness of the entering make-up water.

M = M-alkalinity excluding galvanized steel of the entering make-up water.

T = Max skin temperature

3. Cooling towers shall not allow blowdown until one or more of the parameters in Table 110.2-A-1 reaches the maximum value specified:

Table 110.2-A-1 RECIRCULATING WATER PROPERTIES

Recirculating Water Parameters	**ximum Values**
Conductivity (micro-siemens/cm)	2970 micro-siemens/cm
Total dissolved solids (ppm)	1845 ppm
Total alkalinity as CaCO3 (ppm) excluding galvanized steel	540 ppm
Total alkalinity as CaCO3 (ppm) galvanized steel (passivated)	450 ppm
Calcium hardness as CACO3 (ppm)	540 ppm
Chlorides as Cl (ppm)	270 ppm
Sulfates (ppm)	225 ppm
Silica (ppm)	135 ppm
Langelier saturation index (LSI)	2.5 (LSI)

4. Be equipped with a flow meter with an analog output for flow either hardwired or available through a gateway on the makeup water line.
5. Be equipped with an overflow alarm to prevent overflow of the sump in case of makeup water valve failure. Overflow alarm shall send an audible signal or provide an alert via the energy management control system to the tower operator in case of sump overflow.
6. Be equipped with efficient drift eliminators that achieve drift reduction to 0.002 percent of the circulated water volume for counter-flow towers and 0.005 percent for cross-flow towers.
7. Conductivity controls and overflow alarm shall be verified according to NA 7.5.18.

«» Commentary for Section 110.2(e):

Water-Conservation Measures for Cooling Towers

There are mandatory requirements for the efficient use of water in the operation of open (direct) and closed (indirect) cooling towers.

As water is evaporated off the tower, the concentration of dissolved solids, like calcium carbonate and silica, will increase. The pH of the water will also change. With high levels of silica, or dissolved solids, deposits will form on the tower fill or clog the tower nozzles, which will reduce the tower's heat rejection capacity. High pH is a concern for metal tower basins and structural members. As the thresholds of these contaminants of concern are approached the automated controls should bleed some of the concentrated water out and dilute it with make-up water. The bleed can be controlled by measurement of make-up water flow (an indirect measurement of water drift and evaporation) or through conductivity (a measurement of the dissolved solids). The term "cycles of concentration" is the metric of how concentrated the contaminants are at the controlled level. The right value depends on the characteristics of the supply water, the rate of tower drift, the weather characteristics, and the load on the tower.

Open- and Closed-Circuit Cooling Towers

All open and closed-circuit cooling towers with rated capacity of 150 tons or greater must have a control system that maximizes the cycles of concentration based on the water quality conditions. If the controls system is conductivity based, then the system must automate bleed and chemical feed based on conductivity. The installation criteria for the conductivity controllers must be in accordance with the manufacturer’s specifications to maximize accuracy. If the control system is flow based, then the system must be automated in proportion to metered makeup volume, metered bleed volume, and recirculating pump run time (or bleed time).

The makeup water line must be equipped with an analog flow meter and an alarm to prevent overflow of the sump in the event of water valve failure. The alarm system may send an audible signal or an alert through an EMCS.

Drift eliminators are louvered or comb-like devices that are installed at the top of the cooling tower to capture air stream water particles. These drift eliminators are now required to achieve drift reduction to 0.002 percent of the circulated water volume for counter-flow towers and 0.005 percent for crossflow towers.

Additionally, maximum achievable cycles of concentration must be calculated with an Energy Commission approved calculator based on local water quality conditions (which is reported annually by the local utility) and a Langelier Saturation Index (LSI) of 2.5 or less.

The Langelier Saturation Index predicts scaling. It indicates whether water will precipitate, dissolve, or be in equilibrium with calcium carbonate. The index is a function of hardness, alkalinity, conductivity, pH, and temperature expressed as the difference between the actual system pH and the saturation pH.

The maximum cycles of concentration must be cataloged in the mechanical compliance documentation and reviewed and approved by the Professional Engineer (P.E.) of record. **«»**

(f) Low leakage air-handling units. To qualify as a low leakage air-handling unit for use for meeting the requirements for applicable low leakage air-handling unit compliance credit(s) available in the performance standards set forth in Sections 150.1(b) and 140.1, the manufacturer shall certify to the Energy Commission that the air-handling unit meets the specifications in Reference Joint Appendix JA9.

«» Commentary for Section 110.2(f):

Joint Appendix JA9 provides the qualification requirements for air-handling units to meet the requirements for low leakage air-handling unit compliance credit(s) available in the performance standards set forth in the Energy Code, Sections 170.1(d)2C, 150.1(b) and 140.1. Joint Appendix JA9 is applicable to air-handling units intended for installation in ducted forced-air space conditioning systems. Joint Appendix JA9 is applicable to air-handling units that are rated by the manufacturer to move less than 3,000 cfm (1400 L/s) of air.

Air-handling unit equipment types include furnaces, heat pumps, and air conditioners.

Joint Appendix JA9 does not apply to coil boxes, filter boxes, or other duct system components that are not an integral part of the air-handling unit cabinet or enclosure certified by the manufacturer.

Joint Appendix JA9 does not apply to ducts, plenums, or other field-constructed components. «»

TABLE 110.2-A AIR CONDITIONERS AND CONDENSING UNITS – MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Efficiency	Test Procedure[b]
Air conditioners, air cooled both split system and single package	≥ 65,000 Btu/h and < 135,000 Btu/h	11.2 EER[a] Federal Minimum IEER[a]	AHRI 340/360
Air conditioners, air cooled both split system and single package	≥ 135,000 Btu/h and < 240,000 Btu/h	11.0 EER[a] Federal Minimum IEER[a]	AHRI 340/360
Air conditioners, air cooled both split system and single package	≥ 240,000 Btu/h and < 760,000 Btu/h	10.0 EER[a] Federal Minimum IEER[a]	AHRI 340/360
Air conditioners, air cooled both split system and single package	≥ 760,000 Btu/h	9.7 EER[a] 12.5 IEER[a]	AHRI 340/360

Air conditioners, water cooled	≥ 65,000 Btu/h and < 135,000 Btu/h	Federal Minimum EER[a] 13.9 IEER[a]	AHRI 340/360
Air conditioners, water cooled	≥135,000 Btu/h and < 240,000 Btu/h	Federal Minimum EER[a] 13.9 IEER[a]	AHRI 340/360
Air conditioners, water cooled	≥240,000 Btu/h and < 760,000 Btu/h	Federal Minimum EER[a] 13.6 IEER[a]	AHRI 340/360

CONTINUED: TABLE 110.2-A AIR CONDITIONERS AND CONDENSING UNITS – MINIMUM EFFICIENCY REQUIREMENTS (continued)

Equipment Type	Size Category	Efficiency	Test Procedure[b]
Air conditioners, water cooled	≥ 760,000 Btu/h	12.2EER[a] 13.5 IEER[a]	AHRI 340/360
Air conditioners, evaporatively cooled	≥65,000 Btu/h and < 135,000 Btu/h	Federal Minimum EER[a] 12.3 IEER[a]	AHRI 340/360
Air conditioners, evaporatively cooled	≥ 135,000 Btu/h and < 240,000 Btu/h	Federal Minimum EER[a] 12.2 IEER[a]	AHRI 340/360
Air conditioners, evaporatively cooled	≥240,000 Btu/h and < 760,000 Btu/h	Federal Minimum EER[a] 12.1 IEER[a]	AHRI 340/360
Air conditioners, evaporatively cooled	≥ 760,000 Btu/h	11.7 EER[a] 11.9 IEER[a]	AHRI 340/360
Condensing units, air cooled	≥ 135,000 Btu/h	10.5 EER Federal Minimum IEER	AHRI 365
Condensing units, water cooled	≥ 135,000 Btu/h	13.5 EER Federal Minimum IEER	AHRI 365
Condensing units, evaporatively cooled	≥ 135,000 Btu/h	13.5 EER Federal Minimum IEER	AHRI 365

a Deduct 0.2 from the required EERs and IEERs for units with a heating section other than electric resistance heat.

b Applicable test procedure and reference year are provided under the definitions.

TABLE 110.2-B HEAT PUMPS, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Rating Condition	Efficiency [a]	Test Procedure[b]
Air Cooled (Cooling Mode), both split system and single package	≥ 65,000 Btu/h and < 135,000 Btu/h		11.0 EER Federal Minimum IEER	AHRI 340/360
Air Cooled (Cooling Mode), both split system and single package	≥ 135,000 Btu/h and < 240,000 Btu/h		10.6 EER Federal Minimum IEER	AHRI 340/360
Air Cooled (Cooling Mode), both split system and single package	≥ 240,000 Btu/h		9.5 EER Federal Minimum IEER	AHRI 340/360
Water source (cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	86ºF entering water	Federal Minimum EER	ISO-13256-1
Groundwater source (cooling mode)	< 135,000 Btu/h	59ºF entering water	18.0 EER	ISO-13256-1
Ground source (cooling mode)	< 135,000 Btu/h	77ºF entering water	14.1 EER	ISO-13256-1
Water source water-to-water (cooling mode)	< 135,000 Btu/h	86ºF entering water	10.6 EER	ISO-13256-2
Groundwater source water-to-water (cooling mode)	< 135,000 Btu/h	59ºF entering water	16.3 EER	ISO-13256-2

Ground source brine-to-water (cooling mode)	< 135,000 Btu/h	77ºF entering water	12.1 EER	ISO-13256-2
Air Cooled (Heating Mode) Split system and single package	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	47° F db/43° F wb outdoor air	Federal Minimum COP	AHRI 340/360
Air Cooled (Heating Mode) Split system and single package	≥ 65,000 Btu/h and < 135,000 Btu/h (cooling capacity)	17° F db/15° F wb outdoor air	2.25 COP	AHRI 340/360

CONTINUED: TABLE 110.2-B HEAT PUMPS, MINIMUM EFFICIENCY REQUIREMENTS (continued)

Equipment Type	**Size Category**	**Rating Condition**	**Efficiency** [a]	**Test Procedure**[b]
Air Cooled (Heating Mode) Split system and single package	≥ 135,000 Btu/h and < 240,000 Btu/h (cooling capacity)	47° F db/43° F wb outdoor air	Federal Minimum COP	AHRI 340/360
Air Cooled (Heating Mode) Split system and single package	≥ 240,000 Btu/h and < 760,000 Btu/h	47° F db/43° F wb outdoor air	Federal Minimum COP	AHRI 340/360
Air Cooled (Heating Mode) Split system and single package	≥ 135,000 Btu/h (cooling capacity)	17° F db/15° F wb outdoor air	2.05 COP	AHRI 340/360
Water source (heating mode)	< 135,000 Btu/h (cooling capacity)	68ºF entering water	Federal Minimum COP	ISO-13256-1
Water source (heating mode)	≥ 135,000 Btu/h and < 240,000 Btu/h	68ºF entering water	Federal Minimum COP	ISO-13256-1

Groundwater source (heating mode)	< 135,000 Btu/h (cooling capacity)	50ºF entering water	3.7 COP	ISO-13256-1
Ground source (heating mode)	< 135,000 Btu/h (cooling capacity)	32ºF entering water	3.2 COP	ISO-13256-1
Water source water-to-water (heating mode)	< 135,000 Btu/h (cooling capacity)	68ºF entering water	3.7 COP	ISO-13256-2
Groundwater source water-to-water (heating mode)	< 135,000 Btu/h (cooling capacity)	50ºF entering water	3.1 COP	ISO-13256-2
Ground source brine-to-water (heating mode)	< 135,000 Btu/h (cooling capacity)	32ºF entering water	2.5 COP	ISO-13256-2

a Deduct 0.2 from the required EERs and IEERs for units with a heating section other than electric resistance heat.

b Applicable test procedure and reference year are provided under the definitions.

TABLE 110.2-C AIR-COOLED GAS-ENGINE HEAT PUMPS

Equipment Type	Size Category	Subcategory or Rating Condition	Efficiency	Test Procedure[a]
Air-Cooled Gas-Engine Heat Pump (Cooling Mode)	All Capacities	95° F db Outdoor Air	0.60 COP	ANSI Z21.40.4A
Air-Cooled Gas-Engine Heat Pump (Heating Mode)	All Capacities	47° F db/43° F wb Outdoor Air	0.72 COP	ANSI Z21.40.4A

a Applicable test procedure and reference year are provided under the definitions.

TABLE 110.2-D WATER CHILLING PACKAGES – MINIMUM EFFICIENCY REQUIREMENTS [a,b]

Equipment Type	Size Category	Path A Efficiency [a,b]	Path B Efficiency [a,b]	Test Procedure [c]

Air Cooled, With Condenser Electrically Operated	< 150 Tons	≥ 10.100 EER ≥ 13.700 IPLV	≥ 9.700 EER ≥15.800 IPLV	AHRI 550/590
Air Cooled, With Condenser Electrically Operated	≥ 150 Tons	≥ 10.100 EER ≥ 14.000 IPLV	≥ 9.700 EER ≥16.100 IPLV	AHRI 550/590
Air Cooled, Without Condenser Electrically Operated	All Capacities	Air-cooled chillers without condensers must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements.	Air-cooled chillers without condensers must be rated with matching condensers and comply with the air-cooled chiller efficiency requirements.	AHRI 550/590
Water Cooled, Electrically Operated, Reciprocating	All Capacities	Reciprocating units must comply with the water-cooled positive displacement efficiency requirements.	Reciprocating units must comply with the water-cooled positive displacement efficiency requirements.	AHRI 550/590
Water Cooled, Electrically Operated Positive Displacement	< 75 Tons	≤0.750kW/ton ≤ 0.600 IPLV	≤ 0.780 kW/ton ≤ 0.500 IPLV	AHRI 550/590
Water Cooled, Electrically Operated Positive Displacement	≥ 75 tons and < 150 tons	≤ 0.720 kW/ton ≤ 0.560 IPLV	≤ 0.750 kW/ton ≤ 0.490 IPLV	AHRI 550/590
Water Cooled, Electrically Operated Positive Displacement	≥ 150 tons and < 300 tons	≤ 0.660 kW/ton ≤ 0.540 IPLV	≤ 0.680 kW/ton ≤ 0.440 IPLV	AHRI 550/590
Water Cooled, Electrically Operated Positive Displacement,	≥ 300 Tons and < 600 tons	≤ 0.610kW/ton ≤ 0.520 IPLV	≤ 0.625 kW/ton ≤ 0.410 IPLV	AHRI 550/590
Water Cooled, Electrically Operated Positive Displacement	≥ 600 tons	≤ 0.560 kW/ton ≤ 0.500 IPLV	≤ 0.585 kW/ton ≤ 0.380 IPLV	AHRI 550/590

CONTINUED: TABLE 110.2-D WATER CHILLING PACKAGES – MINIMUM EFFICIENCY REQUIREMENTS [a,b]

Equipment Type	Size Category	Path A Efficiency [a,b]	Path B Efficiency [a,b]	Test Procedure [c]
Water Cooled, Electrically Operated, Centrifugal	< 150 Tons	≤ 0.610 kW/ton ≤ 0.550IPLV	≤ 0.695 kW/ton ≤ 0.440 IPLV	AHRI 550/590
Water Cooled, Electrically Operated, Centrifugal	≥ 150 tons and < 300 tons	≤ 0.610 kW/ton ≤ 0.550 IPLV	≤ 0.635 kW/ton ≤ 0.400 IPLV	AHRI 550/590
Water Cooled, Electrically Operated, Centrifugal	≥ 300 tons and < 400 tons	≤ 0.560 kW/ton ≤ 0.520 IPLV	≤ 0.595 kW/ton ≤ 0.390 IPLV	AHRI 550/590
Water Cooled, Electrically Operated, Centrifugal	≥ 400 tons and < 600 tons	≤ 0.560 kW/ton ≤ 0.500 IPLV	≤ 0.585 kW/ton ≤ 0.380 IPLV	AHRI 550/590
Water Cooled, Electrically Operated, Centrifugal	≥ 600 tons	≤ 0.560 kW/ton ≤ 0.500 IPLV	≤ 0.585 kW/ton ≤ 0.380 IPLV	AHRI 550/590
Air Cooled Absorption, Single Effect	All Capacities	≥0.600 COP	N.A. [d]	AHRI 560
Water Cooled Absorption, Single Effect	All Capacities	≥ 0.700 COP	N.A. [d]	AHRI 560
Absorption Double Effect, Indirect-Fired	All Capacities	≥ 1.000 COP ≥ 1.050 IPLV	N.A. [d]	AHRI 560
Absorption Double Effect, Direct-Fired	All Capacities	≥ 1.000 COP ≥1.000 IPLV	N.A. [d]	AHRI 560

Water Cooled Gas Engine Driven Chiller	All Capacities	≥ 1.2 COP ≥ 2.0 IPLV	N.A. [d]	ANSI Z21.40.4A

a. No requirements for:
   1. Centrifugal chillers with design leaving evaporator temperature < 36°F; or
   2. Positive displacement chillers with design leaving fluid temperature ≤ 32°F; or
   3. Absorption chillers with design leaving fluid temperature < 40°F.

b. Must meet the minimum requirements of Path A or Path B. However, both the full load (COP) and IPLV must be met to fulfill the requirements of the applicable Path.

c. See Section 100.1 for definitions.

d. N.A. means not applicable.

TABLE 110.2-E PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT

Equipment Type	Total System Heat Rejection Capacity at Rated Conditions	Subcategory or Rating Condition	Performance Required ,[a ,b, c, d]	Test Procedure [e]
Propeller or axial fan Open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering air wb	≥ 42.1 gpm/hp	CTI ATC-105 and CTI STD-201 RS
Centrifugal fan Open-circuit cooling towers	All	95°F entering water 85°F leaving water 75°F entering air wb	≥ 20.0 gpm/hp	CTI ATC-105 and CTI STD-201 RS
Propeller or axial fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering air wb	≥ 16.1 gpm/hp	CTI ATC-105S and CTI STD-201 RS
Centrifugal fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F entering air wb	≥ 7.0 gpm/hp	CTI ATC-105S and CTI STD-201 RS

Propeller or axial fan evaporative condensers	All	R-448A test fluid 165ºF entering gas temp 105ºF condensing temp 75ºF entering air wb	≥ 157,000 Btu/h • hp	CTI ATC-106
Propeller or axial fan evaporative condensers	All	Ammonia test fluid 140ºF entering gas temp 96.3ºF condensing temp 75ºF entering air wb	≥ 134,000 Btu/h • hp	CTI ATC-106
Centrifugal fan evaporative condensers	All	R-448A test fluid 165ºF entering gas temp 105ºF condensing temp 75ºF entering air wb	≥ 135,000 Btu/h • hp	CTI ATC-106

CONTINUED: TABLE 110.2-E PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT

Equipment Type	**Total System Heat Rejection Capacity at Rated Conditions**	**Subcategory or Rating Condition**	**Performance Required ,[a ,b, c, d]**	**Test Procedure [e]**
Centrifugal fan evaporative condensers	All	Ammonia test fluid 140ºF entering gas temp 96.3ºF condensing temp 75ºF entering air wb	≥ 110,000 Btu/h • hp	CTI ATC-106
Air cooled condensers	All	125°F condensing temperature 190°F entering gas temperature 15°F subcooling 95°F entering drybulb	≥ 176,000 Btu/h ▪ hp	AHRI 460

Propeller or axial fan dry coolers (air-cooled fluid coolers)	All	115°F entering water 105°F leaving water 95°F entering air db	> 4.5 gpm/hp	CTI ATC-105DS

a For purposes of this table, open-circuit cooling tower performance is defined as the water flow rating of the tower at the given rated conditions divided by the fan motor nameplate power.

b For purposes of this table, closed-circuit cooling tower performance is defined as the process water flow rating of the tower at the given rated conditions divided by the sum of the fan motor nameplate rated power and the integral spray pump motor nameplate power.

c For purposes of this table dry cooler performance is defined as the process water flow rating of the unit at the given thermal rating condition divided by the total fan motor nameplate power of the unit and air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan motor nameplate power of the unit.

d Open cooling towers shall be tested using the test procedures in CTI ATC-105. Performance of factory assembled open cooling towers shall be either certified as base models as specified in CTI STD-201 or verified by testing in the field by a CTI approved testing agency. Open factory assembled cooling towers with custom options added to a CTI certified base model for the purpose of safe maintenance or to reduce environmental or noise impact shall be rated at 90 percent of the CTI certified performance of the associated base model or at the manufacturer's stated performance, whichever is less. Base models of open factory assembled cooling towers are open cooling towers configured in exact accordance with the Data of Record submitted to CTI as specified by CTI STD-201. There are no certification requirements for field erected cooling towers.

e Applicable test procedure and reference year are provided under the definitions. For refrigerated warehouses or commercial refrigeration applications, condensers shall comply with requirements specified by Section 120.6(a) or Section 120.6(b).

TABLE 110.2-F Electrically Operated Variable Refrigerant Flow (VRF) Air Conditioners Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency	Test Procedure[a]
VRF Air Conditioners, Air Cooled	<65,000 Btu/h	All	VRF Multi-split System	13.0 SEER Before 1/1/2023 Federal Minimum SEER2 On or After 1/1/2023	AHRI 1230 Before 1/1/2023 AHRI 210/240 On or After 1/1/2023

VRF Air Conditioners, Air Cooled	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System	10.5 EER Federal Minimum IEER [b]	AHRI 1230
VRF Air Conditioners, Air Cooled	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System	10.3 EER Federal Minimum IEER [b]	AHRI 1230
VRF Air Conditioners, Air Cooled	≥240,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System	9.5 EER Federal Minimum IEER [b]	AHRI 1230

a Applicable test procedure and reference year are provided under the definitions.

b IEERs are only applicable to equipment with capacity control as specified by AHRI 1230 test procedures.

TABLE 110.2-G Electrically Operated Variable Refrigerant Flow Air-to-Air and Applied Heat Pumps - Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency	Test Procedure [b]
VRF Air Cooled, (cooling mode)	<65,000 Btu/h	All	VRF Multi-split System	13.0 SEER Before 1/1/2023 Federal Minimum =SEER2 On or after 1/1/2023	AHRI 1230 Before 1/1/2023 AHRI 210/240 On or After 1/1/2023
VRF Air Cooled, (cooling mode)	≥65,000 Btu/h and <135,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System [a]	10.3 EER Federal Minimum IEER [c]	AHRI 1230

VRF Air Cooled, (cooling mode)	≥135,000 Btu/h and <240,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System [a]	9.9 EER Federal Minimum IEER [c]	AHRI 1230
VRF Air Cooled, (cooling mode)	≥240,000 Btu/h	Electric Resistance (or none)	VRF Multi-split System [a]	9.1 EER Federal Minimum IEER [c]	AHRI 1230
VRF Water source (cooling mode)	<65,000 Btu/h	All	VRF Multi-split systems [a] 86ºF entering water	12.0 EER Federal Minimum IEER [c]	AHRI 1230
VRF Water source (cooling mode)	≥65,000 Btu/h and <135,000 Btu/h	All	VRF Multi-split System [a] 86ºF entering water	12.0 EER Federal Minimum IEER [c]	AHRI 1230
VRF Water source (cooling mode)	≥135,000 Btu/h and < 240,000	All	VRF Multi-split System [a] 86ºF entering water	10.0 EER Federal Minimum IEER [c]	AHRI 1230
VRF Water source (cooling mode)	≥ 240,000 Btu/h	All	VRF Multi-split System[a] 86ºF entering water	10.0 EER Federal Minimum IEER	AHRI 1230

CONTINUED: TABLE 110.2-G Electrically Operated Variable Refrigerant Flow Air-to-Air and Applied Heat Pumps - Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency	Test Procedure [b]

VRF Groundwater source (cooling mode)	<135,000 Btu/h	All	VRF Multi-split System [a] 59ºF entering water	16.2 EER	AHRI 1230
VRF Groundwater source (cooling mode)	≥135,000 Btu/h	All	VRF Multi-split System [a] 59ºF entering water	13.8 EER	AHRI 1230
VRF Ground source (cooling mode)	<135,000 Btu/h	All	VRF Multi-split System [a] 77ºF entering water	13.4 EER	AHRI 1230
VRF Ground source (cooling mode)	≥135,000 Btu/h	All	VRF Multi-split System [a] 77ºF entering water	11.0 EER	AHRI 1230
VRF Air Cooled (heating mode)	<65,000 Btu/h (cooling capacity)	---	VRF Multi-split System	7.7 HSPF Before 1/1/2025 7.5 HSPF2 On or after 1/1/2025	AHRI 1230 Before 1/1/2025 AHRI 210/240 On or After 1/1/2025
VRF Air Cooled (heating mode)	≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)	---	VRF Multi-split system 47ºF db/ 43ºF wb outdoor air	Federal Minimum COP	AHRI 1230
VRF Air Cooled (heating mode)	≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)	---	VRF Multi-split system 17ºF db/15ºF wb outdoor air	2.25 COP	AHRI 1230

VRF Air Cooled (heating mode)	≥135,000 Btu/h (cooling capacity)	---	VRF Multi-split system 47ºF db/ 43ºF wb outdoor air	Federal Minimum COP	AHRI 1230

CONTINUED: TABLE 110.2-G Electrically Operated Variable Refrigerant Flow Air-to-Air and Applied Heat Pumps - Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Sub-Category or Rating Condition	Minimum Efficiency	Test Procedure [b]
VRF Air Cooled (heating mode)	≥135,000 Btu/h (cooling capacity)	---	VRF Multi-split system 17ºF db/15ºF wb outdoor air	2.05 COP	AHRI 1230
VRF Water source (heating mode)	< 65,000 Btu/h (cooling capacity)	---	VRF Multi-split System 68ºF entering water	Federal Minimum COP	AHRI 1230
VRF Water source (heating mode)	≥65,000 Btu/h and <135,000 Btu/h (cooling capacity)	---	VRF Multi-split System 68ºF entering water	Federal Minimum COP	AHRI 1230
VRF Water source (heating mode)	≥135,000 Btu/h and < 240,000 Btu/h (cooling capacity)	---	VRF Multi-split System 68ºF entering water	Federal Minimum COP	AHRI 1230
VRF Water source (heating mode)	≥ 240,000 Btu/h (cooling capacity)	---	VRF Multi-split System 68ºF entering water	Federal Minimum COP	AHRI 1230
VRF Groundwater source (heating mode)	<135,000 Btu/h (cooling capacity)	---	VRF Multi-split System 50ºF entering water	3.6 COP	AHRI 1230

VRF Groundwater source (heating mode)	≥135,000 Btu/h (cooling capacity)	---	VRF Multi-split System 50ºF entering water	3.3 COP	AHRI 1230
VRF Ground source (heating mode)	<135,000 Btu/h (cooling capacity)	---	VRF Multi-split System 32ºF entering water	3.1 COP	AHRI 1230
VRF Ground source (heating mode)	≥135,000 Btu/h (cooling capacity)	---	VRF Multi-split System 32ºF entering water	2.8 COP	AHRI 1230

a. Deduct 0.2 from the required EERs and IEERs for Variable Refrigerant Flow (VRF) Multi-split system units with a heating recovery section.
b. Applicable test procedure and reference year are provided under the definitions.
c. IEERs are only applicable to equipment with capacity control as specified by AHRI 1230 test procedures.

TABLE 110.2-H DX-DOAS Units, Single-Package and Remote Condenser – Minimum Efficiency Requirements

Equipment Type	**Energy Recovery**	**Subcategory or Rating Condition**	**Minimum Efficiency**	**Test Procedure[a]**
Air cooled (dehumidification mode)	Without energy recovery	NA	3.8 ISMRE2	AHRI 920
Air source heat pumps (dehumidification mode)	Without energy recovery	NA	3.8 ISMRE2	AHRI 920
Water cooled (dehumidification mode)	Without energy recovery	Cooling Tower Condenser Water	4.7 ISMRE2	AHRI 920
Water source heat pump (dehumidification mode)	Without energy recovery	Ground source, closed and open loop	4.6 ISMRE2	AHRI 920

Water source heat pump (dehumidification mode)	Without energy recovery	Water source	3.8 ISMRE2	AHRI 920
Air source heat pumps (heating mode)	Without energy recovery	NA	2.05 ISCOP2	AHRI 920
Water source heat pump (heating mode)	Without energy recovery	Ground source, closed and open loop	2.13 ISCOP2	AHRI 920
Water source heat pump (heating mode)	Without energy recovery	Water source	2.13 ISCOP2	AHRI 920
Air cooled (dehumidification mode)	With energy recovery	NA	5.0 ISMRE2	AHRI 920
Air source heat pumps (dehumidification mode)	With energy recovery	NA	5.0 ISMRE2	AHRI 920

CONTINUED: *TABLE 110.2-H DX-DOAS Units, Single-Package and Remote Condenser – Minimum Efficiency Requirements*

Equipment Type	**Energy Recovery**	**Subcategory or Rating Condition**	**Minimum Efficiency**	**Test Procedure[a]**
Water cooled (dehumidification mode)	With energy recovery	Cooling tower condenser water	5.1 ISMRE2	AHRI 920
Water source heat pump (dehumidification mode)	With energy recovery	Ground source, closed and open loop	5.0 ISMRE2	AHRI 920
Water source heat pump (dehumidification mode)	With energy recovery	Water source	4.6 ISMRE2	AHRI 920
Air source heat pumps (heating mode)	With energy recovery		3.2 ISCOP2	AHRI 920
Water source heat pump (heating mode)	With energy recovery	Ground source, closed and open loop	3.5 ISCOP2	AHRI 920
Water source heat pump (heating mode)	With energy recovery	Water source	4.04 ISCOP2	AHRI 920

a Applicable test procedure and reference year are provided under the definitions.

TABLE 110.2-I Heat Pump and Heat Recovery Chiller Packages, Cooling Operation - Minimum Efficiency Requirements

Equipment Type	Size Category Refrigerating Capacity[a], ton_R	Cooling Operation Efficiency[b,c,d,e], Air Source EER (FL/IPLV), Btu/W h, Liquid Source Power Input per Capacity (FL/IPLV), kW/ton_R Path A	Cooling Operation Efficiency[b,c,d,e], Air Source EER (FL/IPLV), Btu/W h, Liquid Source Power Input per Capacity (FL/IPLV), kW/ton_R Path B	Test Procedure
Air Source	< 150	> 5.595 FL > 13.02 IPLV.IP	> 9.215 FL > 15.01 IPLV.IP	AHRI/550/590
Air Source	> 150	> 5.595 FL > 13.30 IPLV.IP	> 9.215 FL > 15.30 IPLV.IP	AHRI/550/590
Liquid source electrically operated positive displacement	> 11.25[f] and < 150	< 0.7895 FL < 0.6316 IPLV.IP	< 0.8211 FL < 0.5263 IPLV.IP	AHRI/550/590
Liquid source electrically operated positive displacement	> 150 and < 300	< 0.7579 FL < 0.5895 IPLV.IP	< 0.7895 FL < 0.5158 IPLV.IP	AHRI/550/590
Liquid source electrically operated positive displacement	> 300 and < 400	< 0.6947 FL < 0.5684 IPLV.IP	< 0.7158 FL < 0.4632 IPLV.IP	AHRI/550/590
Liquid source electrically operated positive displacement	> 400 and < 600	< 0.6421 FL < 0.5474 IPLV.IP	< 0.6579 FL < 0.4316 IPLV.IP	AHRI/550/590
Liquid source electrically operated positive displacement	> 600	< 0.5895 FL < 0.5263 IPLV.IP	< 0.6158 FL < 0.4000 IPLV.IP	AHRI/550/590
Liquid source electrically operated centrifugal	> 11.25[f] and < 150	< 0.6421 FL < 0.5789 IPLV.IP	< 0.7316 FL < 0.4632 IPLV.IP	AHRI/550/590
Liquid source electrically operated centrifugal	> 150 and < 300	< 0.6190 FL < 0.5748 IPLV.IP	< 0.6684 FL < 0.4211 IPLV.IP	AHRI/550/590
Liquid source electrically operated centrifugal	> 300 and < 400	< 0.5895 FL < 0.5526 IPLV.IP	< 0.6263 FL < 0.4105 IPLV.IP	AHRI/550/590
Liquid source electrically operated centrifugal	> 400 and < 600	< 0.5895 FL < 0.5263 IPLV.IP	< 0.6158 FL < 0.4000 IPLV.IP	AHRI/550/590

Liquid source electrically operated centrifugal	> 600	< 0.5895 FL < 0.5263 IPLV.IP	< 0.6158 FL < 0.4000 IPLV.IP	AHRI/550/590

a. The size category is the full-load net refrigeration cooling mode capacity, which is the capacity of the evaporator available for cooling of the thermal load external to the chilling package.
b. Cooling rating conditions are standard rating conditions defined in AHRI 550/590 (I-P), Table 4, except for liquid cooled centrifugal chilling packages which can adjust cooling efficiency for nonstandard rating conditions using K_{adj} procedure in accordance with Section 110.2(a).
c. For cooling operation, compliance with both the FL and IPLV is required, but only compliance with Path A or Path B cooling efficiency is required.
d. For units that operate in both cooling and heating, compliance with both the cooling and heating efficiency is required.
e. For heat recovery heating chilling package applications where there is simultaneous cooling and heating, compliance with the heating performance heat recover COP_{HR} is only required at one of the four heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, Hot-Water 1 or Hot-Water 2. Compliance with the cooling only performance is required as defined in footnotes b and c.
f. Water to water heat pumps with capacity less than 135,000 Btu/h are included in Table 110.2-B Heat Pumps, Minimum Efficiency Requirements.

TABLE 110.2-J Heat Pump and Heat Recovery Chiller Packages, Heat Pump, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Air Source

Size Category Refrigerating Capacity[a], Ton_R	**Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F**	**Test Procedure**
< 150	47 db 43 wb	> 3.29	> 2.77	> 2.31	NA[j]	AHRI 550/590
< 150	17 db 15 wb	> 2.029	> 1.775	> 1.483	NA[j]	AHRI 550/590
> 150	47 db 43 wb	> 3.29	> 2.77	> 2.31	NA[j]	AHRI 550/590
> 150	17 db 15 wb	> 2.029	> 1.775	> 1.483	NA[j]	AHRI 550/590

(CONTINUED) TABLE 110.2-J Heat Pump and Heat Recovery Chiller Packages, Heat Pump, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Liquid source electrically operated positive displacement

Size Category Refrigerating Capacity[a], Ton_R	Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F	Heat Pump Heating Full Load Heating Efficiency (COP_H)[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F	Heat Pump Heating Full Load Heating Efficiency (COP_H)[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F	Heat Pump Heating Full Load Heating Efficiency (COP_H)[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F	Heat Pump Heating Full Load Heating Efficiency (COP_H)[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F	Test Procedure
> 11.25[h] and < 150	44[i]	> 4.64	> 3.68	> 2.68	NA[j]	AHRI 550/590
> 11.25[h] and < 150	65[i]	NA[j]	NA[j]	NA[j]	> 3.55	AHRI 550/590
> 150 and < 300	44[i]	> 4.64	> 3.68	> 2.68	NA[j]	AHRI 550/590
> 150 and < 300	65[i]	NA[j]	NA[j]	NA[j]	> 3.55	AHRI 550/590
> 300 and < 400	44[i]	> 4.64	> 3.68	> 2.68	NA[j]	AHRI 550/590
> 300 and < 400	65[i]	NA[j]	NA[j]	NA[j]	> 3.55	AHRI 550/590
> 400 and < 600	44[i]	> 4.93	> 3.96	> 2.97	NA[j]	AHRI 550/590
> 400 and < 600	65[i]	NA[j]	NA[j]	NA[j]	> 3.9	AHRI 550/590
> 600	44[i]	> 4.93	> 3.96	> 2.97	NA[g]	AHRI 550/590
> 600	65[i]	NA[j]	NA[j]	NA[j]	> 3.9	AHRI 550/590

(CONTINUED) TABLE 110.2-J Heat Pump and Heat Recovery Chiller Packages, Heat Pump, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Liquid source electrically operated centrifugal

Size Category Refrigerating Capacity[a], Ton_R	**Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H)[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H)[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H)[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F**	**Heat Pump Heating Full Load Heating Efficiency (COP_H)[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F**	**Test Procedure**
> 11.25[h] and < 150	44[i]	> 4.64	> 3.68	> 2.68	NA[j]	AHRI 550/590
> 11.25[h] and < 150	65[i]	NA[j]	NA[j]	NA[j]	> 3.55	AHRI 550/590
> 150 and < 300	44[i]	> 4.64	> 3.68	> 2.68	NA[j]	AHRI 550/590
> 150 and < 300	65[i]	NA[j]	NA[j]	NA[j]	> 3.55	AHRI 550/590
> 300 and < 400	44[i]	> 4.64	> 3.68	> 2.68	NA[j]	AHRI 550/590
> 300 and < 400	65[i]	NA[g]	NA[g]	NA[g]	> 3.55	AHRI 550/590
> 400 and < 600	44[i]	> 4.93	> 3.96	> 2.97	NA[j]	AHRI 550/590
> 400 and < 600	65[i]	NA[j]	NA[j]	NA[j]	> 3.9	AHRI 550/590
> 600	44[i]	> 4.93	> 3.96	> 2.97	NA[j]	AHRI 550/590
> 600	65[i]	NA[j]	NA[j]	NA[j]	> 3.9	AHRI 550/590

a. The size category is the full-load net refrigeration cooling mode capacity, which is the capacity of the evaporator available for cooling of the thermal load external to the chilling package.

b. For air source heat pumps, compliance with both the 47 F and 17 F heating source outdoor air temperature (OAT) rating efficiency is required for heating.

c. Heating full load rating conditions are at standard rating conditions defined in AHRI 550/590 (I-P), Table 4, includes the impact of defrost for air source heating ratings.
d. For units that operate in both cooling and heating, compliance with both the cooling and heating efficiency is required.
e. For heat recovery heating chilling package applications where there is simultaneous cooling and heating, compliance with the heating performance heat recover COP_{HR} is only required at one of the four heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, Hot-Water 1 or Hot-Water 2. Compliance with the cooling only performance is required as defined in footnotes b and c of Table 110.2-I.
f. For applications where the chilling package is installed to operate only in heating, compliance only with the heating performance COP_H is required at only one of the heating AHRI 550/590 (I-P) standard rating conditions of Low, Medium, High, or Boost. Compliance with cooling performance is not required.
g. For heat pump chilling package applications where the cooling capacity is not being used for conditioning, compliance with the heating performance COP_H is only required at one of the heating AHRI 550/590 (I-P) standard rating conditions of Low, Medium, High, or Boost. Compliance with the cooling performance is required as defined in footnotes b and c of Table 110.2-I, except as noted in footnote f.
h. Water to water heat pumps with capacity less than 135,000 Btu/h are included in Table 110.2-B Heat Pumps, Minimum Efficiency Requirements.
i. Source leaving liquid temperature.
    1. The cooling evaporator liquid flow rate used for the heating rating for a reverse cycle air to water heat pump shall be the flow rate determined during the full load cooling rating.
    2. The cooling evaporator liquid flow rate for the simultaneous cooling and heating and heat recovery liquid cooled chilling packages rating shall be the liquid flow rates from the cooling operation full load rating.
    3. For heating only fluid to fluid chiller packages, the evaporator flow rate obtained with an entering liquid temperature of 54 F and a leaving liquid temperature of 44 F shall be used.
j. NA means the requirements are not applicable.

TABLE 110.2-K Heat Pump and Heat Recovery Chiller Packages, Simultaneous Cooling and Heating, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Air Source

Size Category Refrigerating Capacity[a], Ton_R	Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F	Test Procedure
< 150	47 db 43 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
< 150	17 db 15 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 150	47 db 43 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 150	17 db 15 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590

(CONTINUED) TABLE 110.2-K Heat Pump and Heat Recovery Chiller Packages, Simultaneous Cooling and Heating, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Liquid source electrically operated positive displacement

Size Category Refrigerating Capacity[a], Ton_R	Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F	Test Procedure
> 11.25[h] and < 150	44[i]	> 8.33	> 6.41	> 4.42	NA[j]	AHRI 550/590
> 11.25[h] and < 150	65[i]	NA[j]	NA[j]	NA[j]	> 6.150	AHRI 550/590
> 150 and < 300	44[i]	> 8.33	> 6.41	> 4.42	NA[j]	AHRI 550/590
> 150 and < 300	65[i]	NA[j]	NA[j]	NA[j]	> 6.150	AHRI 550/590
> 300 and < 400	44[i]	> 8.33	> 6.41	> 4.42	NA[j]	AHRI 550/590
> 300 and < 400	65[i]	NA[j]	NA[j]	NA[j]	> 6.150	AHRI 550/590
> 400 and < 600	44[i]	> 8.9	> 6.98	> 5	NA[j]	AHRI 550/590
> 400 and < 600	65[i]	NA[j]	NA[j]	NA[j]	> 6.85	AHRI 550/590
> 600	44[i]	> 8.9	> 6.98	> 5	NA[j]	AHRI 550/590
> 600	65[i]	NA[j]	NA[j]	NA[j]	> 6.85	AHRI 550/590

(CONTINUED) TABLE 110.2-K Heat Pump and Heat Recovery Chiller Packages, Simultaneous Cooling and Heating, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Liquid source electrically operated centrifugal

Size Category Refrigerating Capacity[a], Ton_R	Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F	Simultaneous Cooling and Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F	Test Procedure
> 11.25[h] and < 150	44[i]	> 8.33	> 6.41	> 4.42	NA[j]	AHRI 550/590
> 11.25[h] and < 150	65[i]	NA[j]	NA[j]	NA[j]	> 6.150	AHRI 550/590
> 150 and < 300	44[i]	> 8.33	> 6.41	> 4.42	NA[j]	AHRI 550/590
> 150 and < 300	65[i]	NA[j]	NA[j]	NA[j]	> 6.150	AHRI 550/590
> 300 and < 400	44[i]	> 8.33	> 6.41	> 4.42	NA[j]	AHRI 550/590
> 300 and < 400	65[i]	NA[j]	NA[j]	NA[j]	> 6.150	AHRI 550/590
> 400 and < 600	44[i]	> 8.9	> 6.98	> 5	NA[j]	AHRI 550/590
> 400 and < 600	65[i]	NA[j]	NA[j]	NA[j]	> 6.85	AHRI 550/590
> 600	44[i]	> 8.9	> 6.98	> 5	NA[j]	AHRI 550/590
> 600	65[i]	NA[j]	NA[j]	NA[j]	> 6.85	AHRI 550/590

a. The size category is the full-load net refrigeration cooling mode capacity, which is the capacity of the evaporator available for cooling of the thermal load external to the chilling package.

b. For air source heat pumps, compliance with both the 47 F and 17 F heating source outdoor air temperature (OAT) rating efficiency is required for heating.

c. Heating full load rating conditions are at standard rating conditions defined in AHRI 550/590 (I-P), Table 4, includes the impact of defrost for air source heating ratings.

d. For units that operate in both cooling and heating, compliance with both the cooling and heating efficiency is required.

e. For heat recovery heating chilling package applications where there is simultaneous cooling and heating, compliance with the heating performance heat recover COP_{HR} is only required at one of the four heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, Hot-Water 1 or Hot-Water 2. Compliance with the cooling only performance is required as defined in footnotes b and c of Table 110.2-I.

f. Heating full load rating conditions are at standard rating conditions defined in AHRI 550/590 (I-P), Table 4, includes the impact of defrost for air source heating ratings.

g. For simultaneous cooling and heating chillers applications where there is simultaneous cooling and heating, compliance with the simultaneous cooling performance heat recovery COP_{SHC} is only required at one of the heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, High, or Boost. Compliance with cooling performance is required as defined in footnotes b and c of Table 110.2-I.

h. Water to water heat pumps with capacity less than 135,000 Btu/h are included in Table 110.2-B Heat Pumps, Minimum Efficiency Requirements.

i. Source leaving liquid temperature.

   1. The cooling evaporator liquid flow rate used for the heating rating for a reverse cycle air to water heat pump shall be the flow rate determined during the full load cooling rating.
   2. The cooling evaporator liquid flow rate for the simultaneous cooling and heating and heat recovery liquid cooled chilling packages rating shall be the liquid flow rates from the cooling operation full load rating.
   3. For heating only fluid to fluid chiller packages, the evaporator flow rate obtained with an entering liquid temperature of 54 F and a leaving liquid temperature of 44 F shall be used.

j. NA means the requirements are not applicable.

TABLE 110.2-L Heat Pump and Heat Recovery Chiller Packages, Heat Recovery, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Air Source

Size Category Refrigerating Capacity[a], Ton_R	Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F	Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F	Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F	Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F	Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F	Test Procedure
< 150	47 db 43 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
< 150	17 db 15 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 150	47 db 43 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 150	17 db 15 wb	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590

(CONTINUED) TABLE 110.2-L Heat Pump and Heat Recovery Chiller Packages, Heat Recovery, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Liquid source electrically operated positive displacement

Size Category Refrigerating Capacity[a], Ton_R	Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F	Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F	Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F	Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F	Heat Recovery Heating Full Load Efficiency (COP_{SHC}) [c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F	Test Procedure
> 11.25[h] and < 150	44[i]	> 8.33	> 6.41	> 4.862	> 4.42	AHRI 550/590
> 11.25[h] and < 150	65[i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 150 and < 300	44[i]	> 8.33	> 6.41	> 4.862	> 4.42	AHRI 550/590
> 150 and < 300	65[i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 300 and < 400	44[i]	> 8.33	> 6.41	> 4.862	> 4.42	AHRI 550/590
> 300 and < 400	65[i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 400 and < 600	44[i]	> 8.9	> 6.98	> 5.5	> 5	AHRI 550/590
> 400 and < 600	65[i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 600	44[i]	> 8.9	> 6.98	> 5.5	> 5	AHRI 550/590
> 600	65[i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590

(CONTINUED) TABLE 110.2-L Heat Pump and Heat Recovery Chiller Packages, Heat Recovery, Heating Operation– Minimum Efficiency Requirements

Equipment Type: Liquid source electrically operated centrifugal

Size Category Refrigerating Capacity[a], Ton_R	**Heating Source Conditions (leaving liquid) or OAT (db/wb)[b], F**	**Heat Recovery Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Low, 95 F/105 F**	**Heat Recovery Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Medium, 105 F/120 F**	**Heat Recovery Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, High, 120 F/140 F**	**Heat Recovery Heating Full Load Efficiency (COP_{SHC})[c,d,e,f,g], W/W, Entering/Leaving Heating Liquid Temperature, Boost, 120 F/140 F**	**Test Procedure**
> 11.25[h] and < 150	44[i]	> 8.33	> 6.41	> 4.862	> 4.42	AHRI 550/590
> 11.25[h] and < 150	65[i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 150 and < 300	44[i]	> 8.33	> 6.41	> 4.862	> 4.42	AHRI 550/590
> 150 and < 300	65[i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 300 and < 400	44[i]	> 8.33	> 6.41	> 4.862	> 4.42	AHRI 550/590
> 300 and < 400	65[i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 400 and < 600	44[i]	> 8.9	> 6.98	> 5.5	> 5	AHRI 550/590
> 400 and < 600	65[i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590
> 600	44[i]	> 8.9	> 6.98	> 5.5	> 5	AHRI 550/590
> 600	65[i]	NA[j]	NA[j]	NA[j]	NA[j]	AHRI 550/590

a. The size category is the full-load net refrigeration cooling mode capacity, which is the capacity of the evaporator available for cooling of the thermal load external to the chilling package.
b. For air source heat pumps, compliance with both the 47 F and 17 F heating source outdoor air temperature (OAT) rating efficiency is required for heating.
c. Heating full load rating conditions are at standard rating conditions defined in AHRI 550/590 (I-P), Table 4, includes the impact of defrost for air source heating ratings.

d. For units that operate in both cooling and heating, compliance with both the cooling and heating efficiency is required.

e. For heat recovery heating chilling package applications where there is simultaneous cooling and heating, compliance with the heating performance heat recover COP_{HR} is only required at one of the four heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, Hot-Water 1 or Hot-Water 2. Compliance with the cooling only performance is required as defined in footnotes b and c of Table 110.2-I.

f. For liquid source heat recovery chilling packages that have capabilities for heat rejection to a heat recovery condenser and a tower condenser the COP_{HR} applies to operation at full load with 100 percent heat recovery (no tower rejection). Units that only have capabilities for partial heat recovery shall meet the requirements of Table 110.2-D Water Chilling Packages Minimum Efficiency.

g. For heat recovery heating chilling package applications where there is simultaneous cooling and heating, compliance with the heating performance heat recover COP_{HR} is only required at one of the four heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, Hot-Water 1 or Hot-Water 2. Compliance with the cooling only performance is required as defined in footnotes b and c of Table 110.2-I.

h. Water to water heat pumps with capacity less than 135,000 Btu/h are included in Table 110.2-B Heat Pumps, Minimum Efficiency Requirements.

i. Source leaving liquid temperature.
    1. The cooling evaporator liquid flow rate used for the heating rating for a reverse cycle air to water heat pump shall be the flow rate determined during the full load cooling rating.
    2. The cooling evaporator liquid flow rate for the simultaneous cooling and heating and heat recovery liquid cooled chilling packages rating shall be the liquid flow rates from the cooling operation full load rating.
    3. For heating only fluid to fluid chiller packages, the evaporator flow rate obtained with an entering liquid temperature of 54 F and a leaving liquid temperature of 44 F shall be used.

j. NA means the requirements are not applicable.

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

SECTION 110.5 – NATURAL GAS CENTRAL FURNACES, COOKING EQUIPMENT, POOL AND SPA HEATERS, AND FIREPLACES: PILOT LIGHTS PROHIBITED

Any natural gas system or equipment listed below may be installed only if it does not have a continuously burning pilot light:

(a) Fan-type central furnaces.

(b) Household cooking appliances.

> **Exception to Section 110.5(b):** Household cooking appliances without an electrical supply voltage connection and in which each pilot consumes less than 150 Btu/hr.

(c) Pool heaters.

(d) Spa heaters.

(e) Indoor and outdoor fireplaces.

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

SECTION 110.9 – MANDATORY REQUIREMENTS FOR LIGHTING CONTROLS

(b) All lighting controls. Lighting controls listed in Section 110.9(b) shall comply with the requirements listed below; and all components of the system considered together as installed shall meet all applicable requirements for the application for which they are installed as required in Sections 130.0 through 130.5, Sections 140.6 through 140.8, Section 141.0, and Section 150.0(k).

4. **Occupant sensing controls.** Occupant sensing controls include occupant sensors, motion sensors, and vacancy sensors, including those with a partial-ON or partial-OFF function. Occupant sensing controls shall:

   A. Be capable of automatically turning the controlled lights in the area either off or down no more than 20 minutes after the area has been vacated;

   B. For manual-on controls, have a grace period of no less than 15 seconds and no more than 30 seconds to turn on lighting automatically after the sensor has timed out; and

   C. Provide a visible status signal that indicates that the device is operating properly, or that it has failed or malfunctioned. The visible status signal may have an override that turns off the signal.

Exception to Section 110.9(b)4: Occupant sensing control systems may consist of a combination of single or multilevel occupant, motion or vacancy sensor controls, provided that components installed to comply with manual-on requirements shall not be capable of conversion by occupants from manual-on to automatic-on functionality.

5. Reserved.

6. **Sensors used to detect occupants.** Sensors that are used by occupant sensing controls to detect occupants shall meet all of the following requirements:

   A. Sensors shall not incorporate switches or mechanical devices that allow the sensor to be disabled without changing the settings of the control.

   B. Sensors that utilize ultrasonic radiation for detection of occupants shall:

      i. comply with 21 C.F.R. part 1002.12;

      ii. not emit audible sound; and

      iii. not emit ultrasound in excess of the decibel levels shown in Table 110.9-A measured no more than 5 feet from the source, on axis.

   C. Sensors that utilize microwave radiation for detection of occupants shall:

      i. comply with 47 C.F.R. parts 2 and 15; and

ii. not emit radiation in excess of 1 milliwatt per square centimeter measured at no more than 5 centimeters from the emission surface of the device.

«» Commentary for Section 110.9(b):

The use of occupant sensor ventilation control devices is mandated for spaces that are also required to use occupant sensing controls to meet the requirements for lighting shut-off controls per Section 160.2(c)5E. Example spaces include offices, multipurpose rooms 1,000 sq. ft. or less, classrooms, conference rooms, and other spaces where the space ventilation is allowed to be reduced to zero. See the commentary below in Section 160.2 for more information on occupant sensor ventilation control devices. **«»**

SECTION 110.12 – MANDATORY REQUIREMENTS FOR DEMAND MANAGEMENT

Buildings, other than healthcare facilities, that install or are required to install demand responsive controls shall comply with the applicable demand responsive control requirements of Sections 110.12(a) through 110.12(e).

(a) Demand responsive controls.

1. All demand responsive controls shall be either:
   A. A certified OpenADR 2.0a or OpenADR 2.0b Virtual End Node (VEN), as specified under Clause 11, Conformance, in the applicable OpenADR 2.0 Specification; or a certified Baseline Profile OpenADR 3.0 Virtual End Node; or
   B. Certified to the Energy Commission as being capable of responding to a demand response signal from a certified OpenADR 2.0b or a certified Baseline Profile OpenADR 3.0 Virtual End Node by automatically implementing the control functions requested by the Virtual End Node for the equipment it controls.
2. All demand responsive controls shall be capable of communicating with the VEN using a wired or wireless bidirectional communication protocol.
3. RESERVED
4. When the demand response signal is disabled or unavailable, all demand responsive controls shall continue to perform all other control functions provided by the control.
5. Demand responsive control thermostats shall comply with Reference Joint Appendix 5 (JA5), Technical Specifications for Occupant Controlled Smart Thermostats.

(b) Demand Responsive Zonal HVAC Controls. Nonresidential HVAC systems with DDC to the Zone level shall be programmed to allow centralized demand shed for noncritical zones as follows:

1. The controls shall have a capability to remotely increase the operating cooling temperature set points by 4 degrees or more in all noncritical zones on signal from a centralized contact or software point within an Energy Management Control System (EMCS).
2. The controls shall have a capability to remotely decrease the operating heating temperature set points by 4 degrees or more in all noncritical zones on signal from a centralized contact or software point within an EMCS.
3. The controls shall have capabilities to remotely reset the temperatures in all noncritical zones to original operating levels on signal from a centralized contact or software point within an EMCS.

4. The controls shall be programmed to provide an adjustable rate of change for the temperature increase, decrease, and reset.
5. The controls shall have the following features:
   A. Disabled. Disabled by authorized facility operators; and
   B. Manual control. Manual control by authorized facility operators to allow adjustment of heating and cooling set points globally from a single point in the EMCS; and
   C. Automatic Demand Shed Control. Upon receipt of a demand response signal, the space-conditioning systems shall conduct a centralized demand shed, as specified in Sections 110.12(b)1 and 110.12(b)2, for noncritical zones during the demand response period.

«» Commentary for Section 110.12(b):

HVAC systems with direct digital controls (DDC) to the zone level in multifamily common use areas must be programmed to allow centralized demand shed for non-critical zones during the demand response period.

The Energy Code defines a critical zone as a zone serving a process where reset of the zone temperature set point during a demand shed event might disrupt the process, including but not limited to data centers, telecom/private branch exchange rooms, and laboratories.

To comply with this requirement, each non-critical zone temperature-control loop will control option that adds in an offset on the cooling temperature set point from a central demand shed signal. A rate of change limiter can either be built into the zone control or into the functional block for the central offset value. The central demand shed signal can be activated either through a global software point or a hardwired digital contact.

«»

SECTION 160.2 – MANDATORY REQUIREMENTS FOR VENTILATION AND INDOOR AIR QUALITY

(a) General requirements.

1. Attached dwelling units in multifamily buildings shall comply with the applicable requirements of Subsection 160.2(b) below. Occupiable spaces in multifamily buildings other than attached dwelling units shall comply with the applicable requirements of Section 160.2(c). When field verification and diagnostic testing of attached dwelling units is required by Section 160.2, buildings with three habitable stories or fewer shall use the applicable procedures in the Residential Appendices, and buildings with four or more habitable stories shall use the applicable procedures in Nonresidential Appendices NA1 and NA2.

   NOTE: Section 160.2 is not applicable to townhouses or dwellings that contain two dwelling units.

2. The required outdoor air-ventilation rate and the air-distribution system design shall be clearly identified on the building design plans submitted to the enforcement agency in accordance with Section 10-103 of Title 24, Part 1.

«» Commentary for Section 160.2:

The standard is structured such that requirements for the dwelling units are separate from requirements for common use areas of the multifamily building (e.g., corridors, parking garages, community rooms, etc.). The dwelling unit requirements are in Section 160.2(b) and generally follow ASHRAE Standard 62.2-2022, with some amendments. They include both ventilation rates and other IAQ requirements, including compartmentalization (air sealing dwelling units to reduce pollutant transfer from the outdoors and from neighboring units and common areas). The common use area requirements are in Section 160.2(c) and follow ASHRAE Standard 62.1-2022 for ventilation rates. «»

(b) Attached dwelling units. Attached dwelling units shall comply with the requirements of Subsections 1 and 2 below**.**

1. **Air filtration.**

   A. System types specified in Subsections i, ii and iii shall be provided with air filters in accordance with Sections 160.2(b)1B, 160.2(b)1C and 160.2(b)1D. System types specified in Subsection i shall also comply with Section 160.2(b)1E.

      i. Mechanical space-conditioning systems that supply air to an occupiable space through ductwork exceeding 10 ft (3 m) in length.

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

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

B. **System design and installation.**

i. The system shall be designed to ensure that all recirculated air and all outdoor air supplied to the occupiable space are filtered before passing through any system's thermal conditioning components.

Exception to Section 160.2(b)1Bi: For heat recovery ventilators and energy recovery ventilators, the location of the filters required by Section 160.2(b)1 may be downstream of a system thermal conditioning component, provided the system is equipped with ancillary filtration upstream of the system's thermal conditioning component.

ii. All systems shall be designed to accommodate the clean-filter pressure drop imposed by the system air filter(s). The design airflow rate, and maximum allowable clean-filter pressure drop at the design airflow rate applicable to each air filter, shall be determined and reported on labels according to Subsection iv below.

Systems specified in Section 160.2(b)1Ai shall be equipped with air filters that meet either Subsection a or b below:

a. Nominal two-inch minimum depth filter(s) shall be sized by the system designer, or

b. Nominal one-inch minimum depth filter(s) shall be allowed if the filter(s) are sized according to Equation 160.2-A, based on a maximum face velocity of 150 ft per minute and according to the maximum allowable clean-filter pressure drop specified in Section 160.2(b)1Dii.

$A_{face} = Q_{filter} / V_{face}$ (Equation 160.2-A)

where:

A_{face} = air filter face area, the product of air filter nominal length × nominal width, ft^2.

Q_{filter} = design airflow rate for the air filter, ft^3/min

V_{face} = air filter face velocity ≤ 150 ft/min

iii. All system air filters shall be located and installed in such a manner as to be accessible for regular service by the system owner.

iv. All system air filter installation locations shall be labeled to disclose the applicable design airflow rate and the maximum allowable clean-filter pressure drop. The labels shall be permanently affixed to the air filter installation location, readily legible, and visible to a person replacing the air filter.

v. Filter racks or grilles shall use gaskets, sealing or other means to close gaps around inserted filters and prevent air from bypassing the filter.

C. **Air filter efficiency**. The system shall be provided with air filters having a designated efficiency equal to or greater than MERV 13 when tested in accordance with ASHRAE Standard 52.2, or a particle size efficiency rating equal to or greater than 50 percent in the 0.30–1.0 μm range, and equal to or greater than 85 percent in the 1.0–3.0 μm range when tested in accordance with AHRI Standard 680.

D. **Air filter pressure drop**. All systems shall be provided with air filters that conform to the applicable maximum allowable clean-filter pressure drop specified in Subsection i, ii, iii or iv below, when tested using ASHRAE Standard 52.2, or as rated using AHRI Standard 680, for the applicable design airflow rates for the system air filters.

i. The maximum allowable clean-filter pressure drop shall be determined by the system design for the nominal two-inch minimum depth air filter required by Section 160.2(b)1Biia, or

ii. A maximum of 25 Pa (0.1 inches water) clean-filter pressure drop shall be allowed for a nominal 1-inch depth air filter sized according to Section 160.2(b)1Biib, or

iii. For systems specified in Sections 160.2(b)1Aii and 160.2(b)1Aiii, the maximum allowable clean filter pressure drop shall be determined by the system design.

iv. If Exception 1 to Section 160.3(b)5Lii or iv is utilized for compliance with cooling system airflow rate and fan efficacy requirements, the clean-filter pressure drop for the system air filter shall conform to the requirements given in Table 160.3-A or 160.3-B.

E. **Air filter product labeling.** Systems described in Section 160.2(b)1Ai shall be equipped with air filters that have been labeled by the manufacturer to disclose the efficiency and pressure drop ratings that demonstrate conformance with Sections 160.2(b)1C and 160.2(b)1D.

Exception to Section 160.2(b)1: Evaporative coolers are not required to comply with the air filtration requirements in Section 160.2(b)1.

«» Commentary for Section 160.2(b)1:

The air filtration requirements in forced air systems serve two purposes:

1. Protects the equipment from dust accumulation that could reduce the capacity or efficiency of the system. Preventing dust buildup may also prevent the system from becoming a host to biological contaminants such as mold, especially if dust is deposited on cooling coils that become wet from water condensation during comfort cooling operation. Air filter efficiencies of Minimum Efficiency Reporting Value (MERV) 6 to MERV 8 are sufficient for protection from these large airborne dust particles.
2. Remove airborne particles which can harm human health. Air filter efficiencies of at least MERV 13 protect occupants from exposure to the smaller airborne particles that are known to adversely affect respiratory health. These smaller particles are often referred to as PM 2.5, which refers to particulate matter of 2.5 microns or smaller. PM2.5 is produced from several sources including combustion from cooking and from exhaust from motor vehicles that enters a dwelling through ventilation openings and infiltration.

All filters used in all system types must be accessible to facilitate replacement, since regular filter replacement is important for proper equipment functioning and energy efficiency.

The intent of the requirement for a 2-inch depth filter or a 1-inch depth filter with a maximum face velocity of 150 ft per minute and a maximum pressure drop of 25 Pa is to reduce the pressure drop across the filter that could result in increased energy use from higher filtration.

Air Filter Grille Sticker

The design airflow rate and maximum allowable clean-filter pressure drop at the design airflow rate applicable to each air filter grille/rack must be determined by the designer/installer and posted on a sticker placed by the installer inside or near the filter grille/rack. The design airflow and initial resistance posted on this sticker should correspond to the conditions used in the system design calculations. This requirement applies to space conditioning systems and also to the ventilation system types described in Section 160.2(b)1A.

An example of an air filter grille sticker showing the design airflow and pressure drop for the filter grille/rack is shown in Table 4-2: Example of Installer's Filter Grille Sticker.

Air Filter Manufacturer Label

Space-conditioning system filters are required to be labeled by the manufacturer to indicate the pressure drop across the filter at several airflow rates. For the system to comply, and to ensure adequate airflow for efficient heating and cooling equipment operation, the manufacturer's air filter label must display information that indicates the filter can meet the design airflow rate for that return grille/rack at a pressure drop less than or equal to the value shown on the installer's filter grille sticker. This requirement does not apply to the ventilation system types described in Section 160.2(b)1A.

Table 4-2: Example of Installer's Filter Grille Sticker

Air Filter Performance Requirement	Air Filter Performance Requirement	Maintenance Instructions
Airflow Rate (CFM) Must be greater than or equal to the value shown	Initial Resistance (IWC) Must be less than or equal to the value shown	Use only replacement filters that are rated to simultaneously meet both of the performance requirements specified on this sticker:
750	0.1	Left Blank

Source: California Energy Commission

Figure 4-4: Example Manufacturer's Filter Label

MERV	(μm)	0.30-1.0	1.0-3.0	3.0-10	Airflow Rate (CFM)	615	925	1230	1540	2085*	*Max Rated Airflow
13	PSE (%)	62	87	95	Initial Resistance (IWC)	0.07	0.13	0.18	0.25	0.38	

Source: California Energy Commission

Air filters manufactured on and after July 1, 2024, are required to comply with the testing, marking, and certification requirements listed in Sections 1601-1609 of Title 20 to be sold or offered for sale in California.

All regulated products are required to be listed on the Energy Commission's Modernized Appliance Efficiency Database System (MAEDBS), available at (https://cacertappliances.energy.ca.gov/Login.aspx) a publicly available database that contains all regulated products that may legally be sold or offered for sale in California. «»

2. **Ventilation and indoor air quality for attached dwelling units**. All attached dwelling units shall meet the requirements of ASHRAE Standard 62.2, Ventilation and Acceptable Indoor Air Quality in Residential Buildings subject to the amendments specified in Section 160.2(b)2A below. All dwelling units shall comply with Section 160.2(b)2B below.

   Exception to Section 160.2(b)2 The following sections of ASHRAE 62.2 shall not be required for compliance: Section 4.1.1, Section 4.1.2, Section 4.1.4, Section 4.2, Section 4.3, Section 4.6, Section 5, Section 6.1.1, Section 6.1.3 and Normative Appendix A.

   A. **Amendments to ASHRAE 62.2 requirements.**

      i. **Window operation**. Window operation is not a permissible method of providing the dwelling unit ventilation airflow specified in Subsection iv or v below.

      ii. **Central fan integrated (CFI) ventilation systems**.

         a. Continuous operation prohibition. Continuous operation of a dwelling unit's central forced air system air handlers used in CFI ventilation systems is not a permissible method of providing the whole-dwelling unit ventilation airflow required by Section 160.2(b)2Aiv.

            Exception to Section 160.2(b)2Aiia: The Energy Commission may approve continuous operation of central fan integrated ventilation systems pursuant to Section 10-109(h).

         b. Outdoor air damper(s). A motorized damper(s) shall be installed on the connected ventilation duct(s) of CFI systems that prevents all airflow into or out of the space-conditioning duct system when the damper(s) is closed.

         c. Damper control. The required motorized damper(s) shall be controlled to be in an opened position when outdoor air ventilation is required for compliance, and shall be in the closed position when ventilation air is not required. The damper(s) shall be closed whenever the space-conditioning system air handling unit is not operating. If the outdoor airflow for the CFI ventilation system is fan-powered, then the outdoor air fan shall not operate when the required motorized damper(s) on the outdoor air ventilation duct(s) is closed.

         d. Variable ventilation. CFI ventilation systems shall incorporate controls that track outdoor air ventilation run time, and either open or close the required motorized damper(s) depending on whether or not outdoor air ventilation is required for compliance with Section 160.2(b)2Aiv. During periods when comfort conditioning is not called for by the space-conditioning thermostat, the CFI ventilation system controls shall operate the space-conditioning system central fan and outdoor air damper(s) when necessary to ensure compliance with the minimum outdoor air ventilation required by Section

160.2(b)2Aiv in accordance with applicable variable mechanical ventilation methods specified in ASHRAE 62.2 Section 4.5.

iii. **Air filtration.** Air filtration shall conform to the specifications in Section 160.2(b)1. Compliance with ASHRAE 62.2 Sections 6.7 (Minimum Filtration) and 6.7.1 (Filter Pressure Drop) shall not be required.

iv. **Whole-dwelling unit mechanical ventilation**. Multifamily attached dwelling units shall comply with Subsections a and b below.

a. Mechanical ventilation airflow shall be provided at rates greater than or equal to the value determined in accordance with Equation 160.2-B.

Total Required Ventilation Rate [ASHRAE 62.2:4.1.1].

$$Qtot = 0.03Afloor + 7.5(Nbr + 1) \quad \text{(Equation 160.2-B)}$$

WHERE:

Qtot = total required ventilation rate, cfm

Afloor = dwelling-unit floor area, ft^2

Nbr = number of bedrooms (not to be less than 1)

b. All dwelling units in a multifamily building shall use the same whole-dwelling unit ventilation system type. The dwelling unit shall comply with Subsections 1 and 2 below.

1. **Balanced or supply ventilation**. A balanced or supply ventilation system shall provide the required whole-dwelling-unit ventilation airflow. Balanced systems with heat recovery or energy recovery that serve a single dwelling unit shall have a fan efficacy of ≤1.0 W/cfm; and

2. **Compartmentalization Testing**. The air leakage rate shall not exceed 0.3 cubic feet per minute at 50 Pa (0.2 inch water) per ft^2 of dwelling unit envelope surface area as confirmed by ECC-rater field verification and diagnostic testing in accordance with the procedures specified in Reference Appendix RA3.8 or NA2.3 as applicable. In multifamily buildings with four or more habitable stories, the field verification and diagnostic testing which requires an ECC-Rater may alternatively be performed by a certified Mechanical Acceptance Test Technician according to the requirements specified in Reference Appendix NA1.9.

«» Commentary for Section 160.2(b)2A:

Whole Dwelling Unit Mechanical Ventilation

As an overview of dwelling unit ventilation requirements, dwelling units must have whole dwelling unit mechanical ventilation to provide outdoor air to the unit for dilution of contaminants, for which Section 160.2(b)2Ai through 160.2(b)2Av include requirements. There are also requirements for local mechanical exhaust for spot ventilation to remove polluted air generated within the unit from kitchens, bathrooms, and clothes dryers before the polluted air mixes with other air in the unit, which are specified in 160.2(b)2Avi. While the Standard allows the use of Central fan integrated (CFI) ventilation systems, it prohibits inefficient systems, including those that continuously operate the central forced air system for ventilation air.

Dwelling Unit Ventilation Strategies

This section provides typical strategies for providing outdoor air for whole-dwelling unit ventilation.

There are generally two system types available for meeting the mandatory whole-dwelling unit ventilation requirements:

1. When supply ventilation is used, filtered outdoor air is supplied directly to the dwelling unit.
2. When balanced ventilation is used, a combination of exhaust and supply in which air is exhausted from a dwelling unit and filtered outdoor air is supplied directly to the dwelling unit at the same rate (within 20%).

For the mandatory requirements of the Energy Code, Section 160.2(b)2Aivb requires the whole-dwelling unit ventilation system to either be a balanced system or a supply system. Exhaust-only ventilation is prohibited for new construction multifamily units, because it may not meet the minimum outdoor airflow rates for ventilation. In an exhaust-only system, air is drawn from the dwelling unit and exhausted to the outdoors, and air from outside the dwelling unit enters through infiltration, which includes both outdoor air and air from adjacent spaces (e.g., corridor, adjacent units) and may be polluted. Because exhaust-only ventilation systems may not meet the minimum outdoor air ventilation rates in multifamily units, they are prohibited in new construction. However, local exhaust systems can be used in existing dwelling units, to meet local exhaust requirements such as in bathrooms, kitchens, and dryers. Exhaust fans can be used as a part of a balanced ventilation system.

Natural ventilation does not satisfy requirements for dwelling unit ventilation. All dwelling unit ventilation systems need to have a mechanical fan.

Multifamily projects can use either of the following strategies to provide supply or balanced ventilation:

1. Unitary ventilation system, in which each dwelling unit has its own ventilation system. These are often simpler designs and use packaged equipment, but present more systems to maintain, may require maintenance by the resident (or at least their cooperation to provide access), and can require more wall penetrations.
2. Central ventilation systems, in which a centrally located (typically rooftop) fan and centralized ductwork serves multiple dwelling units. These can streamline maintenance and reduce exterior wall penetrations. For energy recovery ventilation (ERV) and heat recovery ventilation (HRV) systems, centralized equipment provides economies of scale for features such as bypass, which provides significant energy savings during the cooling season. However, centralized ventilation systems reduce the occupiable square footage in a building and can increase penetrations between units, which should be sealed for indoor air quality (IAQ) concerns.

This section provides more detail on each of these strategies.

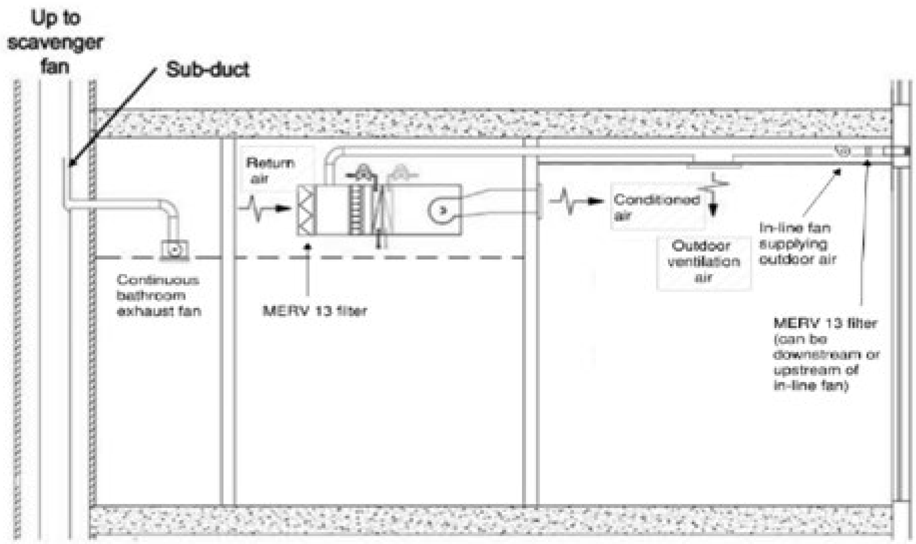
Supply Ventilation

Supply ventilation systems draw outdoor air into the unit using a dedicated supply fan. Indoor air escapes through leaks in the building envelope (exfiltration) and local mechanical exhaust such as range hood fans or bathroom fans. Space conditioning system air handling units cannot be used to provide supply ventilation, unless they meet the Central Fan-Integrated Ventilation approach described below.

Continuously operating ventilation fans must meet mandatory sound requirement of one sone or less. For larger dwelling units, more than one fan may be used. Remotely located fans (fans mounted outside habitable space, bathrooms, toilets, and hallways) are exempt from the sound requirements if there is at least four feet of ductwork between the fan and the interior grille.

Section 160.2(b)1 requires that outside air be filtered using MERV 13 (or greater) particle removal efficiency rated air filters. The filters must be accessible to facilitate replacement. Supply systems may locate the MERV 13 air filter either upstream or downstream of the fan as long as the incoming outdoor air is filtered prior to delivery to the dwelling unit's occupiable space. An example of MERV 13 filter placement in air handling units is shown in Figure 4-5: MERV 13 Locations for Ventilation and Space Conditioning Air Handler Unit in Example Scenario. Fans may be located in dropped ceiling spaces, mechanical closets, or other spaces dedicated for installation of mechanical equipment. As required in Section 10-103(b), builders must provide information to building operators and occupants for the operation of any equipment that requires filter replacement.

Figure 4-5: MERV 13 Locations for Ventilation and Space Conditioning Air Handler Unit in Example Scenario



Source: California Energy Commission

The outdoor air inlet should be located to avoid areas with contaminants such as smoke produced in barbeque areas, products of combustion emitted from gas appliance vents, and vehicle emissions from parking lots or garages. Air may not be drawn from attics or crawlspaces.

To minimize drafts and optimize distribution, supply air can be ducted directly to bedrooms and living areas using an appropriately sized and sealed ventilation- only duct system or by connecting to the HVAC supply plenum. However, distribution of supply air is best practice but not required.

Balanced Ventilation

Balanced systems use an exhaust fan and a supply fan to move approximately the same volume of air into and out of the dwelling. To be considered a balanced ventilation system, the total supply airflow and the total exhaust airflow must be within 20 percent of each other. Specifics on measuring airflows to determine compliance are found in RA3.7.4.1.2. Balanced ventilation may be a single packaged unit containing supply and exhaust fans that moves approximately the same airflow, or it may use separate fans. In both cases, air supplied from outdoors must be filtered. (See Section 160.2(b) for dwelling unit air filter requirements.)

Balanced ventilation can incorporate HRV or ERV systems. HRV and ERV systems temper incoming air with outgoing air, which reduces the thermal effect of ventilation on heating and cooling loads. However, the dual fans increase electrical energy use. Heat recovery is required in certain climate zones under the prescriptive path.

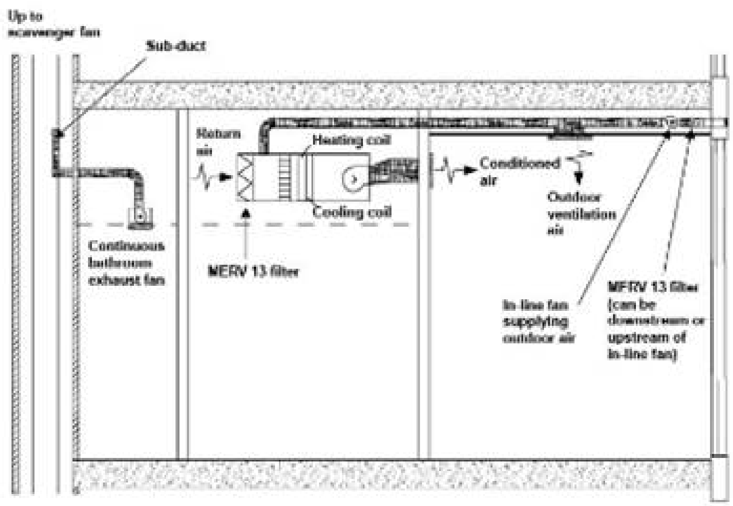
Like supply ventilation systems, balanced systems are required to be equipped with MERV 13 or better filters to remove particles from the intake airflow prior to delivery to the dwelling unit's occupiable space per Section 160.2(b)1. Balanced systems must comply with the same minimum separation distance between intake and exhaust (and other sources of contaminants) as supply-ventilation systems. Air may not be drawn from attics or crawlspaces.

Balanced ventilation systems may be either unitary or central systems. Examples of unitary and central balanced systems are provided below.

Unitary Balanced Ventilation

An example of a balanced ventilation system which couples a continuous exhaust fan with an in-line fan that directly supplies outdoor air is shown in Figure 4-6: Example of Balanced Ventilation Without Heat Recovery: Discrete Supply In-Line Fan with Continuous Bath Exhaust.

Figure 4-6: Example of Balanced Ventilation Without Heat Recovery: Discrete Supply In-Line Fan with Continuous Bath Exhaust



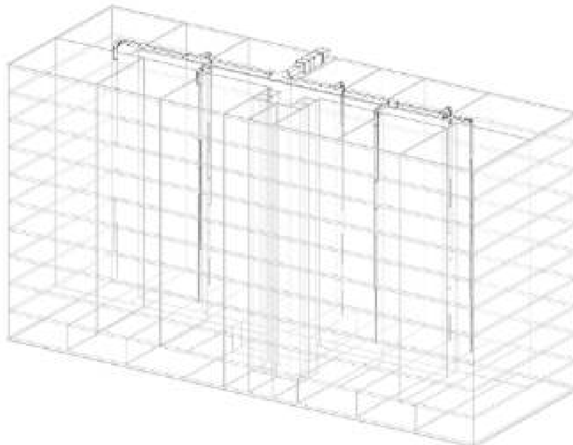
Source: California Energy Commission

Strategies other than an inline fan for providing outdoor air include packaged terminal unit (or packaged terminal air conditioning - PTAC) or supply fans.

Central Balanced Ventilation

A central balanced ventilation system provides supply-air to and exhaust air from multiple dwelling units. A central balanced ventilation approach could use a dedicated outdoor air system (DOAS) for supplying outdoor air to units and unitary bathroom exhaust. Figure 4-7: Dedicated Outdoor Air System (DOAS) for Supplying Fresh Air to Dwelling Units shows an example schematic of DOAS; note, the unitary bathroom exhaust is not shown. Because the building in this diagram assumes that the bottom floor is commercial space, the system does not serve this floor.

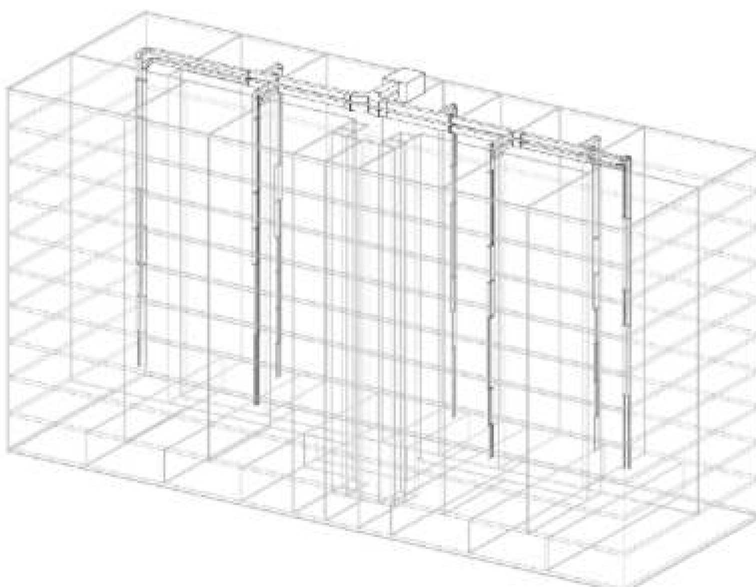
Figure 4-7: Dedicated Outdoor Air System (DOAS) for Supplying Fresh Air to Dwelling Units



Source: California Energy Commission

Alternatively, balanced ventilation could be provided by a rooftop HRV or ERV systems. For the prescriptive path in climate zones 1, 2, 4, 11 – 14 and 16, the Energy Code requires that a central HRV or ERV systems include a bypass or free cooling function that enables the HRV or ERV systems to bring in fresh air from the outdoors. This function allows incoming air to bypass the heat or energy recovery component when the enthalpy of the outdoor air is within certain temperature and relative humidity limits.

Figure 4-8: Central Balanced Ventilation Strategies: DOAS and Central ERV



Source: California Energy Commission

As shown in the figures above, each rooftop supply fan, HRV system, or ERV system would connect (via rooftop ductwork) to vertical shafts. In the example, six vertical shafts serve two dwelling unit from each floor, and one vertical shaft serves one dwelling unit per floor. While not shown in the figure for simplicity, each shaft would need a short horizontal run-out to the dwelling units on each floor and fire smoke dampers (FSDs) at the entry of this duct to the dwelling unit.

Alternatively, central ERV or HRV systems could be located throughout the building (such as one on each floor or for each wing) and serve a cluster of units.

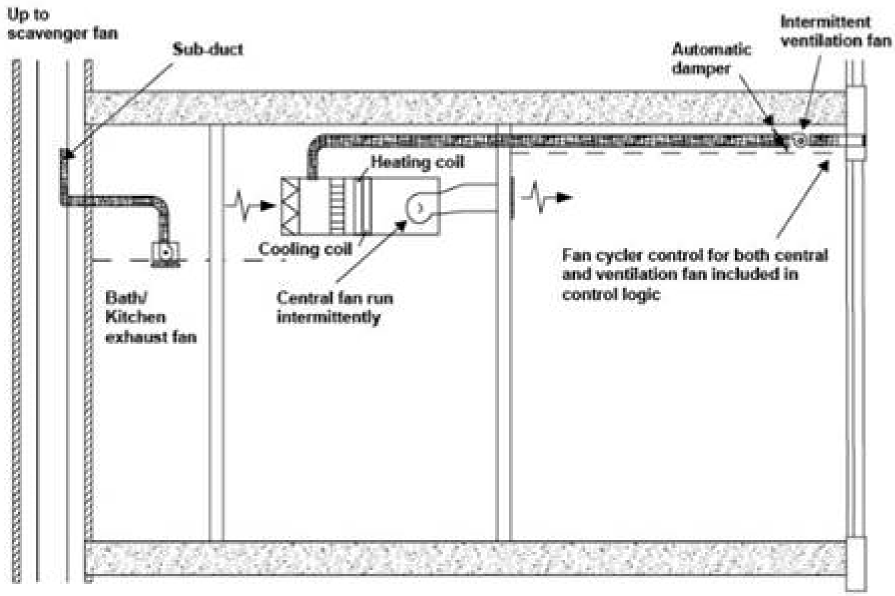
Central Fan-Integrated Ventilation

A CFI ventilation system is a configuration where the ventilation ductwork is connected to the space conditioning duct system, to enable distribution of ventilation air to the dwelling unit when the space conditioning system air handler is operating. This strategy mixes the outdoor air with the large volume of return air from the dwelling unit before being distributed. CFI ventilation systems consume a relatively high amount of energy compared to the other ventilation types because it uses the air handler fan. The Energy Code includes the following requirements specific to CFI ventilation systems:

1. Continuous Operation is Prohibited – The continuous operation of a space conditioning air handler is prohibited in providing whole-dwelling unit ventilation.
2. Outdoor Air Damper(s) – A motorized damper must be installed on any ventilation duct that connects outdoor air to the space conditioning duct system and must prevent airflow into or out of the space conditioning duct system when the damper is in the closed position.
3. Damper Control – The outdoor air damper must be controlled to be in the open position only when outdoor air is required for whole-dwelling unit ventilation and must be in the closed position when outdoor air is not required. The damper must be in the closed position when the air handler is not operating. If the outdoor airflow is fan-powered, then the outdoor air fan must not operate when the outdoor air damper is in the closed position.

Variable Ventilation Control – CFI ventilation systems must have controls that track outdoor air ventilation run time, and open or close the motorized damper depending on whether the required whole-dwelling unit ventilation airflow rate is being met. During periods when space conditioning is not called for by the space conditioning thermostat, the controls must operate the air handler fan and the outdoor air damper(s) when necessary to ensure the required whole-dwelling unit ventilation airflow rate is met. This control strategy must be in accordance with ASHRAE 62.2 section 4.5 which requires controls to operate the fan at least once every three hours, and the average whole-dwelling unit ventilation airflow rate over any 3-hour period must be greater than or equal to the required whole-dwelling unit ventilation airflow rate.

Figure 4-9: Example of Central Fan-Integrated (CFI) Ventilation with MERV 13 Filtration



Source: California Energy Commission

Section 160.2(b)1 requires that outside air be filtered using minimum MERV 13 particle removal efficiency rated air filters. Filters must be accessible to simplify replacement. For CFI systems, the filters must be installed upstream of the cooling or heating coil; thus, the filter rack provided at the inlet to the air handler may be used. In this case, it is not necessary to provide another MERV 13 or greater filter within the outdoor air duct. Otherwise, filters must be provided at the return grill(s) for the central fan, and another filter must be provided in the outside air ductwork before the point the outside air enters the return plenum of the central fan.

For a CFI ventilation system, both the central forced-air system fan total airflow and the much smaller outdoor ventilation airflow rate must be verified by an Energy Code Compliance (ECC)-Rater.

CFI ventilation systems, devices, and controls may be approved for use for compliance with the ECC field verification requirements for whole-dwelling unit mechanical ventilation in accordance with RA3.7.4.2. CFI ventilation systems are considered intermittent mechanical ventilation systems and must be certified to the Energy Commission that the CFI ventilation system will meet the minimum whole-dwelling unit ventilation requirements.

A listing of certified CFI ventilation systems is posted at the Energy Commission webpage, https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment/int-mech-ventilation.

Because CFI ventilation systems can use a large amount of electricity annually compared to other ventilation system types, the air handlers used in CFI ventilation systems are required to meet the fan watt draw requirements given in Section 150.0(m)13B in all climate zones.

Outside Air Intake Location Requirements

Projects using balanced or supply ventilation systems must meet the outdoor air (OA) intake requirements in the California Mechanical Code (CMC). CMC Section 405.2 allows ASHRAE 62.1-2022 Normative Appendix B to be used to calculate a minimum separation distance specific to the project instead of these default values. For multifamily projects using unitary ventilation (i.e., one ventilation system per dwelling unit), this calculation typically results in a shorter separation than the default separation distances for Class 2 air (10 ft) or Class 3 air (15 ft), as described below.

ASHRAE 62.1-2022 Normative Appendix B stipulates the following equation for the minimum separation distance (L) between an OA intake and exhaust air outlets described in ASHRAE 62.1: B-1.

$$L = 0.09 \times Q^{0.5} \times (\sqrt{DF} - \frac{U}{400})$$

Where,

1. L = minimum separation distance in feet
2. Q = exhaust airflow (cfm)
3. DF = dilution factor. For Class 3 air, DF = 15. ASHRAE 62.1 does not specify a DF for Class 2 air, but the engineering standard of care would be to use the same DF as what is specified for Class 3: DF = 15.
4. U = Exhaust air discharge velocity modifier. For exhaust that is capped or that is not directed towards the OA intake, U is zero (or positive, if directed away from the OA intake). See Table B-2 in Standard 62.1-2022 for more detail for determining U.

Dwelling Unit Compartmentalization, Adjacent Spaces and Transfer Air

Compartmentalization (i.e., sealing of the dwelling unit air barrier) is important for maintaining the indoor air quality of multifamily dwelling units because it limits transfer air. Compartmentalization reduces exposure to gaseous pollutants, and noise transfer from exterior and neighboring units. Transfer air is the airflow between adjacent dwelling units or between a dwelling unit and other nearby spaces (e.g., garage or crawlspace) in a multifamily building, that can contribute to poor IAQ in the dwelling units. Transfer airflow is caused by differences in pressure between adjacent spaces that force air to flow through leaks in the dwelling unit enclosure. The pressure differences may be due to stack effects (hot air rising in taller buildings when outside air temperature is low, leading to air pressing upward and exiting the building through upper floors), wind effects, unbalanced mechanical ventilation, and other reasons. Compartmentalization minimizes leaks in all the dwelling enclosures in the building to prevent pollutants such as tobacco smoke, pollution generated from food preparation in the kitchen, odors, and other pollutants from being transferred between adjacent dwellings and other spaces in the building. Drawing ventilation air from the garage could introduce carbon monoxide or volatile organic compounds into the indoor air. Drawing ventilation air from an unconditioned crawlspace could cause elevated allergen concentrations in the dwelling. In addition to maintaining good IAQ, compartmentalization provides energy benefits, by reducing leakage of conditioned air to the exterior. The reduction in indoor air losses means less makeup air needs to be conditioned to replace the lost condition air.

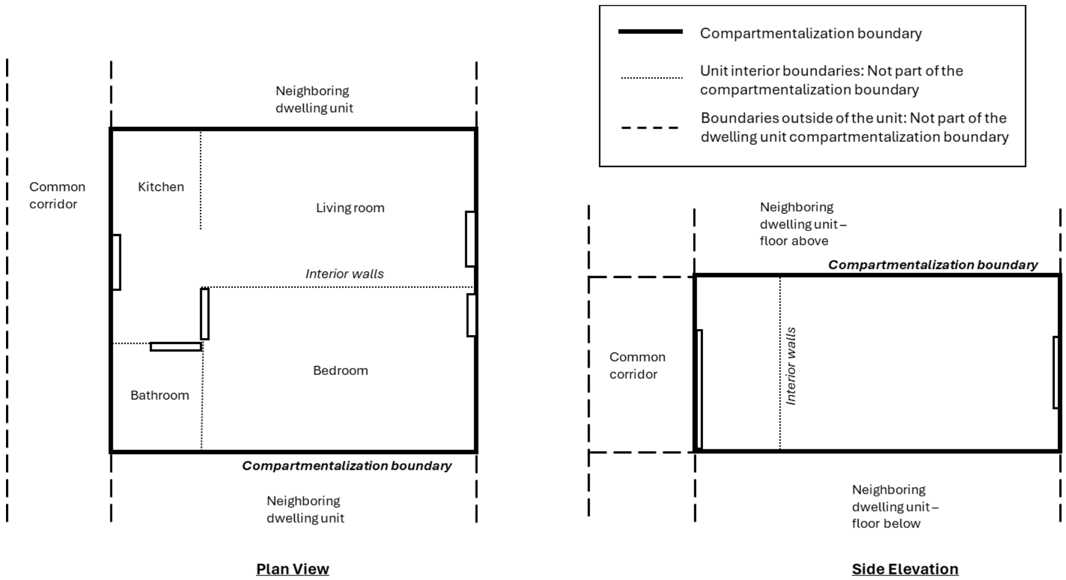
The 2025 Energy Code in Section 160.2(b)2Aiv requires that each dwelling unit be compartmentalized such that the dwelling unit leakage is not greater than 0.3 CFM per sq. ft of dwelling unit enclosure area as verified using a blower door test. The procedure for a compartmentalization blower door test is described in RA3.8 (blower door test for multifamily buildings with up to three habitable stories) and NA2.3 (blower door test for multifamily buildings with four or more habitable stories). When reporting dwelling unit leakage for compartmentalization blower door testing, whole dwelling unit enclosure surface area should be recorded and used. Whole dwelling unit enclosure surface area (to be included in the calculation for compartmentalization) include areas of walls, ceilings, floors shared with exterior spaces or with adjacent spaces (e.g., corridor, neighboring units) in the building. Sampling is allowed for the blower door testing, according to RA2.6 and NA1.6.

To compartmentalize the unit, project teams should seal areas that include, but are not limited to the following:

1. Vent and pipe penetrations, including those from water piping, drain waste and vent piping
2. HVAC piping and sprinkler heads
3. Electrical penetrations, including those for receptacles, lighting, communications wiring, and smoke alarms
4. HVAC penetrations, including those for fans and for exhaust, supply, transfer, and return air ducts

In addition, project teams should seal leaks and gaps in the dwelling-unit air barrier, including but not limited to the intersections of baseboard trim and floor, the intersections of walls and ceilings, around window trim and dwelling-unit doors, and the termination points of internal chases in attics, between floors, and crawlspaces.

Figure 4-10: Example of compartmentalization boundary in a common-entry multifamily dwelling unit – plan view and side elevation



Source: California Energy Commission

The requirements for balanced or supply ventilation works hand-in-hand with the requirement for compartmentalization; the first ensures that outdoor air is provided at the required rates, and the second reduces pollutant transfer between dwelling units. Similarly, the loss of conditioned air to the outside environment is reduced.«»

v. **Multifamily building central ventilation system airflow rate tolerance.** Multifamily building central ventilation systems that serve multiple dwelling units shall have airflow rates in each dwelling unit served that meet or exceed a design ventilation airflow rate specification.

a. Designers shall specify a design ventilation airflow rate for each dwelling unit that is equal to or greater than the rate specified by Equation 160.2-B.

b. The design ventilation airflow rate for each dwelling unit shall be stated on the building design plans approved by the enforcement agency.

c. Airflow in each dwelling unit shall be no more than twenty percent greater than the specified design ventilation airflow rate. Ventilation systems shall utilize mechanical or software airflow control means to ensure each of the dwelling-unit airflows can be maintained at the design ventilation airflow within this tolerance at all times. System airflow control-means may include but are not limited to constant air regulation devices, orifice plates and variable speed central fans.

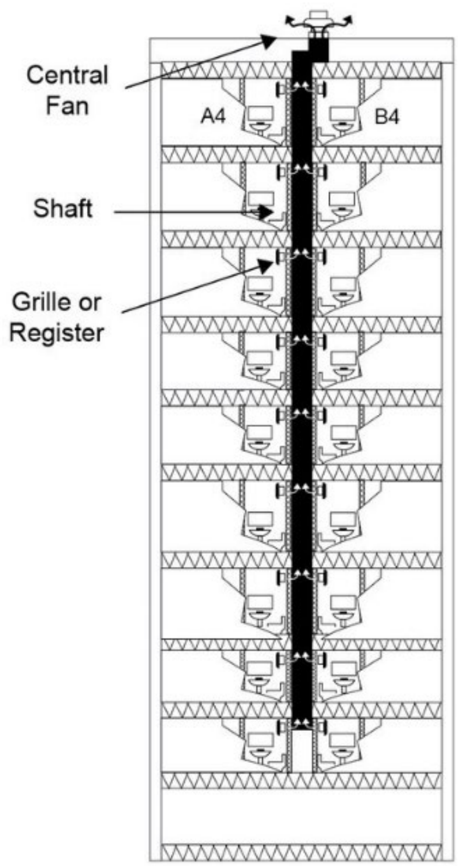
Commentary for Section 160.2(b)2Av:

Requirements for Multifamily building central ventilation system airflow tolerance

Central ventilation systems serving multiple dwelling units are sometimes used, particularly in tall buildings, to provide supply air (such as in a dedicated outdoor air system [DOAS] system), local exhaust, or balanced ventilation (such as a central ERV or HRV systems). These systems reduce the number of fans that must be maintained and the number of envelope penetrations for supply intakes or exhaust discharges.

The central ventilation system is typically comprised of a central fan (often located at the rooftop), a central ventilation duct (shaft) that runs between floors, horizontal branches to connect the dwelling units to the shaft, and in-unit connection points such as grilles to deliver (for supply) or remove (for exhaust) air from each dwelling unit. Figure 4-11: Diagram of Central Exhaust Ventilation Duct System Components illustrates an example with no horizontal branches.

Figure 4-11: Diagram of Central Exhaust Ventilation Duct System Components



Source: Center for Energy and Environment 2016

The intent of this requirement is to ensure that each dwelling unit meets minimum ventilation airflow rates for IAQ, but does not exceed that rate by more than twenty percent for energy conservation reasons. Requirements ensure that ventilation significantly greater than what is designed for does not occur, reducing the amount of conditioned air ventilated outside. These systems must use balancing devices to ensure the dwelling-unit airflows can be adjusted to meet this balancing requirement. These system balancing devices may include, but are not limited to, constant air-regulation devices (often referred to as “CAR dampers”), orifice plates, and variable-speed central fans.

The specified rate for the systems that share a common fan/shaft may be the minimum rate required for compliance, in which case each of the dwellings receiving airflow from a common fan/shaft must have ventilation airflow no more than 20% greater than the minimum dwelling unit ventilation airflow required. If the lowest airflow provided to any of the dwellings served by the common fan/shaft is a specific percent value greater than the minimum required for compliance, then each of the dwellings receiving airflow from that common fan/shaft must have ventilation airflow no more than 20% greater than that lowest dwelling unit ventilation airflow. For example, if the lowest ventilation airflow among all dwellings served by the common fan/shaft is 2% greater than the minimum required for compliance, then all dwellings served by the common fan/shaft must be balanced to have ventilation airflow that is no more than 22% greater than the minimum ventilation airflow required for compliance. **«»**

vi. **Local mechanical exhaust.** A local mechanical exhaust system shall be installed in each kitchen and bathroom. Systems shall be rated for airflow in accordance with ASHRAE 62.2 Section 7.1.

a. **Nonenclosed kitchens** shall have a demand-controlled mechanical exhaust system meeting the requirements of Section 160.2(b)2Avic.

b. **Enclosed kitchens and all bathrooms** shall have either one of the following options 1 or 2:

1. A demand-controlled mechanical exhaust system meeting the requirements of Section 160.2(b)2Avic; or

2. A continuous mechanical exhaust system meeting the requirements of Section 160.2(b)2Avid.

c. **Demand-controlled mechanical exhaust.** A local mechanical exhaust system shall be designed to be operated as needed.

1. **Control and operation.** Demand-controlled mechanical exhaust systems shall be provided with at least one of the following controls:

A. A readily accessible occupant-controlled ON-OFF control.

B. An automatic control that does not impede occupant ON control.

2. **Ventilation rate and capture efficiency.** The system shall meet or exceed either the minimum airflow in accordance with Table 160.2-E or the minimum capture efficiency in accordance with Table 160.2-E, and Table 160.2-G. Capture efficiency ratings shall be determined in accordance with ASTM E3087, and listed in a product directory approved by the Energy Commission.

«» Commentary for Section 160.2(b)2Avi:

Requirements for Kitchen Exhaust

Kitchen exhaust is important to remove pollution created during cooking processes, including fine particles ($PM_{2.5}$) and relative humidity; combustion gases such as nitrogen dioxide (NO_2) and carbon monoxide (CO) from natural gas and propane-fueled cooktops and ovens; and odors. One option for removing pollutants generated from cooking is to use a vented kitchen range hood, which removes pollutants above the cooking surface before they mix with the air in the rest of the home. The Energy Code incorporates a metric for local exhaust called capture efficiency. Capture efficiency is determined in accordance with ASTM E3087 as the fraction of emitted tracer gas that is directly exhausted by a range hood.

The Energy Code allows different options for kitchen exhaust including intermittent (typically demand-controlled) range hoods, a continuously operating fan in the kitchen, or a downdraft fan. For the demand-controlled option, the Energy Code allows the traditional airflow (in cubic feet per minute, or CFM) path for compliance or a capture efficiency path.

Under the Energy Code, dwelling units can use any one of the following options for kitchen exhaust:

1. A demand-controlled, vented range hood with at least one setting with a capture efficiency (CE) that meets or exceeds the values shown in Table 4-3: Kitchen Range Hood Airflow Rates (CFM) and ASTM E3087 Capture Efficiency (CE) Ratings According to Dwelling Unit Floor Area and Kitchen Range Fuel Type.
2. A demand-controlled, vented range hood with an airflow that meets or exceeds the exhaust rates shown in Table 4-3: Kitchen Range Hood Airflow Rates (CFM) and ASTM E3087 Capture Efficiency (CE) Ratings According to Dwelling Unit Floor Area and Kitchen Range Fuel Type.
3. A demand-controlled, vented downdraft kitchen exhaust fan (not represented in the table below) in enclosed kitchens with a minimum airflow of 300 cfm or a capacity of 5 air changes per hour. In a nonenclosed kitchen, the fan must have a minimum airflow of 300 cfm (no air changes per hour option).
4. For enclosed kitchens only: Continuous exhaust system with a minimum airflow equal to five kitchen air changes per hour.

Table 4-3: Kitchen Range Hood Airflow Rates (CFM) and ASTM E3087 Capture Efficiency (CE) Ratings According to Dwelling Unit Floor Area and Kitchen Range Fuel Type

Dwelling Unit Floor Area (sq. ft)	Hood Over Electric Range	Hood Over Natural Gas Range
>1500	50% CE or 110 CFM	70% CE or 180 CFM
>1000 - 1500	50% CE or 110 CFM	80% CE or 250 CFM
750-1000	55% CE or 130 CFM	85% CE or 280 CFM
<750	65% CE or 160 CFM	85% CE or 280 CFM

Source: from Table 160.2-G in the Energy Code

The minimum capture efficiency or airflow requirement for the range hood is the minimum required to adequately capture the moisture, particulates, and other products of cooking and/or combustion. While many products do not have published capture efficiency results as of the time of the publication of this manual, the captur efficiency path is intended to be a forward-looking approach and will support future listings.

While capture efficiency is the metric that directly measures pollutant removal, the airflow path (Option 2) is provided because capture efficiency generally increases with airflow, and the HVI and AHAM databases list airflow for kitchen exhaust appliances. ASHRAE Standard 62.2 includes a similar path as Option 2, but with lower required airflows (minimum 100 CFM). Because there is less air available for dilution in small dwelling units, the Energy Code set higher minimum requirements for smaller dwelling units. Because gas ranges emit NO2 and CO, in addition to the PM2.5 released from cooking processes, the capture efficiency and airflow requirements are higher for hoods over gas ranges.

The vented downdraft compliance option (Option 3) and continuous kitchen exhaust option (Option 4) are taken directly from ASHRAE Standard 62.2. The definition of an "enclosed kitchen", which must be met to use continuous kitchen exhaust, is also taken from ASHRAE Standard 62.2, and is defined as "permanent openings to interior adjacent spaces do not exceed a total of 60 square feet". Only in enclosed kitchens, the exhaust requirement can also be met with either a ceiling or wall-mounted exhaust fan or with a ducted fan or ducted ventilation system that can provide at least five air changes of the kitchen volume per hour.

Recirculating range hoods that do not exhaust pollutants to the outside cannot be used to meet the Energy Code requirements, unless paired with an exhaust system exhausting to the outside that can provide at least one of the following:

1. Continuous operation in an enclosed kitchen providing five air changes of the kitchen volume per hour, or
2. Demand-controlled operation in an enclosed or unenclosed kitchen providing at least 300 cfm of exhaust.

Generally, HRV/ERV manufacturers do not recommend that kitchen exhaust pass through HRV or ERV equipment, because the heat, moisture, grease, and particulates could damage heat exchange core.

The Energy Code does not explicitly specify a static pressure at which range hoods should be measured for airflow. However, the Energy Code requires that range hoods be listed in the HVI or AHAM product directories, and both of those directories list range hood airflows at 0.1" w.c. (and some at 0.25" w.c.), since 0.1" is the basic rating point for range hoods in HVI Standard 920. Note that some product airflows are listed at working-speed at lower static pressures, but working-speed airflows can only be used for compliance with the sound requirement, not airflow requirement. «»

d. **Continuous mechanical exhaust.** A mechanical exhaust system shall be installed to operate continuously. The system may be part of a balanced mechanical ventilation system.

1. **Control and operation**. A manual ON-OFF control shall be provided for each continuous mechanical exhaust system. The system shall be designed to operate during all occupiable hours. For multifamily dwelling units, the manual ON-OFF control may be accessible to the dwelling unit

occupant; however, the manual ON-OFF control shall not be required to be accessible to the dwelling unit occupant.

2. **Ventilation rate.** The minimum delivered ventilation shall be at least the amount indicated in Table 160.2-F during each hour of operation.

«» Commentary for Section 160.2(b)2Avid:

Dwelling unit ventilation systems may operate continuously or on a short-term basis. If fan operation is not continuous, the average ventilation rate over any three-hour period must be greater than or equal to the ventilation rate calculated using Equation 160.2-B.

The Energy Code allows for scheduled ventilation and real-time control. A control method must be chosen so that the relative exposure does not exceed specified peak and average relative exposure limits of ASHRAE Standard 62.2. Normative Appendix C provides direction on calculating the relative exposure and provides standardized calculations for complex ventilation controls implemented by use of digital controls that rely on the manufacturer's product-specific algorithms or software. Users installing any type of intermittent ventilation control system (scheduled or real-time) must submit an application to the Energy Commission to have the control approved. The manufacturers must provide documentation that the system will perform to provide the required whole-dwelling unit mechanical ventilation. Listings of systems approved by the Energy Commission and certified by the manufacturer are located at the following link: www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment-6.

While dwelling unit ventilation systems should operate (i.e., be in the ON position) in almost all circumstances, the Energy Code requires a manual ON-OFF control, with the purpose of allowing occupants or staff to temporarily turn off the system for extreme events, such as during wildfires. The dwelling unit ventilation system dilutes pollutants that can worsen IAQ such as particulate matter; combustion gases due to imperfect exhaust systems; volatile organic compounds from personal care products, dry cleaning, and other sources; and other pollutants. The dwelling unit ventilation system also reduces relative humidity, which can cause mold or damage the building.

In alignment with ASHRAE Standard 62.2, while the Energy Code requires that the manual ON-OFF control be accessible to the occupants in single-family units, there is an exception for multifamily units; it is not required to be readily accessible to the dwelling unit occupants. For multifamily buildings, manual ON-OFF control may be accessible to occupants or only to building maintenance staff. The control strategy where it is only accessible to maintenance staff may be appropriate for multifamily buildings that use central ventilation systems. Continuous operation of all ventilation fans in the building tends to minimize ventilation fan-induced pressure differences between adjoining dwellings, thus, reducing the leakage of transfer air between dwelling units. However, designers should consider the possibility of wildfire smoke or other outdoor air pollution events that could impact the IAQ of dwelling units and ensure there is a means for occupants or maintenance staff to quickly turn off dwelling unit ventilation systems in the circumstances when these systems may inadvertently degrade IAQ. The ventilation system should be returned to the ON position after the extreme event passes. **«»**

e. **Airflow measurement of local mechanical exhaust by the system installer.** The airflow required by Section 160.2(b)2Avi is the quantity of indoor air exhausted by the ventilation system as installed in the dwelling unit. When a vented range hood utilizes a capture efficiency rating to demonstrate compliance with Section 160.2(b)2Avic2, the airflow listed in the approved directory corresponding to the compliant capture efficiency rating point shall be met by the installed system. The as-installed airflow shall be verified by the system installer to ensure compliance by use of either Subsection 1 or 2 below:

1. The system installer shall measure the airflow by using a flow hood, flow grid or other airflow measuring device at the mechanical ventilation fan's inlet terminals/grilles or outlet terminals/grilles in accordance with the procedures in Reference Appendix RA3.7 or NA2.2 as applicable.
2. As an alternative to performing an airflow measurement of the system as installed in the dwelling unit, compliance may be demonstrated by installing an exhaust fan and duct system that conforms to the specifications of Table 160.2-H. Visual inspection shall verify the installed system conforms to the requirements of Table 160.2-H.

   When using Table 160.2-H for demonstrating compliance, the airflow rating shall be greater than or equal to the value required by Section 160.2(b)2Avi at a static pressure greater than or equal to 0.25 in. of water (62.5 Pa). When a vented range hood utilizes a capture efficiency rating to demonstrate compliance with Section 160.2(b)2Avic2, a static pressure greater than or equal to 0.25 in. of water at the rating point shall not be required, and the airflow listed in the approved directory corresponding to the compliant capture efficiency rating point shall be applied to Table 160.2-H for determining compliance.

   Use of Table 160.2-H is limited to ventilation systems that conform to all of the following three specifications:

   A. Total duct length is less than or equal to 25 feet (8 m),
   B. Duct system has no more than three elbows, and
   C. Duct system has exterior termination fitting with a hydraulic diameter greater than or equal to the minimum duct diameter and not less than the hydraulic diameter of the fan outlet.

«» Commentary for Section 160.2(b)2Avie:

For local exhaust systems, there are two ways to demonstrate compliance with airflow requirements of Section 160.2(b)2Avie:

1. Test the ventilation system using an airflow measuring device after completion of the installation to confirm that the delivered ventilation airflow meets the requirement.
2. Follow a prescriptive duct sizing table. Use a fan that has a certified airflow rating that meets or exceeds the required ventilation airflow and ventilation ducts that meet the duct design requirements given in Table 160.2-H of the Energy Code. This option is limited to ventilation systems with a total duct length less than or equal to 25 ft (8m), with no more than three elbows, and has exterior termination fitting with a hydraulic diameter greater than or equal to the minimum duct diameter and not less than the hydraulic diameter of the fan outlet. This path recognizes the challenge of testing airflow, particularly from range hoods which can be irregularly shaped.

When using the duct sizing table or manufacturer's design criteria for compliance, the certified airflow rating of the fan must be based on tested performance at the 0.25 inches water column (w.c.) static pressure. The airflow rating of a fan is available from the HVI Certified Products Directory at the HVI website (www.hvi.org/hvi-certified-products-directory).

If the manufacturer's duct system design specifications are used for compliance, the enforcement agency may require that the manufacturer's published system design documentation be provided for use for inspection of the installation(s).

The duct design criteria provided in Table 160.2-H of the Energy Code identifies the minimum exhaust duct diameter based on airflow. The higher the airflow, the larger the required diameter. Smooth rigid duct can be used to reduce pressure losses for longer duct runs. Interpolation and extrapolation of Table 160.2-H of the Energy Code are not allowed. **«»**

f. **Sound ratings for local mechanical exhaust**. Local mechanical exhaust systems shall be rated for sound in accordance with Section 7.3 of ASHRAE 62.2 at no less than the minimum airflow rate required by Section 160.2(b)2Avi.

   Exception to Section 160.2(b)2Avif: Kitchen range hoods may be rated for sound at a static pressure determined at working speed as specified in HVI 916 Section 7.2.

«» Commentary for Section 160.2(b)2Avif:

Studies have shown that many occupants do not operate their demand-controlled ventilation fans because of excessive noise, or complain about continuously operating fans that are too noisy. Air-moving equipment used to meet the whole-dwelling unit ventilation requirement and the local exhaust requirement, including kitchen local mechanical exhaust, must be rated by HVI or AHAM, which provides ratings for kitchen local mechanical exhaust, for airflow and sound. The sone metric for sound accounts for both the level and frequency of the sound, since these both impact occupant comfort.

1. Whole-dwelling unit ventilation and continuously operating local exhaust fans must be rated at a maximum of 1.0 sone (measurement of sound).
2. Demand-controlled local exhaust fans must be rated at a maximum of 3.0 sone.
3. Kitchen exhaust fans must be rated at a maximum of 3.0 sone at one or more airflow settings greater than or equal to 100 CFM. (The Energy Code requires kitchen range hoods to have a higher airflow than 100 CFM, but the range hoods must be tested for sound at a minimum of 100 CFM.) Range hoods that have a minimum airflow setting exceeding 400 CFM are exempt from the sound requirement. HVI listings are available at https://www.hvi.org/hvi-certified-products-directory. AHAM listings are available at: https://www.aham.org/AHAM/What_We_Do/Kitchen_Range_Hood_Certification.
4. Remotely located air-moving equipment (mounted outside habitable space, bathrooms, toilets, and hallways) is exempt from the sound requirements provided there is at least 4 ft. of ductwork between the fan and the interior grille. Kitchen range hoods are also exempt from the sound requirements provided they have a minimum airflow setting exceeding 400 cfm. **«»**

vii. **Airflow measurement of whole-dwelling unit ventilation**. The airflow required by Section 160.2(b)2Aiv or 160.2(b)2Av is the quantity of outdoor ventilation air supplied or indoor air exhausted by the mechanical ventilation system as installed and shall be measured by using a flow hood, flow grid or other airflow measuring device at the mechanical ventilation fan's inlet terminals/grilles or outlet terminals/grilles in accordance with the procedures in Reference Appendix Section RA3.7.4.1.1 or NA2.2.4.1.1 as applicable for supply and exhaust systems or RA3.7.4.1.2 or NA2.2.4.1.2 as applicable for balanced systems. Balanced mechanical ventilation system airflow shall be the average of the supply fan and exhaust fan flows.

«» Commentary for Section 160.2(b)2Avii:

Section 160.2(b)2Avii requires airflow measurement of the whole-dwelling unit ventilation system. The purpose is to ensure that the specified ventilation rate is delivered to the unit.

All whole-dwelling unit ventilation systems must demonstrate compliance by direct airflow measurement using a flow hood (such as shown in Figure 4-12: System Airflow Rate Measurement Using Flow Capture Equipment), flow grid, or other approved measuring device. ECC verification of whole-dwelling unit ventilation airflow is required for newly constructed buildings and existing buildings with additions greater than 1,000 sq. ft or an increase in the number of dwelling units.

Residential Appendix RA3.7.4 (for multifamily buildings up to three habitable stories) and Nonresidential Appendix NA2.2.4.1.1 (for multifamily buildings four or more habitable stories) provide guidance for measurement of supply, exhaust, and balanced system types. These measurement procedures are applicable when there is a fixed airflow rate required for compliance, such as for systems that operate continuously at a specific airflow rate or systems that operate intermittently at a fixed speed (averaged over any three-hour period), according to a fixed programmed pattern that is verifiable by a ECC-Rater on site. (Refer to ASHRAE Standard 62.2 Section 4.5.1 Short Term Average Ventilation.)

For exhaust-only systems, measurement of the whole-dwelling unit ventilation airflow should be done by measuring airflow of the exhaust fan(s). While this approach will over-represent the airflow from the outdoors, it is difficult to determine the fraction of the infiltration from the outdoors versus adjacent spaces in the building.

For whole-dwelling unit ventilation systems that use scheduled ventilation or real-time controls, the Energy Commission may consider the ventilation system for approval, if the manufacturer provides a method that can be used by a ECC-Rater or Acceptance Test Technician (ATT) to verify that an installed system is operating as designed. Figure 4-12: System Airflow Rate Measurement Using Flow Capture Equipment shows examples of an airflow rate measuring device.

Figure 4-12: System Airflow Rate Measurement Using Flow Capture Equipment

Source: California Statewide CASE Team

«»

viii. **Sound ratings for whole-dwelling unit ventilation systems.** Whole-dwelling unit ventilation systems shall be rated for sound in accordance with Section 7.3 of ASHRAE 62.2 at no less than the minimum airflow rate required by Section 160.2(b)2Aiv or 160.2(b)2Av as applicable.

«» Commentary for Section 160.2(b)2Aviii:

Whole-dwelling unit ventilation and continuously operating local exhaust fans must be rated at a maximum of 1.0 sone (measurement of sound). This is to reduce discomfort from continuously operating fans that are excessively noisy, causing occupant discomfort. However, the equipment must also meet requirements in Section 160.2(b)2Aiv or 160.2(b)2Av to reduce excess ventilation.«»

ix. **Label for whole-dwelling unit ventilation system on-off control**. Compliance with ASHRAE 62.2 Section 4.4 (Control and Operation) shall require manual ON-OFF control switches associated with whole-dwelling unit ventilation systems to have a label clearly displaying the following text, or equivalent text: "This switch controls the indoor air quality ventilation for the home. Leave switch in the 'on' position at all times unless the outdoor air quality is very poor."

«» Commentary for Section 160.2(b)2Aix:

As noted above, Section 160.2(b)2Avic1 and Section 160.2(b)2Avid1 require a readily accessible manual ON-OFF control, except in multifamily buildings. The requirement for a label is so that controls include text or an icon indicating the system's function by stating that the switch controls the indoor air quality and ventilation for the home and that the switch must always be 'on' unless outdoor air quality is very poor. The purpose of the label is to educate the occupants and building manager so they will be more likely to keep the ventilation system running during typical conditions, and turn it back on if it is temporarily turned off due to wildfires or other events. «»

x. **Combustion air and compensating outdoor air or makeup air.**

a. All dwelling units shall conform to the applicable requirements specified in California Mechanical Code Chapter 7, Combustion Air.

b. All dwelling units shall conform to the requirements in ASHRAE 62.2 Section 6.4, Combustion and Solid-Fuel-Burning Appliances.

xi. Balanced and supply ventilation component accessibility. Balanced and supply ventilation systems shall meet the following requirements for accessibility:

a. IAQ filter and HRV/ERV accessibility. System air filters and HRV/ERV heat/energy recovery cores shall be located such that they are accessible for service from within occupiable spaces, basements, garages, balconies, mechanical closets or accessible rooftops. Filters and heat/energy recovery cores behind access panels, access doors, or grilles located no more than 10 feet above a walking surface inside a space specified above comply with this requirement.

Exception to Section 160.2(b)2Axia: Systems that require servicing from inside the attic shall have the following:

1. A Fault Indicator Display (FID) meeting the requirements of Reference Appendix JA 17; and
2. An attic access door located in a wall or, where attic access is provided through a ceiling, an attic access hatch that includes an integrated ladder; and
3. A walkway from the attic access door to the HRV/ERV.

b. IAQ system component accessibility. Fans, motors, heat exchangers, filters and recovery cores shall meet all applicable requirements of California Mechanical Code 304.0 accessibility of service.

«» Commentary for Section 160.2(b)2Axi:

Ventilation systems need periodic maintenance, including removal of debris from intakes and replacement of filters. The intent of this requirement is to ensure that ventilation system components can be serviced easily to maintain acceptable indoor air quality and energy performance. The ventilation system components should be accessible from within the building, including occupiable spaces, basements, garages, balconies, mechanical closets or accessible rooftops. If servicing is to be done from inside an accessible attic, the system should have a Fault Indicator Display (FID). «»

B. **Dwelling unit field verification and diagnostic testing.**

i. The whole-dwelling unit ventilation airflow required by Section 160.2(b)2Aiv or 160.2(b)2Av shall be confirmed through field verification and diagnostic testing in accordance with Reference Appendix RA3.7.4.1.1 or NA2.2.4.1.1 as applicable for supply and exhaust systems or RA3.7.4.1.2 or NA2.2.4.1.2 as applicable for balanced systems. Balanced mechanical ventilation system airflow shall be the average of the supply fan and exhaust fan flows. Ventilation airflow of systems with multiple operating modes shall be tested in all modes designed to comply with the required ventilation airflows.

ii. **Kitchen local mechanical exhaust—vented range hoods.** Vented range hoods installed to comply with local mechanical exhaust requirements specified in Section 160.2(b)2Avi shall be field verified in accordance with Reference Appendix RA3.7.4.3 or NA2.2.4.1.4 as applicable to confirm the model is rated by HVI or AHAM to comply with the following requirements:

a. The minimum ventilation airflow rate as specified by Section 160.2(b)2Avi, or alternatively the minimum capture efficiency as specified by Section 160.2(b)2Avi; and

b. The maximum sound rating as specified in Section 160.2(b)2Avif.

«» Commentary for Section 160.2(b)2Bi-ii:

The dwelling unit ventilation airflow and the rated airflow rate for the kitchen range hood fans are required to be verified by an ECC-Rater. The dwelling unit ventilation airflow should be field tested, as described in the Commentary for Section 160.2(b)2A, and as illustrated in Figure 4-12: System Airflow Rate Measurement Using Flow Capture Equipment. To verify the range hood model, the rater shall compare the installed model to ratings in the Home Ventilating Institute (HVI) or Association of Home Appliance Manufacturers (AHAM) directory of certified ventilation products to confirm the installed range hood is rated to meet the required airflow in the Energy Code, as well as the sound requirements specified in ASHRAE Standard 62.2. See the section, Requirements for Kitchen Exhaust below for more detail.

Kitchen range hood fans that exhaust more than 400 CFM at minimum speed are exempt from the sound requirement. «»

iii. **Heat recovery ventilation (HRV) and energy recovery ventilation (ERV) system fan efficacy.** At a minimum, systems with heat or energy recovery serving a single dwelling unit shall have a fan efficacy of ≤1.0 W/cfm as confirmed by field verification in accordance with Reference Appendix RA3.7.4.4 or NA2.2.4.1.5 as applicable. If Section 170.2(c)3Biva requirements are applicable to the dwelling unit, then field verification shall instead confirm compliance with the maximum fan efficacy and minimum sensible recovery efficiency specified in Section 170.2(c)3Biva in accordance with the procedures specified in Reference Appendix RA3.7.4.4 or NA2.2.4.1.5 as applicable.

iv. In multifamily buildings with four or more habitable stories, the field verification and diagnostic testing required in Section 160.2(b)2Bi, ii and iii which requires an ECC-Rater may alternatively be performed by a certified Mechanical Acceptance Test Technician according to the requirements specified in Reference Appendix NA1.9.

«» Commentary for Section 160.2(b)2Biii-iv:

There is a mandatory requirement that all HRV and ERV systems serving a single dwelling unit must have a fan efficacy of one W/CFM or less. Under the prescriptive requirement of Section 170.2(c)3Biv, HRV and ERV systems serving individual multifamily dwelling units using balanced ventilation in climate zones 1, 2, 4, 11 – 14 and 16 must meet more stringent fan efficacy requirements of 0.6 W/CFM or less.

Fan efficacy is calculated as the Power Consumed in Watts divided by the Net Airflow in CFM. If the HVI database or other Energy Commission approved directories do not list the fan energy for the installed model or the proposed product is a large central ERV/HRV systems whose airflow rate exceeds the maximum listed in the HVI database, use information from the manufacturer's published documentation.

In multifamily buildings with four or more habitable stories, certified Mechanical ATTs may perform the field verification and diagnostic testing required in Section 160.2(b)2Bi,ii and iii according to Reference Appendix NA1.9. ATTs are not allowed to use sampling for this testing. «»

C. **Multifamily building central ventilation system field verification.**

i. **Central ventilation system duct sealing.** Ventilation ducts that conform to Subsections a and b below shall meet the duct sealing requirements in California Mechanical Code Section 603.10 and have leakage that is no greater than six percent of the rooftop fan or central fan design airflow rate as confirmed by field verification in accordance with the procedures in Reference Appendix NA7.18.3. The leakage test shall be conducted using a test pressure of 25 Pa (0.1 inches) for ducts serving six or fewer dwelling units and 50 Pa (0.2 inches) for ducts serving more than six dwelling units, and shall measure the leakage of all ductwork between the central fan and the connection point to the in-unit grille or fan.

a. The ventilation ducts serve multiple dwelling units.

b. The ventilation ducts provide continuous airflows or airflows to provide balanced ventilation to meet the requirements specified in Section 160.2(b)2Aiv or 160.2(b)2Av as applicable.

Exception to Section 160.2(b)2C: Multifamily buildings with three or fewer habitable stories in Climate Zone 6 are not required to comply with Section 160.2(b)2C.

«» Commentary for Section 160.2(b)2C:

In addition to the requirement for central ventilation system airflow tolerance limits specified in Section 160.2(b)2Av, the Energy Code includes a mandatory sealing and leakage testing requirement for central ventilation systems providing continuous airflow or an airflow to meet the balanced ventilation path in Section 160.2(b)2Aiv. The requirement saves energy. For central ventilation ducts that are excessively leaky, if the units furthest from the fan receive sufficient airflow, the units closer to the fan are overventilated. This results in wasted fan energy use, and conditioned air that is displaced from overventilation. To avoid this, the Energy Code requires sealing and testing of these ducts.

An ATT must conduct a fan pressurization test to show that central shaft leakage is no greater than 6% compared to a nominal airflow rate of the central fan at 0.2 inches water column (inch w.c.) (50 Pa) for ducts serving more than six dwelling units. For ducts serving six or fewer dwelling units, the maximum leakage is the same, but the test must be conducted at 0.1 inches w.c. (25 Pa), since these systems typically have a lower operating pressure. As described in the NA1.6 procedures, sampling may be used for this duct testing requirement, and the ATT may conduct the leakage test at rough-in.

Central ventilation systems providing intermittent flows, such as demand-controlled exhaust from kitchens, bathrooms, or driers, are exempt from this testing requirement (since their operation has lower energy impacts), although careful sealing is still recommended.

The airflow, sealing, and leakage testing requirements for central ventilation ducts work in tandem to provide better control of airflow to each unit so that units are not overventilated (which would waste energy) or under-ventilated (which would degrade IAQ). **«»**

(c) Common use areas. All occupiable spaces shall comply with the requirements of Subsection 1 and shall also comply with either Subsection 2 or Subsection 3:

1. **Air filtration.**

A. Mechanical system types specified in Subsections i, ii and iii below shall be designed to ensure that all recirculated air and all outdoor air supplied to the occupiable space are filtered before passing through any system’s thermal conditioning components. Air filters shall conform to the requirements of Sections 160.2(c)1B, 160.2(c)1C and 160.2(c)1D.

i. Mechanical space-conditioning systems that supply air to an occupiable space through ductwork exceeding 10 ft (3 m) in length.

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

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

Exception to Section 160.2(c)1A: For heat recovery ventilators and energy recovery ventilators, the location of the filters required by Section 160.2(c)1A may be downstream of a system's thermal conditioning component, provided the system is equipped with ancillary filtration upstream of the system's thermal conditioning component.

«» Commentary for Section 160.2(c)1A:

Ventilation and Indoor Air Quality Requirements for Common Use Areas

Within a building, all occupied space that is normally used by humans must be continuously ventilated during occupied hours with outdoor air, using either natural or mechanical ventilation.

"Spaces normally used by humans" refers to spaces where people can be reasonably expected to remain for an extended period of time. Spaces where occupancy will be brief and intermittent that do not have any unusual sources of air contaminants do not need to be directly ventilated. For example:

1. A closet, provided it is not normally occupied
2. A storeroom that is only infrequently or briefly occupied. However, a storeroom that can be expected to be occupied for extended periods for clean-up or inventory must be ventilated, preferably with systems controlled by a local switch so that the ventilation system operates only when the space is occupied.

For common use areas, there are three types of ventilation requirements:

1. Natural ventilation where openings on the wall allow outside air to come into the building,
2. Mechanical ventilation that constantly or intermittently provide outdoor air, and
3. Mechanical exhaust for certain spaces that are expected to have contaminants with the intent of removing the polluted air.

«»

B. **Air filter efficiency**. The filters shall have a designated efficiency equal to or greater than MERV 13 when tested in accordance with ASHRAE Standard 52.2, or a particle size efficiency rating equal to or greater than 50 percent in the 0.30–1.0 μm range, and equal to or greater than 85 percent in the 1.0–3.0 μm range when tested in accordance with AHRI Standard 680; and

«» Commentary for Section 160.2(c)1B:

Occupied spaces may be subjected to poor indoor air quality if poor quality outdoor air is brought in without first being cleaned. Particles less than 2.5 μm are referred to as "fine" particles, and because of their small size, can lodge deeply into the lungs. MERV 13 filters remove the majority of fine particles. There is a strong correlation between exposure to fine particles and premature mortality. Other effects of particulate matter exposure include respiratory and cardiovascular disease. Because of these adverse health effects, advances in filtration technology and market availability, removal of fine particulate contaminants by use of filtration is reasonable and achievable. **«»**

C. Systems shall be equipped with air filters that meet either Subsection i or ii below.

i. Nominal two inch minimum depth filter(s); or

ii. Nominal one inch minimum depth filter(s) shall be allowed if the filter(s) are sized according to Equation 160.2-A, based on a maximum face velocity of 150 ft per minute.

D. Filter racks or grilles shall be gasketed or sealed to eliminate any gaps around the filter to prevent air from bypassing the filter.

2. **Natural ventilation.** Naturally ventilated spaces shall be designed in accordance with Sections 160.2(c)2A through 160.2(c)2D.

A. Floor area to be ventilated. Spaces or portions of spaces to be naturally ventilated shall be located within a distance based on the ceiling height, as specified in i, ii and iii. The ceiling height (H) to be used in i, ii or iii shall be the minimum ceiling height in the space, or for ceilings that are increasing in height as distance from the operable openings is increased, the ceiling height shall be determined as the average height of the ceiling within 20 ft from the operable opening. [ASHRAE 62.1:6.4.1.1]

i. Single side opening. For spaces with operable opening on one side of the zone, the naturally ventilated area shall extend to a distance not greater than two times the height (H) of the ceiling from the openings. [ASHRAE 62.1:6.4.1.3]

ii. Double side opening. For zones with openings on two opposite sides of the zone, the naturally ventilated area shall extend between the openings separated by a distance not greater than five times the height of the ceiling. [ASHRAE 62.1:6.4.1.4]

iii. Corner opening. For zones with operable openings on two adjacent sides of a zone, the naturally ventilated area shall extend to a distance not greater than five times the height of the ceiling along a line drawn between the outside edges of the two openings that are the farthest apart. Floor area outside that line shall comply with i as having openings on only one side of the zone. [ASHRAE 62.1:6.4.1.5]

Informative Note: "Floor area outside that line" refers to the remaining area of the zone that is not bounded by the walls that have the openings and the line drawn between the openings.

iv. Ceiling height. The ceiling height (H) to be used in Sections 160.2(c)2Ai through 160.2(c)2Aiii shall be the minimum ceiling height in the space.

Exception to Section 160.2(c)2Aiv: For ceilings that are increasing in height as distance from the opening is increased, the ceiling height shall be determined as the average height of the ceiling within 20 feet from the operable openings. [ASHRAE 62.1:6.4.1.1]

B. Location and size of openings. Zones or portions of zones to be naturally ventilated shall have a permanently open airflow path to openings directly connected to the outdoors. The openable area shall be not less than 4 percent of the net occupiable floor area. Where openings are covered with louvers or otherwise obstructed, the openable area shall be based on the net free unobstructed area through the opening. Where interior rooms, or portions of rooms, without direct openings to the outdoors are ventilated through adjoining rooms, the opening between rooms shall be permanently unobstructed and have a free area of not less than 8 percent of the area of the interior room or less than 25 square feet. [ASHRAE 62.1:6.4.1.6]

C. Control and accessibility. The means to open the required operable opening shall be readily accessible to building occupants whenever the space is occupied. Controls shall be designed to coordinate operation of the natural and mechanical ventilation systems. [ASHRAE 62.1:6.4.3]

D. Naturally ventilated spaces shall also include a mechanical ventilation system designed in accordance with 160.2(c)3.

Exception 1 to Section 160.2(c)2D: Spaces not served by a space-conditioning system.

Exception 2 to Section 160.2(c)2D: Spaces where natural ventilation openings complying with 120.1(c)2 are either permanently open or have controls that prevent the openings from being closed during periods of expected occupancy.

«» Commentary for Section 160.2(c)2:

The way naturally ventilated spaces are calculated in the Energy Code aligns with ASHRAE 62.1. Under these requirements, naturally ventilated spaces or portions of spaces must be permanently open to and within certain distances of operable wall openings to the outdoors. The space being ventilated, the size of the operable opening, and the control of the opening are all considered under these new requirements. Naturally ventilated spaces must also include a mechanical ventilation system designed in accordance with Section 160.2(c)3 except when the spaces are not served by a space-conditioning system or the opening to the outdoors is permanently open or has controls that prevent the opening from being closed during periods of expected occupancy. This requirement for mechanical ventilation back-up to a naturally ventilated space protects the occupants from times or events where the outdoor air is not adequate for ventilation and does not rely on an individual to open the opening.

The space to be naturally ventilated is determined based on the configuration of the walls (cross-ventilation, single-sided or adjacent walls) and the ceiling height. For spaces with an operable opening on only one side of the space, only the floor area within two times the ceiling height from the opening is permitted to be naturally ventilated. For spaces with operable openings on two opposite sides of the space, only the floor areas within five times the ceiling height from the openings are permitted to be naturally ventilated. For spaces with operable openings on two adjacent sides of the space (two sides of a corner), only the floor areas along lines connecting the two openings that are within five times the ceiling height meet the requirement. Floor areas not along these lines connecting the windows must meet the one side opening calculation to be permitted to be naturally ventilated. The ceiling height for all of these cases is the minimum ceiling height, except for when the ceiling is sloped upwards from the opening. In that case, the ceiling height is calculated as the average within 20 feet of the opening.

Zones or portions of zones being naturally ventilated must have a permanently open airflow path to openings directly connected to the outdoors. The minimum openable area is required to be 4 percent of the net occupiable floor area being naturally ventilated. Where openings are covered with louvers or otherwise obstructed, the openable area must be based on the free unobstructed area through the opening. Where interior spaces without direct openings to the outdoors are ventilated through adjoining rooms, the opening between rooms must be permanently unobstructed and have a free area of not less than 8 percent of the area of the interior room nor less than 25 sq. ft.

The means to open required operable openings must be readily accessible to building occupants whenever the space is occupied. The operable opening must be monitored to coordinate the operation of the operable opening and the mechanical ventilation system. **«»**

3. **Mechanical ventilation.** Occupiable spaces shall be ventilated with a mechanical ventilation system capable of providing an outdoor airflow rate (V_z) to the zone no less than the Equation 160.2-H as described below:

V_z = The larger of $R_p \times P_z$ or $R_a \times A_z$ (Equation 160.2-H)

Where:

R_p = 15 cubic feet per minute of outdoor airflow per person

P_z = The expected number of occupants. For spaces without fixed seating, the expected number of occupants shall be the expected number specified by the building designer or the default occupancy density in Table 160.2-B times the occupiable floor area of the zone, whichever is greater. For spaces with fixed seating, the expected number of occupants shall be determined in accordance with the California Building Code Section 1004.6.

R_a = The area-based minimum ventilation airflow rate in Table 160.2-B.

A_z = The net occupiable floor area of the ventilation zone in square feet.

Exception to Section 160.2(c)3: Transfer air. The rate of outdoor air required by Section 160.2(c)3 may be provided with air transferred from other ventilated space if:

i. Use of transfer air is in accordance with Section 160.2(c)8; and

ii. The outdoor air that is supplied to all spaces combined is sufficient to meet the requirements of Section 160.2(c)3 for each space individually.

«» Commentary for Section 160.2(c)3:

Mechanical outdoor ventilation must be provided for all spaces normally occupied. The Energy Code requires that a mechanical ventilation system provide outdoor air equal to or exceeding the ventilation rates required for each of the spaces that it serves. At the space, the required ventilation can be provided either directly through supply air or indirectly through transfer of air from the plenum or an adjacent space. The required minimum ventilation airflow at the space can be provided by an equal quantity of supply or transfer air. At the air-handling unit, the minimum outside air must be the sum of the ventilation requirements of each of the spaces that it serves. The designer may specify higher outside air ventilation rates based on the owner's preference or specific ventilation needs associated with the space. However, specifying more ventilation air than the minimum allowable ventilation rates increases energy consumption and electrical peak demand and increases the costs of operating the HVAC equipment. Thus, the designer should have a compelling reason to specify higher design minimum outside air rates than the calculated minimum outside air requirements.

The minimum outside air (OSA) as measured by acceptance testing, is required to be within 10 percent of the design minimum for both variable air volume (VAV) and constant volume units. The design minimum outside air can be no less than the calculated minimum outside air.

For each space requiring mechanical ventilation, the ventilation rates must be the larger of:

1. The net occupiable floor area (A_z) floor area of the space multiplied by the area outdoor air rate (R_a) from Table 160.2-B of the Energy Code. This provides dilution for the building-borne contaminants like off-gassing of paints and carpets, or
2. For spaces without fixed seating, the expected number of occupants (P_z) is either the number specified by the building designer or the default occupancy density in Table 160.2-B times the occupiable floor area of the zone, whichever is greater. For spaces with fixed seating (such as a theater or auditorium), the expected number of occupants (P_z) is the number of fixed seats or as determined by the California Building Code Section 1004.6. The amount of ventilation is determined by multiplying P_z by the outdoor air rate per person (R_p) of 15 cfm.

Direct Air Transfer

The Energy Code allows air to be directly transferred from one space to another to meet part of the ventilation supply, provided the total outdoor quantity required by all spaces served by the building's ventilation system is supplied by the mechanical systems. This method can be used for any space, but is particularly applicable to conference rooms, toilet rooms, and other rooms that have high ventilation requirements. Transfer air may be a mixture of air from multiple spaces or locations, in which case the air mixture must be classified at the mixed highest classification. Transfer air must meet the requirements of air classification and recirculation limitations, as described in Section 160.2(c)8.

Air may be transferred using any method that ensures a positive airflow. Examples include dedicated transfer fans, exhaust fans, and fan powered VAV boxes. A system having a ducted return may be balanced so that air naturally transfers into the space. Exhaust fans serving the space may discharge directly outdoors, or into a return plenum. Transfer systems should be designed to minimize recirculation of transfer air back into the space; duct work should be arranged to separate the transfer air intake and return points.

When each space in a two-space building is served by a separate constant volume system, the calculation and application of ventilation rate is straightforward, and each space will always receive its design outdoor air quantity. However, a central system serving both spaces does not deliver the design outdoor air quantity to each space. Instead, one space receives more than its allotted share, and the other less. This is because some spaces have a higher design outdoor ventilation rate and/or a lower cooling load relative to the other space. **«»**

4. **Exhaust ventilation.** The design exhaust airflow shall be determined in accordance with the requirements in Table 160.2-C. Exhaust makeup air shall be permitted to be any combination of outdoor air, recirculated air or transfer air. [ASHRAE 62.1:6.5.1]

«» Commentary for Section 160.2(c)4:

The exhaust ventilation requirements are aligned with ASHRAE 62.1 and require certain occupancy categories to be exhausted to the outdoors. Exhaust flow rates must meet or exceed the minimum rates specified in Table 160.2-C of the Energy Code. The spaces listed are expected to have contaminants not generally found in adjacent occupied spaces. Therefore, the air supplied to the space to replace the air exhausted may be any combination of outdoor air, recirculated air, and transfer air – all of which are expected to have low or zero concentration of the pollutants generated in the listed spaces. For example, the exhaust from a toilet room can draw air from either the outdoors, adjacent spaces, or from a return air duct or plenum. Because these sources of makeup air have essentially zero concentration of toilet-room odors, they are equally good at diluting odors in the toilet room.

The rates specified must be provided during all periods when the space is expected to be occupied, similar to the requirement for ventilation air. **«»**

5. **Operation and control requirements for minimum quantities of outdoor air**.

   A. **Times of occupancy.** The minimum rate of outdoor air required by Section 160.2(c) shall be supplied to each space at all times when the space is usually occupied.

   Exception 1 to Section 160.2(c)5A: Demand control ventilation. In intermittently occupied spaces that do not have processes or operations that generate dusts, fumes, mists, vapors or gases and are not provided with local exhaust ventilation (such as indoor operation of internal combustion engines or areas designated for unvented food service preparation), the rate of outdoor air may be reduced if the ventilation system serving the space is controlled by a demand control ventilation device complying with Section 160.2(c)5D or by an occupant sensor ventilation control device complying with Section 160.2(c)5E.

   Exception 2 to Section 160.2(c)5A: Temporary reduction. The rate of outdoor air provided to a space may be reduced below the level required by Section 160.2(c) for up to 30 minutes at a time if the average rate for each hour is equal to or greater than the required ventilation rate.

«» Commentary for Section 160.2(c)5A:

While Section 160.2(c)5A requires that ventilation be continuous during normally occupied hours when the space is usually occupied, Exception 2 allows the ventilation to be disrupted for not more than 30 minutes at a time. In this case, the ventilation rate during the time the system is ventilating must be increased so the average rate over the hour is equal to the required rate.

It is important to review any related ventilation and fan cycling requirements in Title 8, which is the Division of Occupational Safety and Health (Cal/OSHA) regulations. Section 5142 specifies the operational requirements related to HVAC minimum ventilation. It states:

Operation:

1. The HVAC system shall be maintained and operated to provide at least the quantity of outdoor air required by the State Building Standards Code, Title 24, Part 2, California Administrative Code, in effect at the time the building permit was issued.
2. The HVAC system shall be operated continuously during working hours except:
3. During scheduled maintenance and emergency repairs.

Title 8, California Code of Regulations, Section 5142(a)(1) refers to Title 24, Part 2 (the California Building Code) for the minimum ventilation requirements. Section 1203 in the California Building Code specifies the ventilation requirements, but simply refers to the California Mechanical Code, which is Title 24, Part 4.

Chapter 4 in the California Mechanical Code specifies the ventilation requirements. Section 402.3 states, "The system shall operate so that all rooms and spaces are continuously provided with the required ventilation rate while occupied." Section 403.5.1 states, "Ventilation systems shall be designed to be capable of providing the required ventilation rates in the breathing zone whenever the zones served by the system are occupied, including all full and part-load conditions." In addition, Section 403.6 states, "The system shall be permitted to be designed to vary the design outdoor air intake flow or the space or zone airflow as operating conditions change." This provides further validation to fan cycling as operating conditions change between occupied and unoccupied. A vacant zone has no workers present and is thus not subject to working hours requirements until the zone is actually occupied by a worker. Finally, Title 24, Part 4, states; "Ventilation air supply requirements for occupancies regulated by the California Energy Commission are found in the California Energy Code." Thus, it refers to Title 24, Part 6 as the authority on ventilation.

Title 8 Section 5142(a)(2) states, "The HVAC system shall be operated continuously during working hours." This regulation does not indicate that the airflow, cooling, or heating needs to be continuous. If the HVAC system is designed to maintain average ventilation with a fan cycling algorithm and is active in that mode providing average ventilation air as required during working hours, it is considered to be operating continuously per its mode and sequence. During unoccupied periods, the HVAC system is turned off except for setback and it no longer operates continuously. During the occupied period, occupant sensors or CO_2 sensors in the space provide continuous monitoring and the sequence is operating, cycling the fan and dampers as needed to maintain the ventilation during the occupied period. The HVAC system is operating with the purpose of providing ventilation, heating, and cooling continuously during the working hours. The heater, air conditioner, fans, and dampers all cycle on and off subject to their system controls to meet the requirements during the working hours.

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

B. **Preoccupancy.** The lesser of the minimum rate of outdoor air required by Section 160.2(c) or three complete air changes shall be supplied to the entire building during the 1-hour period immediately before the building is normally occupied.

«» Commentary for Section 160.2(c)5B:

Since many indoor air pollutants are out gassed from the building materials and furnishings, the Energy Code ventilation options are described for preoccupancy per Section 160.2(c)5B. Immediately prior to occupancy, outdoor ventilation must be provided in an amount equal to the lesser of:

1. The minimum required ventilation rate for 1 hour
2. Three complete air changes

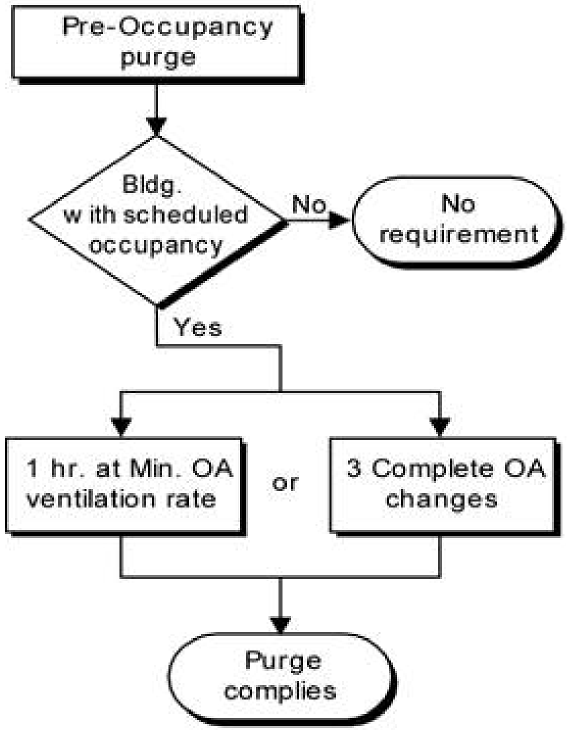
Either criterion can be used to comply with the Energy Code. This air may be introduced at any rate provided for and allowed by the system, so that the actual purge period may be less than an hour.

Pre-occupancy ventilation is not required for buildings or spaces that are not occupied on a scheduled basis, such as storage rooms. Also, a this is not required for spaces provided with natural ventilation.

Where pre-occupancy purge is required, it does not have to be coincident with morning warm-up (or cool-down). The simplest way to integrate the two controls is to schedule the system to be occupied one hour prior to the actual time of anticipated occupancy. This allows the optimal start, warm-up, or pull-down routines to bring the spaces up to (or down to) desired temperatures before opening the outdoor air damper for ventilation. This will reduce the required system heating capacity and ensure that the spaces will be at the desired temperatures and fully purged at the start of occupancy.

However, for spaces with occupancy controls which turn ventilation off when occupancy is not sensed, care must be taken in specifying controls and control sequences that the lack of sensed occupancy does not disable or override ventilation during the pre-occupancy purge period.

Figure 4-13: Pre-Occupancy Purge Flowchart



Source: California Energy Commission

«»

C. **Required demand control ventilation.** Demand ventilation controls complying with Section 160.2(c)5D are required for a space with a design occupant density, or a maximum occupant load factor for egress purposes in the CBC, greater than or equal to 25 people per 1000 square feet (40 square feet or less per person) if the system serving the space has one or more of the following:

i. an air economizer; or

ii. modulating outside air control; or

iii. design outdoor airflow rate > 3,000 cfm.

«» Commentary for Section 160.2(c)5C:

Demand control ventilation (DCV) systems reduce the amount of ventilation supply air in response to a measured level of carbon dioxide (CO2) in the breathing zone, thereby saving energy. The Energy Code only permits CO2 sensors, as discussed below, for the purpose of meeting this requirement; volatile organic compounds (VOC) and so-called "indoor air quality (IAQ)" sensors are not approved as alternative devices to meet this requirement. The Energy Code only permits DCV systems to vary the ventilation component that corresponds to occupant bioeffluents (this is the basis for the 15 cfm/person portion of the ventilation requirement in Section 160.2(c)3). The purpose of CO2 sensors is to track occupancy in a space; however, there are many factors that must be considered when designing a DCV system. There is often a lag time in the detection of occupancy through the build-up of CO2.

This lag time may be increased by any factors that affect mixing, such as short circuiting of supply air or inadequate air circulation, as well as sensor placement and sensor accuracy. Build-up of odors, bioeffluents, and other health concerns may also delay changes in occupancy. Therefore, the designers must be careful to specify CO2 based DCV systems that are designed to provide adequate ventilation to the space by ensuring proper mixing, avoiding short circuiting, and proper placement and calibration of the sensors. **«»**

Exception 1 to Section 160.2(c)5C: Where space exhaust is greater than the design ventilation rate specified in Section 160.2(c)3 minus 0.2 cfm per ft² of conditioned area.

«» Commentary for Section 160.2(c)5C:

This exception relates to the fact that spaces with high exhaust requirements won't be able to provide sufficient turndown to justify the cost of the DCV controls. An example of this is a restaurant seating area where the seating area air is used as make-up air for the kitchen hood exhaust. **«»**

Exception 2 to Section 160.2(c)5C: Spaces that have processes or operations that generate dusts, fumes, mists, vapors or gases and are not provided with local exhaust ventilation, such as indoor operation of internal combustion engines or areas designated for unvented food service preparation, daycare sickrooms, science labs, barber shops or beauty and nail salons, shall not install demand control ventilation.

«» Commentary for Section 160.2(c)5C:

This exception recognizes that some spaces may need additional ventilation due to contaminants that are not occupant borne. It addresses spaces like theater stages where theatrical fog may be used or movie theater lobbies where unvented popcorn machines may be emitting odors and vapors into the space in either case justifying the need for higher ventilation rates. DCV devices shall not be installed in spaces included in this exception. **«»**

Exception 3 to Section 160.2(c)5C: Spaces with an area of less than 150 square feet or a design occupancy of less than 10 people as specified by Section 160.2(c)3.

«» Commentary for Section 160.2(c)5C:

This recognizes the fact that DCV devices may not be cost effective in small spaces such as a 15 ft. by 10 ft. conference room or spaces with only a few occupants at design conditions. **«»**

D. **Demand control ventilation devices.**

i. For each system with demand control ventilation (DCV), CO_2 sensors shall be installed in each room that meets the criteria of Section 160.2(c)5C with no less than one sensor per 10,000 ft² of floor space. When a zone or a space is served by more than one sensor, a signal from any sensor indicating that CO_2 is near or at the setpoint within the zone or space shall trigger an increase in ventilation.

«» Commentary for Section 160.2(c)5Di:

When a zone or a space is served by more than one sensor, signals from any sensor indicating that CO2 is near or at the set point within a space, must trigger an increase in ventilation to the space. This requirement ensures that the space is adequately ventilated in case a sensor malfunctions. Design professionals should ensure that sensors are placed throughout a large space, so that all areas are monitored by a sensor. «»

ii. CO_2 sensors shall be located in the room between 3 ft and 6 ft above the floor or at the anticipated height of the occupants' heads.

iii. Demand ventilation controls shall maintain CO_2 concentrations less than or equal to 600 ppm plus the outdoor air CO_2 concentration in all rooms with CO_2 sensors.

Exception to Section 160.2(c)5Diii: The outdoor air ventilation rate is not required to be larger than the design outdoor air ventilation rate required by Section 160.2(c)3 regardless of CO_2 concentration.

iv. Outdoor air CO_2 concentration shall be determined by one of the following:

a. CO_2 concentration shall be assumed to be 400 ppm without any direct measurement; or

b. CO_2 concentration shall be dynamically measured using a CO_2 sensor located within 4 ft of the outdoor air intake.

«» Commentary for Section 160.2(c)5Dii-iv:

The ambient levels of CO2 can either be assumed to be 400 ppm or dynamically measured by a sensor that is installed within four feet of the outdoor air intake. At 400 ppm outside CO2 concentration, the resulting DCV CO2 set point would be 1000 ppm. (A 600-ppm differential is less than the 700 ppm that corresponds to the 15 cfm/person ventilation rate. This provides a margin of safety against sensor error, and because 1000 ppm CO2 is a commonly recognized guideline value and referenced in earlier versions of ASHRAE Standard 62.) Note that the 1,000 ppm setpoint required by Title 24 is not the same approach to DCV as specified in the current version of ASHRAE 62.1 or ASHRAE 90.1 which do not have a fixed CO2 target for all spaces, and ASHRAE Standards 90.1 and 62.1 have lower ventilation rates per person. «»

v. When the system is operating during hours of expected occupancy, the controls shall maintain system outdoor air ventilation rates no less than Ra × Az per Equation 160.2-H for each space with a CO_2 sensor(s), plus the greater of either the exhaust air rate or the rate required by Section 160.2(c)3 for other spaces served by the system.

«» Commentary for Section 160.2(c)5Dv:

Regardless of the CO_2 sensor's reading, the system is not required to provide more than the minimum ventilation rate required by Section 160.2(c)3. This prevents a faulty sensor reading from causing a system to provide more than the code required ventilation for system without DCV control. This high limit can be implemented in the controls.

The system shall always provide a minimum ventilation of the sum of the minimum air rate for all spaces served by the system. This is a low limit setting that must be implemented in the controls. «»

vi. CO_2 sensors shall be certified by the manufacturer to be accurate within plus or minus 75 ppm at a 600 and 1000 ppm concentration when measured at sea level and 25°C, factory calibrated, and certified by the manufacturer to require calibration no more frequently than once every 5 years. Upon detection of sensor failure, the system shall provide a signal that resets to supply the minimum quantity of outside air to levels required by Section 160.2(c)3 to the zone serviced by the sensor at all times that the zone is occupied.

«» Commentary for Section 160.2(c)5Dvi:

A number of manufacturers now have self-calibrating sensors that either adjust to ambient levels during unoccupied times or adjust to the decrease in sensor bulb output through use of dual sources or dual sensors. For all systems, sensor manufacturers must provide a document to installers that their sensors meet these requirements. The installer must make this certification information available to the builder, building inspectors and, if specific sensors are specified on the plans, to plan checkers.

The sensor failure reset signal ensures that the space is adequately ventilated in case a sensor malfunctions. A sensor that provides a high CO2 signal on sensor failure will comply with this requirement. «»

vii. The CO_2 sensor(s) reading for each zone shall be displayed continuously, and shall be recorded on systems with digital direct controls (DDC) to the zone level.

«» Commentary for Section 160.2(c)5Dvii:

The energy management control system (EMCS) may be used to display and record the sensors' readings. The display(s) must be readily available to maintenance staff so they can monitor the system's performance. «»

E**. Occupied-Standby Zone Controls.**

i. Space conditioning zones shall include occupied standby controls complying with Table 160.2-B when all of the following are true:

a. All rooms served by the zone are permitted to have their ventilation air reduced to zero while in occupied-standby mode per Table 160.2-B; and

b. Occupant sensors are required by Section 160.5(b)4Cv and vi; and

c. The zone and ventilation system is not served by a pneumatic controls.

ii. Occupied-standby zone controls shall comply with the following:

a. Occupant sensors shall have suitable coverage and placement to detect occupants in the entire space. In 20 minutes or less after no occupancy is detected by any sensors covering the room, occupant sensing controls shall indicate a room is vacant.

b. When occupant sensors controlling lighting are also used for ventilation, the ventilation signal shall be independent of daylighting, manual lighting overrides or manual control of lighting.

c. When a single zone damper or a single zone system serves multiple spaces, there shall be an occupant sensor in each space and the zone shall not be considered vacant until all spaces in the zone are vacant.

d. One hour prior to normal scheduled occupancy, the occupant sensor ventilation control shall allow preoccupancy purge as described in Section 160.2(c)5B.

e. When the zone is scheduled to be occupied and occupant sensing controls in all spaces served by the zone indicate the spaces are unoccupied, the zone shall be placed in occupied- standby mode.

f. In 5 minutes or less after entering occupied-standby mode, mechanical ventilation to the zone shall be shut off until the space becomes occupied or until ventilation is needed to provide space heating or conditioning. When mechanical ventilation is shut off to the zone, the ventilation system serving the zone shall reduce the system outside air rate by the amount of outside air required for the zone.

g. Where the system providing space conditioning also provides ventilation to the zone, in 5 minutes or less after entering occupied-standby mode, space-conditioning zone setpoints shall be reset in accordance with Section 120.2(e)3.

«» Commentary for Section 160.2(c)5E:

The use of occupied-standby zone controls is mandated for spaces that are also required to use occupant sensing controls to meet the requirements for lighting shut-off controls per Section 160.5(b)4Cv and vi. Example spaces include offices, multipurpose rooms 1,000 sq. ft. or less, conference rooms, and other spaces where the space ventilation is allowed to be reduced to zero in Table 160.2-B. (See note F in the right-hand column of the table).

The HVAC system shall be controlled by an occupancy sensing control that resets temperature setpoints and ventilation air in accordance with Section 160.2(c)5E and 160.3(a)2Diii when a space meets both the following conditions.

1. Section 160.5(b)4Cv and vi specify that occupant sensing, as opposed to time-switch, is required to implement shutoff controls.
2. Table 160.2-B specifies that ventilation air in the space is allowed to be reduced to zero when the space is in occupied standby mode.
3. The zone and ventilation system are not served by pneumatic controls.

Table 4-4: Multifamily Common Use Occupancy Categories Qualifying for Occupied Standby Control Requirements lists all the occupancy categories that meet the conditions above and thus are required to install occupied standby controls if the ventilation zone is serving only qualifying spaces.

Table 4-4: Multifamily Common Use Occupancy Categories Qualifying for Occupied Standby Control Requirements

Occupancy Category
Multiuse assembly (only those less than 1,000 square feet)
Corridors
Office Space
Conference/meeting

Source: California Energy Commission

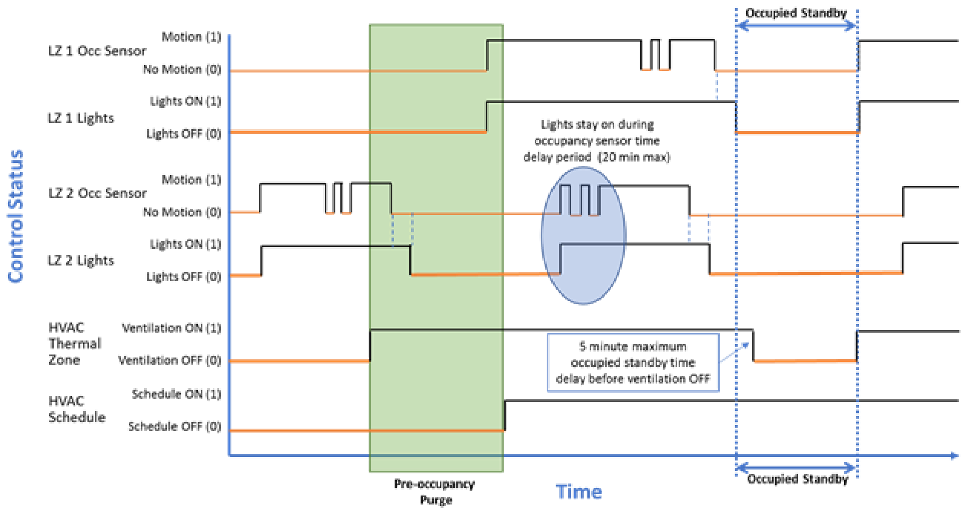
Occupied-standby zone controls are used to implement "occupied standby control." This control is used when the HVAC is scheduled to be ON, but occupancy sensors do not detect any activity in the spaces served by the HVAC zone. Occupant sensing controls must indicate the zone to be vacant within 20 min of the occupancy sensors covering the zone detects no occupancy. During occupied standby, zone temperatures are reset (higher cooling setpoint and lower heating setpoint) and during times when there is neither a call for cooling nor heating the ventilation air is shut off to the zone. When ventilation air is shut off to the zone, the ventilation system serving the zone shall reduce the system outside air by the same amount of outside air reduced at the individual zone.

For example, if a DOAS unit is used to ventilate multiple spaces without any downstream modulation controls then the entire DOAS unit is treated as one ventilation zone for the purposes of the occupied standby requirement and would only be subject to use occupied-standby controls if all ventilated spaces were listed under Table 4-4: Multifamily Common Use Occupancy Categories Qualifying for Occupied Standby Control Requirements. To comply, the unit would be required to implement occupied standby controls to reduce ventilation to zero (i.e., shut off the DOAS unit) and operate independent of the space-conditioning setpoints.

Additionally, if a DOAS unit features any ventilation modulation controls downstream of the DOAS unit, then any branches of ventilation air with modulation control shall be considered a separate ventilation zone for the purposes of this requirement.

The ventilation zone may be serving more than one room, in which case all rooms served by the space conditioning zone must be sensed as unoccupied before the system is placed in occupied standby mode. The illustration below (Figure 4-14 Control Sequence Diagram of Occupied Standby Control of HVAC Thermal Zone Serving Two Lighting Zones (LZ1 and LZ2)) provides an example of the sequence of events for two rooms (LZ1 and LZ2) served by one ventilation zone and how the occupant-sensing lighting controls relate to the HVAC ventilation controls.

Figure 4-14 Control Sequence Diagram of Occupied Standby Control of HVAC Thermal Zone Serving Two Lighting Zones (LZ1 and LZ2)



Source: California Energy Commission

«»

6. **Ducting for zonal heating and cooling units.** Where a return plenum is used to distribute outdoor air to a zonal heating or cooling unit that then supplies the air to a space in order to meet the requirements of Section 160.2(c)3, the outdoor air shall be ducted to discharge either:

   A. Within 5 feet of the unit; or

   B. Within 15 feet of the unit, substantially toward the unit and at a velocity not less than 500 feet per minute.

«» Commentary for Section 160.2(c)6B:

Water source heat pumps and fan coils are the most common application of this configuration. The unit fans should be controlled to run continuously during occupancy in order for the ventilation air to be circulated to the occupied space.

Not all spaces are required to have a direct source of outdoor air. Transfer air is allowed from adjacent spaces with direct outdoor air supply if the system supplying the outdoor air is capable of supplying the required outdoor air to all spaces at the same time. Air classification and recirculation limitations will apply, as explained above. An example of an appropriate use of transfer would be in buildings having central interior space-conditioning systems with outdoor air supply, and zonal units on the perimeter without a direct outdoor air supply. «»

7. **Design and control requirements for quantities of outdoor air**.

   A. All mechanical ventilation and space-conditioning systems shall be designed with and have installed ductwork, dampers and controls to allow outside air rates to be operated at the minimum levels specified in Section 160.2(c)3 or the rate required for make-up of exhaust systems that are required for an exempt or covered process, for control of odors or for the removal of contaminants within the space.

B. All variable air volume mechanical ventilation and space-conditioning systems shall include dynamic controls that maintain measured outside air ventilation rates within 10 percent of the required outside air ventilation rate at both full and reduced supply airflow conditions. Fixed minimum damper position is not considered to be dynamic and is not an allowed control strategy.

C. Measured outdoor air rates of constant volume mechanical ventilation and space-conditioning systems shall be within 10 percent of the required outside air rate.

8. **Air classification and recirculation limitations.** Air classification and recirculation limitations of air shall be based on the air classification as listed in Table 160.2-B or Table 160.2-D, in accordance with the following:

A. Class 1 air is air with low contaminant concentration, low sensory-irritation intensity or inoffensive odor. Recirculation or transfer of Class 1 air to any space shall be permitted; [ASHRAE 62.1:5.13.3.1]

B. Class 2 air is air with moderate contaminant concentration, mild sensory-irritation intensity or mildly offensive odor (Class 2 air also includes air that is not necessarily harmful or objectionable but that is inappropriate for transfer or recirculation to spaces used for different purposes). Recirculation or transfer of Class 2 air shall be permitted in accordance with Sections 160.2(c)8Bi through 160.2(c)8Bv:

i. Recirculation of Class 2 air within the space of origin shall be permitted [ASHRAE 62.1:5.13.3.2.1].

ii. Recirculation or transfer of Class 2 to other Class 2 or Class 3 spaces shall be permitted, provided that the other spaces are used for the same or similar purpose or task and involve the same or similar pollutant sources as the Class 2 space [ASHRAE 62.1:5.13.3.2.2]; or

iii. Transfer of Class 2 air to toilet rooms [ASHRAE 62.1:5.13.3.2.3]; or

iv. Recirculation or transfer of Class 2 air to Class 4 spaces [ASHRAE 62.1:5.13.3.2.4]; or

v. Class 2 air shall not be recirculated or transferred to Class 1 spaces. [ASHRAE 62.1:5.13.3.2.5]

Exception to Section 160.2(c)8Bv: When using any energy recovery device, recirculation from leakage, carryover or transfer from the exhaust side of the energy recovery device is permitted. Recirculated Class 2 air shall not exceed 10 percent of the outdoor air intake flow.

«» Commentary for Section 160.2(c)8B:

Some examples spaces that might use class 2 air include warehouses, restaurants, and auto repair rooms. «»

C. Class 3 air is air with significant contaminant concentration, significant sensory-irritation intensity or offensive odor. Recirculation or transfer of Class 3 air shall be permitted in accordance with Sections 160.2(c)8Ci and 160.2(c)8Cii:

   i. Recirculation of Class 3 air within the space of origin shall be permitted. [ASHRAE 62.1:5.13.3.3.1]

   ii. Class 3 air shall not be recirculated or transferred to any other space. [ASHRAE 62.1:5.13.3.3.2].

   Exception to Section 160.2(c)8Cii: When using any energy recovery device, recirculation from leakage, carryover or transfer from the exhaust side of the energy recovery device is permitted. Recirculated Class 3 air shall not exceed 5 percent of the outdoor air intake flow.

«» Commentary for Section 160.2(c)8C:

Some examples of spaces that might use Class 3 air include general manufacturing, excluding heavy industrial and processes using chemicals and janitor closets. «»

D. Class 4 air is air with highly objectionable fumes or gases or with potentially dangerous particles, bioaerosols or gases at concentrations high enough to be considered as harmful. Class 4 air shall not be recirculated or transferred to any space or recirculated within the space of origin. [ASHRAE 62.1:5.13.3.4]

«» Commentary for Section 160.2(c)8D:

Some examples of spaces that might use Class 4 air include spray paint booths and chemical storage rooms. «»

E. Ancillary spaces. Redesignation of Class 1 air to Class 2 air shall be permitted for Class 1 spaces that are ancillary to Class 2 spaces. [ASHRAE 62.1:5.13.2.3]

F. Transfer. A mixture of air that has been transferred through or returned from spaces or locations with different air classes shall be redesignated with the highest classification among the air classes mixed. [ASHRAE 62.1:5.13.2.2]

G. Classification. Air leaving each space or location shall be designated at an expected air-quality classification not less than that shown in Table 160.2-B, 160.2-C or 160.2-D. Air leaving spaces or locations that are not listed in Table 160.2-B, 160.2-C or 160.2-D shall be designated with the same classification as air from the most similar space or location listed in terms of occupant activities and building construction.

«» Commentary for Section 160.2(c)8G:

This section contains air classification, a process that assigns an air class number based on the occupancy category then sets limits on transferring or recirculating that air. This offers designers clear guidance on what can and cannot be used for transfer, makeup, or recirculation air. «»

(d) Parking garages. Mechanical ventilation systems for enclosed parking garages in multifamily buildings shall comply with Section 120.6(c).

TABLE 160.2-B – Minimum Occupant Load Density and Ventilation Rates for Multifamily Common Use Areas

Space Type	Minimum Occupant Load Density (p/1000 ft²)[1]	Area-based Minimum Ventilation Ra (cfm/ft²)	Air Class	Notes
Bars, cocktail lounges	33	0.2	2	
Break rooms	33	0.15	1	F
Coffee stations	33	0.15	1	F
Conference/meeting	33	0.15	1	F
Corridors	5	0.15	1	F
Computer (not printing)	5	0.15	1	F
Daycare (through age 4)	14	0.15	2	
Dining rooms	33	0.15	2	
Disco/dance floors	100	0.15	2	F
Freezer and refrigerated spaces (<50oF)	0	0	2	E
Game arcades	45	0.15	1	
Gym, sports arena (play area)	10	0.15	2	E
Health club/aerobics room/weight rooms	10	0.15	2	
Kitchen (cooking)	3	0.15	2	
Laundry rooms, central	5	0.15	2	
Lobbies/pre-function	33	0.15	1	F
Multiuse assembly	33	0.15	1	F
Occupiable storage	2	0.15	1	

rooms for dry materials				
Occupiable storage rooms for liquids or gels	2	0.15	2	B
Office space	5	0.15	1	F
Reception areas	5	0.15	1	F
Shipping/receiving	2	0.15	2	B
Spectator areas	33	0.15	1	F
Swimming (deck)	33	0.15	2	C
Swimming (pool)	10	0.15	2	C
Telephone/data entry	33	0.15	1	F
All others	5	0.15	2	

General:

1. The minimum occupant density is one half of the maximum occupant load assumed for egress purposes in the CBC.
2. If this column specifies a minimum cfm/ft^2 then it shall be used to comply with Section160.2(c)5E.
3. For spaces not included in this table, the spaces in Table 120.1-A shall apply.

Specific Notes:

A – RESERVED
B – Rate may not be sufficient where stored materials include those having potentially harmful emissions.
C – Rate does not allow for humidity control. "Deck area" refers to the area surrounding the pool that is capable of being wetted during pool use or when the pool is occupied. Deck area that is not expected to be wetted shall be designated as an occupancy category.
D – RESREVED.
E – Where combustion equipment is intended to be used on the playing surface or in the space, additional dilution ventilation, source control, or both shall be provided.
F – Ventilation air for this occupancy category shall be permitted to be reduced to zero when the space is in occupied-standby mode.

TABLE 160.2-C – Minimum Exhaust Rates
[ASHRAE 62.1: TABLE 6-2]

Occupancy Category[3]	**Exhaust Rete, cfm/unit**	**Exhaust Rate, cfm/ft^2**	**Air Class**	**Notes**
Copy, printing rooms	-	0.50	2	-
Janitor closets, trash rooms, recycling	-	1.00	3	-
Kitchenettes	-	0.30	2	-
Kitchens – commercial	-	0.70	2	-
Locker rooms for athletic or industrial facilities	-	0.50	2	-
All other locker rooms	-	0.25	2	-
Shower rooms	20/50	-	2	G, H
Parking garages	-	0.75	2	C
Pet shops (animal areas)	-	0.90	2	-
Soiled laundry storage rooms	-	1.00	3	F
Storage rooms, chemical	-	1.50	4	F
Toilets – private	25/50	-	2	E
Toilets – public	50/70	-	2	D

General:

3 For spaces not included in this table, the spaces in Table 120.1-B shall apply.

Notes:

A –Reserved
B –Reserved
C – Exhaust shall not be required where two or more sides comprise walls that are at least 50% open to the outside.
D – Rate is per water closet, urinal, or both. Provide the higher rate where periods of heavy use are expected to occur. The lower rate shall be permitted to be used otherwise.
E – Rate is for a toilet room intended to be occupied by one person at a time. For continuous systems operation during hours of use, the lower rate shall be permitted to be used. Otherwise the higher rate shall be used.
F – See other applicable standards for exhaust rate.
G – For continuous system operation, the lower rate shall be permitted to be used. Otherwise the higher rate shall be used.
H – Rate is per showerhead.

TABLE 160.2-D – Airstreams or Sources
[ASHRAE 62.1:Table 6-3]

Description	**Air Class**
Commercial kitchen grease hoods	4
Commercial kitchen hoods other than grease	3
Hydraulic elevator machine room	2
Refrigerating machinery rooms	3

Table 160.2-E: Demand-Controlled Local Ventilation Exhaust Airflow Rates and Capture Efficiency

Application	**Compliance Criteria**
Enclosed Kitchen or Nonenclosed Kitchen	Vented range hood, including appliance-range hood combinations shall meet either the capture efficiency (CE) or the airflow rate specified in Table 160.2-G as applicable.
Enclosed Kitchen or Nonenclosed Kitchen	Other kitchen exhaust fans, including downdraft: 300 cfm (150 L/s).
Bathroom	50 cfm (25 L/s)

Table 160.2-F: Continuous Local Ventilation Exhaust Airflow Rates

Application	**Airflow**
Enclosed kitchen	5 ach, based on kitchen volume
Bathroom	20 cfm (10 L/s)

Table 160.2-G: Kitchen Range Hood Airflow Rates (cfm) and ASTM E3087 Capture Efficiency (CE) Ratings According to Dwelling Unit Floor Area and Kitchen Range Fuel Type

Dwelling Unit Floor Area (ft^2)	**Hood Over Electric Range**	**Hood Over Natural Gas Range**
>1500	50% CE or 110 cfm	70% CE or 180 cfm
>1000 - 1500	50% CE or 110 cfm	80% CE or 250 cfm
750 - 1000	55% CE or 130 cfm	85% CE or 280 cfm
<750	65% CE or 160 cfm	85% CE or 280 cfm

Table 160.2-H: Prescriptive Ventilation System Duct Sizing [ASHRAE 62.2:Table 5-3]

Fan Airflow Rating, cfm at minimum static pressuref 0.25 in. water (L/s at minimum 62.5 Pa)	≤50 (25)	≤80 (40)	≤100 (50)	≤125 (60)	≤150 (70)	≤175 (85)	≤200 (95)	≤250 (120)	≤350 (165)	≤400 (190)	≤450 (210)	≤700 (330)	≤800 (380)
Minimum Duct Diameter, in. (mm) a,b For Rigid duct	4[e] (100)	5 (125)	5 (125)	6 (150)	6 (150)	7 (180)	7 (180)	8 (205)	9 (230)	10 (255)	10 (255)	12 (305)	12 d (305)
Minimum Duct Diameter, in. (mm) a,b For Flex duct c	4 (100)	5 (125)	6 (150)	6 (150)	7 (150)	7 (180)	8 (205)	8 (205)	9 (230)	10 (255)	NP	NP	NP

Footnotes for Table 150.0-H:

a. For noncircular ducts, calculate the diameter as four times the cross-sectional area divided by the perimeter.

b. NP = application of the prescriptive table is not permitted for this scenario.

c. Use of this table for verification of flex duct systems requires flex duct to be fully extended and any flex duct elbows to have a minimum bend radius to duct diameter ratio of 1.0.

d. For this scenario, use of elbows is not permitted.

e. For this scenario, 4 in. (100 mm) oval duct shall be permitted, provided the minor axis of the oval is greater than or equal to 3 in. (75 mm)

f. When a vented range hood utilizes a capture efficiency rating to demonstrate compliance with 160.2(b)2Avic2, a static pressure greater than or equal to 0.25 in. of water at the rating point shall not be required, and the airflow listed in the approved directory corresponding to the compliant capture efficiency rating point shall be applied to Table 160.2-H for determining compliance.

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

SECTION 160.3 – MANDATORY REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS IN MULTIFAMILY BUILDINGS

Space conditioning systems serving multifamily dwelling units and common use areas shall comply with the applicable requirements of Sections 160.3(a) through 160.3(c).

(a) Controls. Space-conditioning systems serving dwelling units and common use areas in multifamily buildings shall comply with applicable requirements of Section 160.3(a)1 or 160.3(a)2.

1. **Dwelling unit thermostats.** All heating or cooling systems, including heat pumps, not controlled by a central energy management control system (EMCS) shall have a setback thermostat, as specified in Section 110.2(c).
2. **Common use area controls**. Heating or cooling systems serving common use areas of multifamily buildings shall comply with application requirements of Sections 160.3(a)2A through 160.3(a)2J.

   Exception to Section 160.3(a)2: Heating or cooling systems exclusively serving dwelling units and common use areas providing shared provisions for living, eating, cooking or sanitation to dwelling units that would otherwise lack these provisions may instead comply with Section 160.3(a)1.

   A. **Thermostatic controls for each zone.** The supply of heating and cooling energy to each space-conditioning zone shall be controlled by an individual thermostatic control that responds to temperature within the zone and that meets the applicable requirements of Section 160.3(a)2B. An energy management control system (EMCS) may be installed to comply with the requirements of one or more thermostatic controls if it complies with all applicable requirements for each thermostatic control.

   Exception to Section 160.3(a)2A: An independent perimeter heating or cooling system may serve more than one zone without individual thermostatic controls if:

   i. All zones are also served by an interior cooling system; and

   ii. The perimeter system is designed solely to offset envelope heat losses or gains; and

   iii. The perimeter system has at least one thermostatic control for each building orientation of 50 feet or more; and

   iv. The perimeter system is controlled by at least one thermostat located in one of the zones served by the system.

   B. **Criteria for zonal thermostatic controls.** The individual thermostatic controls required by Section 160.3(a)2A shall meet the following requirements as applicable:

i. Where used to control comfort heating, the thermostatic controls shall be capable of being set, locally or remotely, down to 55°F or lower.

ii. Where used to control comfort cooling, the thermostatic controls shall be capable of being set, locally or remotely, up to 85°F or higher.

iii. Where used to control both comfort heating and comfort cooling, the thermostatic controls shall meet Items i and ii and shall be capable of providing a temperature range or deadband of at least 5°F within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

Exception to Section 160.3(a)2Biii: Systems with thermostats that require manual changeover between heating and cooling modes.

iv. Thermostatic controls for all single zone air conditioners and heat pumps shall comply with the requirements of Sections 110.2(c) and 110.12(a) and, if equipped with DDC to the zone level, with the automatic demand shed controls of Section 110.12(b).

Exception to Section 160.3(a)2Biv: Package terminal air conditioners, package terminal heat pumps, room air conditioners and room air-conditioner heat pumps.

C. **Heat pump controls.**

All heat pumps with supplementary electric resistance heaters shall be installed with controls that comply with Section 110.2(b).

D. **Shut-off and reset controls for space-conditioning systems.** Each space-conditioning system shall be installed with controls that comply with the following:

i. The control shall be capable of automatically shutting off the system during periods of nonuse and shall have:

a. An automatic time switch control device complying with Section 110.9, with an accessible manual override that allows operation of the system for up to 4 hours; or

b. An occupancy sensor; or

c. A 4-hour timer that can be manually operated.

ii. The control shall automatically restart and temporarily operate the system as required to maintain:

a. A setback heating thermostat setpoint if the system provides mechanical heating; and

Exception to Section 160.3(a)2Diia: Thermostat setback controls are not required in multifamily buildings in areas where the Winter Median of Extremes outdoor air temperature determined in accordance with Section **170.2(c)1C** is greater than 32°F.

b. A setup cooling thermostat setpoint if the system provides mechanical cooling.

Exception to Section 160.3(a)2Diib: Thermostat setup controls are not required in multifamily buildings in areas where the summer design dry-bulb 0.5-percent temperature determined in accordance with Section 170.2(c)1C is less than 100°F.

iii. **Occupant sensing zone controls**. Where the system providing space conditioning also provides the ventilation required by Section 160.2(c)3 and includes occupant sensor ventilation control as specified in Section 160.2(c)5E, the occupant sensing zone controls shall additionally comply with the following:

a. Occupant sensing zone controls shall comply with the occupant sensor ventilation control device requirements of Section 160.3(c)5E and allow preoccupancy ventilation requirements of Section 160.3(c)5B; and

b. In 5 minutes or less after entering occupied-standby mode as described in Section 160.2(c)5:

I. Automatically set up the operating cooling temperature setpoint by 2°F or more and set back the operating heating temperature setpoint by 2°F or more; or

II. For multiple zone systems with Direct Digital Controls (DDC) to the zone level, set up the operating cooling temperature setpoint by 0.5°F or more and set back the operating heating temperature setpoint by 0.5°F or more.

c. In 5 minutes or less after entering occupied-standby mode, mechanical ventilation to the zone shall remain off whenever the space temperature is between the active heating and cooling setpoints.

Exception to Section 160.3(a)2Diii: Zones that are only ventilated by a natural ventilation system in accordance with Section 120.1(c)2.

Exception 1 to Sections 160.3(a)2Di, ii and iii: Where it can be demonstrated to the satisfaction of the enforcing agency that the system serves an area that must operate continuously.

Exception 2 to Sections 160.3(a)2Di, ii and iii: Systems with full load demands of 2 kW or less, if they have a readily accessible manual shut-off switch.

E. **Dampers for air supply and exhaust equipment.** Outdoor air supply and exhaust equipment shall be installed with dampers that automatically close upon fan shutdown.

Exception 1 to Section 160.3(a)2E: Equipment that serves an area that must operate continuously.

Exception 2 to Section 160.3(a)2E: Gravity and other nonelectrical equipment that has readily accessible manual damper controls.

Exception 3 to Section 160.3(a)2E: At combustion air intakes and shaft vents.

Exception 4 to Section 160.3(a)2E: Where prohibited by other provisions of law.

F. **Isolation area devices**. Each space-conditioning system serving multiple zones with a combined conditioned floor area of more than 25,000 square feet shall be designed, installed and controlled to serve isolation areas.

   i. Each zone, or any combination of zones not exceeding 25,000 square feet, shall be a separate isolation area.

   ii. Each isolation area shall be provided with isolation devices, such as valves or dampers that allow the supply of heating or cooling to be reduced or shut off independently of other isolation areas.

   iii. Each isolation area shall be controlled by a device meeting the requirements of Section 160.3(a)2Di.

   Exception to Section 160.3(a)2F: Zones designed to be conditioned continuously.

G. **Automatic demand shed controls.** See Section 110.12 for requirements for automatic demand shed controls.

H. **Economizer Fault Detection and Diagnostics (FDD).** All newly installed air handlers with a mechanical cooling capacity over 33,000 Btu/hr and an installed air economizer shall include a stand-alone or integrated Fault Detection and Diagnostics (FDD) system in accordance with Subsections 160.3(a)2Hi through 160.3(a)2Hviii.

   i. The following temperature sensors shall be permanently installed to monitor system operation: outside air, supply air and, when required for differential economizer operation, a return air sensor; and

   ii. Temperature sensors shall have an accuracy of ±2°F over the range of 40°F to 80°F; and

   iii. The controller shall have the capability of displaying the value of each sensor; and

   iv. The controller shall provide system status by indicating the following conditions:

      a. Free cooling available;

      b. Economizer enabled;

      c. Compressor enabled;

      d. Heating enabled, if the system is capable of heating; and

      e. Mixed air low limit cycle active.

v. The unit controller shall allow manual initiation of each operating mode so that the operation of cooling systems, economizers, fans and heating systems can be independently tested and verified; and

vi. Faults shall be reported in one of the following ways:

a. Reported to an Energy Management Control System regularly monitored by facility personnel.

b. Annunciated locally on one or more zone thermostats, or a device within five feet of zone thermostat(s), clearly visible, at eye level and meeting the following requirements:

I. On the thermostat, the device or an adjacent written sign, display instructions to contact appropriate building personnel or an HVAC technician; and

II. In buildings with multiple tenants, the annunciation shall either be within property management offices or in a common space accessible by the property or building manager.

c. Reported to a fault management application that automatically provides notification of the fault to remote HVAC service provider.

vii. The FDD system shall detect the following faults:

a. Air temperature sensor failure/fault;

b. Not economizing when it should;

c. Economizing when it should not;

d. Damper not modulating; and

e. Excess outdoor air.

viii. The FDD system shall be certified to the Energy Commission as meeting the requirements of Sections 160.3(a)2Hi through 160.3(a)2Hvii in accordance with Section 110.0 and JA6.3.

Exception to Section 160.3(a)2Hviii: FDD algorithms based in direct digital control systems are not required to be certified to the Energy Commission.

I. **Direct Digital Controls (DDC).** Direct digital controls to the zone shall be provided as specified by Table 160.3-C.

i. The provided DDC system shall meet the control logic requirements of Sections 160.3(a)2E and 160.3(a)2G, and be capable of the following:

ii. Monitoring zone and system demand for fan pressure, pump pressure, heating and cooling;

iii. Transferring zone and system demand information from zones to air distribution system controllers and from air distribution systems to heating and cooling plant controllers;

iv. Automatically detecting the zones and systems that may be excessively driving the reset logic and generate an alarm or other indication to the system operator;

v. Readily allow operator removal of zone(s) from the reset algorithm;

vi. For new buildings, trending and graphically displaying input and output points; and

vii. Resetting heating and cooling setpoints in all noncritical zones upon receipt of a signal from a centralized contact or software point as described in Section 160.3(a)2G.

J. **Optimum start/stop controls.** Space-conditioning systems with DDC to the zone level shall have optimum start/stop controls. The control algorithm shall, as a minimum, be a function of the difference between space temperature and occupied setpoint, the outdoor air temperature, and the amount of time prior to scheduled occupancy. Mass radiant floor slab systems shall incorporate floor temperature onto the optimum start algorithm.

Exception to Section 160.3(a)2J: Systems that must operate continuously.

(b) Dwelling unit space-conditioning and air distribution systems.

1. **Building cooling and heating loads.** Building heating and cooling loads shall be determined using a method based on any one of the following, using cooling and heating loads as two of the criteria for equipment sizing and selection:

   A. The ASHRAE Handbook, Equipment Volume, Applications Volume and Fundamentals Volume; or

   B. The SMACNA Residential Comfort System Installation Standards Manual; or

   C. The ACCA Manual J.

   Exception to Section 160.3(b)1: Block loads, the total load for all rooms combined that are served by the central equipment, may be used for the purpose of system sizing for additions.

   Note: Heating systems are required to have a minimum heating capacity adequate to meet the minimum requirements of the CBC.

«» Commentary for Section 160.3(b)1:

Equipment Sizing

The Energy Code does not set limits on the sizing of heating and cooling equipment, but does require that heating and cooling loads be calculated for new HVAC systems. Oversized equipment typically operates less efficiently and can create comfort problems due to excessive cycling and improper airflow. Ducts must be sized correctly, otherwise the system airflow rate may be restricted, adversely affecting the efficiency of the system and preventing the system from meeting the mandatory minimum airflow rate requirements.

Acceptable load calculation procedures include methods described in the following publications:

1. The ASHRAE Handbook – Equipment
2. The ASHRAE Handbook – Applications
3. The ASHRAE Handbook – Fundamentals
4. The SMACNA Residential Comfort System Installation Standards Manual
5. ACCA Manual J

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2. **Design conditions.** Design conditions shall be determined in accordance with the following:

A. For the purpose of sizing the space-conditioning (HVAC) system, the indoor design temperatures shall be 68°F for heating and 75°F for cooling.

B. Outdoor design conditions shall be selected from one of the following:

i. Reference Joint Appendix JA2, which is based on data from the ASHRAE Climatic Data for Region X; or

ii. The ASHRAE Handbook Fundamentals Volume; or

iv. The ACCA Manual J

C. The outdoor design temperatures for heating shall be no lower than the 99.0 percent Heating Dry Bulb or the Heating Winter Median of Extremes values.

D. The outdoor design temperatures for cooling shall be no greater than the 1.0 percent Cooling Dry Bulb and Mean Coincident Wet Bulb values.

«» Commentary for Section 160.3(b)2:

The Energy Code requires that the outdoor design conditions for heating load calculations be selected from JA2, the ASHRAE Fundamentals Volume, or ACCA Manual J and that the indoor design temperature for heating load calculations must be 68°F. The outdoor design temperature must be no lower than the "Heating Winter Median of Extremes," as listed in JA2. In the case of the "99.0 percent Dry Bulb," the phrase "no lower than" does not refer to the design temperature itself, but rather to the "99.0%" value, meaning the 99.6% dry bulb heating value could be selected, but not the 97.5% dry bulb heating value. The outdoor design conditions for cooling load calculations must be selected from JA2, Table 2-3, The ASHRAE Fundamentals Volume, or ACCA Manual J using values no greater than the "1.0 percent Cooling Dry Bulb" and "Mean Coincident Wet Bulb" values listed. In the case of the "1.0 percent Cooling Dry Bulb," the phrase "no greater than" does not refer to the design temperature itself, but rather to the 1.0% value. The indoor design temperature for cooling load calculations must be 75°F.

If the actual city location for a project is not included in JA2, or if the data given for a particular city do not match the conditions at the actual site as well as that given for another nearby city, consult the local building department for guidance.

The load calculations may be submitted with the compliance documentation when requested by the building department.

The load calculations may be prepared by a mechanical engineer, the mechanical contractor who is installing the equipment or someone who is qualified to do so in the State of California according to Division 3 of the Business and Professions Code.

3. **Outdoor condensing units**.

   A. **Clearances.** Installed air conditioner and heat pump outdoor condensing units shall have a clearance of at least five feet (1.5 meters) from the outlet of any dryer vent.

   B. **Liquid line drier.** Installed air conditioner and heat pump systems shall be equipped with liquid line filter driers if required, as specified by manufacturer's instructions.

«» Commentary for Section 160.3(b)3:

Any obstruction of the airflow through the outdoor unit of an air conditioner or heat pump lowers efficiency. Dryer vents are prime sources for substances that clog outdoor coils and sometimes discharge substances that can cause corrosion. Therefore, condensing units must not be placed within five feet of a dryer vent. Regardless of location, condenser coils should be cleaned regularly. The manufacturer installation instructions may include requirements for minimum horizontal and vertical distance to surrounding objects that should be met if greater than the minimum distance required by the Energy Code. Figure 4-15: Noncompliant Condensing Unit Clearance from Dryer Vents shows an example when a condensing unit installed location does not meet the clearance requirement.

Figure 4-15: Noncompliant Condensing Unit Clearance from Dryer Vents

Source: California Energy Commission

Liquid line filter driers are components of split system air-conditioners and split system heat pumps that are installed in the refrigerant line to remove moisture and particles from the refrigerant stream. These contaminants may be introduced in the refrigerant as a result of improper flushing, evacuation, and charging procedures, causing the efficiency and capacity of the air conditioner to be impaired or damaging components. If required by manufacturer's instructions, liquid line filter dryers must be installed. Sometimes, liquid line filter dryers are preinstalled by manufacturers within condensing units. Some manufacturers install liquid line filter dryers outside condensers, so they can be easily serviced by technicians and more easily verified by ECC-Raters.

The quality of the filter dryer installation impacts the effectiveness of the liquid line filter dryer, as some liquid line filter dryers can be installed without regard to the direction of refrigerant flow. Heat pumps, for example, allow refrigerant flow in both directions. However, in other air conditioners where refrigerant flow occurs in only one direction, correct orientation of the liquid line filter dryer is important. **«»**

4. **Central forced-air heating furnaces**.

   A. **Temperature rise**. Central forced-air heating furnace installations shall be configured to operate in conformance with the furnace manufacturer's maximum inlet-to-outlet temperature rise specifications.

5. **Air-distribution and ventilation system ducts, plenums and fans.**

   A. **CMC compliance.**

      i. All air-distribution system ducts and plenums, including, but not limited to, mechanical closets and air-handler boxes, shall meet the requirements of the CMC Sections 601.0, 602.0, 603.0, 604.0 and 605.0 and ANSI/SMACNA-006-2006 HVAC Duct Construction Standards Metal and Flexible 3rd Edition, incorporated herein by reference.

      ii. Portions of supply-air and return-air ducts and plenums of a space heating or cooling system shall be insulated in accordance with either Subsection a or b below:

         a. Ducts shall have a minimum installed level of R-6.0, or

         Exception to Section 160.3(b)5Aiia: Portions of the duct system located in conditioned space below the ceiling separating the occupiable space from the attic are not required to be insulated if all of the following conditions are met:

         i. The noninsulated portion of the duct system is located entirely inside the building's thermal envelope as confirmed by visual inspection.

         ii. At all locations where noninsulated portions of the duct system penetrate into unconditioned space, the penetration shall be draft stopped compliant with CFC Sections 703.1 and 704.1 and air-sealed to the construction materials that are penetrated, using materials compliant with CMC Section E502.4.2 to prevent air infiltration into the cavity. All connections in unconditioned space are insulated to a minimum of R-6.0 as confirmed by visual inspection.

«» Commentary for Section 160.3(b)5Aiia:

Portions of supply-air and return-air ducts and plenums that are not installed entirely in conditioned space must have a minimum R-value of R-6.0. Ducts installed in conditioned space do not require insulation if the following conditions are met and verified by visual inspection by the building department:

1. The noninsulated portion of the duct system is located entirely inside conditioned space within the building's thermal envelope.
2. At all locations where noninsulated portions of the duct system penetrate unconditioned space, the penetration must be draft stopped compliant with California Fire Code (CFC) sections 703.1 and 704.1 and air-sealed with materials complaint with California Mechanical Code (CMC) section E502.4.2. All connections in unconditioned space must be insulated to at least R-6.0. «»

b. Ducts do not require insulation when the duct system is located entirely in conditioned space. For buildings with three or fewer habitable stories, duct systems located entirely in conditioned space shall be confirmed through field verification and diagnostic testing in accordance with the requirements of Reference Residential Appendix RA3.1.4.3.8.

«» Commentary for Section 160.3(b)5Aiib:

Alternatively, ducts may be uninsulated if the entire duct system is verified to be entirely in conditioned space as defined in Section 100.1 by field verification and by using the protocols of RA3.1.4.3.8.

RA3.1.4.3.8 describes the duct leakage to outside test that determines whether the ducts are within the pressure boundary of the space being served by the duct system. A basic visual inspection of the ducts ensures that no portion of the duct system is obviously outside the apparent pressure/thermal boundary.

Leakage to outside means conditioned air leaking from the ducts to anywhere outside the pressure boundary of the dwelling unit conditioned space served by the duct system, which includes leakage to outside the building and leakage to adjacent dwelling units or other interior building spaces. «»

iii. Connections of metal ducts and the inner core of flexible ducts shall be mechanically fastened.

iv. Openings shall be sealed with mastic, tape, or other duct-closure system that meets the applicable requirements of UL 181, UL 181A or UL 181B or aerosol sealant that meets the requirements of UL 723. If mastic or tape is used to seal openings greater than 1/4 inch, the combination of mastic and either mesh or tape shall be used.

v. Building cavities, support platforms for air handlers, and plenums designed or constructed with materials other than sealed sheet metal, duct board or flexible duct shall not be used for conveying conditioned air. Building cavities and support platforms may contain ducts. Ducts installed in cavities and support platforms shall not be compressed to cause reductions in the cross-sectional area of the ducts.

«» Commentary for Section 160.3(b)5Aiii-v:

Building spaces such as cavities between walls, support platforms for air handlers, and plenums defined or constructed with materials other than sealed sheet metal, duct board, or flexible duct must not be used for conveying conditioned air, including return air and supply air. Using drywall materials as the interior surface of a return plenum is not allowed. Building cavities and support platforms may contain ducts. Ducts installed in cavities and support platforms must not be compressed to cause reductions in the cross-sectional area of the ducts. Although a ECC-Rater or acceptance test technician may examine this as a part of his or her responsibilities when involved in a project, the enforcement of these minimum standards for ducts is the responsibility of the building official. **«»**

Exception to Section 160.3(b)5A: Ducts and fans integral to a wood heater or fireplace.

B. **Factory-fabricated duct systems**.

i. All factory-fabricated duct systems shall comply with UL 181 for ducts and closure systems, including collars, connections and splices, and be labeled as complying with UL 181. UL 181 testing may be performed by UL laboratories or a laboratory approved by the Executive Director.

«» Commentary for Section 160.3(b)5Bi:

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

1. Polyken 558CA, manufactured by Berry Plastics Tapes and Coatings Division.
2. Nashua 558CA, manufactured by Berry Plastics Tapes and Coatings Division.
3. Shurtape PC 858CA, manufactured by Shurtape Technologies, Inc.

These tapes passed Lawrence Berkeley Laboratory tests comparable to those that cloth-backed, rubber-adhesive duct tapes failed. (The LBNL test procedure has been adopted by the American Society of Testing and Materials as ASTM E2342.) These tapes are allowed to be used to seal flex duct to fittings without being in combination with mastic. These tapes cannot be used to seal other duct system joints, such as the attachment of fittings to plenums and junction boxes. These tapes have on the backing a drawing of a fitting to plenum joint in a red circle with a slash through it (the international symbol of prohibition) to illustrate where they are not allowed to be used, installation instructions in the packing boxes that explain how to install them on duct core to fittings, and a statement that the tapes cannot be used to seal fitting to plenum and junction box joints. **«»**

ii. All pressure-sensitive tapes, heat-activated tapes and mastics used in the manufacture of rigid fiberglass ducts shall comply with UL 181 and UL 181A.

iii. All pressure-sensitive tapes and mastics used with flexible ducts shall comply with UL 181 and UL 181B.

iv. Joints and seams of duct systems and their components shall not be sealed with cloth back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands.

C. **Field-fabricated duct systems.**

i. Factory-made rigid fiberglass and flexible ducts for field-fabricated duct systems shall comply with UL 181. All pressure-sensitive tapes, mastics, aerosol sealants or other closure systems used for installing field-fabricated duct systems shall meet the applicable requirements of UL 181, UL 181A and UL 181B.

ii. Mastic sealants and mesh.

   a. Sealants shall comply with the applicable requirements of UL 181, UL 181A and UL 181B, and be nontoxic and water resistant.

   b. Sealants for interior applications shall be tested in accordance with ASTM C731 and D2202, incorporated herein by reference.

   c. Sealants for exterior applications shall be tested in accordance with ASTM C731, C732 and D2202, incorporated herein by reference.

   d. Sealants and meshes shall be rated for exterior use.

iii. Pressure-sensitive tape. Pressure-sensitive tapes shall comply with the applicable requirements of UL 181, UL 181A and UL 181B.

iv. Joints and seams of duct systems and their components shall not be sealed with cloth back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands.

v. Drawbands used with flexible duct.

   a. Drawbands shall be either stainless-steel worm-drive hose clamps or UV-resistant nylon duct ties.

   b. Drawbands shall have a minimum tensile strength rating of 150 pounds.

   c. Drawbands shall be tightened as recommended by the manufacturer with an adjustable tensioning tool.

vi. Aerosol-sealant closures.

   a. Aerosol sealants shall meet the requirements of UL 723 and be applied according to manufacturer specifications.

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

D. **Duct insulation R-value ratings.** All duct insulation product R-values shall be based on insulation only (excluding air films, vapor retarder or other duct components) and tested C-values at 75°F mean temperature at the installed thickness, in accordance with ASTM C518 or ASTM C177, incorporated herein by reference, and certified pursuant to Section 110.8.

E. **Duct insulation thickness.** The installed thickness of duct insulation used to determine its R-value shall be determined as follows:

   i. For duct board, duct liner and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used**.**

ii. For duct wrap, installed thickness shall be assumed to be 75 percent (25 percent compression) of nominal thickness.

iii. For factory-made flexible air ducts, the installed thickness shall be determined by dividing the difference between the actual outside diameter and nominal inside diameter by two.

F. **Duct labeling.** Insulated flexible duct products installed to meet this requirement shall include labels, in maximum intervals of 3 feet, showing the thermal performance R-value for the duct insulation itself (excluding air films, vapor retarder or other duct components), based on the tests in Section 160.3(b)5D and the installed thickness determined by Section 160.3(b)5Eiii.

G. **Backdraft dampers.** All fan systems, regardless of volumetric capacity, that exchange air between the building conditioned space and the outside of the building shall be provided with backdraft or automatic dampers to prevent unintended air leakage through the fan system when the fan system is not operating.

«» Commentary for Section 160.3(b)5G:

Fan systems that exhaust air from the building to the outside must be provided with back draft or automatic dampers. **«»**

H. **Gravity ventilation dampers.** All gravity ventilating systems that serve conditioned space shall be provided with either automatic or readily accessible, manually operated dampers in all openings to the outside except combustion inlet and outlet air openings and elevator shaft vents.

«» Commentary for Section 160.3(b)5H:

This may clothes dryer exhaust vents when installed in conditioned space. **«»**

I. **Protection of insulation.** Insulation shall be protected from damage, including that due to sunlight, moisture, equipment maintenance and wind but not limited to the following: Insulation exposed to weather shall be suitable for outdoor service (e.g., protected by aluminum, sheet metal, painted canvas or plastic cover). Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation that can cause degradation of the material.

J. **Porous inner core flex duct.** Flexible ducts having porous inner cores shall have a nonporous layer or air barrier between the inner core and the outer vapor barrier.

K. **Duct system sealing and leakage testing.** When space-conditioning systems utilize forced air duct systems to supply conditioned air to an individual dwelling unit, the ducts shall be sealed, as confirmed through field verification and diagnostic testing, in accordance with all applicable procedures specified in Reference Residential Appendix RA3.1. Air handler airflow for calculation of duct leakage rate compliance targets shall be determined according to methods specified in Reference Residential Appendix RA3.1.4.2**.**

For multifamily dwellings with the air-handling unit installed and the ducts connected directly to the air handler, regardless of duct system location:

i. The total leakage of the duct system shall not exceed 12 percent of the air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1; or

ii. The duct system leakage to outside shall not exceed 6 percent of the air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.4.

Exception 1 to Section 160.3(b)5K: The field verification and ECC-Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four habitable stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

Exception 2 to Section 160.3(b)5K: Multifamily dwelling units in buildings four habitable stories and greater in Climate Zones 1, 3, 5 and 7.

«» Commentary for Section 160.3(b)5K:

Duct systems in newly constructed multifamily dwellings are required to comply with the sealing and leakage testing requirements regardless of the duct system location, except for buildings with four or more habitable stories in climate zones 1, 3, 5, and 7, which are exempt from the testing requirements. When the air-handling unit is installed and the ducts connected directly to the air handler, the total leakage of the duct system must not exceed 12% of the nominal system air handler airflow or the duct system leakage to outside must not exceed 6% of the nominal system air handler airflow.

The duct system leakage must be determined according to the applicable procedures outlined in RA3.1.4.3. Verification of duct leakage must be conducted by a ECC-Rater for multifamily buildings with up to three habitable stories. For other multifamily buildings in climate zones 2, 4, 6, and 8 – 16, testing only needs to be conducted and certified by the installing contractor and neither a ECC-Rater nor registration with a ECC-Provider is required. Entirely new or complete replacement duct systems as part of an addition or alteration in all climate zones are required to comply with these mandatory maximum leakage criteria. A duct system in an existing building is considered entirely new when:

1. At least 75% of the duct material is new.
1. All remaining components from the previous system are accessible and can be sealed.«»

L. **System airflow rate and fan efficacy.** Space-conditioning systems that utilize forced air ducts to supply cooling to an individual dwelling unit shall:

i. **Static pressure probe.** Have a hole for the placement of a static pressure probe (HSPP), or a permanently installed static pressure probe (PSPP) in the supply plenum downstream of the air conditioning evaporator coil. The size, location and labeling of the HSPP or PSPP shall conform to the requirements specified in Reference Residential Appendix RA3.3.1.1 as confirmed by field verification and diagnostic testing; and

Exception to Section 160.3(b)5Li: Systems that cannot conform to the specifications for hole location in Reference Residential Appendix Figure RA3.3-1 shall not be required to provide holes as described in Figure RA3.3-1.

«» Commentary for Section 160.3(b)5L:

Space-conditioning systems that use forced air ducts to cool occupiable space must have a HSPP or PSPP installed downstream from the evaporator coil. The HSPP or PSPP must be installed in the required location, in accordance with the specifications detailed in Reference Residential Appendix RA3.3. The HSPP or PSPP are required to promote system airflow measurement when using devices/procedures that depend on supply plenum pressure measurements. The HSPP or PSPP allows ECC-Raters to perform the required diagnostic airflow testing in a nonintrusive manner by eliminating the necessity for the raters to drill holes in the supply plenum for placement of pressure measurement probes.

The size and placement of the HSPP/PSPP must be in accordance with RA3.3.1.1 and must be verified by a ECC-Rater. If the HSPP/PSPP cannot be installed as shown in Figure RA3.3-1 because of the configuration of the system or that the location is not accessible, an alternative location may be provided that can accurately measure the average static pressure in the supply plenum. If an alternative location cannot be provided, then the HSPP/PSPP is not required to be installed. The ECC-Rater will verify this for multifamily buildings up to three stories. Not installing an HSPP/PSPP will limit the airflow measurement method to either a powered flow hood or passive (traditional) flow hood.

The HSPP/PSPP requirement also applies when the plenum pressure matching method or the flow grid method of airflow measurement is used by either the installer or the rater to verify airflow in an altered system. The HSPP/PSPP must be installed by the installer, not the rater. «»

ii. **Single zone central forced air systems**. Demonstrate, in every control mode, airflow greater than or equal to 350 cfm per ton of nominal cooling capacity through the return grilles, and an air-handling unit fan efficacy less than or equal to the maximum W/cfm specified in Subsection a or b below. The airflow rate and fan efficacy requirements in this section shall be confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3.

a. 0.45 W/cfm for gas furnace air-handling units.

b. 0.58 W/cfm for air-handling units that are not gas furnaces.

Exception 1 to Section 160.3(b)5Lii: Standard ducted systems without zoning dampers may comply by meeting the applicable requirements in Table 160.3-A or 160.3-B as confirmed by field verification and diagnostic testing in accordance with the procedures in Reference Residential Appendix Sections

RA3.1.4.4 and RA3.1.4.5. The design clean-filter pressure drop requirements specified by Section 160.2(b)1Div for the system air filter(s) shall conform to the requirements given in Table 160.3-A or 160.3-B.

Exception 2 to Section 160.3(b)5Lii: Multispeed compressor systems or variable speed compressor systems shall verify airflow (cfm/ton) and fan efficacy (watt/cfm) for system operation at the maximum compressor speed and the maximum air handler fan speed.

Exception 3 to Section 160.3(b)5Lii: Gas furnace air-handling units manufactured prior to July 3, 2019 shall comply with a fan efficacy value less than or equal to 0.58 w/cfm as confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3.

«» Commentary for Section 160.3(b)5Lii:

Adequate airflow is critical for cooling equipment efficiency. Further, it is important to maintain adequate airflow without expending excessive fan power. Section 160.3(b)5L establishes mandatory requirements that are intended to ensure adequate cooling airflow through properly sized ducts and efficient fan motors.

There are two options allowed to ensure adequate air flow. The first option is to design and install the systems using standard design criteria and then have the airflow and fan efficacy of the system tested in the field. The second option is to size the return ducts according to Exception 1 to Section 160.3(b)5Lii and iv.

Both options require verification. Verification must be conducted by a ECC-Rater for multifamily buildings with up to three habitable stories. For other multifamily buildings in Climate Zones 2-16, verification only needs to be conducted and certified by the installing contractor and neither a ECC-Rater nor registration with a ECC-Provider is required. Buildings with four or more habitable stories in Climate Zone 1 are exempt from these mandatory requirements.

Return Duct System Design Method

This method allows the designer to specify, and the contractor to install, a system that does not have to undergo field verification and diagnostic testing for airflow and fan efficacy. This method can be used for systems with either one or two return grilles. Each return must not exceed 30 ft. as measured from the return plenum to the filter grille. When bends are needed, sheet metal elbows are desirable. Each return can have up to 180 degrees of bend, and flex duct can have no more than 90° of bend. To use this method, the designer and installer must provide return system sizing that meets the appropriate criteria in Energy Code Tables 160.3-A and B.

Energy Code Tables 160.3-A and B allow for only one or two returns. There may be times where three returns are necessary on a single system. Furthermore, Table 160.3-B does not allow for deviation from the two sizes specified. For example, the table requires two 14-inch return ducts for a 2.5-ton system, but specific airflow requirements and architectural constraints may dictate an 18-inch and a 12-inch. In this situation, airflow and fan efficacy diagnostic testing are required.

Historically, duct systems have been sized to fit into the dwelling unit at the expense of proper airflow. The performance of these systems, in terms of efficiency and capacity, has suffered greatly because of this practice. The dwelling unit should be designed to accommodate properly sized ducts. This requires improved coordination among the architect, structural engineer, and mechanical designer early in the process.

Tables 160.3-A and B require the use of return grilles that are sized to achieve an optimal face velocity and static pressure drop. Tables 160.3-A and B also require the return grille devices to be labeled in accordance with the requirements in Section 160.2(b)1A to disclose the design airflow rate of the grille and the maximum allowable clean-filter pressure drop for the air filter media, as determined by the system design or applicable standards requirements. The nominal size of the air filter grille or air filter media should be used to calculate the return filter grille gross area for determining compliance with Tables 160.3-A and B. The nominal size of the filter grille is expected to be the same as the nominal size of the air filter media that is used in the grille and is most often the information used to identify these items for purchases. For example, a nominal 20-inch x 30-inch filter grille will use nominal 20-inch x 30-inch air filter media.

Nominal Cooling Capacity

To determine the required airflow for compliance in CFM/ton, the nominal cooling capacity of the system in tons must be known. The nominal cooling capacity system may be obtained from the manufacturer's product literature or from listings of certified product ratings from organizations such as AHRI, but the nominal capacity is usually shown in the unit model number on the manufacturers nameplate attached to the outdoor condensing unit. A two- or three-digit section of the manufacturer's model number typically indicates the nominal capacity in thousands of BTU/hour. Given that there are 12,000 BTU/hour per ton of cooling capacity, the nameplate will display something similar to one of the following number groupings: "018" which represents 1.5 tons; "024," which represents 2 tons; "030," which represents 2.5 tons; "036," which represents 3 tons; "042," which represents 3.5 tons; "048," which represents 4 tons; or “060,” which represents 5 tons.

The following design guidelines will increase the chances of the system passing the airflow and fan efficacy testing:

1. Right-size the HVAC system. If a two-ton unit is enough to satisfy the cooling load, do not install a three-ton unit just to be safe. Oversizing equipment can cause comfort problems in addition to excessive energy use.
2. The HVAC designer must coordinate closely with the architect and structural engineer to make sure that the ducts will fit into the dwelling unit as designed.
3. Prepare a detailed mechanical plan that can be followed in the field. If deviations must occur in the field, make sure that they are coordinated with the designer and that the design is adjusted as needed.
4. Follow Manual D for duct sizing:
   - Make sure that the correct duct type is used (vinyl flex, sheet metal, rigid fiberglass, or other).
   - Make sure that all equivalent lengths and pressure drops are correctly accounted for (bends, plenum start collars, t-wyes, filters, grilles, registers, and so forth.
   - Select an air handler that will provide at least 400 CFM/ton at the desired static pressure of 125 to 150 Pa (0.5 to 0.6 inches w.c.).
   - Design the duct system to a static pressure across the fan of no more than 150 Pa (0.6 inches w.c.).
   - Consider upsizing the evaporator coil relative to the condenser to reduce the static pressure drop. This upsizing results in better airflow and slightly better capacity and efficiency. Manufacturers commonly provide performance data for such condenser coil combinations.
   - Consider specifying an air handler with a high efficiency (brushless permanent magnet) fan motor.
5. Install a large grill area and use a proper filter for the system.
6. Locate registers and equipment to make duct runs as short as possible.
7. Make all short-radius 90° bends out of rigid ducting.
8. Install flex duct properly by stretching all flex duct tight and cutting off excess ducting. Ensure the duct is not kinked or compressed and is properly supported every four ft. or less using one inch strapping. Flex duct should have less than two inches of sag between supports.
9. Consider using better quality supply and filter grilles. Bar-type registers have considerably better airflow performance than standard stamped-face registers. Refer to the manufacturer’s specifications and select accordingly.

«»

iii. **Zonally controlled central forced air systems.** Zonally controlled central forced air cooling systems shall be capable of simultaneously delivering, in every zonal control mode, an airflow from the dwelling, through the air handler fan and delivered to the dwelling, of greater than or equal to 350 cfm per ton of nominal cooling capacity, and operating at an air-handling unit fan efficacy of less than or equal to the maximum W/cfm specified in Subsection a or b below. The airflow rate and fan efficacy requirements in this section shall be confirmed by field verification and diagnostic testing in accordance with the applicable procedures specified in Reference Residential Appendix RA3.3.

a. 0.45 W/cfm for gas furnace air-handling units.

b. 0.58 W/cfm for air-handling units that are not gas furnaces.

Exception 1 to Section 160.3(b)5Liii: Multispeed or variable speed compressor systems, with controls that vary fan speed subject to the number of zones, as certified by the installer may demonstrate compliance with the airflow (cfm/ton) and fan efficacy (watt/cfm) requirements of Section 160.3(b)5Liii by operating the system at maximum compressor capacity and system fan speed with all zones calling for conditioning.

Exception 2 to Section 160.3(b)5Liii: Gas furnace air-handling units manufactured prior to July 3, 2019 shall comply with a fan efficacy value less than or equal to 0.58 w/cfm as confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3.

«» Commentary for Section 160.3(b)5Liii:

The primary purpose of zoning ducted air conditioners, heat pumps, and furnaces is to improve comfort and reduce energy usage. Increased comfort is attained by having the capacity of the HVAC system (cooling or heating delivered) follow the shift in load as it changes across the dwelling unit.

Since the most common dwelling unit is single-zoned and has only one thermostat placed near the center of the unit, temperatures in the rooms distant from that thermostat will vary, sometimes significantly. If zoning is added, the more distant rooms may be conditioned to a more comfortable temperature. This increased conditioning requires more energy. When designed correctly, zoning allows only the zones that need conditioning to be conditioned, thus potentially saving energy.

It is common for single-speed zonally controlled central forced-air cooling systems to produce lower total system airflow through the returns when fewer than all zones are calling for conditioning. The reduced airflow lowers the sensible efficiency of single-stage heating or cooling equipment. Two primary causes of lower airflow in multiple zone dampered systems are:

1. Restriction of some system supply ducts by closing zoning dampers in zones that do not need additional cooling, while other zones do need cooling.
2. Recirculation of already-cooled air from the supply plenum directly back to the return plenum without first delivering the cooled air to the conditioned space by use of a bypass duct.

To prevent the lower efficiency that results from reduced system airflow or from recirculated bypass duct airflow, single-speed compressor zonally controlled central cooling systems must demonstrate they simultaneously meet mandatory fan efficacy and airflow requirements in all zonal control modes, which is possible with a duct system design that does not restrict the system total airflow when fewer than all zones are calling for conditioning and does not use a bypass duct. Section 170.2(c)3v prohibits use of bypass ducts prescriptively, but bypass ducts may be used if the efficiency penalty due to the reduced airflow through the return grille is modeled as described later in this section.

Zonally controlled cooling systems with or without bypass dampers (multiple zones served by a single air handler with motorized zone dampers) usually do not meet the airflow and fan efficacy requirements when fewer than all zones are calling. The energy penalty that results from this is greater than the benefit of having zonal control; therefore, zonal control is not always a better-than-minimum condition.

Zonal control accomplished by using multiple single-zone systems is not subject to the requirements specified in Section 160.3(b)5Liii. **«»**

iv. **Small duct high velocity forced air systems.** Demonstrate, in every control mode, airflow greater than or equal to 250 cfm per ton of nominal cooling capacity through the return grilles, and an air-handling unit fan efficacy less than or equal to 0.62 W/cfm as confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3.

Exception 1 to Section 160.3(b)5Liv: Standard ducted systems without zoning dampers may comply by meeting the applicable requirements in Table 160.3-A or 160.3-B as confirmed by field verification and diagnostic testing in accordance with the procedures in Reference Residential Appendix Sections RA3.1.4.4 and RA3.1.4.5. The design clean-filter pressure drop requirements specified by Section 160.2(b)1Div for the system air filter(s) shall conform to the requirements given in Table 160.3-A or 160.3-B.

Exception 2 to Section 160.3(b)5Liv: Multispeed compressor systems or variable speed compressor systems shall verify airflow (cfm/ton) and fan efficacy (watt/cfm) for system operation at the maximum compressor speed and the maximum air handler fan speed.

Exception 1 to Section 160.3(b)5L: The field verification and ECC-Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four habitable stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

Exception 2 to Section 160.3(b)5L: Multifamily dwelling units in buildings four habitable stories and greater in Climate Zone 1.

«» Commentary for Section 160.3(b)5L:

Table 4-5: Central Forced-Air Cooling Systems Airflow & Fan Efficacy Requirements

Compressor & Zone Type	Mandatory Requirements for Airflow[1]	Mandatory Requirements for Fan Efficacy[1]
Single Zone Single-Speed or Multispeed (tested on highest speed only)	≥ 350 CFM/ton ≥ 250 CFM/ton if a small duct high velocity (SDHV) type	≤ 0.45 W/CFM for gas furnaces (GF) ≤ 0.58 W/CFM for all other air handlers ≤ 0.62 W/CFM for SDHV type
Zonally Controlled Single Speed (tested	≥ 350 CFM/ton	≤ 0.45 W/CFM for gas furnaces (GF)

Compressor & Zone Type	**Mandatory Requirements for Airflow[1]**	**Mandatory Requirements for Fan Efficacy[1]**
at all zonal control modes)[2]	≥ 250 CFM/ton if a small duct high velocity (SDHV) type	≤ 0.58 W/CFM for all other air handlers ≤ 0.62 W/CFM for SDHV type
Zonally Controlled Multispeed (tested at all zonal control modes)	≥ 350 CFM/ton ≥ 250 CFM/ton if a small duct high velocity (SDHV) type	≤ 0.45 W/CFM for gas furnaces (GF) ≤ 0.58 W/CFM for all other air handlers ≤ 0.62 W/CFM for SDHV type

[1]Exception: Airflow and fan efficacy testing not required if return system meets Tables 160.3-A or B. However, verification that return duct installation meets Tables 160.3-A or B is required

[2]For the prescriptive approach, use of a bypass duct is not allowed. For the performance approach, use of a bypass duct may be specified in the compliance software input for the zoned system type.

Source: California Energy Commission

«»

6. Piping for space-conditioning systems, solar water-heating system collector loop, and distribution piping for steam and hydronic heating system shall meet the requirements of Section 160.3(c)1.

7. **Defrost**.

   A. If a heat pump is equipped with a defrost delay timer, the delay timer must be set to greater than or equal to 90 minutes.

   B. The installer shall certify on the Certificate of Installation that the control configuration has been tested in accordance with the testing procedure found in the Certificate of Installation.

   Exception to 160.3(b)7. Dwelling units in Climate Zones 1, 6 through 10, 15, and 16 shall not be required to comply with the 90 minute delay timer requirements.

8. **Capacity variation with third-party thermostats. Variable or multi-speed systems shall comply with the following requirements:**

   A. The space conditioning system and thermostat together shall be capable of responding to heating and cooling loads by modulating system compressor speed.

   B. The installer shall certify on the Certificate of Installation that the control configuration has been tested in accordance with the testing procedure found in the Certificate of Installation.

«» Commentary for Section 160.3(b)8:

The requirement ensures that the installer selects an appropriate thermostat for the space conditioning system being installed. Manufacturers are not expected to make their systems compatible with all thermostats. **«»**

(c) Fluid distribution systems; common area space-conditioning systems. Multifamily buildings shall comply with the applicable requirements of Section 160.3(a)1. Multifamily common areas shall comply with the applicable requirements of Sections 160.3(a)2A through 160.3(a)2J.

1. **Pipe insulation**. Multifamily buildings shall comply with the applicable requirements of Sections 160.3(c)1A through 160.3(c)1D.

   A. **General requirements.** The piping conditions listed below for space-conditioning systems with fluid normal operating temperatures listed in Table 160.3-D shall have at least the amount of insulation specified in Section 160.3(c)1D:

      i. **Space cooling systems.** All refrigerant suction, chilled water and brine fluid distribution systems.

      ii. **Space heating systems.** All refrigerant suction, steam, steam condensate and hot water fluid distribution systems.

      Exception to Section 160.3(c)1Aii: Heat pumps refrigerant vapor line shall be installed with a minimum of 0.75 inch thick or R-6.0 insulation. No insulation is required on the refrigerant liquid line.

   B. Insulation conductivity shall be determined in accordance with ASTM C335 at the mean temperature listed in Table 160.3-D, and shall be rounded to the nearest 1/100 Btu-inch per hour per square foot per °F. Fluid distribution systems include all elements that are in series with the fluid flow, such as pipes, pumps, valves, strainers, coil u-bends and air separators, but not including elements that are not in series with the fluid flow, such as expansion tanks, fill lines, chemical feeders and drains.

   C. **Insulation protection.** Pipe insulation shall be protected from damage due to sunlight, moisture, equipment maintenance and wind. Protection shall, at minimum, include the following:

      i. Pipe insulation exposed to weather shall be protected by a cover suitable for outdoor service. The cover shall be water retardant and provide shielding from solar radiation that can cause degradation of the material. Adhesive tape shall not be used to provide this protection.

      ii. Pipe insulation covering chilled water piping and refrigerant suction piping located outside the conditioned space shall include, or be protected by, a Class I or Class II vapor retarder. All penetrations and joints shall be sealed.

      iii. Pipe insulation buried below grade must be installed in a waterproof and noncrushable casing or sleeve.

   D. **Insulation thickness.**

      i. For insulation with a conductivity in the range shown in Table 160.3-D for the applicable fluid temperature range, the insulation shall have the applicable minimum thickness or R-value shown in Table 160.3-D.

ii. For insulation with a conductivity outside the range shown in Table 160.3-D for the applicable fluid temperature range, the insulation shall have a minimum R-value shown in Table 160.3-D or thickness as calculated with Equation 160.3-A:

$$T = PR\left[\left(1+\frac{t}{PR}\right)^{\frac{K}{k}} - 1\right]$$ (Equation 160.3-A)

WHERE:

T = Minimum insulation thickness for material with conductivity K, inches.

PR = Pipe actual outside radius, inches.

t = Insulation thickness from TABLE 160.3-D, inches.

K = Conductivity of alternate material at the mean rating temperature indicated in TABLE 160.3-D for the applicable fluid temperature range, in Btu-inch per hour per square foot per °F.

k = The lower value of the conductivity range listed in TABLE 160.3-D for the applicable fluid temperature range, Btu-inch per hour per square foot per °F.

Exception 1 to Section 160.3(c)1: Factory-installed piping within space-conditioning equipment certified under Section 110.1 or 110.2.

Exception 2 to Section 160.3(c)1: Piping that conveys fluids with a design operating temperature range between 60°F and 105°F.

Exception 3 to Section 160.3(c)1: Where the heat gain or heat loss to or from piping without insulation will not increase building source energy use.

Exception 4 to Section 160.3(c)1: Piping that penetrates framing members shall not be required to have pipe insulation for the distance of the framing penetration. Metal piping that penetrates metal framing shall use grommets, plugs, wrapping or other insulating material to ensure that no contact is made with the metal framing.

«» Commentary for Section 160.3(c)1:

For air conditioners and heat pumps, two refrigerant lines connect the indoor and outdoor units of split-system air conditioners and heat pumps: the liquid line (the smaller diameter line) and the suction line (the larger diameter line). If the liquid line is at an elevated temperature relative to outdoor and indoor temperatures, it should not be insulated. In those areas, heat escaping from it is helpful.

The suction line carries refrigerant vapor that is cooler than ambient in the summer and (with heat pumps) warmer than ambient in the winter. This line must be insulated to the required thickness (in inches).

Insulation used for refrigerant suction lines located outside of conditioned space must include a Class I or Class II vapor retarder. The vapor retarder and insulation must be protected from physical damage, UV deterioration, and moisture with a covering that can be removed for equipment maintenance without destroying the insulation. Insulation is typically protected by aluminum, sheet metal jacket, painted canvas, or plastic cover. Adhesive tape should not be used as insulation protection because removal of the tape will damage the integrity of the original insulation during preventive maintenance. See Figure 4-16: Refrigerant Line Insulation for example of refrigerant line insulation.

Figure 4-16: Refrigerant Line Insulation

Source: Airex Manufacturing Inc.

Most piping conveying mechanically heated or chilled fluids for space conditioning or service water heating must be insulated. The required thickness of piping insulation depends on the temperature of the fluid passing through the pipe, the pipe diameter, the function of the pipe within the system, and the insulation’s thermal conductivity. «»

2. **Requirements for air distribution system, ducts and plenum.** Multifamily common areas shall comply with the applicable requirements of Sections 160.3(c)2A through 160.3(c)2F.

   A**. CMC compliance.** All air distribution system ducts and plenums, including, but not limited to, building cavities, mechanical closets, air-handler boxes and support platforms used as ducts or plenums shall meet the requirements of CMC Sections 601.0, 602.0, 603.0, 604.0 and 605.0, and ANSI/SMACNA-006-2006 HVAC Duct Construction Standards Metal and Flexible 3rd Edition, incorporated herein by reference. Connections of metal ducts and the inner core of flexible ducts shall be mechanically fastened. Openings shall be sealed with mastic, tape, aerosol sealant or other duct-closure system that meets the applicable requirements of UL 181, UL 181A or UL 181B. If mastic or tape is used to seal openings greater than 1/4 inch, the combination of mastic and either mesh or tape shall be used.

«» Commentary for Section 160.3(c)2A:

Poorly sealed or poorly insulated duct work can cause substantial losses of air volume and energy. All air distribution system ducts and plenums, including building cavities, mechanical closets, air handler boxes and support platforms used as ducts or plenums, are required to be in accordance with the California Mechanical Code Sections 601, 602, 603, 604, 605 and ANSI/SMACNA-006-2006 HVAC Duct Construction Standards - Metal and Flexible, 3rd Edition. **«»**

B. Portions of supply-air and return-air ducts conveying heated or cooled air located in one or more of the following spaces shall be insulated to a minimum installed level of R-8:

   i. Outdoors; or

   ii. In a space between the roof and an insulated ceiling; or

   iii. In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces; or

   iv. In an unconditioned crawl space; or

   v. In other unconditioned spaces.

   Portions of supply-air ducts that are not in one of these spaces, including ducts buried in concrete slab, shall be insulated to a minimum installed level of R-4.2 or be enclosed in directly conditioned space.

C. **Duct and plenum materials.**

   i. **Factory-fabricated duct systems.**

      a. All factory-fabricated duct systems shall comply with UL 181 for ducts and closure systems, including collars, connections and splices, and be labeled as complying with UL 181. UL 181 testing may be performed by UL laboratories or a laboratory approved by the Executive Director.

«» Commentary for Section 160.3(c)2B-C:

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

1. Polyken 558CA, manufactured by Berry Plastics Tapes and Coatings Division.
2. Nashua 558CA, manufactured by Berry Plastics Tapes and Coatings Division.
3. Shurtape PC 858CA, manufactured by Shurtape Technologies, Inc.

These tapes passed Lawrence Berkeley Laboratory tests comparable to those that cloth-backed, rubber-adhesive duct tapes failed. (The LBNL test procedure has been adopted by the American Society of Testing and Materials as ASTM E2342.) These tapes are allowed to be used to seal flex duct to fittings without being in combination with mastic. These tapes cannot be used to seal other duct system joints, such as the attachment of fittings to plenums and junction boxes. These tapes have on the backing a drawing of a fitting to plenum joint in a red circle with a slash through it (the international symbol of prohibition) to illustrate where they are not allowed to be used, installation instructions in the packing boxes that explain how to install them on duct core to fittings, and a statement that the tapes cannot be used to seal fitting to plenum and junction box joints. «»

b. All pressure-sensitive tapes, heat-activated tapes and mastics used in the manufacture of rigid fiberglass ducts shall comply with UL 181 and UL 181A.

c. All pressure-sensitive tapes and mastics used with flexible ducts shall comply with UL 181 and UL 181B.

d. Ductwork and plenums with pressure class ratings shall be constructed to Seal Class A. Joints and seams of duct systems and their components shall not be sealed with cloth back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands.

Exception to Section 160.3(c)2Cid: Ductwork located in occupied space and exposed to view.

«» Commentary for Section 160.3(c)2C:

The Energy Code requires all ductwork to be sealed to meet Seal Class A. Sealing means the use of adhesives, gaskets, and/or tape systems to close openings in the surface of ductwork and field erected plenums and casings through which air leakage would occur, or the use of continuous welds. Seal Class A means sealing all ductwork connections and applicable duct wall penetrations. Penetrations include pipe, tubing, rods, and wire. Rods that penetrate the duct wall must be allowed to move to function properly (such as a control rod for a volume damper) and should not be sealed in a way that prevents operation. Penetrations do not include screws and other fasteners. «»

ii. **Field-fabricated duct systems.**

a. Factory-made rigid fiberglass and flexible ducts for field-fabricated duct systems shall comply with UL 181. All pressure-sensitive tapes, mastics, aerosol sealants or other closure systems used for installing field-fabricated duct systems shall meet the applicable requirements of UL 181, UL 181A and UL 181B.

b. Mastic sealants and mesh.

I. Sealants shall comply with the applicable requirements of UL 181, UL 181A and UL 181B, and be nontoxic and water resistant.

II. Sealants for interior applications shall pass ASTM C731 (extrudability after aging) and D2202 (slump test on vertical surfaces), incorporated herein by reference.

III. Sealants for exterior applications shall pass ASTM C731, C732 (artificial weathering test) and D2202, incorporated herein by reference.

IV. Sealants and meshes shall be rated for exterior use.

c. Pressure-sensitive tape. Pressure-sensitive tapes shall comply with the applicable requirements of UL 181, UL 181A and UL 181B.

d. Ductwork and plenums with pressure class ratings shall be constructed to Seal Class A. Joints and seams of duct systems and their components shall not be sealed with cloth back rubber adhesive duct tapes unless such tape is used in combination with mastic and drawbands.

«» Commentary for Section 160.3(c)2C:

The Energy Code requires all ductwork to be sealed to meet Seal Class A. Sealing means the use of adhesives, gaskets, and/or tape systems to close openings in the surface of ductwork and field erected plenums and casings through which air leakage would occur, or the use of continuous welds. Seal Class A means sealing all ductwork connections and applicable duct wall penetrations. Penetrations include pipe, tubing, rods, and wire. Rods that penetrate the duct wall must be allowed to move to function properly (such as a control rod for a volume damper) and should not be sealed in a way that prevents operation. Penetrations do not include screws and other fasteners. **«»**

e. Drawbands used with flexible duct.

I. Drawbands shall be either stainless-steel worm-drive hose clamps or UV-resistant nylon duct ties.

II. Drawbands shall have a minimum tensile strength rating of 150 pounds.

III. Drawbands shall be tightened as recommended by the manufacturer with an adjustable tensioning tool.

f. Aerosol-sealant closures.

I. Aerosol sealants shall meet the requirements of UL 723 and be applied according to manufacturer specifications.

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

D. All duct insulation product R-values shall be based on insulation only (excluding air films, vapor retarders or other duct components) and tested C-values at 75°F mean temperature at the installed thickness, in accordance with ASTM C518 or ASTM C177, incorporated herein by reference, and certified pursuant to Section 110.8.

E. The installed thickness of duct insulation used to determine its R-value shall be determined as follows:

i. For duct board, duct liner and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used.

ii. For duct wrap, installed thickness shall be assumed to be 75 percent (25 percent compression) of nominal thickness.

iii. For factory-made flexible air ducts, the installed thickness shall be determined by dividing the difference between the actual outside diameter and nominal inside diameter by two.

F. Insulated flexible duct products installed to meet this requirement must include labels, in maximum intervals of 3 feet, showing the thermal performance R-value for the duct insulation itself (excluding air films, vapor retarder or other duct components), based on the tests in Section 160.3(c)2D and the installed thickness determined by Section 160.3(c)2Eiii.

G. Insulation shall be protected from damage, including that due to sunlight, moisture, equipment maintenance and wind but not limited to the following: Insulation exposed to weather shall be suitable for outdoor service; e.g., protected by aluminum, sheet metal, painted canvas or plastic cover. Cellular foam insulation shall be protected as above or painted with a coating that is water retardant and provides shielding from solar radiation that can cause degradation of the material.

H. Duct systems shall be tested in accordance with i or ii below:

i. New duct systems that meet the criteria in Subsections a, b and c below or ductwork that is part of a system that meets the criteria of Section 180.2(b)2B shall be sealed to a leakage rate not to exceed 6 percent of the nominal air handler airflow rate as confirmed through acceptance testing, in accordance with Reference Nonresidential Appendix NA7.5.3.

a. The duct system provides conditioned air to an occupiable space for a constant volume, single zone, space-conditioning system; and

b. The space-conditioning system serves less than 5,000 square feet of conditioned floor area; and

c. The combined surface area of the ducts located in the following spaces is more than 25 percent of the total surface area of the entire duct system:

   I. Outdoors; or

   II. In a space directly under a roof that has a U-factor greater than the U-factor of the ceiling, or if the roof does not meet the requirements of Section 170.2(a)1; or

   III. In a space directly under a roof that has fixed vents or openings to the outside or unconditioned spaces; or

   IV. In an unconditioned crawl space; or

   V. In other unconditioned spaces.

ii. All duct systems that do not meet the criteria in Section 160.3(c)2H shall meet the duct leakage testing requirements of CMC Section 603.9.2.

«» Commentary for Section 160.3(c)2H:

The 2019 California Mechanical Code (CMC) introduced mandatory requirements to seal and test all nonresidential air distribution systems and all systems that do not meet the criteria for testing according to the Energy Code may be required to meet the requirements in the CMC.

The outside air ducts for CFI ventilation systems are not allowed to be sealed/taped off during duct leakage testing. However, CFI outdoor air ductwork that uses controlled motorized dampers that open only when outdoor air ventilation is required and close when outdoor air ventilation is not required may be closed during duct leakage testing. **«»**

(d) **Mechanical acceptance testing.**

1. Common areas. Before an occupancy permit is granted, the following systems and equipment serving multifamily common areas shall be certified as meeting the Acceptance Requirements for Code Compliance, as specified by Reference Nonresidential Appendix NA7. These systems and equipment shall also comply with the applicable requirements of Section 160.3(d)3. A Certificate of Acceptance shall be submitted to the enforcement agency that certifies that the equipment and systems meet the acceptance requirements:

   A. Outdoor air ventilation systems shall be tested in accordance with NA7.5.1.

«» Commentary for Section 160.3(d)1A:

This test (NA7.5.1) ensures the constant volume air handling unit provides adequate outdoor air ventilation to the spaces served under all operating conditions. Systems requiring demand ventilation controls per Section 160.2(c)5C must conform to Section 160.2(c)5D regarding the minimum ventilation rate when the system is in occupied mode. Related acceptance tests for these systems include the following:

1. NA7.5.2 Constant-Volume, Single-Zone, Unitary Air Conditioners and Heat Pump Systems Acceptance
2. NA7.5.4 Air Economizer Controls Acceptance (if applicable)
3. NA7.5.5 Demand-Controlled Ventilation Systems Acceptance (if applicable)Text

This test (NA7.5.1) is restricted to certified Mechanical ATTs only, using Certificate of Acceptance NRCA-MCH-02-A. **«»**

B. Constant volume, single zone air conditioning and heat pump unit controls shall be tested in accordance with NA7.5.2.

«» Commentary for Section 160.3(d)1B:

This acceptance test (NA7.5.2) is meant for constant volume, single zone, unitary (packaged and split) air conditioner and heat pump systems. This test verifies the components of a constant volume, single-zone, unitary air conditioner and heat pump system function correctly, including: thermostat installation and programming, supply fan, heating, cooling, and damper operation. Testing of the economizer, outdoor air ventilation, and demand-controlled ventilation are located in the following sections of the Reference Appendices:

1. NA7.5.1.2 Constant Volume System Outdoor Air Acceptance
2. NA7.5.4 Air Economizer Controls (if applicable)
3. NA7.5.5 Demand Control Ventilation (DCV) Systems (if applicable)

This test (NA7.5.2) is restricted to certified Mechanical ATTs only, using Certificate of Acceptance NRCA-MCH-03-A. **«»**

C. Duct systems shall be tested in accordance with NA7.5.3 where either:

   a. They are new duct systems; or

   b. They are part of an altered system.

«» Commentary for Section 160.3(d)1C:

This test (NA7.5.3) verifies all duct work associated with all nonexempt constant volume, single-zone HVAC units (in other words, air conditioners, heat pumps, and furnaces) meet the material, installation, and insulation R-values per Section 160.3(c)2A through G and leakage requirements outlined either in Section 160.3(c)2H for new duct systems or Section 180.2(b)2Bii for existing duct systems.

This test may either be verified by a ECC-Rater (sampling permitted) with the technician testing each installation and using LMCV-MCH-20-H (less than or equal to 3 stories) or NRCV-MCH-04-H (greater than or equal to 4 stories) to record the results or performed by a certified Mechanical ATT (no sampling permitted) using NRCA-MCH-04-A and recording it with an Acceptance Test Technician Certification Provider (ATTCP). **«»**

D. Air economizers, DOAS, HRV or ERV systems shall be tested in accordance with NA7.5.4.

   Exception to Section 160.3(d)1D: Air economizers installed by the HVAC system manufacturer and certified to the Commission as being factory calibrated and tested are not required to comply with the Functional Testing section of the Air Economizer Controls acceptance test as described in NA7.5.4.2.

«» Commentary for Section 160.3(d)1D:

This test (NA7.5.4) is restricted to certified Mechanical ATTs and is intended to verify Energy Code compliance for multifamily common use areas with newly installed economizers, dedicated outdoor air system (DOAS), HRV system, and ERV system. Economizers must be certified to the Energy Commission in compliance with JA6.3

Submit one Certificate of Acceptance (NRCA-MCH-05-A) for each economizer, DOAS, HRV system, or ERV system that must demonstrate compliance with the Energy Code. For direct Energy Code reference see JA6.3, NA7.5.4, and Section 160.3(d)1D.

Functionally testing an air economizer cycle verifies that an HVAC system uses outdoor air to satisfy space-cooling loads. There are two types of economizer controls: stand-alone packages and DDC controls. The stand-alone packages are commonly associated with small unitary rooftop HVAC equipment. DDC controls are typically associated with built-up or large packaged air handling systems.

Cooling fan systems greater than 33,000 Btu/hr may use an economizer to comply with prescriptive requirements. Air economizers must be able to provide 100 percent of the design supply air with outside air; water economizers must be able to provide 100 percent of the design cooling load at 50°F dry-bulb and 45°F wet-bulb. «»

E. Demand control ventilation systems required by Section 160.2(c)3 shall be tested in accordance with NA7.5.5.

«» Commentary for Section 160.3(d)1E:

The purpose of the test (NA7.5.5) is to verify that systems required to employ demand controlled ventilation (refer to Section 160.2(c)5C) can vary outside ventilation flow rates based on maintaining interior carbon dioxide (CO2) concentration setpoints. DCV refers to an HVAC system's ability to reduce outdoor air ventilation flow below design values when the space served is at less than design occupancy. CO_2 is a good indicator of occupancy load and is the basis used for modulating ventilation flow rates.

DCV complying with Section 160.2(c)5D are required for a space with a design occupant density, or a maximum occupant load factor for egress purposes in the CBC, greater than or equal to 25 people per 1000 square feet (40 square feet or less per person) if the ventilation system serving the space has one or more of the following:

1. an air economizer, modulating outside air control, or
2. design outdoor airflow rate > 3,000 cfm (Section 160.2(c)3).

This acceptance test is limited to certified Mechanical ATTs using NRCA-MCH-06-A to verify that a system required to employ DCV can vary outside air ventilation flow rates based on maintaining interior carbon dioxide (CO2) concentration setpoints in compliance with Section 160.2(c)5D. NRCA-MCH-02-A must be completed either prior to or concurrently with this acceptance test for the space in which the CO2 monitor is located. One NRCA-MCH-06-A must be completed for each CO2 sensor in the system that must demonstrate compliance. For direct Energy Code reference see Section 160.2(c)5C, Section 160.2(c)5D, Section 160.3(d)1E, NA7.5.1, and NA7.5.5. **«»**

F. Supply fan variable flow controls shall be tested in accordance with NA7.5.6.

«» Commentary for Section 160.3(d)1F:

The purpose of the test (NA7.5.6) is to ensure that the supply fan in a variable air volume application modulates to meet system airflow demand. In most applications, the individual VAV boxes serving each space will modulate the amount of air delivered to the space based on heating and cooling requirements. As a result, the total supply airflow provided by the central air handling unit must also vary to maintain sufficient airflow through each VAV box. Airflow is typically controlled using a variable frequency drive (VFD) to modulate supply fan speed and vary system airflow. The most common strategy for controlling the VFD is to measure and maintain static pressure within the duct.

This test is restricted to a certified Mechanical ATT using NRCA-MCH-07-A to verify that the supply fan speed in a variable air volume system modulates to meet system airflow demand. NRCA-MCH-07-A can be performed in conjunction with NRCA-MCH-02-A Outdoor Air Acceptance since testing activities overlap. **«»**

G. Hydronic system variable flow controls shall be tested in accordance with NA7.5.7 and NA7.5.9.

«» Commentary for Section 160.3(d)1G:

This test (NA7.5.7) ensures that control valves serving variable flow systems are designed to withstand the pump pressure over the full range of operation. Valves with insufficient actuators will lift under certain conditions causing water to leak and loss of flow control. This test applies to the variable flow systems covered by Section 170.2(c)4Ii chilled and hot-water variable flow systems, Section 170.2(c)4Iii chiller isolation valves, Section 170.2(c)4Iiii boiler isolation valves, and Section 170.2(c)4Iv water-cooled air conditioner and hydronic heat pump systems.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-08-A to ensure that control valves serving variable flow systems can withstand the pump pressure over the full range of operation. Related acceptance tests for these systems include NA7.5.9 Hydronic System Variable Flow Controls Acceptance Testing time will be greatly reduced if these acceptance tests are done simultaneously.

This test (NA7.5.9) is for all hydronic variable flow chilled water and water-loop heat pump systems with total circulating pump power larger than 5 hp shall vary system flow rate by modulating pump speed using either a variable frequency drive (VFD) or equivalent according to Section 170.2(c)4Ivi. Pump speed and flow must be controlled as a function of differential pressure, and pump motor demand must be no more than 30 percent design wattage at 50 percent design flow.

As the loads within the building fluctuate, control valves should modulate the amount of water passing through each coil and add or remove the desired amount of energy from the air stream to satisfy the load. In the case of water-loop heat pumps, each two-way control valve associated with a heat pump closes when not operating. The purpose of the test is to ensure that, as each control valve modulates, the pump variable frequency drive (VFD) responds accordingly to meet system water flow requirements.

This test is restricted to certified mechanical ATTs using NRCA-MCH-10-A to ensure that hydronic pump speed varies with building heating and cooling loads. The related acceptance tests for this system is NA7.5.7 Valve Leakage Test – NRCA-MCH-08-A (if applicable). **«»**

H. Boilers or chillers that require isolation controls as specified by Section 170.2(c)4Iii or 170.2(c)4Iiii shall be tested in accordance with NA7.5.7.

«» Commentary for Section 160.3(d)1H:

This test (NA7.5.7) ensures that control valves serving variable flow systems are designed to withstand the pump pressure over the full range of operation. Valves with insufficient actuators will lift under certain conditions causing water to leak and loss of flow control. This test applies to the variable flow systems covered by Section 170.2(c)4Ii chilled and hot-water variable flow systems, Section 170.2(c)4Iii chiller isolation valves, Section 170.2(c)4Iiii boiler isolation valves, and Section 170.2(c)4Iv water-cooled air conditioner and hydronic heat pump systems.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-08-A to ensure that control valves serving variable flow systems can withstand the pump pressure over the full range of operation. Related acceptance tests for these systems include NA7.5.9 Hydronic System Variable Flow Controls Acceptance Testing time will be greatly reduced if these acceptance tests are done simultaneously. **«»**

I. Hydronic systems with supply water temperature reset controls shall be tested in accordance with NA7.5.8.

«» Commentary for Section 160.3(d)1I:

This test (NA7.5.8) ensures that both the chilled water and hot water supply temperatures are automatically reset based on either building loads or outdoor air temperature, as indicated in the control sequences. Many HVAC systems are served by central chilled and heating hot water plants. The supply water operating temperatures must meet peak loads when the system is operating at design conditions. As the loads vary, the supply water temperatures can be adjusted to satisfy the new operating conditions. Typically the chilled water supply temperature can be raised as the cooling load decreases, and heating hot water supply temperature can be lowered as the heating load decreases.

This requirement only applies to chilled and hot water systems that are not designed for variable flow and that have a design capacity greater than or equal to 500 kBtuh (thousand BTU's per hour), according to Section 170.2(c)4Iiv.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-09-A to ensure that both the chilled water and hot water supply temperatures are automatically reset based on either building loads or outdoor air temperature, as indicated in the control sequences. (Section 170.2(c)4Iiv).

Note the following exception: Hydronic systems that use variable flow to reduce pumping energy. (Section 170.2(c)4Ii.) **«»**

J. Automatic demand shed controls shall be tested in accordance with NA7.5.10.

«» Commentary for Section 160.3(d)1J:

This test (NA7.5.10) is used if the building has direct digital control (DDC) to the zone level, the HVAC control system must be capable receiving a Demand Response Signal and automatically initiating a control strategy once the signal is received. This acceptance test confirms that the HVAC control system is programmed so that it is capable of initiating the control strategy specified in Section 110.12(b). That is, modify the temperature setpoints in non-critical zones up by 4ºF if the system is cooling the space or down by 4ºF if the system is heating the space. The building owner or occupant has the option of selecting another control strategy than the one tested here if they choose to enroll in a demand response program.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-11-A to ensure that the central demand shed sequences have been properly programmed into the DDC system. **«»**

K. Fault detection and diagnostics (FDD) for packaged direct expansion units shall be tested in accordance with NA7.5.11.

«» Commentary for Section 160.3(d)1K:

The purpose of this test (NA7.5.11) is to verify proper fault detection and diagnostic (FDD) reporting for automated fault detection and diagnostics systems for packaged DX units. Automated FDD systems ensure proper equipment operation by identifying and diagnosing common equipment problems such as temperature sensor faults, low airflow or faulty economizer operation. FDD systems help to maintain equipment efficiency closer to rated conditions over the life of the equipment.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-12-A and is recommended to be performed simultaneity with NRCA-MCH-02-A (Outside Air) and NRCA-MCH-05-A (Air Economizer Controls). **«»**

L. Automatic fault detection and diagnostics (FDD) for air handling units and zone terminal units shall be tested in accordance with NA7.5.12.

«» Commentary for Section 160.3(d)1L:

The purpose of this test (NA7.5.12) is to verify proper FDD reporting for air handling unit (AHU) and zone terminal unit (ZTU) systems. Fault detection and diagnostics can also be used to detect common faults with air handling units and zone terminal units. Many FDD tools are standalone software products that process trend data offline. Maintenance problems with built-up air handlers and variable air volume boxes are often not detected by energy management systems because the required data and analytical tools are not available. Performing the FDD analysis within the distributed unit controllers is more practical because of the large volume of data.

The acceptance tests are designed to verify that the system detects common faults in air handling units and terminal units. FDD systems for air handling units and zone terminal units require DDC controls to the zone level. Successful completion of this test provides a compliance credit when using the performance approach. An FDD system that does not pass this test may still be installed, but no compliance credit will be given.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-13-A to verify that the system detects common faults in air handling units and zone terminal units. «»

M. Distributed energy storage DX AC systems shall be tested in accordance with NA7.5.13.

«» Commentary for Section 160.3(d)1M:

This test (NA7.5.13) verifies proper operation of distributed energy storage DX systems. Distributed energy systems reduce peak demand by operating during off peak hours and storing cooling, usually in the form of ice. During peak cooling hours the ice is melted to avoid compressor operation.

This acceptance test applies to direct expansion (DX) system with distributed energy storage (DES/DXAC). These acceptance requirements are in addition to those for those other systems or equipment such as economizers or packaged equipment. This acceptance test was developed by AEC for Distributed Energy Storage for Direct-Expansion Air Conditioners, January 27, 2005, and is directly referenced by the Energy Code.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-14-A to verify that the system conforms with the Energy Code requirements. «»

N. Thermal energy storage (TES) systems shall be tested in accordance with NA7.5.14.

«» Commentary for Section 160.3(d)1N:

This test (NA7.5.14) verifies proper operation of thermal energy storage (TES) systems. TES systems reduce energy consumption during peak demand periods by shifting energy consumption to nighttime. Operation of the thermal energy storage compressor during the night produces cooling energy, which is stored in the form of cooled fluid or ice in tanks. During peak cooling hours the thermal storage is used for cooling to prevent the need for chiller operation.

The test will ensure that the TES system is able to charge the storage tank during off-peak hours and conversely discharge the storage tank during on peak hours. Since the chiller may operate more efficiently at night when ambient temperatures are lower, the system may save cooling energy in some climate zones. This acceptance test is intended for TES systems that are used in conjunction with chilled water air conditioning systems.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-15-A to verify that the system conforms with the Energy Code requirements. **«»**

O. Supply air temperature reset controls shall be tested in accordance with NA7.5.15.

«» Commentary for Section 160.3(d)1O:

The purpose of the test (NA7.5.15) is to ensure that the supply air temperature in a constant or variable air volume application serving multiple zones, according to Section 170.2(c)4D, modulates to meet system heating and cooling loads. Space conditioning systems must have zone level controls to avoid reheat, re-cool, and simultaneous cooling and heating (Section 170.2(c)4B); or must have controls to reset supply air temperature (SAT) by at least 25 percent of the difference between the design supply-air temperature and the design room air temperature (Section 170.2(c)4Dii). Air distribution systems serving zones with constant loads must be designed for the air flows resulting from the fully reset (e.g. lowest/highest) supply air temperature. The requirements for SAT reset apply to both CAV and VAV systems. Exceptions include:170.2(c)4B; or must have controls to reset SAT by at least 25 percent of the difference between the design supply-air temperature and the design room air temperature (Section 170.2(c)4Dii). Air distribution systems serving zones with constant loads must be designed for the air flows resulting from the fully reset (e.g. lowest/highest) supply air temperature. The requirements for SAT reset apply to both CAV and VAV systems. Exceptions include:

1. Systems with specific humidity needs for exempt process loads (computer rooms or spaces serving only IT equipment are not exempt).
2. Zones served by space conditioning systems in which at least 75 percent of the energy for reheating, or providing warm air in mixing systems, is provided from a site-recovered or site-solar energy source.
3. Systems in which supply air temperature reset would increase overall building energy use.
4. Systems with controls to prevent reheat, re-cool, and/or simultaneous cooling and heating.

Supply air temperature may be reset in response to building loads, zone temperature, outside air temperature, or any other appropriate variable.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-16-A to verify that the supply air temperature modulates to meet system temperature setpoint(s). **«»**

P. Water-cooled chillers served by cooling towers with condenser water reset controls shall be tested in accordance with NA7.5.16.

«» Commentary for Section 160.3(d)1P:

The intent of the test (NA7.5.16) is to verify that the condenser water supply (entering condenser water) temperature is automatically reset as indicated in the control sequences; based upon building loads, outdoor air wet-bulb temperature, or another appropriate control variable. All cooling tower system components (e.g. fans, spray pumps) should operate per the control sequences to maintain the proper condenser water temperature and pressure set points.

Chilled water plants serve many buildings, responding to the varying cooling loads throughout the year. As the loads vary, the chilled water supply temperatures adjust to satisfy the new operating conditions. Often, water-cooled chilled water plants can decrease the condenser water temperature in times of low cooling load. This occurrence can be demonstrated by running the cooling tower fans at a higher speed, staging on additional fans, or varying water distribution across the tower fill by closing and opening bypass valves. As a result, the cooling tower produces an energy penalty, however the chiller efficiency and the overall plant efficiency improves.

The purpose of this test is not to evaluate whether a particular control sequence is the most appropriate for the facility, but whether the system follows the intended control sequence. This test is restricted to certified Mechanical ATTs using NRCA-MCH-17-A to ensure that the condenser water supply temperature is automatically reset as indicated in the control sequence(s). **«»**

Q. When an energy management control system is installed, it shall functionally meet all of the applicable requirements of Part 6.

«» Commentary for Section 160.3(d)1Q:

The purpose of this acceptance test is to ensure that when an Energy Management Control System (EMCS) is installed for the purpose of compliance with the Energy Code, it is properly installed, operational, and is in compliance with each relevant requirement in the Energy Code.

This test is restricted to certified Mechanical ATTs using NRCA-MCH-18-A to ensure that when an EMCS is installed for the purpose of compliance with the Energy Code, it is properly installed, operational, and is in compliance with each relevant requirement in the Energy Code. **«»**

R. Occupant sensing zone controls shall be tested in accordance with NA7.5.17.

«» Commentary for Section 160.3(d)1R:

This test (NA7.5.17) verifies that an installed occupancy sensor is functional and in compliance with the approved project designs and Energy Code. The technician must submit one Certificate of Acceptance for each occupancy sensor installed.

This test is restricted to certified mechanical ATTs using NRCA-MCH-19-A to ensure that the occupancy sensor is functional and in compliance with the design and with the Energy Code. **«»**

2. Multifamily dwelling units. Before an occupancy permit is granted, the following systems and equipment serving multifamily dwelling units shall be certified as meeting the acceptance requirements for code compliance, as specified by the Reference Nonresidential Appendix NA7. These systems and equipment shall also comply with the applicable requirements of Section 160.3(d)3. A Certificate of Acceptance shall be submitted to the enforcement agency that certifies that the equipment and systems meet the acceptance requirements:

«» Commentary for Section 160.3(d)2:

This test (NA7.18.1) can be performed by a certified Mechanical ATT or uncertified technician and ECC-Rater to verify that the continuous ventilation airflow (supply, exhaust, or balanced) system, the kitchen exhaust fan, and/or the HRV system or ERV system conforms to the requirements of the Energy Code and ANSI/ASHRAE Standards 62.2-2016. If using supply-only or exhaust-only ventilation, Certificate of Acceptance NRCA-MCH-21-H must be completed prior to beginning this acceptance test.

This test is not restricted to certified Mechanical ATTs if a ECC-Rater is used as a verification for an uncertified technician to perform the same test and the verification is registered with a ECC-Provider. Alternatively, these same forms can be used by a mechanical ATT without need of a ECC-Rater.

NRCA-MCH-20a-H must be completed (once) for all of the subsequent forms for dwelling ventilation requirements. NRCA-MCH-20b-H is used to verify the kitchen range hood complies with the Energy Code requirements. NRCA-MCH-20c-H is used to verify the indoor air quality ventilation systems complies with the Energy Code requirements. NRCA-MCH-20d-H is used to verify HRV or ERV (if installed) systems comply with the Energy Code requirements.

This acceptance test is intended for multifamily dwelling units where CONTINUOUS ventilation is used. Ventilation airflow of systems with multiple operating modes shall be tested in all modes designed to comply with the required ventilation airflows. Approved systems, devices, or controls, and field verification and diagnostic test protocols for intermittent mechanical ventilation systems will be listed in directories published by the Energy Commission.

This acceptance test (NA7.18.2) is used to verify that the envelope leakage rate for multifamily dwelling units conforms to the requirements of the Energy Code.

This test is not restricted to certified Mechanical ATTs if an ECC-Rater is used as a verification for an uncertified technician to perform the same test and the verification is registered with a ECC-Provider. Alternatively, this same form can be used by a mechanical ATT without need of an ECC-Rater.

NRCA-MCH-21-H must be completed for each dwelling unit using a supply-only or exhaust-only ventilation system to verify that the envelope leakage conforms to the requirements of the Energy Code Section 160.2(b)2 and Nonresidential Reference Appendices NA7.18.2, NA2.3, ANSI/RESNET/ICC 380-2016, and ASTM E779-10 (2010). The certified mechanical ATT or technician and ECC-Rater is required to complete this compliance certificate prior to completing NRCA-MCH-20-H. **«»**

A. Multifamily building central ventilation ducts subject to Section 160.2(b)2C shall be leak tested in accordance with NA7.18.3.

«» Commentary for Section 160.3(d)2A:

The objective of this procedure (NA7.18.3) is to verify the leakage of a new central ventilation duct system(s) (Section 160.2(b)2Ci) that serve multiple dwelling units and provides continuous airflows or are part of a balanced ventilation system to meet the requirements specified in Sections 160.2(b)2Aiv or 160.2(b)2Av. This compliance document (NRCA-MCH-22-A) is used to record the results of one system duct leakage test performed. These test procedures are based on ATSM 1554 Method D – Total duct leakage test. This test may only be performed by a certified Mechanical ATT. «»

B. Multifamily building central ventilation system heat recovery or energy recovery systems in multifamily buildings with four or more habitable stories shall be tested in accordance with NA7.18.4.

«» Commentary for Section 160.3(d)2B:

The objective of this acceptance test is to verify the HRV or ERV system requirement in multifamily buildings for compliance with Section 170.2(c)3Bivb, a central ERV/HRV systems serving multiple dwelling units. This test may only be performed by a certified Mechanical ATT. «»

3. When certification is required by Title 24, Part 1, Section 10-103.2, the acceptance testing specified by Section 160.3(d)1 and 2 shall be performed by a Certified Mechanical Acceptance Test Technician (CMATT). If the CMATT is operating as an employee, the CMATT shall be employed by a Certified Mechanical Acceptance Test Employer. The CMATT shall disclose on the Certificate of Acceptance a valid CMATT certification identification number issued by an approved Acceptance Test Technician Certification Provider. The CMATT shall complete all Certificate of Acceptance documentation in accordance with the applicable requirements in Section 10-103(a)4.

«» Commentary for Section 160.3(d)3:

Detailed instructions on how to conduct acceptance tests are located at the Energy Commission website, https://www.energy.ca.gov/programs-and-topics/programs/acceptance-test-technician-certification-provider-program. «»

TABLE 160.3-A: Return Duct Sizing for Single Return Duct Systems

Return duct length shall not exceed 30 feet and shall contain no more than 180 degrees of bend. If the total bending exceeds 90 degrees, one bend shall be a metal elbow.

Return grille devices shall be labeled in accordance with the requirements in Section 160.2(b)1Biv to disclose the grille's design airflow rate and a maximum allowable clean-filter pressure drop of 25 Pa (0.1 inches water) for the air filter when tested using

ASHRAE Standard 52.2, or as rated in accordance with AHRI Standard 680 for the design airflow rate for the return grille.

System Nominal Cooling Capacity (Ton)*	Return Duct Minimum Nominal Diameter (inch)	Minimum Total Return Filter Grille Nominal Area (inch^2)
1.5	16	500
2.0	18	600
2.5	20	800

*Not applicable to systems with nominal cooling capacity greater than 2.5 tons or less than 1.5 ton

TABLE 160.3-B: Return Duct Sizing for Multiple Return Duct Systems

Each return duct length shall not exceed 30 feet and shall contain no more than 180 degrees of bend. If the total bending exceeds 90 degrees, one bend shall be a metal elbow.

Return grille devices shall be labeled in accordance with the requirements in Section 160.2(b)1Biv to disclose the grille's design airflow rate and a maximum allowable clean-filter pressure drop of 25 Pa (0.1 inches water) for the air filter when tested using ASHRAE Standard 52.2, or as rated in accordance with AHRI Standard 680 for the design airflow rate for the return grille.

System Nominal Cooling Capacity (Ton)*	Return Duct 1 Minimum Nominal Diameter (inch)	Return Duct 2 Minimum Nominal Diameter (inch)	Minimum Total Return Filter Grille Nominal Area (inch^2)
1.5	12	10	500
2.0	14	12	600
2.5	14	14	800
3.0	16	14	900
3.5	16	16	1000
4.0	18	18	1200
5.0	20	20	1500

*Not applicable to systems with nominal cooling capacity greater than 5.0 tons or less than 1.5 tons.

TABLE 160.3-C DDC Applications and Qualifications

Building Status	Applications	Qualifications
Newly Constructed Buildings	Air handling system and all zones served by the system	Individual systems supplying more than three zones and with design heating or cooling capacity of 300 kBtu/h and larger
Newly Constructed Buildings	Chilled water plant and all coils and terminal units served by the system	Individual plants supplying more than three zones and with design cooling capacity of 300 kBtu/h (87.9 kW) and larger

Newly Constructed Buildings	Hot water plant and all coils and terminal units served by the system	Individual plants supplying more than three zones and with design heating capacity of 300 kBtu/h (87.9 kW) and larger
Additions or Alterations	Zone terminal unit such as VAV box	Where existing zones served by the same air handling, chilled water, or hot water systems that have DDC
Additions or Alterations	Air handling system or fan coil	Where existing air handling system(s) and fan coil(s) served by the same chilled or hot water plant have DDC
Additions or Alterations	New air handling system and all new zones served by the system	Individual systems with design heating or cooling capacity of 300 kBtu/h and larger and supplying more than three zones and more than 75 percent of zones are new
Additions or Alterations	New or upgraded chilled water plant	Where all chillers are new and plant design cooling capacity is 300 kBtu/h (87.9 kW) and larger
Additions or Alterations	New or upgraded hot water plant	Where all boilers are new and plant design heating capacity is 300 kBtu/h (87.9 kW) and larger

TABLE 160.3-D PIPE INSULATION THICKNESS

Space heating (Steam, Steam Condensate, Refrigerant, Space Heating)

Fluid Operating Temperature Range (°F)	**Insulation Conductivity (Btu·in/h·ft² °F)**	**Insulation Conductivity Mean Rating Temp. (°F)**	**Nominal Pipe Diameter (in inches) < 1**	**Nominal Pipe Diameter (in inches) 1 to <1.5**	**Nominal Pipe Diameter (in inches) 1.5 to < 4**	**Nominal Pipe Diameter (in inches) 4 to < 8**	**Nominal Pipe Diameter (in inches) 8 and larger**
Above 350	0.32-0.34	250	4.5 (R 37)	5.0 (R 41)	5.0 (R 37)	5.0 (R 27)	5.0 (R 23)
251-350	0.29-0.32	200	3.0 (R 24)	4.0 (R 34)	4.5 (R 35)	4.5 (R 26)	4.5 (R 22)
201-250	0.27-0.30	150	2.5 (R 21)	2.5 (R 20)	2.5 (R 17.5)	3.0 (R 17)	3.0 (R 14.5)
141-200	0.25-0.29	125	1.5 (R 11.5)	1.5 (R 11)	2.0 (R 14)	2.0 (R 11)	2.0 (R 10)
105-140	0.22-0.28	100	1.0 (R 7.7)	1.5 (R 12.5)	1.5 (R 11)	1.5 (R 9)	1.5 (R 8)

CONTINUED: TABLE 160.3-D PIPE INSULATION THICKNESS REQUIRED (thickness in inches or R-Value)

Space cooling systems (chilled water, refrigerant and brine)

Fluid Operating Temperature Range (°F)	**Insulation Conductivity (Btu·in/h·ft^2 °F)**	**Insulation Conductivity Mean Rating Temp. (°F)**	**Nominal Pipe Diameter (in inches) < 1**	**Nominal Pipe Diameter (in inches) 1 to <1.5**	**Nominal Pipe Diameter (in inches) 1.5 to < 4**	**Nominal Pipe Diameter (in inches) 4 to < 8**	**Nominal Pipe Diameter (in inches) 8 and larger**
40-60	0.21-0.27	75	0.75 (R 6)	0.75 (R 5)	1.0 (R 7)	1.0 (R 6)	1.0 (R 5)
Below 40	0.20-0.26	50	1.0 (R 8.5)	1.5 (R 14)	1.5 (R 12)	1.5 (R 10)	1.5 (R 9)

Footnote to TABLE 160.3-D:

1. These thicknesses are based on energy efficiency considerations only. Issues such as water vapor permeability or surface condensation sometimes require vapor retarders or additional insulation.

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

SECTION 160.9 – MANDATORY REQUIREMENTS FOR ELECTRIC READY BUILDINGS

(a) General Requirements. Multifamily buildings shall comply with the applicable requirements of subsection 160.9. The building electrical system shall be sized to meet the future electric requirements of the electric ready equipment specified in sections 160.9(b) through (f). The building main service conduit, the electrical system to the point specified in each subsection, and any on-site distribution transformers shall have sufficient capacity to supply full rated amperage at each electric ready appliance in accordance with the California Electrical Code.

(b) Heat Pump Space Heater Ready. Systems using gas or propane furnaces to serve individual dwelling units shall include the following:

1. A dedicated 240 volt branch circuit wiring shall be installed within 3 feet from the furnace and accessible to the furnace with no obstructions. The branch circuit conductors shall be rated at 30 amps minimum. The blank cover shall be identified as "240V ready." All electrical components shall be installed in accordance with the California Electrical Code.
2. The main electrical service panel shall have a reserved space to allow for the installation of a double pole circuit breaker for a future heat pump space heater installation. The reserved space shall be permanently marked as "For Future 240V use."

«» Commentary for Section 160.9(b):

Installation of branch circuits per 160.9(b)1 are dedicated to future electric replacement equipment and cannot be used for other appliances. Other electrical components must be installed in accordance with the California Electrical Code.

Dedicated space is required for double breakers in the main service panel that will serve the future in-unit space heating. The Energy Code does not require the installation of breakers at time of construction.

Dedicated space in the panel next to the location of the water heater breaker to accommodate converting it to 240V in the future, per Section 160.4. The dedicated space in the panels must be identified as "Future 240V Use." The code does not require the installation of breakers at time of construction.

There are no electric ready requirements for additions or alterations. There are no performance or prescriptive electric ready requirements for multifamily buildings.

The unused circuits must have a blank cover identified as "240V ready." Receptacles are required for dwelling unit water heating, and must be connected to the panel with a 120/240V, 3-conductor circuit rated at 30 amps minimum with both ends of the unused conductor labeled as "spare" and be electrically isolated.

Electric Ready requirements for other building systems and appliances, as specified in Section 160.9(c)-(f), are described in Chapter 6 – Electrical and Lighting Systems. **«»**

SECTION 170.1 – PERFORMANCE APPROACH

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

(a) Energy budget. The Energy budget is expressed in terms of Long-Term System Cost (LSC) and Source Energy:

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

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

«» Commentary for Section 170.1(a):

HVAC Performance Approach

Under the performance approach, the energy use of the building is modeled using a compliance software program approved by the Energy Commission. Program users and those checking for enforcement should consult the most current version of the user's manuals and associated compliance supplements for specific instructions on the operation of the program. All compliance software programs, however, are required to have the same basic modeling capabilities.

The compliance rules used by the computer methods in generating the energy budget and compliance credits are based on features required for prescriptive compliance. Detailed information can be found in the 2025 Nonresidential and Multifamily Alternative Calculation Method (ACM) Reference Manual.

There are minimum modeling capabilities required for programs that are used for the performance approach. All certified programs are tested for conformance with the requirements of the 2025 Nonresidential and Multifamily ACM Reference Manual. The designer has to use an approved program to show compliance.

Compliance is shown by running two models: a base case budget building that nominally meets the mandatory and prescriptive requirements and a proposed building that represents the actual proposed envelope, lighting, and mechanical systems of the building. To create a level playing field the base case and proposed designs are compared using the same assumptions of occupancy, proscribed climatic conditions and operating schedules. The results are compared using standardized time of use rates, or long-term system cost (LSC) of energy cost.

The proposed building complies if its annual source Energy and LSC energy is less than or equal to that of the budget building. Reference Appendix JA3 describes the derivation of the LSC energy multipliers.

Compliance in the Performance Approach is across all building systems. The design team can use more glass than with the prescriptive approach and comply by making a more efficient HVAC system. Energy can be traded off between prescriptive requirements in the envelope, HVAC system, water heating, indoor lighting, photovoltaics, battery energy storage system and covered processes.

The alternative calculation method defines the modeling rules for developing the base-case model of the building and mechanical systems. The base-case HVAC system(s) is modeled on a system(s) according to occupancy type, floor area of building, number of floors, and zoning.

The following are some examples of how to get credit in the Performance Approach from HVAC systems:

1. Use of high efficiency equipment that exceeds the minimum requirements of Section 110.1 and Section 110.2
2. Application of economizers where they are not required
3. Oversizing ducts and pipes to reduce fan and pump energy
4. Use of heat recovery for space or water heating
5. Use of thermal energy storage systems or building mass to move cooling off peak
6. Reduce reheating and recooling
7. Use of thermally driven cooling equipment, such as absorption chillers.

HVAC Issues

When a building has no cooling system, the software simulates a hypothetical system with the characteristics required by Table 170.2-K as if a cooling system were installed. The result is neither a penalty nor a credit.

Alternative Calculation Methods (Compliance Software)

Compliance software must be approved by the Energy Commission. Approval involves the demonstration of minimum modeling capabilities, required input and output, and adequate user documentation. The compliance software must be able to:

1. Automatically calculate the energy budget of the standard design.
2. Calculate the energy budget of the proposed design in accordance with specific fixed and restricted inputs.
3. Print the appropriate standardized compliance documents with the required information and format when a proposed building complies. Other reports that do not resemble compliance documents may be printed for buildings that do not comply.

Input and Output Requirements

Input and output requirements and modeling capabilities are tested by using the compliance software to calculate the energy use of certain prototype buildings under specific conditions. These results are compared with the results from the reference public domain compliance software, CBECC, which uses EnergyPlus as the simulation engine. This is explained in detail in the Nonresidential and Multifamily ACM Reference Manual.

Long-Term System Cost (LSC)

Under the performance approach, energy use of the building is modeled by compliance software approved by the Energy Commission. The compliance software simulates the Long-Term System Cost (LSC) energy budget of the proposed building, including a detailed accounting of envelope heat transfers using the assemblies and fenestration input, and the precise geometry of any exterior overhangs or side fins. The most accurate tradeoffs between different envelope components – and among the envelope, the space-conditioning system, and the installed common area lighting – are accounted for and compared with the standard design version of the building. The proposed design must have LSC energy less than or equal to the standard design. **«»**

(b) Compliance demonstration requirements for performance standards.

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

Installation pursuant to Section 10-103(a)3 and applicable Certificates of Verification pursuant to Section 10-103(a)5.

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

«» Commentary for Section 170.1(b)2A:

For individual dwelling units, the minimum efficiency is required to be met for prescriptive compliance or performance compliance. When the performance compliance approach is used, additional compliance credit may be available from higher efficiency heating equipment which can be used to offset less efficient building features.

When a heat pump is providing space heating, if the efficiency used for compliance is higher than the minimum required HSPF2, the system efficiency must be verified by an ECC-Rater. Moreover, because the capacity of the heat pump affects the amount of back-up electric resistance heating required to attain and maintain comfort conditions, if the capacity proposed for compliance is different than the default capacity used in the performance compliance software, the Air Conditioning, Heating, and Refrigeration Institute (AHRI) ratings for heating capacity of the installed heat pump must be verified by an ECC-Rater to confirm the heating capacities at 47 °F and 17 °F are equal or greater than the heating capacities given on the certificate of compliance. See RA3.4 for more information about this ECC verification.

Air conditioner efficiencies are determined according to federal test procedures. The efficiencies are reported in terms of seasonal energy efficiency ratio (SEER2) and energy efficiency ratio (EER2). Savings can be achieved by choosing an air conditioner that exceeds the minimum efficiency requirements.

The EER2 is the efficiency at specific operating conditions. It is possible that two units with the same SEER2 can have different EER2s. In cooling climate zones of California, for two units with a given SEER2, the unit with the higher EER2 is more effective in saving energy. Using the performance compliance method, credit is available for specifying an air conditioner with an EER2 greater than the minimum. When credit is taken for a high EER2 and/or SEER2 in multifamily buildings with three or fewer habitable stories, field verification by an ECC-Rater is required. (See RA3.4.4). «»

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

«» Commentary for Section 170.1(b)2B:

Several manufacturers offer variable capacity mini-split or multi-split heat pump equipment that may or may not use air distribution ducts to heat or cool spaces. These systems provide advanced controls and multispeed compressors for optimizing performance through a wide range of conditioning loads.

These systems are required to be modeled as minimally efficient systems unless the variable capacity heat pump (VCHP) compliance credit is taken. This option is available to provide credit for systems meeting the eligibility requirements published in the Residential Appendices RA3.4.4.3. The credit can be applied through a CEC-approved modeling software by selecting the VCHP compliance option for the HVAC system type. The Certificate of Compliance will indicate when a space conditioning system requires verification of the VCHP compliance option eligibility requirements. A system that does not meet the eligibility requirements upon verification will not be eligible to claim the VCHP performance compliance credit for the specified space conditioning system.

Compliance with the mandatory duct system sealing and leakage (Section 160.3(b)5K) and fan airflow rate and fan efficacy testing (Section 160.3(b)5L) are not required for systems that use this VCHP performance compliance option. However, there are requirements to verify that VCHP system indoor unit ducts are located entirely in conditioned space that are specified as eligibility requirements for this compliance option. There are also requirements for verification of minimum airflow rates for VCHP system indoor units that are specified as eligibility requirements for this compliance option.

Additional verification requirements apply depending on the system type and credit taken, see below.

1. Low-Static Certification for Ducted Systems
2. Non-Continuous Indoor Unit Fan Operation
3. Refrigerant Charge Verification
4. Ducts Located Entirely in Conditioned Space
5. Indoor Units Located Entirely in Conditioned Space
6. Supply to All Habitable Spaces
7. Wall-Mounted Thermostat
8. Space-Conditioning System Airflow
9. Air Filter Sizing
10. Air Filter Pressure Drop Rating

Default indoor unit fan configuration settings may require modification in order for the installed fan airflow to meet the required rate. The manufacturer’s product documentation should provide direction for configuring the indoor unit fan for operation at airflow rates equal to or greater than the minimum rates required for compliance. The list of low-static ducted VCHP systems certified to the Energy Commission including the manufacturer’s product documentation can be found at: https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment-2. «»

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

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

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

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

«» Commentary for Section 170.1(b)2F

As a compliance option, additional energy savings is available for achieving a tighter level of compartmentalization (reduce envelope leakage) than is required. See the ACM Manual for more details. «»

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

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

SECTION 170.2 – PRESCRIPTIVE APPROACH

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

(c) **Space-conditioning systems.** All space heating, space cooling and ventilation equipment shall comply with minimum Appliance Efficiency Regulations as specified in Sections 110.0 through 110.2 and the applicable requirements of Subsections 1 through 4.

1. Sizing and equipment selection—common use areas. Mechanical heating and mechanical cooling equipment serving common use areas of multifamily buildings shall be the smallest size, within the available options of the desired equipment line, necessary to meet the design heating and cooling loads of the building, as calculated according to Subsection 2 below.

   Exception 1 to Section 170.2(c)1: Where it can be demonstrated to the satisfaction of the enforcing agency that oversizing will not increase building LSC energy use.

   Exception 2 to Section 170.2(c)1: Standby equipment with controls that allow the standby equipment to operate only when the primary equipment is not operating.

   Exception 3 to Section 170.2(c)1: Multiple units of the same equipment type, such as multiple chillers and boilers, having combined capacities exceeding the design load, if they have controls that sequence or otherwise optimally control the operation of each unit based on load.

«» Commentary for Section 170.2(c)1:

The Energy Code requires mechanical heating and cooling equipment (including electric heaters and boilers) serving common use areas in multifamily buildings to be the smallest size available, while still meeting the design heating and cooling loads of the building or spaces being served. Depending on the equipment, oversizing can be either a penalty or benefit to energy usage. For vapor compression equipment, gross oversizing can drastically increase the energy usage and in some cases cause premature failure from short cycling of compressors. Boilers and water-heaters generally suffer lower efficiencies and higher standby losses if they are oversized. On the other hand, cooling towers, cooling coils, and variable speed driven cooling tower fans can actually improve in efficiency if oversized. Oversized distribution ductwork and piping can reduce system pressure losses and reduce fan and pump energy.

When equipment is offered in size increments, such that one size is too small and the next is too large, the larger size may be selected.

Packaged HVAC equipment may serve a space with substantially different heating and cooling loads. The unit size should be selected on the larger of the loads, based on either capacity or airflow. The capacity for the other load should be selected as required to meet the load, or if very small, should be the smallest capacity available in the selected unit. For example, packaged air-conditioning units with gas heat are usually sized on the basis of cooling loads. The furnace is sized on the basis of airflow and is almost always larger than the design heating load.

Equipment may be oversized provided one or more of the following conditions are met:

1. It can be demonstrated (to the satisfaction of the enforcing agency) that oversizing will not increase building LSC use
2. Oversizing is the result of standby equipment that will operate only when the primary equipment is not operating. Controls must be provided that prevent the standby equipment from operating simultaneously with the primary equipment
3. Multiple units of the same equipment type are used, each having a capacity less than the design load. In combination, however, the units have a capacity greater than the design load. Controls must be provided to sequence or otherwise optimally control the operation of each unit based on load.

«»

2. **Calculations**—common use areas**.** In making equipment sizing calculations under Subsection (c)1, all of the following rules shall apply:

   A. **Heating and cooling loads.** Heating and cooling system design loads shall be determined in accordance with the method in the 2017 ASHRAE Handbook, Fundamentals Volume, or as specified in a method approved by the Commission.

   B. **Indoor design conditions.** Indoor design temperature and humidity conditions for comfort applications shall be determined using ASHRAE Standard 55 or the 2021 ASHRAE Handbook, Fundamentals Volume, except that winter humidification and summer dehumidification shall not be required.

   C. **Outdoor design conditions.** Outdoor design conditions shall be selected from Reference Joint Appendix JA2, which is based on data from the ASHRAE Climatic Data for Region X or the ASHRAE Handbook Fundamentals Volume. Heating design temperatures shall be no lower than the 99.0 percent Heating Dry Bulb or the Heating Winter Median of Extremes values. Cooling design temperatures shall be no greater than the 0.5 percent Cooling Dry Bulb and Mean Coincident Wet Bulb values.

   Exception to Section 170.2(c)2C: Cooling design temperatures for cooling towers shall be no greater than the 0.5 percent Cooling Design Wet Bulb values.

   D**. Ventilation.** Outdoor air ventilation loads shall be calculated using the ventilation rates required in Section 160.2(c)3.

   E**. Envelope**. Envelope heating and cooling loads shall be calculated using envelope characteristics, including square footage, thermal conductance, solar heat gain coefficient or shading coefficient, and air leakage, consistent with the proposed design.

F. **Lighting.** Lighting heating and cooling loads shall be based on actual design lighting levels or power densities as specified in Section 170.2(e)1.

G. **People.** Occupant density shall be based on the expected occupancy of the building and shall be the same as determined under Section 160.2(c)3A, if used. Sensible and latent heat gains shall be as listed in the 2017 ASHRAE Handbook—Fundamentals, Chapter 18.

H. **Process loads.** Loads caused by a process shall be based upon actual information on the intended use of the building.

I. **Miscellaneous equipment.** Equipment loads other than process loads shall be calculated using design data compiled from one or more of the following sources:

   i. Actual information based on the intended use of the building; or

   ii. Published data from manufacturers' technical publications or from technical societies, such as the ASHRAE Handbook, Applications Volume; or

   iii. Other data based on the designer's experience of expected loads and occupancy patterns.

J. **Internal heat gains.** Internal heat gains may be ignored for heating load calculations.

K**. Safety factor.** Calculated design loads based on Sections 170.2(c)2A through K may be increased by up to 10 percent to account for unexpected loads or changes in space usage.

L. **Other loads.** Loads such as warm-up or cool-down shall be calculated from principles based on the thermal capacity of the building and its contents, the degree of setback, and desired recovery time; or may be assumed to be no more than 30 percent for heating and 10 percent for cooling of the steady-state design loads. In addition, the steady-state load may include a safety factor in accordance with Section 170.2(c)2K.

«» Commentary for Section 170.2(c)2L:

For the purposes of sizing HVAC equipment, the designer shall use all of the following criteria for load calculations:

1. The heating and cooling system design loads must be calculated in accordance with the procedures described in the ASHRAE Handbook, Fundamentals Volume, Chapter 30, Table 1. Other load calculation methods (e.g., ACCA, SMACNA) are acceptable provided that the method is ASHRAE-based. If the designer is unclear as to whether or not the calculation method is ASHRAE-based, the vendor or organization providing the calculation method should be contacted to verify that the method is derived from ASHRAE.
2. Indoor design conditions of temperature and relative humidity for general comfort applications are not explicitly defined. Designers may use any temperature conditions within the "comfort envelope" defined by ANSI/ASHRAE 55-1992 or the 2022 ASHRAE Handbook, Fundamentals Volume. Winter humidification or summer dehumidification is not required.
3. Outdoor design conditions shall be selected from Reference Joint Appendix JA2., which is based on data from the ASHRAE Climatic Data for Region X, for the following design conditions:
    - Heating design temperatures shall be no lower than the temperature listed in the Heating Winter Median of Extremes value.
    - Cooling design temperatures shall be no greater than the 0.5 percent Cooling Dry Bulb and Mean Coincident Wet Bulb values.
    - Cooling design temperatures for cooling towers shall be no greater than the 0.5 percent cooling design wet bulb values.
4. Outdoor air ventilation loads must be calculated using the ventilation rates required in Section 160.2(c)3.
5. Envelope heating and cooling loads must be calculated using envelope characteristics including square footage, thermal conductance, solar heat gain coefficient or shading coefficient and air leakage, consistent with the proposed design.
6. Lighting, heating, or cooling loads shall be based on actual design lighting levels or power densities consistent with Section 170.2(e)1.
7. People, sensible, and latent gains must be based on the expected occupant density of the building and occupant activities as determined under Section 160.2(c)3A. If ventilation requirements are based on a cfm/person basis, then people loads must be based on the same number of people as ventilation. Sensible and latent gains must be selected for the expected activities as listed in ASHRAE Handbook, Fundamentals Volume, Cooling and Heating Load Calculations chapters.
8. Loads caused by a process shall be based on actual information (not speculative) on the intended use of the building.
9. Miscellaneous equipment loads include such things as duct losses, process loads and infiltration and shall be calculated using design data compiled from one or more of the following sources:
    - Actual information based on the intended use of the building
    - Published data from manufacturer's technical publications or from technical societies (such as the ASHRAE Handbook, HVAC Applications Volume)

- Other data based on the designer's experience of expected loads and occupancy patterns

10. Internal heat gains may be ignored for heating load calculations.
11. A safety factor of up to 10 percent may be applied to design loads to account for unexpected loads or changes in space usage.
12. Other loads such as warm-up or cool-down shall be calculated using one of the following methods:
    - A method using principles based on the heat capacity of the building and its contents, the degree of setback, and desired recovery time
    - The steady state design loads may be increased by no more than 30 percent for heating and 10 percent for cooling. The steady state load may include a safety factor of up to 10 percent as discussed above.
13. The combination of safety factor and other loads allows design cooling loads to be increased by up to 21 percent (1.10 safety x 1.10 other), and heating loads by up to 43 percent (1.10 safety x 1.30 other). **«»**

3. **Dwelling unit space-conditioning systems**.

A. **Heating** system type**.** Space-conditioning systems serving dwelling units shall meet i or ii. Systems that cannot meet the requirements of i or ii, including multi-zone systems and systems using central boilers or chillers, shall comply with the performance requirements of Section 170.1.

i. Multifamily buildings three habitable stories or fewer. For Climate Zones 1 through 15, the space-conditioning system shall be a heat pump. For Climate Zone 16, the space-conditioning system shall be an air conditioner with furnace. Additionally, balanced ventilation systems serving these dwelling units shall meet the applicable requirements of Section 170.2(c)3Bivc.

ii. Multifamily buildings four habitable stories or greater. For Climate Zones 2 through 15, the space-conditioning system shall be a heat pump. For Climate Zones 1 and 16, the space-conditioning system shall be a dual-fuel heat pump.

Exception to Section 170.2(c)3A: A supplemental heating unit may be installed in a space served directly or indirectly by a primary heating system, provided that the unit thermal capacity does not exceed 2 kW or 7,000 Btu/hr and is controlled by a time-limiting device not exceeding 30 minutes.

«» Commentary for Section 170.2(c)3A:

Prescriptive compliance requires the installation of a heat pump for dwelling units in buildings up to three habitable stories in climate zones 1 – 15. For climate zone 16, the installation of an air conditioner with gas-fired furnace is prescriptively required. For buildings with four or more habitable stories, prescriptive compliance requires installation of a heat pump for climate zones 2 – 15. For climate zone 1 and 16, prescriptive compliance requires the installation of a dual-fuel heat pump that uses gas as supplemental heat.

Dual-fuel Heat Pump System

For Climate Zones 1 and 16, the prescriptive requirement includes the use of a dual-fuel heat pump for buildings four habitable stores or greater. This system pairs an electric heat pump with a gas-fired furnace and alternates between the two fuel sources for heating. Heat pumps face a challenge in colder climates where their capacity for providing heat and the efficiency of the equipment reduces as the outdoor temperature drops. This is especially true for the type of minimal efficiency heat pumps that are the basis for the federal appliance standards for heat pumps. To address these challenges, gas-fired furnaces can be used for space heating when outdoor air temperature is below a certain threshold, normally between 35 – 45°F.

The dual-fuel heat pump system can be controlled similarly to a heat pump with electric resistance required by Section 110.2(b). The control should have the capability to set the cut-on and cut-off temperatures for the heat pump and supplementary gas-fired heating at different levels. For example, if the heat pump begins heating when the inside temperature reaches 68°F, the gas-fired furnace heating may be set to come on if the temperature goes below 65°F, if the heat pump alone could not maintain the set point of 68°F. Also, there should be an OFF mode that automatically shuts off the gas-fired heating when the inside temperature reaches 68°F. The system may also have a control capability that prevents the supplemental gas-fired furnace from operating if the outdoor air temperature is above a pre-set threshold.

Supplemental Heating System

Supplemental heating systems are allowed prescriptively, and the designer may elect to provide supplemental heating to a space such as a bathroom. In this instance, the supplemental heating system must be installed in a space that is served by the primary heating system and must have a thermal capacity of less than 2 kilowatts (kW) or 7,000 Btu/h while being controlled by a time-limiting device not exceeding 30 minutes. Electric resistance and electric radiant heating installation are not allowed as the primary heating system when using the prescriptive compliance method. **«»**

B. **Space-conditioning and ventilation systems**. All space heating and space cooling equipment serving dwelling units shall comply with minimum Appliance Efficiency Regulations as specified in Sections 110.0 through 110.2 and meet all applicable requirements of Sections 160.3(b) and 170.2(c)2.

i. Refrigerant charge—systems serving individual dwelling units. When refrigerant charge verification or fault indicator display is shown as required by Table 170.2-K, the system shall comply with either Section 170.2(c), 170.2(c)3Bia or 170.2(c)3Bib:

a. Air-cooled air conditioners and air-source heat pumps, including but not limited to ducted split systems, ducted packaged systems, small duct high velocity systems and mini-split systems, shall comply with Subsections I, II and III, unless the system is of a type that cannot be verified using the specified procedures:

I. Have measurement access holes (MAH) installed according to the specifications in Reference Residential Appendix Section RA3.2.2.3; and

«» Commentary for Section 170.2(c)3BiaI:

The measurement access hole (MAH) provides a nonintrusive means for refrigerant charge verification by ECC-Raters or ATT and other third-party inspectors. They eliminate the need for raters/inspectors to drill holes into the installed air conditioning equipment enclosures to place the temperature sensors that are required by the refrigerant charge verification test procedures described in the Reference Residential Appendix RA3.2.

Installation of MAH must be performed by the installer of the air conditioner or heat pump equipment according to the specifications given in Reference Residential Appendix RA3.2.

The MAH feature consists of one 5/8-inch (16 millimeters [mm]) diameter hole in the return plenum, upstream from the evaporator coil. (See Figure RA3.2-1 in Reference Residential Appendix RA3.2.) **«»**

II. System airflow rate in accordance with Subsection A or B below shall be confirmed through field verification and diagnostic testing in accordance with all applicable procedures specified in Reference Residential Appendix Section RA3.3 or an approved alternative procedure as specified by RA1; and

A. For small duct high velocity systems, the system airflow rate shall be greater than or equal to 250 cfm per ton; or

B. For all other air-cooled air conditioner or air-source heat pump systems, the system airflow rate shall be greater than or equal to 350 cfm per ton.

«» Commentary for Section 170.2(c)3BiaII:

Ducted forced-air cooling systems must comply with the minimum system airflow rate of greater than or equal to 350 CFM/ton, or 250 CFM/ton for small duct, high velocity systems, when performing the refrigerant charge verification. The airflow is important when performing the refrigerant charge verification to validate the measured values for pressure and temperature. The correct airflow will also improve the performance of the air-conditioning equipment.

The airflow verification procedure is documented in Reference Residential Appendix RA3.3. **«»**

III. The installer shall charge the system according to manufacturer's specifications. Refrigerant charge shall be verified according to one of the following options, as applicable:

A. The installer and rater shall perform the standard charge procedure as specified by Reference Residential Appendix Section RA3.2.2 or an approved alternative procedure as specified by RA1; or

B. The installer shall perform the weigh-in charging procedure as specified by Reference Residential Appendix Section RA3.2.3.1, provided the system is of a type that can be verified using the RA3.2.2 standard charge verification procedure and RA3.3 airflow rate verification procedure or approved alternatives in RA1. The ECC-Rater shall verify the charge using RA3.2.2 and RA3.3 or approved alternatives in RA1.

Exception to Section 170.2(c)3BiaI: Systems that cannot conform to the specifications for hole location in Reference Residential Appendix Figure RA3.2-1 shall not be required to provide holes as described in Figure RA3.2-1.

Exception to Section 170.2(c)3BiaII: Standard ducted systems without zoning dampers may comply with the minimum airflow rate by meeting the applicable requirements in Table 160.3-A and Table 160.3-B as confirmed by field verification and diagnostic testing in accordance with the procedures in Reference Residential Appendix Sections RA3.1.4.4 and RA3.1.4.5. The design clean-filter pressure drop requirements of Section 160.2(b)1D for the system air filter device(s) shall conform to the requirements given in Table 160.3-A and Table 160.3-B.

Exception to Section 170.2(c)3BiaIII: When the outdoor temperature is less than 55 degrees F and the installer utilizes the weigh-in charging procedure in Reference Residential Appendix Section RA3.2.3.1 to verify the refrigerant charge, the installer may elect to utilize the verification procedure in Reference Residential Appendix Section RA3.2.3.2. If the verification procedure in Section RA3.2.3.2 is used for compliance, the system's thermostat shall conform to the specifications in Section 110.12. Ducted systems shall comply with the minimum system airflow rate requirement in Section 170.2(c)3BiaII.

b. For air-cooled air conditioners and air-source heat pumps, including but not limited to ducted split systems, ducted packaged systems, small duct high velocity systems and mini-split systems, which are of a type that cannot comply with the requirements of Section 170.2(c)3Bi:

I. The installer shall confirm the refrigerant charge using the weigh-in charging procedure specified in Reference Residential Appendix Section RA3.2.3.1, as verified by an ECC-Rater according to the procedures specified in Reference Residential Appendix Section RA3.2.3.2; and

II. Systems that utilize forced air ducts shall comply with the minimum system airflow rate requirement in Section 170.2(c)3BiaII, provided the system is of a type that can be verified using the procedures in RA3.3 or an approved alternative procedure in RA1.

Exception 1 to Section 170.2(c)3Bi: Packaged systems for which the manufacturer has verified correct system refrigerant charge prior to shipment from the factory are not required to have refrigerant charge confirmed through field verification and diagnostic testing. The installer of these packaged systems shall certify that the packaged system was precharged at the factory and has not been altered in a way that would affect the charge. Ducted systems shall comply with minimum system airflow rate requirement in Section 170.2(c)3Bib, provided that the system is of a type that can be verified using the procedure specified in RA3.3 or an approved alternative in RA1.

Exception 2 to Section 170.2(c)3Bi: The field verification and ECC-Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four habitable stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

«» Commentary for Section 170.2(c)3BiaIII and Section 170.2(c)3Bib:

Refrigerant charge refers to the actual amount of refrigerant present in the system. Excessive refrigerant charge (overcharge) reduces system efficiency and can lead to premature compressor failure. Insufficient refrigerant charge (undercharge) also reduces system efficiency and can cause compressors to overheat. Ensuring correct refrigerant charge can significantly improve the performance of air-conditioning equipment. Refrigerants are the working fluids in air-conditioning and heat-pump systems that absorb heat energy from one area (through the evaporator), transfer, and reject it to another (through the condenser).

Verification of proper refrigerant charge must occur after the HVAC contractor has installed and charged the system in accordance with the manufacturer's specifications. The procedure requires properly calibrated digital refrigerant gauges, thermocouples, and digital thermometers. When multiple systems in the same dwelling unit require testing, test each system.

In a typical cooling system, there are two important performance criteria that are relatively easy to verify that there is neither too much nor too little refrigerant in the system. In systems with a fixed-orifice device in the evaporator coil, the number to check is called the superheat. In a system with a variable-metering device, the number to check is called the subcooling.

Superheat refers to the number of degrees the refrigerant is raised after it evaporates into a gas. This occurs inside the evaporator coil (or indoor coil). The correct superheat for a system will vary depending on certain operating conditions. The target superheat for a system must be obtained from a table provided in the RA3.2 protocols or the manufacturer’s superheat table. There is an allowed range of several degrees between the measured superheat and the target superheat for a system to pass.

Subcooling refers to the number of degrees the refrigerant is lowered after it condenses into a liquid. This occurs inside the condenser coil (or outdoor coil). The manufacturer specifies the correct subcooling for a system. It may vary depending on operating conditions. Like superheat, there is an allowed range of several degrees between the measured subcooling and the target subcooling for a system to pass.

The temperature at which a refrigerant condenses or evaporates is called the saturation temperature. Above the saturation temperature, a refrigerant is always a gas. Below the saturation temperature, a refrigerant is always a liquid.

Saturation is when a refrigerant exists as both a liquid and a gas. It always occurs at the same temperature, depending on what the pressure of the refrigerant happens to be. At higher pressures, the saturation temperature goes up and vice versa. This convenient property is what makes refrigeration work.

The saturation temperature can be determined by simply measuring the pressure of a refrigerant and referring to a table, known as a pressure-temperature (PT) table, for that specific refrigerant. Saturation temperatures are well-documented for all common refrigerants.

Because variable refrigerant metering devices are prone to failure and even more so to improper installation, it is important that the operation of these devices be checked. A metering device maintains a relatively constant superheat over a wide range of operating conditions; therefore, checking the superheat, in addition to the other tests performed, will indicate if the metering device is operating correctly.

Unfortunately, checking superheat and subcooling can be done only under certain indoor and outdoor conditions. This verification procedure, called the Standard Charge Verification Method, is very weather-dependent.

There is another way to verify proper refrigerant charge that is not weather–dependent, and that is by weighing the refrigerant. Called the Weigh-in Charge Verification Method, this approach can be performed only by the installer. It can be verified by the ECC-Rater either by simultaneous observation or by using the standard method when conditions permit.

Minimum System Airflow Verification for Refrigerant Charge Verification

To have a valid charge test, the system airflow must be verified to be at least 300 CFM/ton for altered systems and 350 CFM/ton for new systems. The procedures for measuring total system airflow are found in RA3.3. They include plenum pressure matching using a fan flow meter, a flow grid, a powered flow hood, and the traditional (nonpowered) flow hood. The airflow verification procedures for refrigerant charge verification no longer include the temperature split method.

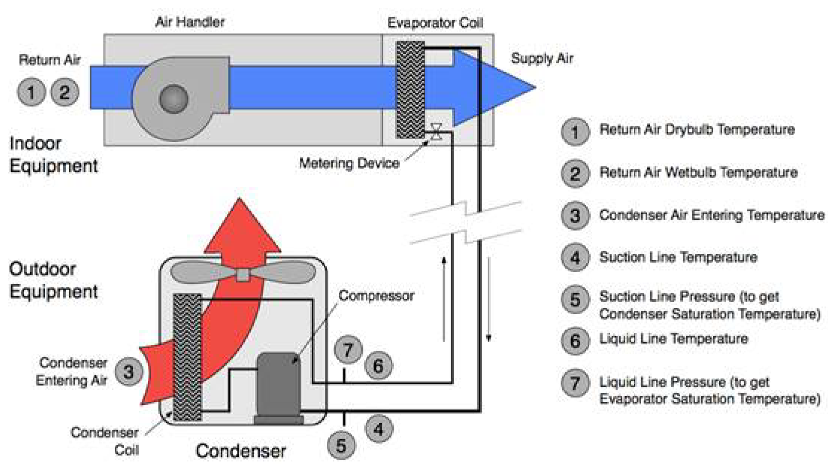
If an altered system does not meet the minimum airflow requirements, remedial steps are required to increase system airflow. More airflow is generally better for systems with air conditioning. Not only does this allow proper refrigerant charge to be verified, but it improves the overall performance of the system. When able to be performed on a system, regardless of the refrigerant charge verification procedure, minimum system airflow must always be verified.

In some alterations, improving airflow may be cost-prohibitive, and there is a process for documenting this (RA3.3.3.1.5). When this option is used, verification by sample groups is not allowed. Minimum airflow is critical to proper air-conditioner operation. Reducing airflow reduces cooling capacity and efficiency. Many systems in California have oversized equipment and undersized ducts. In newly installed duct systems, the minimum airflow requirement is higher because the opportunity exists to design and install a better system. In altered systems, the installer may be required to modify the ducts system to meet the minimum airflow. The minimums of 300 and 350 CFM/ton are lower than the desired airflow for most systems, which is usually 400 CFM/ton and higher.

Standard Charge Verification Procedure (RA3.2.2)

The first step is to turn on the air-conditioning system and let it run for at least 15 minutes to stabilize temperatures and pressures. While the system is stabilizing, the ECC-Rater or the installer may attach the instruments needed to take the measurements.

Figure 4-17: Measurements for Refrigerant Charge and Airflow Tests



Source: California Energy Commission

The following measurements must be taken by the technician or ECC-Rater, when applicable.

1. The return air wet bulb and dry bulb temperatures are measured in the return plenum before the blower at the location labeled "Title 24 – Return Plenum Measurement Access Hole." This hole must be provided by the installer, not the rater (See Points 1 and 2 in Figure 4-17: Measurements for Refrigerant Charge and Airflow Tests). See Figure RA 3.2-1 for more information on the placement of the measurement access hole (MAH).
2. Moreover, the outdoor air dry bulb temperature is measured at the point where the air enters the outdoor condensing coil. (See Point 3 in Figure 4-17: Measurements for Refrigerant Charge and Airflow Tests. It is important that this outdoor temperature sensor be shaded from direct sun during the verification procedure.

In addition to the air temperature measurements, four refrigerant properties need to be measured. Two of these measurements are taken near the suction line service valve before the line enters the outdoor unit and are used to check the superheat.

1. The first measurement is the temperature of the refrigerant in the suction line, which is taken by a clamp-on thermocouple or other suitable device insulated from the outdoor air. (See Point 4 in Figure 4-17: Measurements for Refrigerant Charge and Airflow Tests.)
2. The second measurement determines the saturation temperature of the refrigerant in the evaporator coil. (See Point 5 in Figure 4-17: Measurements for Refrigerant Charge and Airflow Tests.) The saturation temperature can be determined from the low-side (suction line) pressure and a saturation temperature table for the applicable refrigerant.

To check the subcooling, two more refrigerant properties are required and may be measured near the liquid line service valve at the point where the line exits the outdoor unit.

1. The liquid refrigerant temperature in the liquid line is measured by a clamp-on thermocouple insulated from the outdoor air. (See Point 6 in Figure 4-17: Measurements for Refrigerant Charge and Airflow Tests.)
2. The condenser saturation temperature can be determined from the liquid line pressure and a saturation temperature table for the applicable refrigerant. (See Point 7 in Figure 4-17: Measurements for Refrigerant Charge and Airflow Tests)

Determination of the condenser saturation temperature and the liquid line temperature is used only for the subcooling verification method on systems with thermostatic expansion valve (TXV) or electronic expansion valve (EXV) metering devices.

Superheat Charge Verification Method (RA3.2.2.6.1)

The Superheat Charge Verification Method is used on units with a fixed-orifice refrigerant metering device (not a TXV or EXV).

Airflow verification must be confirmed before starting the Superheat Verification Method.

The Superheat Verification Method compares the actual (measured) superheat temperature to a target value from a table. The actual superheat temperature is the measured suction line temperature ($T_{Suction,\ db}$) minus the evaporator saturation temperature ($T_{Evaporator,\ Saturation}$). The target superheat value is read from a table (Table RA3.2-2 or the manufacturer's superheat table).

Only an EPA-certified technician may add or remove refrigerant. Under no circumstances may ECC-Raters add or remove refrigerant on systems that they are verifying.

Subcooling Verification Method (RA3.2.2.6.2)

The Subcooling Verification Method is used on units with a variable refrigerant metering device (a TXV or EXV).

Airflow verification must be confirmed before starting the Subcooling Verification Method.

The Subcooling Verification Method compares the actual subcooling temperature to the target value supplied by the manufacturer. The actual subcooling is the condenser saturation temperature ($T_{Condenser, Saturation}$) minus the liquid line temperature (T_{Liquid}).

Weigh-In Charging Procedure (RA3.2.3)

The weigh-in charging procedure charges the system by determining the appropriate weight of refrigerant based on the size of the equipment and refrigerant lines rather than by measuring steady-state performance of the system. Systems using the weigh-in procedure to meet the refrigerant charge verification requirement may not use group sampling procedures for ECC-verification compliance.

The weigh-in procedure does not relieve the installer of the responsibility to comply with the required minimum system airflow.

There are two installer options for completing the weigh-in procedure. One involves adjusting the amount of refrigerant supplied by the manufacturer in a new system, as specified by the manufacturer (weigh-in charge adjustment). The other involves evacuating the entire system and recharging it with the correct total amount of refrigerant, by weight (weigh-in total charge).

The weigh-in charge adjustment procedure may be used only when a new factory-charged outdoor unit is being installed and the manufacturer provides adjustment specifications based on evaporator coil size and refrigerant line size and length.

The weigh-in total charge may be used for any weigh-in procedure but still requires manufacturer's adjustment specifications. Only the installer/technician may perform any kind of weigh-in procedure.

Equipment Limitations

The Energy Code specifically requires verification of refrigerant charge only for air-cooled air conditioners and air-source heat pumps. All other types of systems are not expressly exempt from the refrigerant charge requirements. Certain portions of the requirements may still apply, such as the minimum system airflow requirement. The installer would have to confirm with the manufacturer and the CEC. The installer must adhere strictly to the manufacturer's specifications.

Variable refrigerant flow systems and systems such as some mini-split systems that cannot be verified using the standard charge verification procedure in RA3.2.2 must demonstrate compliance using the weigh-in method. Verification by the ECC-Rater can be accomplished only by simultaneous observation of the installer's weigh-in as specified by RA3.2.3.2, and only if use of ECC-Rater observation procedure is specified by the Energy Code. **«»**

ii. Space-conditioning distribution systems. All space-conditioning systems shall meet all applicable requirements of a or b below:

a. High performance attics. Air handlers or ducts are allowed to be in ventilated attic spaces when the roof and ceiling insulation level meet Option B in Table 170.2-A.

b. Duct and air handlers located in conditioned space. Duct systems and air handlers of HVAC systems shall be located in conditioned space, and confirmed by field verification and diagnostic testing to meet the criterion of Reference Residential Appendix RA3.1.4.3.8.

Note: Gas heating appliances installed in conditioned spaces must meet the combustion air requirements of California Mechanical Code Chapter 7, as applicable.

«» Commentary for Section 170.2(c)3Bii:

Duct Location

Standard multifamily construction practice in California is to place ducts and associated air handling equipment in conditioned space. Ducts are typically in a dropped soffit or in-between floors, and equipment may also be in the ceiling or an interior mechanical closet. When meeting the prescriptive requirements for the Energy Code, there are two options for where ducts and equipment can be located:

1. Ducts in conditioned space (DCS) with the duct system and air handler(s) within the thermal envelope and air barrier of the building. This DCS option requires field verification to meet the prescriptive requirement. This option applies to both attic roofs and non-attic roofs.
2. For buildings with attic roofs, ducts may be installed in a vented attic if Option B in Table 170.2-A is met. Option B requires a high-performance attic (HPA) design in climate zones 4 and 8 – 16. A HPA implements requirements that minimize temperature differences between the attic space and the conditioned air being transported through ductwork in the attic. The package consists of insulation below the roof in addition to insulation at the ceiling. These requirements and approaches to meet the requirements are explained in Chapter 3 Building Envelope.

For the DCS prescriptive approach, additional requirements apply:

1. Air handlers containing a combustion component should be direct-vent (sealed combustion chambers) and must not use air from any conditioned or unconditioned space as combustion air. Other types of combustion heating systems are possible if the system installer adheres to the combustion air requirements found in Chapter 7 of the California Mechanical Code.
2. Duct location needs to be verified through a visual inspection per Reference Residential Appendix RA3.1.4.1.3. This must be conducted by a ECC-Rater for multifamily buildings up to three habitable stories. Otherwise, the installing contractor can certify the results.
3. Duct leakage to outside needs to be confirmed by field verification and diagnostic testing in accordance with Reference Residential Appendix RA3.1.4.3.8. This must be conducted by a ECC-Rater for multifamily buildings up to three habitable stories. Otherwise, the installing contractor can certify the results.

For the vented attic with HPA prescriptive approach, additional requirements apply (Refer to Chapter 3.5 of the Single-Family Compliance Manual for more information on this option):

1. Ducts are insulated to a level required in Table 170.2-K.
2. Ceiling and below roof deck insulation must meet the levels required in Table 170.2-A Option B. Roof deck insulation must be installed with an air space present between the roofing and the roof deck, such as is typical with standard installation of concrete or clay tile.
3. Roofing products must meet the reflectance and emittance values in Table 170.2-A Option B.
4. A radiant barrier is required is climate zones 2, 3, and 5 – 7 per Table 170.2-A Option B.

If a building is not able to meet all the requirements listed above, it must use the performance approach. Multifamily buildings with vented attics may have ductwork in the attic above the top floor units with lower floor unit ductwork in conditioned space. To comply prescriptively, the top floor units need to meet the requirement for ducts in a vented attic, which may include HPA depending on climate zone. The lower floor units need to meet all the requirements for DCS. «»

iii. Central fan integrated ventilation systems—systems serving individual dwelling units. Central forced air system fans used to provide outside air shall have an air-handling unit fan efficacy less than or equal to the maximum W/cfm specified in a or b below. The airflow rate and fan efficacy requirements in this section shall be confirmed through field verification and diagnostic testing in accordance with all applicable procedures specified in Reference Residential Appendix RA3.3. Central Fan Integrated Ventilation Systems shall be certified to the Energy Commission as Intermittent Ventilation Systems as specified in Reference Residential Appendix RA3.7.4.2.

a. 0.45 W/cfm for gas furnace air-handling units; or

b. 0.58 W/cfm for air-handling units that are not gas furnaces.

«» Commentary for Section 170.2(c)3Biii:

CFI ventilation uses a central forced air heating and/or cooling system that operates regularly to pull outside air into the air distribution system and distribute air around the dwelling unit. There is a prescriptive requirement that CFI systems meet the same mandatory fan efficacy requirements for other forced air cooling systems. This requires no greater than 0.45 W/CFM for gas furnaces and 0.58 W/CFM for all other air handler including heat pumps. This can be traded-off using the performance approach. Verification must be conducted by a ECC-Rater for multifamily buildings with up to three habitable stories. For other multifamily buildings, verification only needs to be conducted and certified by the installing contractor, and neither a ECC-Rater nor registration with a ECC-Provider is required. **«»**

iv. Balanced ventilation systems with heat/energy recovery in climate zones 1, 2, 4, 11-14, and 16. A balanced ventilation system with heat or energy recovery shall be used to meet Section 160.2(b)2Aivb1, and shall meet the applicable requirements of a, or b below:

a. In Climate Zones 1, 2, 4, 11-14, and 16, balanced ventilation systems serving individual dwelling units shall:

1. Be an energy recovery ventilator (ERV) or heat recovery ventilator (HRV),
2. Have a minimum sensible recovery efficiency of 67 percent, rated at 32 degrees Fahrenheit (0 degrees Celsius), and
3. Have a fan efficacy less than or equal to 0.6 W per cfm.

These measures shall be confirmed through field verification in accordance with the procedures in RA3.7.4.4 for buildings with three habitable stories or less, or the procedures in NA2.2.4.1.5 for buildings with four or more habitable stories.

b. In Climate Zones 1, 2, 4, 11-14, and 16, balanced ventilation systems serving multiple dwelling units in buildings with four or more habitable stories shall:

1. Be an ERV or HRV,
2. Have a minimum sensible recovery efficiency or effectiveness of 67 percent, rated at 32 degrees Fahrenheit (0 degrees Celsius),
3. Meet the fan power requirements of Section 170.2(c)4A, and
4. Have recovery bypass or control to directly economize with ventilation air based on outdoor air temperature limits specified in Table 170.2-G.

These measures shall be field verified in accordance with NA7.18.4.

v. In buildings with three habitable stories or less in Climate Zones 5–10 and Climate Zone 15, when a heat pump space-conditioning system is installed to meet the requirements of Section 170.2(c)3Ai, balanced ventilation systems without an ERV or HRV shall have a fan efficacy less than or equal to 0.4 W/cfm.

Exception to Section 170.2(c)3B: The field verification and ECC-Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four habitable stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

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

Balanced Ventilation

If a balanced system is used to satisfy mandatory requirements, the prescriptive requirements of Section 170.2(c)3Biv requires multifamily units to install HRVs or ERVs in climate zones 1, 2, 4, 11 – 14 and 16. Multifamily units that do not trigger this requirement may still choose to use an HRV or ERV.

For multifamily buildings up to three stories in Climate Zones 5 – 10 and 15, balanced ventilation systems without heat or energy recovery are required by Section 170.2(c)3 to have a fan efficacy of 0.4 W/CFM or less. For example, if the balanced ventilation system includes a bathroom exhaust fan and an in-line supply fan, the total rated fan efficacy must be less than 0.4 W/CFM. The total fan efficiency for the ventilation system is calculated using the parameters in the following equation:

$$Total\ fan\ efficiency = \frac{Total\ rated\ power\ of\ exhaust\ and\ supply\ fan\ at\ ventilation\ flow\ rate\ (W)}{Outdoor\ air\ ventilation\ flow\ rate\ (CFM)}$$

Compliance with the fan efficiency requirements for ventilation can be verified by reviewing product certification data from the HVI database or the AHAM Certified Range Hood Directory. Linear interpolation of rated performance parameters may be used when calculating the fan efficacy at the required outdoor airflow rate as described in Reference Residential Appendix RA3.7.4.4. The HVI database can be found at https://www.hvi.org/hvi-certified-products-directory/. The AHAM Directory can be found at https://www.aham.org/AHAM/What_We_Do/Kitchen_Range_Hood_Certification.

CFI Ventilation Systems Fan Watt Draw

When using the prescriptive approach, the fan efficacy of CFI systems must be verified by a ECC-Rater (for multifamily dwelling units in buildings up to three habitable stories) or an ATT (for multifamily dwelling units in buildings four or more habitable stories) using the same methods as required for furnaces and air handlers. (See Reference Residential Appendix RA3.3.) For verification, the central system air handler must be operating in ventilation mode with the outdoor air damper open and with outdoor ventilation air flowing into the return plenum from the supply duct. Furthermore, the airflow that must be measured is the total airflow through the air handler (system airflow), which is the sum of the return airflow, and the outside air ducted to the return plenum (ventilation airflow).

The watt draw must be less than or equal to 0.45 W/CFM for furnaces, 0.58 W/CFM for air handlers that are not gas furnaces, and 0.62 W/CFM for small duct, high-velocity systems. If not, the performance approach must be used.

ERV/HRV Fan Efficacy and Heat Recovery

For Climate Zones 1, 2, 4, 11 – 14, and 16, in addition to requiring heat recovery for ventilation, the prescriptive requirements require that HRVs and ERVs serving a single dwelling unit must have a fan efficacy of 0.6 W/CFM or less per Section 170.2(c)3Biva3.

Central ERVs or HRVs (serving multiple dwelling units) must meet fan efficacy requirements per Section 170.2(c)4A using the fan power allowance formula below. For ERVs and HRVs, the fan power allowance must be separately calculated for the supply and return airflows, and then summed.

$$FPA_{adj} = \frac{Q_{comp}}{Q_{sys}} \times FPA_{comp}$$

Where,

1. FPA_{adj} = The corrected fan power allowance for component in W/CFM
2. Q_{comp} = The airflow through component in CFM
3. Q_{sys} = The system airflow
4. FPA_{comp} = The fan power allowance of the component from Table 170.2-B or Table 170.2-C

ERV and HRV systems meeting the Section 170.2(c)3Biv prescriptive requirements must also meet a minimum sensible recovery efficiency or effectiveness of 67%, rated at 32°F.

Compliance with the requirements for unitary equipment can be verified by reviewing product certification data from the HVI database at the URL below. See Reference Residential Appendix RA3.7.4.4 for more information on verification of unitary equipment performance parameters.

Central equipment must have a bypass function for free cooling, in which the incoming outdoor air bypasses the heat exchanger when the outdoor air temperature is below the cooling set point. This allows the ventilation system to operate in economizing mode taking advantage of cool outdoor temperatures. The bypass mode is an important feature, particularly in mild climates where heat recovery without bypass can increase cooling loads. The controls must meet the air economizer high limit shut off control requirements in Table 170.2-G.

For ERV or HRV systems that are not meeting the prescriptive requirements, the fan efficacy need only meet the mandatory requirement of 1.0 W/CFM or less. «»

C. HVAC system bypass ducts. Bypass ducts that deliver conditioned supply air directly to the space-conditioning system return duct airflow shall not be used.

4. **Common use area space-conditioning systems**. A building complies with this section by being designed with and having constructed and installed a space-conditioning system that meets the applicable requirements of Subsections A through O.

   A. **Fan systems**. Each fan system moving air into, out of, or between spaces or circulating air for the purpose of conditioning air within a space shall meet the requirements of Items i, ii and iii below.

      i. **Fan power budget.** For each fan system that includes at least one fan or fan array with fan electrical input power ≥ 1 kW, fan system electrical input power (Fan $kW_{design,system}$) determined per Section 170.2(c)4Aib at the fan system design airflow shall not exceed Fan kW_{budget} as calculated per Section 170.2(c)4Aia.

a. Calculation of fan power budget (Fan kW_{budget}). For each fan system:

I. Determine the fan system airflow and choose the appropriate table(s) for fan power allowance.

A. For single-cabinet fan systems, use the fan system airflow and the power allowances in both Tables 170.2-B and Table 170.2-C.

B. For supply-only fan systems, use the fan system airflow and power allowances in Table 170.2-B.

C. For relief fan systems, use the design relief airflow and the power allowances in Table 170.2-C.

D. For exhaust, return and transfer fan systems, use the fan system airflow and the power allowances in Table 170.2-C.

E. For complex fan systems, separately calculate the fan power allowance for the supply and return/exhaust systems and sum them. For the supply airflow, use supply airflow at the fan system design conditions, and the power allowances in Table 170.2-B. For the return/exhaust airflow, use return/exhaust airflow at the fan system design conditions, and the power allowances in Table 170.2-C.

II. For each fan system, determine the components included in the fan system and sum the fan power allowances of those components. All fan systems shall include the system base allowance. If, for a given component, only a portion of the fan system airflow passes through the component, calculate the fan power allowance for that component per this equation:

$$FPA_{adj} = \frac{Q_{comp}}{Q_{sys}} \times FPA_{comp}$$

Where:

FPA_{adj} = The correct/ed fan power allowance for the component in w/cfm

Q_{comp} = The airflow through component in cfm

Q_{sys} = The fan system airflow in cfm

FPA_{comp} = The fan power allowance of the component from Table 170.2-B or Table 170.2-C

III. Multiply the fan system airflow by the sum of the fan power allowances for the fan system.

IV. Divide by 1000 to convert to Fan kW_{budget}.

V. For building sites at elevations greater than 3,000 feet, multiply Fan kW_{budget} by the correction factor in Table 170.2-D.

b. Determining fan system electrical input power (Fan $kW_{design,system}$). Fan $kW_{design,system}$ is the sum of Fan kW_{design} for each fan or fan array included in the fan system with Fan kW_{design} ≥ 1 kW. If variable speed drives are used, their efficiency losses shall be included. Fan input power shall be calculated with two times the clean filter pressure drop, which is the mean of the clean filter pressure drop and design final filter pressure drop. The Fan kW_{design} for each fan or fan array shall be determined using one of the following methods. There is no requirement to use the same method for all fans in a fan system:

I. Use the default Fan kW_{design} in Table 170.2-E-1 for one or more of the fans. This method cannot be used for complex fan systems.

II. Use the Fan kW_{design} at fan system design conditions provided by the manufacturer of the fan, fan array, or equipment that includes the fan or fan array calculated per a test procedure included in USDOE 10 CFR Part 430, USDOE 10 CFR Part 431, ANSI/AMCA Standard 208-2018, ANSI/AMCA Standard 210-2016, AHRI Standard 430-2020, AHRI Standard 440-2019 or ISO 5801-2017.

III. Use the Fan kW_{design} provided by the manufacturer, calculated at fan system design conditions per one of the methods listed in Section 5.3 of ANSI/AMCA 208-2018.

IV. Determine the Fan kW_{design} by using the maximum electrical input power provided on the motor nameplate.

ii. **VAV systems.**

a. Static pressure sensor location. Static pressure sensors used to control variable air volume fans shall be placed in a position such that the controller setpoint is no greater than one-third the total design fan static pressure, except for systems with zone reset control complying with Section 170.2(c)4Aiib. If this results in the sensor being located downstream of any major duct split, multiple sensors shall be installed in each major branch with fan capacity controlled to satisfy the sensor furthest below its setpoint; and

b. Setpoint reset. For systems with direct digital control of individual zone boxes reporting to the central control panel, static pressure setpoints shall be reset based on the zone requiring the most pressure, i.e., the setpoint is reset lower until one zone damper is nearly wide open.

iii. **Fractional HVAC motors for fans.** HVAC motors for fans that are less than 1 hp and 1/12 hp or greater shall be electronically commutated motors or shall have a minimum motor efficiency of 70 percent when rated in accordance with NEMA Standard MG 1-2006 at full load rating conditions. These motors shall also have the means to adjust motor speed for either balancing or remote control. Belt-driven fans may use sheave adjustments for airflow balancing in lieu of a varying motor speed.

Exception 1 to Section 170.2(c)4Aiii: Motors in fan-coils and terminal units that operate only when providing heating to the space served.

Exception 2 to Section 170.2(c)4Aiii: Motors in space-conditioning equipment certified under Section 110.1 or 110.2.

Exception 1 to 170.2(c)4A: Fan system power caused solely by process loads.

TABLE 170.2-B: Supply Fan Power Allowances (watts/cfm)

Component	Multi-Zone VAV Systems ≤5,000 cfm	Multi-Zone VAV Systems >5,000 and ≤10,000 cfm	Multi-Zone VAV Systems >10,000 cfm	All Other Fan Systems ≤5,000 cfm	All Other Fan Systems >5,000 and ≤10,000 cfm	All Other Fan Systems >10,000 cfm
Supply System Base Allowance for AHU Serving Spaces < 6 Floors Away.	0.395	0.453	0.413	0.232	0.256	0.236
Supply System Base Allowance for AHU Serving Spaces > 6 Floors Away	0.508	0.548	0.501	0.349	0.356	0.325
MERV 13 to MERV 16 Filter Upstream of Thermal Conditioning Equipment (two times the clean filter pressure drop)[2]	0.136	0.114	0.105	0.139	0.120	0.107
MERV 13 to MERV 16 Final Filter Downstream of Thermal Conditioning Equipment. (two times the clean filter pressure drop) [2]	0.225	0.188	0.176	0.231	0.197	0.177
Filtration Allowance for > Merv 16 or HEPA Filter (two times the clean filter pressure drop) [2]	0.335	0.280	0.265	0.342	0.292	0.264
Central Hydronic Heating Coil Allowance	0.046	0.048	0.052	0.046	0.050	0.054
Electric Heat Allowance	0.046	0.038	0.035	0.046	0.040	0.036

TABLE 170.2-B: Supply Fan Power Allowances (watts/cfm) (Continued)

Component	Multi-Zone VAV Systems ≤5,000 cfm	Multi-Zone VAV Systems >5,000 and ≤10,000 cfm	Multi-Zone VAV Systems >10,000 cfm	All Other Fan Systems ≤5,000 cfm	All Other Fan Systems >5,000 and ≤10,000 cfm	All Other Fan Systems >10,000 cfm
Gas Heat Allowance	0.069	0.057	0.070	0.058	0.060	0.072

Hydronic/DX Cooling Coil, or Heat Pump Coil (wet) Allowance	0.135	0.114	0.105	0.139	0.120	0.107
Solid or Liquid Desiccant System Allowance	0.157	0.132	0.123	0.163	0.139	0.124
Reheat Coil for Dehumidification Allowance	0.045	0.038	0.035	0.046	0.040	0.036
Allowance for evaporative humidifier/cooler in series with a cooling coil. Value shown is allowed watts/cfm per 1.0 in. wg. Determine pressure loss (in. wg) at 400 fpm or maximum velocity allowed by the manufacturer, whichever is less. *[Calculation required, see note 4]*	0.224	0.188	0.176	0.231	0.197	0.177
Allowance for 100% outdoor air system meeting the requirements of Note 5.	0.000	0.000	0.000	0.070	0.100	0.107
Energy Recovery Allowance for 0.50 ≤ ERR <0.55 [6]	0.135	0.114	0.105	0.139	0.120	0.107
Energy Recovery Allowance for 0.55 ≤ ERR <0.60 [6]	0.160	0.134	0.124	0.165	0.141	0.126
Energy Recovery Allowance for 0.60 ≤ ERR <0.65 [6]	0.184	0.155	0.144	0.190	0.163	0.146
Energy Recovery Allowance for 0.65 ≤ ERR <0.70 [6]	0.208	0.175	0.163	0.215	0.184	0.165
Energy Recovery Allowance for 0.70 ≤ ERR <0.75 [6]	0.232	0.196	0.183	0.240	0.205	0.184
Energy Recovery Allowance for 0.75 ≤ ERR <0.80 [6]	0.257	0.216	0.202	0.264	0.226	0.203
Energy Recovery Allowance for ERR ≥ 0.80 [6]	0.281	0.236	0.222	0.289	0.247	0.222
Coil Runaround Loop	0.135	0.114	0.105	0.139	0.120	0.107
Allowance for gas phase filtration required by code or accredited standard. Value shown is allowed w/cfm per 1.0 in. wg air pressure drop. *[Calculation required, see note 4]*	0.224	0.188	0.176	0.231	0.197	0.177

TABLE 170.2-B: Supply Fan Power Allowances (watts/cfm) (Continued)

Component	**Multi-Zone VAV Systems ≤5,000 cfm**	**Multi-Zone VAV Systems >5,000 and ≤10,000 cfm**	**Multi-Zone VAV Systems >10,000 cfm**	**All Other Fan Systems ≤5,000 cfm**	**All Other Fan Systems >5,000 and ≤10,000 cfm**	**All Other Fan Systems >10,000 cfm**
Economizer Return Damper	0.045	0.038	0.035	0.046	0.040	0.036
Air Blender Allowance	0.045	0.038	0.035	0.046	0.040	0.036
Allowance for sound attenuation section [fans serving spaces with design background noise goals below NC35].	0.034	0.029	0.026	0.035	0.030	0.027
Deduction for systems that feed a terminal unit with a fan with electrical input power < 1kW.	-0.100	-0.100	-0.100	-0.100	-0.100	-0.100
Low-turndown single-zone VAV fan systems meeting the requirements in note 7.	0.000	0.000	0.000	.070	0.100	0.089

Footnote to TABLE 170.2-B:

1. See FAN SYSTEM, MULTI-ZONE VARIABLE AIR VOLUME (VAV) in definition a Multi-Zone VAV System.
2. Filter fan power allowance can only be counted once per fan system.
3. RESERVED.
4. Power allowance requires further calculation by multiplying the actual in. wg. of the device/ component by the watts/ cfm in Table 170.2-B.
5. The 100% outdoor air system must serve 3 or more HVAC zones and airflow during non-economizer operating periods must not exceed 135% of minimum requirements in Section 120.1(c)(3).
6. Energy Recovery Ratio (ERR) calculated per ANSI/ASHRAE 84-2020.
7. A low-turndown single-zone VAV fan system must be capable of and configured to reduce airflow to 50 percent of design airflow and use no more than 30 percent of the design wattage at that airflow. No more than 10 percent of the design load served by the equipment shall have fixed loads.

TABLE 170.2-C: EXHAUST, RETURN, RELIEF, TRANSFER FAN POWER ALLOWANCES (WATT/CFM)

Component	**Multi-Zone VAV Systems ≤5,000 cfm[1]**	**Multi-Zone VAV Systems >5,000 and ≤10,000 cfm[1]**	**Multi-Zone VAV Systems >10,000 cfm[1]**	**All Other Fan Systems ≤5,000 cfm**	**All Other Fan Systems >5,000 and ≤10,000 cfm**	**All Other Fan Systems >10,000 cfm**
Exhaust System Base Allowance	0.221	0.246	0.236	0.186	0.184	0.190
Filter (any MERV value)[2]	0.046	0.041	0.036	0.046	0.041	0.035
Energy Recovery Allowance for 0.50 ≤ ERR <0.55 [3]	0.139	0.120	0.107	0.139	0.123	0.109
Energy Recovery Allowance for 0.55 ≤ ERR <0.60 [3]	0.165	0.142	0.126	0.165	0.144	0.128
Energy Recovery Allowance for 0.60 ≤ ERR <0.65 [3]	0.190	0.163	0.146	0.191	0.166	0.148
Energy Recovery Allowance for 0.65 ≤ ERR <0.70 [3]	0.215	0.184	0.165	0.216	0.188	0.167
Energy Recovery Allowance for 0.70 ≤ ERR <0.75 [3]	0.240	0.206	0.184	0.241	0.209	0.186
Energy Recovery Allowance for 0.75 ≤ ERR <0.80 [3]	0.265	0.227	0.203	0.266	0.231	0.205
Energy Recovery Allowance for ERR ≥ 0.80 [3]	0.289	0.248	0.222	0.291	0.252	0.225
Coil Runaround Loop	0.139	0.120	0.107	0.139	0.123	0.109

TABLE 170.2-C: EXHAUST, RETURN, RELIEF, TRANSFER FAN POWER ALLOWANCES (WATT/CFM) (Continued)

Component	**Multi-Zone VAV Systems ≤5,000 cfm[1]**	**Multi-Zone VAV Systems >5,000 and ≤10,000 cfm[1]**	**Multi-Zone VAV Systems >10,000 cfm[1]**	**All Other Fan Systems ≤5,000 cfm**	**All Other Fan Systems >5,000 and ≤10,000 cfm**	**All Other Fan Systems >10,000 cfm**
Return or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms	0.116	0.100	0.089	0.116	0.102	0.091
Return and/or exhaust airflow control devices required for space pressurization control	0.116	0.100	0.089	0.116	0.102	0.091
Laboratory and vivarium exhaust systems in high-rise buildings for vertical duct exceeding 75 ft. Value shown is allowed w/cfm per 0.25 in. wg for each 100 feet exceeding 75 feet. [Calculation required, see note 4]	0.058	0.051	0.045	0.058	0.052	0.046
Biosafety cabinet. Value shown is allowed w/cfm per 1.0 in. wg air pressure drop. [Calculation required, see note 4]	0.231	0.198	0.177	0.232	0.202	0.179
Exhaust filters, scrubbers, or other exhaust treatment required by code or standard. Value shown is allowed w/cfm per 1.0 in. wg air pressure drop. [Calculation required, see note 4]	0.231	0.198	0.177	0.232	0.202	0.179
Sound attenuation section [Fans serving spaces with design background noise goals below NC35.]	0.035	0.030	0.027	0.035	0.031	0.028

Footnote to TABLE 170.2-C:

1. For requirements to be classified as a Multi-Zone VAV System see definition for Multi-Zone Variable Air Volume Fan System.
2. Filter pressure loss can only be counted once per fan system.
3. Energy Recovery Ratio (ERR) calculated per ANSI/ASHRAE 84-2020.
4. Power allowance requires further calculation, multiplying the actual pressure drop (in. wg.) of the device/ component by the watts/cfm in the Table 170.2-C.

TABLE 170.2-D AIR DENSITY CORRECTION FACTORS

Altitude (ft)	Correction factor
<3,000	1.000
≥3,000 and <4,000	0.896
≥4,000 and <5,000	0.864
≥5,000 and <6,000	0.832
≥6,000	0.801

TABLE 170.2-E-1: Default values for Fan kW_{design} Based on Motor Nameplate HP[1,2]

Motor Nameplate HP	Default Fan kW_{design} with variable speed drive (Fan kW_{design})	Default Fan kW_{design} without variable speed drive (Fan kW_{design})
<1	0.96	0.89
≥1 and <1.5	1.38	1.29
≥1.5 and <2	1.84	1.72
≥2 and <3	2.73	2.57
≥3 and <5	4.38	4.17
≥5 and <7.5	6.43	6.15
≥7.5 and <10	8.46	8.13
≥10 and <15	12.47	12.03
≥15 and <20	16.55	16.04
≥20 and <25	20.58	19.92
≥25 and <30	24.59	23.77
≥30 and <40	32.74	31.70
≥40 and <50	40.71	39.46
≥50 and <60	48.50	47.10
≥60 and <75	60.45	58.87
≥75 and ≤100	80.40	78.17

Footnote to TABLE 170.2-E-1:

1. This table cannot be used for Motor Nameplate Horsepower values greater than 100.
2. This table is to be used only with motors with a service factor ≤1.15. If the service factor is not provided, this table may not be used.

«» Commentary for Section 170.2(c)4A:

Maximum fan power is regulated in individual fan systems where the power of at least one fan or fan array in the fan system is greater than or equal to 1kW of fan electrical input power at design conditions (see Section 100.1 for definitions). A system consists of only the components that must function together to deliver air to a given area; fans that can operate independently of each other comprise separate systems. Included are all fans associated with moving air from a given space-conditioning system to the conditioned spaces and back to the source, or to exhaust air to the outdoors.

The 1 kW total criteria apply to:

1. All supply and return fans within the space-conditioning system that operate at peak load conditions.
2. All exhaust fans at the system level that operate at peak load conditions. Exhaust fans associated with economizers are not counted, provided they do not operate at peak conditions, including fans that circulate air for the purpose of conditioning air within the space.
3. Fan-powered VAV boxes if these fans run during the cooling peak. This is always the case for fans in series type boxes. Fans in parallel boxes may be ignored if they are controlled to operate only when zone heating is required, are normally off during the cooling peak, and there is no design heating load, or they are not used during design heating operation.
4. Elevator equipment room exhausts (or other exhausts that draw air from a conditioned space) through an otherwise unconditioned space, to the outdoors.

The criteria are applied individually to each space-conditioning system. In buildings having multiple space-conditioning systems, the criteria apply only to the systems having a fan or fan array whose demand exceeds 1 kW of fan electrical input power.

Meeting the fan power limit is accomplished in two parts. First, the designer calculates the allowable fan input power for their fan systems (Fan kW_{budget}). Second, the designer calculates the actual electrical input power (Fan kW_{design}, system) values of the fans in the system by summing up the Fan kW_{design} value of each fan in the fan system. The total power input must be less than the allowable power input for the fan system to comply.

To calculate the fan kW_{budget}, the designer must know the following pieces of information:

1. The type of fan system (described below)
2. The fan system control type (i.e., either Multi-Zone VAV or all other fan systems) and airflow passing through each component of the fan system
3. Knowledge of the status of all components (e.g., presence or absence of DX cooling coils, gas furnace, energy recovery wheel, economizer return damper, etc.) in the fan system. This determines which allowances from the given allowance table (e.g., Table 170.2-B, Table 170.2-C, etc.) apply to the fan system when calculating Fan kWbudget.
4. The altitude of the building to account for reduced air density (if greater than 3,000 feet).

The fan system type contributes to the determination of how the fan power budget is calculated. The fan system types are listed and described below.

Single-cabinet Fan System

This is a fan system where a single fan, single fan array, a single set of fans operating in parallel, or fans or fan arrays in series and embedded in the same cabinet that both supply air to a space and recirculate the air. Designers of this type of system will use the applicable allowances from the given supply fan power allowance table (e.g., Table 170.2-B) and exhaust/return/relief/transfer fan power allowance table (e.g., Table 170.2-C) at the fan system design airflow.

Examples include:

1. A rooftop unit with a single fan that both supplies air to the space and recirculates air.
2. An air handler with a supply and return fan in the same cabinet.
3. A rooftop unit with a relief fan that only runs during economizer operation.

Supply-only Fan System

This is a fan system that provides supply air to interior spaces and does not recirculate the air. Designers of this type of system will use the applicable allowances from the given supply table (e.g., Table 170.2-B) at the fan system design supply airflow.

Examples include:

1. An air handler with only a supply fan where the return fan is not in the same cabinet.
2. The supply fan of an ERV, even if there is an exhaust fan in the same cabinet.
3. The fan of a make-up air unit where air is exhausted from the building by a different fan.

Relief Fan System

This is a fan system dedicated to the removal of air from interior spaces to the outdoors that operates only during economizer operation. Designers of this type of system will use the applicable allowances from the given exhaust/return/relief/transfer fan power allowance table (e.g., Table 170.2-C) at the fan system design relief airflow.

Exhaust, Return, and Transfer Fan Systems

An exhaust fan system is a fan system dedicated to the removal of air from interior spaces to the outdoors that may operate at times other than economizer operation. A return fan system is a fan system dedicated to removing air from interior where some or all the air is to be recirculated except during economizer operation. A transfer fan system is a fan system that exclusively moves air from one occupied space to another. Designers of any of these three system types will use the applicable allowances from the given exhaust/return/relief/transfer fan power allowance table (e.g., Table 170.2-C) at the fan system design airflow.

Complex Fan System

This is a fan system that combines a single-cabinet fan system with other supply fans, exhaust fans, or both. The designer will separately calculate the fan power allowance for the supply component and then return/exhaust component, and then arrive at a total fan power allowance. This approach differs from a single-cabinet fan system in that for the single-cabinet fan system, the individual allowances from the supply and exhaust/return/relief/transfer tables are added before arriving at a Fan kW budget value, whereas for complex fan systems, a supply power allowance value is calculated using its allowances, a return/exhaust power value is calculated using its allowances, and then the two are added together to determine the overall Fan kW budget value.

Once the required information and fan system classification has been determined, the designer will apply the appropriate allowances from the appropriate budget table before calculating the overall Fan kW_{budget} value. All fan systems should use the base allowance from the applicable table, as well as other allowances that apply to their individual fan system. For fan system components that only receive a fraction of the airflow passing through the rest of the system, the adjusted fan power allowance should be calculated according to the following formula.

$$FPA_{adj} = \frac{Q_{comp}}{Q_{sys}} \times FPA_{comp}$$

Where,

1. FPA_{adj} = The corrected fan power allowance for the component in w/cfm
2. Q_{comp} = The airflow through component in cfm
3. Q_{sys} = The fan system airflow in cfm
4. FPA_{comp} = The fan power allowance of the component from the applicable table (e.g., Table 170.2-B or Table 170.2-C)

If the site is at an altitude of 3,000 feet above sea level or greater, the designer should apply the appropriate correction factor from Table 170.2-D to the resulting Fan kW_{budget} value.

Fan electrical input power (Fan kW_{design}) is the electrical input power in kilowatts required to operate an individual fan or fan array at design conditions. It includes the power consumption of motor controllers, if present. This value encompasses all wire-to-air losses, including motor controller, motor, and belt losses.

There are four methods available to determine Fan kW_{design} for an individual fan in a fan system. There is no requirement to use the same method for different fans in the fan system. For all methods, fan input power shall be calculated with twice the clean filter pressure drop.

1. Use the default values for Fan kW_{design} (Table 170.2-E-1) based on minimum U.S. DOE motor efficiencies. There are values for input power with and without a motor controller. This method can be used if only the motor nameplate horsepower is known. This table will likely provide a conservative estimate of fan input electrical power. This method cannot be used for complex fan systems.
2. Use the fan input power at fan system design conditions provided by the manufacturer of the fan, fan array, or equipment that includes the fan or fan array calculated per a test procedure included in USDOE 10 CFR 430, USDOE 10 CFR 431, ANSI/AMCA Standard 208, ANSI/AMCA Standard 210, AHRI Standard 430:2020, AHR Standard 440:2019 and ISO 5801:2017.
3. Use one of the options listed in Section 5.3 of ANSI/AMCA Standard 208 at design conditions. This method can be used in cases where the fan shaft input power is provided by the manufacturer, and the designer needs to calculate the input power to the motor or motor controller.
4. Use the maximum electrical input power included on the fan motor nameplate. Note that this value does not account for the loading of the fan in question (which will usually be lower than this value) and thus is likely to be a conservative method.

Once the designer has calculated the fan power budget value (Fan kW_{budget}) and their fan system's input electrical power at design conditions (Fan kW_{design}, system), the two values are compared against each other to determine if the fan system complies.

$$Fan\ kW_{design,system} \ \leq \ Fan\ kW_{budget}$$

If the above inequality is valid, then the fan system complies with the fan power budget.

Selected Fan Power Budget Allowance

The types of devices listed in Tables 170.2-B and 170.2-C that qualify for additional fan power are as follows:

1. Return or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms. The basic input power allowance is based on the assumption that return air passes through an open plenum on its way back to the fan system. For systems where all of the return air is ducted back to the return, an additional allowance equivalent to a pressure drop of 0.5 inches of water is allowed. This allowance may not be applied for air systems that have a mixture of ducted and non-ducted return.
2. Return and/or exhaust airflow control devices required for space pressurization control. Some types of spaces, such as laboratories, test rooms, and operating rooms, require that an airflow control device be provided at both the supply air delivery point and at the exhaust. The exhaust airflow control device is typically modulated to maintain a negative or positive space pressure relative to surrounding spaces. An additional pressure drop and associated input power adjustment are permitted when this type of device is installed. The allowance may be taken when some spaces served by an air handler have exhaust airflow devices and other spaces do not. However, the allowance is taken only for the cfm of air that is delivered to spaces with a qualifying exhaust airflow device.
3. Exhaust filters, scrubbers, or other exhaust treatment. Some applications require the air leaving the building be filtered to remove dust or contaminants. Exhaust air filters are also associated with some types of heat recovery systems, such as run-around coils. In this application, the purpose of the filters is to help keep the coils clean, which is necessary to maintain the effectiveness of the heat recovery system. When such devices are specified and installed, the pressure drop of the device at the fan system design condition may be included as an allowance. When calculating the additional input power, only consider the volume of air that is passing through the device under fan system design conditions.
4. Particulate filtration allowance: greater than MERV 16 and electronically enhanced filters. The primary purpose of filters is to keep the fans, coils, and ducts clean, and to reduce maintenance costs. A secondary purpose is to improve indoor air quality. MERV ratings are used as the basis of this allowance. These ratings indicate the amount of particulate removed from the airstream. A higher MERV rating is more efficient and removes more material. The allowance for filters with a MERV rating of 16 and greater and all electronically enhanced filters is based on two times the clean pressure drop of the filter at fan system design conditions. These clean pressure drop data are taken from manufacturers' literature.
5. Carbon and other gas-phase air cleaners. For carbon and other gas-phase air cleaners, additional input power is based on the rated clean pressure drop of the air-cleaning device at fan system design conditions.
6. Biosafety cabinet. If the device is listed as a biosafety cabinet, you can use this allowance.

7. Energy recovery device. Energy recovery devices exchange heat between the outside air intake stream and the exhaust airstream. There are two common types of heat recovery devices: heat wheels and air-to-air heat exchangers. Both increase the pressure drop and require a system with a larger input power. The allowance increases linearly with an increasing energy recovery ratio. There are seven rows, but designers can only choose one allowance corresponding to their energy recovery device's energy recovery ratio. The allowance is a function of the enthalpy recovery ratio. This is intended to encourage designers to select energy recovery devices that have low pressure drops and high enthalpy recovery ratios, and thus provide a net energy reduction. This allows systems that have trouble meeting the fan power limit to gain a higher fan power allowance — by using larger energy recovery devices with higher enthalpy recovery ratios.
8. Coil runaround loop. The coil runaround loop is a form of energy recovery device that uses separate coils in the exhaust and outdoor air intakes with a pump in between. The allowance is to account for the increased air pressure of these two coils.
9. Exhaust systems that serve fume hoods. Exhaust systems that serve fume hoods get an allowance equivalent to an additional 0.35 inches of water to account for the pressure through the fume hood, ductwork, and zone valve or balancing devices. This allowance applies to the exhaust fans only.

«»

B. **Space-conditioning zone controls.** Each space-conditioning zone shall have controls designed in accordance with i or ii:

   i. Each space-conditioning zone shall have controls that prevent:

      a. Reheating; and

      b. Recooling; and

      c. Simultaneous provisions of heating and cooling to the same zone, such as mixing or simultaneous supply of air that has been previously mechanically heated and air that has been previously cooled either by cooling equipment or by economizer systems; or

«» Commentary for Section 170.2(c)4Bi:

Each space-conditioning zone shall have controls that prevent:

1. Reheating of air that has been previously cooled by mechanical cooling equipment or an economizer.
2. Recooling of air that has been previously heated. This does not apply to air returned from heated spaces.
3. Simultaneous heating and cooling in the same zone, such as mixing supply air that has been previously mechanically heated with air that has been previously cooled, either by mechanical cooling or by economizer systems.

«»

ii. Zones served by variable air-volume systems that are designed and controlled to reduce, to a minimum, the volume of reheated, recooled, or mixed air are allowed only if the controls meet all of the following requirements:

a. For each zone with direct digital controls (DDC), the volume of primary air that is reheated, recooled, or mixed air supply shall not exceed the larger of:

I. 50 percent of the peak primary airflow; or

II. The design zone outdoor airflow rate as specified by Section 160.2(c)3.

b. The volume of primary air in the deadband shall not exceed the design zone outdoor airflow rate as specified by Section 160.2(c)3.

c. The first stage of heating consists of modulating the zone supply air temperature setpoint up to a maximum setpoint no higher than 95 F degrees F while the airflow is maintained at the deadband flow rate.

d. The second stage of heating consists of modulating the airflow rate from the deadband flow rate up to the heating maximum flow rate.

e. For each zone without DDC, the volume of primary air that is reheated, recooled, or mixed air supply shall not exceed the larger of the following:

I. 30 percent of the peak primary airflow; or

II. The design zone outdoor airflow rate as specified by Section 160.2(c)3.

Exception 1 to Section 170.2(c)4B: Zones with special pressurization relationships or cross-contamination control needs.

Exception 2 to Section 170.2(c)4B: Zones served by space-conditioning systems in which at least 75 percent of the energy for reheating, or providing warm air in mixing systems, is provided from a site-recovered or site-solar energy source.

Exception 3 to Section 170.2(c)4B: Zones in which specific humidity levels are required to satisfy exempt process loads. Computer rooms or other spaces where the only process load is from IT equipment may not use this exception.

Exception 4 to Section 170.2(c)4B: Zones with a peak supply-air quantity of 300 cfm or less.

«» Commentary for Section 170.2(c)4Bii:

VAV System is a space conditioning system that maintains comfort levels by varying the volume of conditioned air to the zones served. This system delivers conditioned air to one or more zones. There are two styles of VAV systems, single-duct VAV (where mechanically cooled air is typically supplied and reheated through a duct mounted coil) and dual-duct VAV (where heated and cooled streams of air are blended at the zone level). In single-duct VAV systems, the duct serving each zone is provided with a motorized damper that is modulated by a signal from the zone thermostat. The thermostat also controls the reheat coil. In dual-duct VAV systems, the ducts serving each zone are provided with motorized dampers that blend the supply air based on a signal from the zone thermostat.

Space Conditioning Zone Controls

Zones served by VAV systems are designed with controls to reduce the volume of reheated, recooled, or mixed air to a minimum. The controls must meet all of the following.

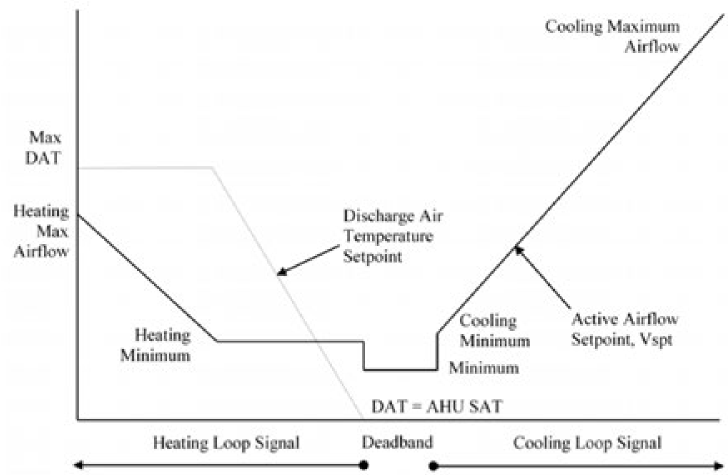
For each zone with DDC:

1. The volume of primary air that is reheated, re-cooled, or mixed air supply shall not exceed the larger of 50 percent of the peak primary airflow or the design zone outdoor airflow rate, per Section 160.2(c)3.
2. The volume of primary air in the dead band shall not exceed the design zone outdoor airflow rate, per Section 160.2(c)3.
    - The first stage of heating consists of modulating the zone supply air temperature set point up to a maximum set point no higher than 95 °F while the airflow is maintained at the deadband flow rate.
    - The second stage of heating consists of modulating the airflow rate from the deadband flow rate up to the heating maximum flow rate.
    - For each zone without DDC, the volume of primary air that is reheated, re-cooled, or mixed air supply shall not exceed the larger of 30 percent of the peak primary airflow or the design zone outdoor airflow rate, per Section 160.2(c)3.

For systems with DDC to the zone level, the controls must be able to support two different maximums -- one each for heating and cooling. This control is depicted in Figure 4-18: Dual-Maximum VAV Box Control Diagram with Minimum Flow in Deadband below. In cooling, this control scheme is similar to a traditional VAV reheat box control. The difference is what occurs in the deadband between heating and cooling and in the heating mode. With traditional VAV control logic, the minimum airflow rate is typically set to the largest rate allowed by code. This airflow rate is supplied to the space in the deadband and heating modes. With the "dual maximum" logic, the minimum rate is the lowest allowed by code (e.g., the minimum ventilation rate) or the minimum rate the controls system can be set to (which is a function of the VAV box velocity pressure sensor amplification factor and the accuracy of the controller to convert the velocity pressure into a digital signal). As the heating demand increases, the dual maximum control first resets the discharge air temperature (typically from the design cold deck temperature up to 85 or 90 °F) as a first stage of heating then, if more heat is required, it increases airflow rate up to a “heating” maximum airflow set point, which is the same value as what traditional control logic uses as the minimum airflow set point. Using this control can save significant fan, reheat and cooling energy while maintaining better ventilation effectiveness as the discharge heating air is controlled to a temperature that will minimize stratification.

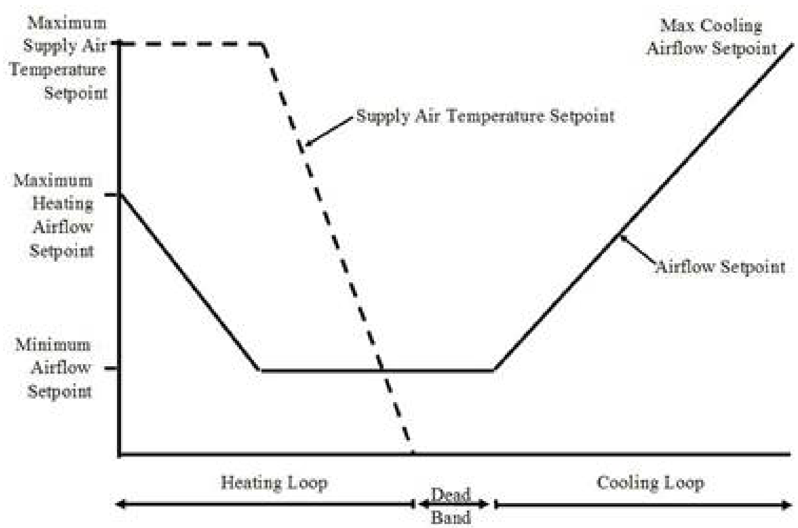
This control requires a discharge air sensor and may require a programmable VAV box controller. The discharge air sensor is very useful for diagnosing control and heating system problems even if they are not actively used for control.

Figure 4-18: Dual-Maximum VAV Box Control Diagram with Minimum Flow in Deadband



Source: California Energy Commission

Figure 4-19: Dual-Maximum VAV Box Control Diagram (for systems without DDC)



Source: California Energy Commission

For systems without DDC to the zone (such as electric or pneumatic thermostats), the airflow that is reheated is limited to a maximum of either 30 percent of the peak primary airflow or the minimum airflow required to ventilate the space, whichever is greater.

Certain exceptions exist for space conditioned zones with one of the following:

1. Special pressurization relationships or cross contamination control needs (laboratories are an example of spaces that might fall in this category)
2. Site-recovered or site-solar energy providing at least 75 percent of the energy for reheating, or providing warm air in mixing systems
3. Specific humidity requirements to satisfy exempt process needs (computer rooms are explicitly not covered by this exception)
4. Zones with a peak supply air quantity of 300 cfm or less

«»

C. **Economizers**.

i. Each cooling air handler that has a design total mechanical cooling capacity over 33,000 Btu/hr, or chilled-water cooling systems without a fan or that use induced airflow that has a cooling capacity greater than the systems listed in Table 170.2-E-2, shall include either:

a. An air economizer capable of modulating outside-air and return-air dampers to supply 100 percent of the design supply air quantity as outside air; or

b. A water economizer capable of providing 100 percent of the expected system cooling load, at outside air temperatures of 50°F dry-bulb and 45°F wet-bulb and below.

Exception 1 to Section 170.2(c)4Ci: Where special outside air filtration and treatment, for the reduction and treatment of unusual outdoor contaminants, makes compliance infeasible.

Exception 2 to Section 170.2(c)4Ci: Where the use of outdoor air for cooling will affect other systems, such as humidification or dehumidification, so as to increase overall building LSC energy use.

Exception 3 to Section 170.2(c)4Ci: Systems serving dwelling units.

Exception 4 to Section 170.2(c)4Ci: Where comfort cooling systems have the cooling efficiency that meets or exceeds the cooling efficiency improvement requirements in Table 170.2-F.

Exception 5 to Section 170.2(c)4Ci: Fan systems primarily serving computer rooms. See Section 140.9(a) for computer room economizer requirements.

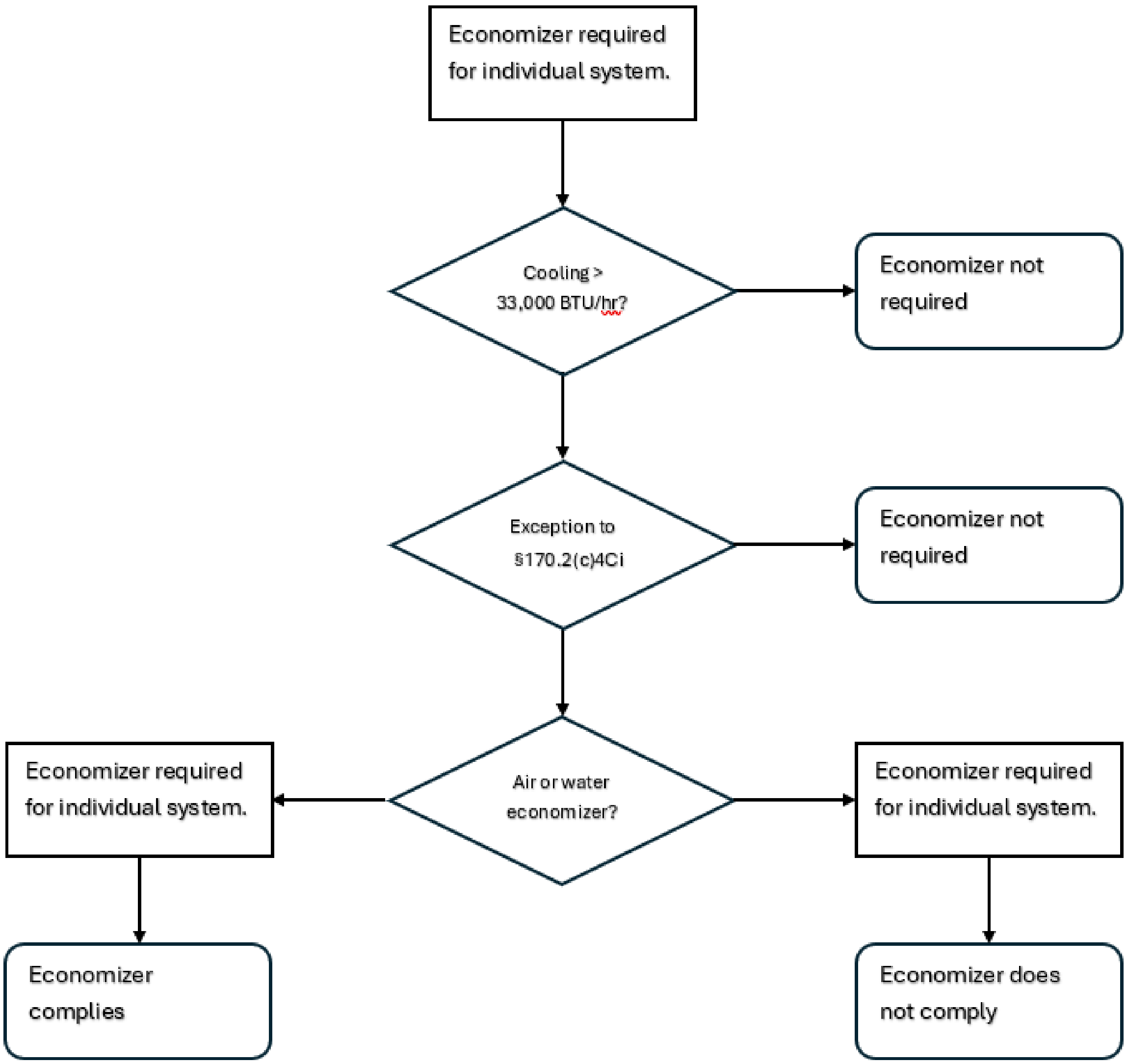
Exception 6 to Section 170.2(c)4Ci: In all climate zones, each air handler that has a design total mechanical cooling capacity less than 54,000 Btu/hr where ventilation is provided by a dedicated outdoor air system (DOAS) with exhaust air heat recovery in accordance with Section 140.4(p) and the following:

A. The DOAS unit shall meet the exhaust air heat recovery ratio as specified in Section 140.4(q)1 and include bypass or control to disable energy recovery as specified in Section 140.4(q)2.

B. The DOAS unit shall provide at least the minimum ventilation air flow rate as specified in Section 120.1(c)3 and provide no less than 0.3 cfm/ft^2 during economizer conditions.

«» Commentary for Section 170.2(c)4C:

Figure 4-20: Economizer Flowchart



Source: California Energy Commission

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TABLE 170.2-E-2 CHILLED WATER SYSTEM COOLING CAPACITY

Climate Zones	Building Water-Cooled Chilled Water System	Air-Cooled Chilled Water Systems or District Chilled Water Systems
15	≥ 960,000 Btu/h (280 kW)	≥ 1,250,000 Btu/h (365 kW)
1-14	≥720,000 Btu/h (210 kW)	≥940,000 Btu/h (275 kW)
16	≥1,320,000 Btu/h (385 kW)	≥1,720,000 Bu/h (505 kW)

Note for Table 170.2-E-2:

Total Building Chilled Water System Capacity, Minus Capacity of the Cooling units with Air Economizers

TABLE 170.2-F ECONOMIZER TRADE-OFF TABLE FOR COOLING SYSTEMS

Climate Zone	Efficiency Improvement [a]
1	70%
2	65%
3	65%
4	65%
5	70%
6	30%
7	30%
8	30%
9	30%
10	30%
11	30%
12	30%
13	30%
14	30%
15	30%
16	70%

Footnote to TABLE 170.2-F:

a. If a unit is rated with an annualized or part-load metric, then to eliminate the required economizer, only the annualized or part-load minimum cooling efficiency of the unit must be increased by the percentage shown. If the unit is only rated with a full load metric, like EER2 or COP cooling, then that metric must be increased by the percentage shown. To determine the efficiency required to eliminate economizer, when the unit *equipment efficiency* is rated with an energy-input divided by work-output metric, the metric shall first be converted to COP prior to multiplying by the *efficiency* improvement percentage and then converted back to the rated metric.

ii. If an economizer is required by Section 170.2(c)4Ci, and an air economizer is used to meet the requirement, then it shall be:

a. Designed and equipped with controls so that economizer operation does not increase the building heating energy use during normal operation; and

Exception to Section 170.2(c)4Ciia: Systems that provide 75 percent of the annual energy used for mechanical heating from site-recovered energy or a site-solar energy source.

b. Capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.

c. Designed and equipped with a device type and high limit shut off complying with Table 170.2-G.

TABLE 170.2-G AIR ECONOMIZER HIGH LIMIT SHUT OFF CONTROL REQUIREMENTS

Device Type[a]	Climate Zones	Required High Limit (Economizer Off When): Equation[b]	Required High Limit (Economizer Off When): Description
Fixed Dry Bulb	1, 3, 5, 11-16	$T_{OA} > 75°F$	Outdoor air temperature exceeds 75°F
Fixed Dry Bulb	2, 4, 10	$T_{OA} > 73°F$	Outdoor air temperature exceeds 73°F
Fixed Dry Bulb	6, 8, 9	$T_{OA} > 71°F$	Outdoor air temperature exceeds 71°F
Fixed Dry Bulb	7	$T_{OA} > 69°F$	Outdoor air temperature exceeds 69°F
Differential Dry Bulb	1, 3, 5, 11-16	$T_{OA} > T_{RA}°F$	Outdoor air temperature exceeds return air temperature
Differential Dry Bulb	2, 4, 10	$T_{OA} > T_{RA}-2°F$	Outdoor air temperature exceeds return air temperature minus 2°F
Differential Dry Bulb	6, 8, 9	$T_{OA} > T_{RA}-4°F$	Outdoor air temperature exceeds return air temperature minus 4°F
Differential Dry Bulb	7	$T_{OA} > T_{RA}-6°F$	Outdoor air temperature exceeds return air temperature minus 6°F

Fixed Enthalpy[c] + Fixed Drybulb	All	h_{OA} > 28 Btu/lb[c] or T_{OA} > 75°F	Outdoor air enthalpy exceeds 28 Btu/lb of dry air[c] or Outdoor air temperature exceeds 75°F

Footnote to TABLE 170.2-G:

a. Only the high limit control devices listed are allowed to be used and at the setpoints listed. Others such as Dew Point, Fixed Enthalpy, Electronic Enthalpy, and Differential Enthalpy Controls, may not be used in any Climate Zone for compliance with Section 170.2(c)4Ci unless approval for use is provided by the Energy Commission Executive Director.
b. Devices with selectable (rather than adjustable) setpoints shall be capable of being set to within 2°F and 2 Btu/lb of the setpoint listed.
c. At altitudes substantially different than sea level, the Fixed Enthalpy limit value shall be set to the enthalpy value at 75°F and 50% relative humidity. As an example, at approximately 6,000 foot elevation, the fixed enthalpy limit is approximately 30.7 Btu/lb.

«» Commentary for Section 170.2(c)4Cii:

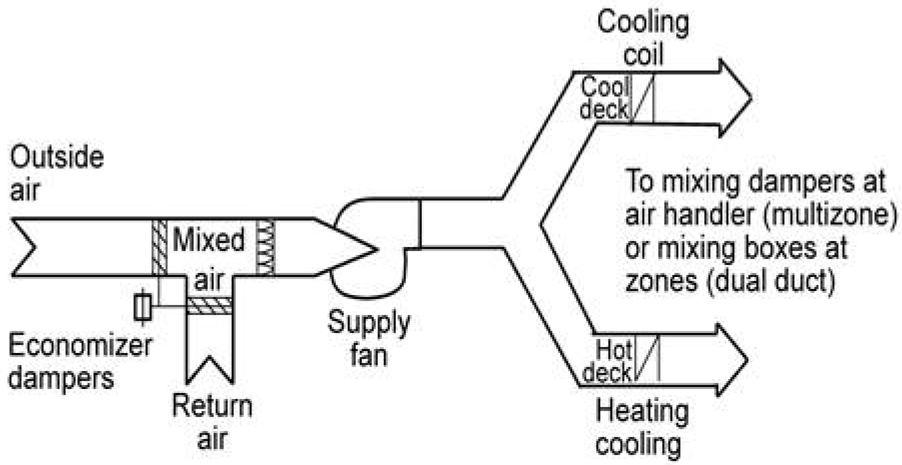
If an economizer is required, it must be:

1. Designed and equipped with controls that do not increase the building heating energy use during normal operation. This prohibits the application of single-fan dual-duct systems and traditional multizone systems using the Prescriptive Approach of compliance (Figure 4-21: Single-Fan Dual-Duct System). With these systems, the operation of the economizer to precool the air entering the cold deck also precools the air entering the hot deck and thereby increases the heating energy. An exception is available when at least 75 percent of the annual heating is provided by site-recovered or site-solar energy.
2. Fully integrated into the cooling system controls so that the economizer can provide partial cooling even when mechanical cooling is required to meet the remainder of the cooling load. On packaged units with stand-alone economizers, a two-stage thermostat is necessary to meet this requirement.

The requirement that economizers be designed for concurrent operation is not met by some popular water economizer systems, such as those that use the chilled water system to convey evaporatively-cooled condenser water for "free" cooling. Such systems can provide all of the cooling load, but when the point is reached where condenser water temperatures cannot be sufficiently cooled by evaporation; the system controls throw the entire load to the mechanical chillers. Because this design cannot allow simultaneous economizer and refrigeration system operation, it does not meet the requirements of this section. An integrated water-side economizer which uses condenser water to precool the Chilled Water Return (CHWR) before it reaches the chillers (typically using a plate-and-frame heat exchanger) can meet this integrated operation requirement.

The Energy Code eliminated the use of fixed enthalpy, differential enthalpy, and electronic enthalpy controls unless approval for use is provided by the Executive Director. Research on the accuracy and stability of enthalpy controls led to their elimination (with the exception of use when combined with a fixed dry-bulb sensor). The enthalpy-based controls can be employed if the project uses the performance approach.

Figure 4-21: Single-Fan Dual-Duct System



Source: California Energy Commission

«»

iii. The air economizer and all air dampers shall have the following features:

a. **Warranty.** 5-year manufacturer warranty of economizer assembly.

b. **Damper reliability testing.** Suppliers of economizers shall certify that the economizer assembly, including but not limited to outdoor air damper, return air damper, drive linkage and actuator, has been tested and is able to open and close against the rated airflow and pressure of the system for 60,000 damper opening and closing cycles.

c. **Damper leakage.** Economizer outdoor air and return air dampers shall have a maximum leakage rate of 10 cfm/sf at 250 Pascals (1.0 in. of water) when tested in accordance with AMCA Standard 500-D. The economizer outside air and return air damper leakage rates shall be certified to the Energy Commission in accordance with Section 110.0.

d. **Adjustable setpoint.** If the high-limit control is fixed dry-bulb or fixed enthalpy + fixed dry-bulb then the control shall have an adjustable setpoint.

e. **Sensor accuracy.** Outdoor air, return air, mixed air and supply air sensors shall be calibrated within the following accuracies.

I. Drybulb and wetbulb temperatures accurate to ±2°F over the range of 40°F to 80°F;

II. Enthalpy accurate to ±3 Btu/lb over the range of 20 Btu/lb to 36 Btu/lb;

III. Relative humidity (RH) accurate to ±5 percent over the range of 20 percent to 80 percent RH.

f. **Sensor calibration data.** Data used for control of the economizer shall be plotted on a sensor performance curve.

g. **Sensor high limit control.** Sensors used for the high limit control shall be located to prevent false readings, including but not limited to being properly shielded from direct sunlight.

h. **Relief air system.** Relief air systems shall be capable of providing 100 percent outside air without over-pressurizing the building.

iv. The space-conditioning system shall include the following:

a. Unit controls shall have mechanical capacity controls interlocked with economizer controls such that the economizer is at 100 percent open position when mechanical cooling is on and does not begin to close until the leaving air temperature is less than 45 degree F.

b. Direct Expansion (DX) units greater than 65,000 Btu/hr that control the capacity of the mechanical cooling directly based on occupied space temperature shall have a minimum of two stages of mechanical cooling capacity.

c. DX units not within the scope of Section 170.2(c)4Ciib shall (i) comply with the requirements in Table 170.2-H, and (ii) have controls that do not false load the mechanical cooling system by limiting or disabling the economizer or by any other means except at the lowest stage of mechanical cooling capacity.

TABLE 170.2-H DIRECT EXPANSION (DX) UNIT REQUIREMENTS FOR COOLING STAGES AND COMPRESSOR DISPLACEMENT

Cooling Capacity	Minimum Number of Mechanical Cooling Stages	Minimum Compressor Displacement
≥ 65,000 Btu/h and < 240,000 Btu/h	3 stages	≤ 35% full load
≥ 240,000 Btu/h	4 stages	≤ 25% full load

v. Systems that include a water economizer to meet Section 170.2(c)4Ci shall include the following:

a. Maximum pressure drop. Precooling coils and water-to-water heat exchangers used as part of a water economizer shall either have a waterside pressure drop of less than 15 feet of water, or a secondary loop shall be installed so that the coil or heat exchanger pressure drop is not contributing to pressure drop when the system is in the normal cooling (non-economizer) mode.

b. Economizer systems shall be integrated with the mechanical cooling system so that they are capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load. Controls shall not false load the mechanical cooling system by limiting or disabling the economizer or by any other means, such as hot gas bypass, except at the lowest stage of mechanical cooling.

«» Commentary for Section 170.2(c)4Cv:

Unlike air-side economizers, water economizers have parasitic energy losses that reduce the cooling energy savings. One of these losses comes from increases in pumping energy. To limit the losses, the Energy Code requires that precooling coils and water-to-water heat exchangers used as part of a water economizer system have either:

1. A water-side pressure drop of less than 15 feet of water, or
2. A secondary loop so that the coil or heat exchanger pressure drop is not seen by the circulating pumps when the system is in the normal cooling (non-economizer) mode.

Water economizer systems must also be integrated with the mechanical cooling system so that they are capable of providing partial cooling, even when additional mechanical cooling is required to meet the remainder of the cooling load. This includes controls that do not false load the mechanical cooling system by limiting or disabling the economizer, or by any other means, such as hot gas bypass, except at the lowest stage of mechanical cooling. **«»**

D. **Supply air temperature reset controls.** Space-conditioning systems supplying heated or cooled air to multiple zones shall include controls that automatically reset supply-air temperatures. Air distribution systems serving zones that are likely to have constant loads shall be designed for the air flows resulting from the fully reset supply air temperature. Supply air temperature reset controls shall be:

i. In response to representative building loads or to outdoor air temperature; and

ii. At least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

Exception 1 to Section 170.2(c)4D: Systems that meet the requirements of Section 170.2(c)3Bi, without using Exception 1 to that section.

Exception 2 to Section 170.2(c)4D: Where supply-air temperature reset would increase overall building energy use.

Exception 3 to Section 170.2(c)4D: Systems supplying zones in which specific humidity levels are required to satisfy process loads. Computer rooms or other spaces with only IT equipment may not use this exception.

«» Commentary for Section 170.2(c)4D:

Mechanical space-conditioning systems supplying heated or cooled air to multiple zones must include controls that automatically reset the supply-air temperature in response to representative building loads or to outdoor air temperature. The controls must be capable of resetting the supply-air temperature by at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

For example, if the design supply temperature is 55 °F and the design room temperature is 75 °F, then the difference is 20 °F, of which 25 percent is 5 °F. Therefore, the controls must be capable of resetting the supply temperature from 55 °F to 60 °F.

Air distribution zones that are likely to have constant loads, such as interior zones, shall have airflow rates designed to meet the load at the fully reset temperature. Otherwise, these zones may prevent the controls from fully resetting the temperature or will unnecessarily limit the hours when the reset can be used.

Supply air reset is required for VAV reheat systems even if they have variable-speed drive (VSD) fan controls. The recommended control sequence is to lead with supply temperature set point reset in cool weather where reheat might dominate the equation and to keep the chillers off as long as possible. Thereafter the system can return to a fixed low set point in warmer weather when the chillers are likely to be on. During reset a demand-based control is employed that uses the warmest supply air temperature to satisfy all of the zones in cooling.

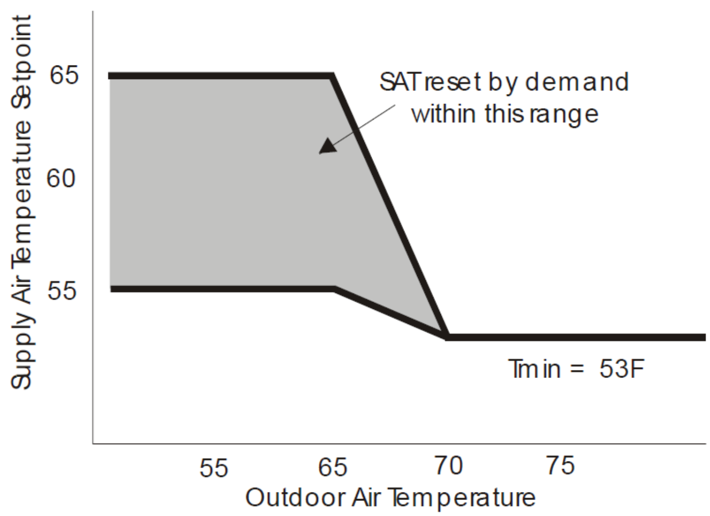
This sequence is described as follows: during occupied mode the set point is reset from T-min (53 °F) (when the outdoor air temperature is 70 °F and above) proportionally up to T-max (when the outdoor air temperature is 65 °F and below). T-max shall range from 55 °F to 65 °F and shall be the output of a slow reverse-acting proportional-integral loop that maintains the cooling loop of the zone served by the system with the highest cooling loop at a set point of 90 percent (See Figure 4-22: Energy Efficient Supply Air Temperature Reset Control for VAV Systems).

Supply temperature reset is also required for constant volume systems with reheat justified on the basis of special zone pressurization relationships or cross-contamination control needs.

Supply-air temperature reset is not required when:

1. The space-conditioning zone has controls that prevent reheating and recooling and simultaneously provide heating and cooling to the same zone.
2. Where it can be demonstrated that supply air reset would increase overall building energy use.
3. The zone(s) must have specific humidity levels required to meet exempt process needs. Computer rooms cannot use this exception.

Figure 4-22: Energy Efficient Supply Air Temperature Reset Control for VAV Systems



Source: California Energy Commission

«»

E. **Electric-resistance heating.** Electric-resistance heating systems shall not be used for space heating.

   Exception 1 to Section 170.2(c)4E: Where an electric-resistance heating system supplements a heating system in which at least 60 percent of the annual energy requirement is supplied by site-solar or recovered energy.

   Exception 2 to Section 170.2(c)4E: Where an electric-resistance heating system supplements a heat pump heating system, and the heating capacity of the heat pump is more than 75 percent of the design heating load calculated in accordance with Section 170.2(c)1 at the design outdoor temperature specified in Section 170.2(c)2.

Exception 3 to Section 170.2(c)4E: Where the total capacity of all electric-resistance heating systems serving the entire building is less than 10 percent of the total design output capacity of all heating equipment serving the entire building.

Exception 4 to Section 170.2(c)4E: Where the total capacity of all electric-resistance heating systems serving the entire building, excluding those allowed under Exception 2, is no more than 3 kW.

Exception 5 to Section 170.2(c)4E: Heating systems serving as emergency backup to gas heating equipment.

«» Commentary for Section 170.2(c)4E:

The Energy Code strongly discourages the use of electric-resistance space heat. **«»**

F. **Heat rejection systems.** Heat rejection equipment used in comfort cooling systems such as air-cooled condensers, open cooling towers, closed-circuit cooling towers and evaporative condensers shall include the following:

   i. **Fan speed control.** Each fan powered by a motor of 7.5 hp (5.6 kW) or larger shall have the capability to operate that fan at 2/3 of full speed or less, and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature or pressure of the heat rejection device.

   Exception 1 to Section 170.2(c)4Fi: Heat rejection devices included as an integral part of the equipment listed in Table 110.2-A through Table 110.2-N.

   Exception 2 to Section 170.2(c)4Fi: Condenser fans serving multiple refrigerant circuits.

   Exception 3 to Section 170.2(c)4Fi: Condenser fans serving flooded condensers.

   Exception 4 to Section 170.2(c)4Fi: Up to one-third of the fans on a condenser or tower with multiple fans where the lead fans comply with the speed control requirement.

   ii. **Tower flow turndown.** Open cooling towers configured with multiple condenser water pumps shall be designed so that all cells can be run in parallel with the larger of:

      a. The flow that is produced by the smallest pump; or

      b. 50 percent of the design flow for the cell.

«» Commentary for Section 170.2(c)4Fii:

The Energy Code requires that open cooling towers with multiple condenser water pumps be designed so that all cells can be run in parallel with the larger of the flow that is produced by the smallest pump or 50 percent of the design flow for the cell.

Cooling towers are very efficient at unloading the fan energy drops off as the cube of the airflow. It is always more efficient to run the water through as many cells as possible- two fans at half speed use less than one third of the energy of one fan at full speed for the same load. Unfortunately, there is a limitation with flow on towers. The flow must be sufficient to provide full coverage of the fill. If the nozzles do not fully wet the fill, air will go through the dry spots providing no cooling benefit and cause the water at the edge of the dry spot to flash evaporate, depositing dissolved solids on the fill.

Fortunately, the cooling tower manufacturers do offer low-flow nozzles (and weirs on basin type towers) to provide better flow turndown. As low-flow nozzles can eliminate the need for a tower isolation control point, this option provides energy savings at a reduced first cost. **«»**

iii. **Limitation on centrifugal fan cooling towers.** Open cooling towers with a combined rated capacity of 900 gpm and greater at 95°F condenser water return, 85°F condenser water supply and 75°F outdoor wet-bulb temperature shall use propeller fans and shall not use centrifugal fans.

Exception 1 to Section 170.2(c)4Fiii: Cooling towers that are ducted (inlet or discharge) or have an external sound trap that requires external static pressure capability.

Exception 2 to Section 170.2(c)4Fiii: Cooling towers that meet the energy efficiency requirement for propeller fan towers in Section 110.2, Table 110.2-F.

«» Commentary for Section 170.2(c)4Fiii:

The 95 °F condenser water return, 85 °F condenser water supply and 75 °F outdoor wet-bulb temperature are test conditions for determining the rated flow capacity in gpm. Centrifugal fans use approximately twice the energy as propeller fans for the same duty. **«»**

iv. **Multiple cell heat rejection equipment.** Multiple cell heat rejection equipment with variable speed fan drives shall:

a. Operate the maximum number of fans allowed that comply with the manufacturer's requirements for all system components, and

b. Control all operating fans to the same speed. Minimum fan speed shall comply with the minimum allowable speed of the fan drive as specified by the manufacturer's recommendation. Staging of fans is allowed once the fans are at their minimum operating speed.

v. **Cooling tower efficiency.** Axial fan, open-circuit cooling towers serving condenser water loops for chilled water plants with a total of 900 gpm or greater shall have a minimum rated efficiency based on Table 170.2-I when rated in accordance with the conditions as listed in Table 110.2-F.

Table 170.2-I MINIMUM EFFICIENCY FOR PROPELLER OR AXIAL FAN OPEN-CIRCUIT COOLING TOWERS (GPM/hp)

CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16

42.1	70	60	70	70	80	80	80	80	80	60	70	80	60	80	42.1

Exception 1 to Section 170.2(c)4Fv: Replacement of existing cooling towers that are inside an existing building or on an existing roof.

«» Commentary for Section 170.2(c)4Fv:

Prescriptively, axial fan open-circuit cooling towers with a combined rated capacity of 900 gpm or greater must achieve a rated efficiency as specified in Table 170.2-I. This efficiency is rated at specific temperature conditions which are 95 °F condenser water return; 85 °F condenser water supply; and 75 °F outdoor wet-bulb temperature as listed in Table 110.2-E. **«»**

G. **Minimum chiller efficiency.** Chillers shall meet or exceed Path B from Table 110.2-D.

Exception 1 to Section 170.2(c)4G: Chillers with electrical service > 600 V.

Exception 2 to Section 170.2(c)4G: Chillers attached to a heat recovery system with a design heat recovery capacity > 40 percent of the design chiller cooling capacity.

Exception 3 to Section 170.2(c)4G: Chillers used to charge thermal energy storage systems where the charging temperature is < 40°F.

Exception 4 to Section 170.2(c)4G: In buildings with more than three chillers, only three chillers are required to meet the Path B efficiencies.

«» Commentary for Section 170.2(c)4G:

In Table 110.2-D, there are two paths of efficiency for almost every size and type of chiller. Path A represents fixed speed compressors and Path B represents variable speed compressors. For each path, there are two efficiency requirements: a full load efficiency and an integrated part-load efficiency. Path A typically has a higher full load efficiency and a lower part-load efficiency than Path B. In all California climates, the cooling load varies enough to justify the added cost for a Path B chiller. This is a prescriptive requirement, so Path B is used in the base case model in the performance method. **«»**

H. **Limitation of air-cooled chillers.** Chilled water plants shall not have more than 300 tons provided by air-cooled chillers.

«» Commentary for Section 170.2(c)4H:

New chilled water plants and cooling plant expansions will be limited on the use of air-cooled chillers. For both types, the limit is 300 tons per plant. **«»**

Exception 1 to Section 170.2(c)4H: Where the water quality at the building site fails to meet manufacturer's specifications for the use of water-cooled chillers.

«» Commentary for Exception 1 to Section 170.2(c)4H:

This exception recognizes that some parts of the state have exceptionally high quantities of dissolved solids that could foul systems or cause excessive chemical treatment or blow down. **«»**

Exception 2 to Section 170.2(c)4H: Chillers that are used to charge a thermal energy storage system with a design temperature of less than 40°F (4°C).

«» Commentary for Exception 2 to Section 170.2(c)4H:

This addresses the fact that air-cooled chillers can operate very efficiently at low ambient air temperatures. Since thermal energy storage systems operate for long hours at night, these systems may be as efficient as a water-cooled plant. The chiller must be provided with head pressure controls to achieve these savings. **«»**

I. **Hydronic system measures**.

i. **Hydronic variable flow systems.** HVAC chilled and hot water pumping shall be designed for variable fluid flow and shall be capable of reducing pump flow rates to no more than the larger of: a) 50 percent or less of the design flow rate; or b) the minimum flow required by the equipment manufacturer for the proper operation of equipment served by the system.

Exception 1 to Section 170.2(c)4I: Systems that include no more than three control valves.

Exception 2 to Section 170.2(c)4I: Systems having a total pump system power less than or equal to 1.5 hp.

«» Commentary for Section 170.2(c)4Ii:

Hot water and chilled-water systems are required to be designed for variable flow. Variable flow is provided by using 2-way control valves. The Energy Code only requires that flow is reduced to whichever value is greater: 50 percent or less of design flow or the minimum flow required by the equipment manufacturer for operation of the central plant equipment.

There are two exceptions for this requirement:

1. Systems that include no more than three control valves.
2. Systems having a total pump system power less than or equal to 1.5 hp.

It is not necessary for each individual pump to meet the variable flow requirement. These requirements can be met by varying the total flow for the entire pumping system in the plant. Strategies that can be used to meet these requirements include but are not limited to variable frequency drives on pumps and staging of the pumps. **«»**

ii. **Chiller isolation.** When a chilled water system includes more than one chiller, provisions shall be made so that flow through any chiller is automatically shut off when that chiller is shut off while still maintaining flow through other operating chiller(s). Chillers that are piped in series for the purpose of increased temperature differential shall be considered as one chiller.

iii**. Boiler isolation.** When a hot water plant includes more than one boiler, provisions shall be made so that flow through any boiler is automatically shut off when that boiler is shut off while still maintaining flow through other operating boiler(s).

iv**. Chilled and hot water temperature reset controls.** Systems with a design capacity exceeding 500,000 Btu/hr supplying chilled or heated water shall include controls that automatically reset supply water temperatures as a function of representative building loads or outside air temperature.

Exception to Section 170.2(c)4Iiv: Hydronic systems that use variable flow to reduce pumping energy in accordance with Section 170.2(c)4Ii.

v. **Water-cooled air conditioner and hydronic heat pump systems.** Water circulation systems serving water-cooled air conditioners, hydronic heat pumps or both, that have total pump system power exceeding 5 hp, shall have flow controls that meet the requirements of Section 170.2(c)4Ivi. Each such air conditioner or heat pump shall have a two-position automatic valve interlocked to shut off water flow when the compressor is off.

vi. **Variable flow controls.**

a. Variable speed drives. Individual pumps serving variable flow systems and having a motor horsepower exceeding 5 hp shall have controls or devices (such as variable speed control) that will result in pump motor demand of no more than 30 percent of design wattage at 50 percent of design water flow. The pumps shall be controlled as a function of required differential pressure.

b. Pressure sensor location and setpoint.

c. For systems without direct digital control of individual coils reporting to the central control panel, differential pressure shall be measured at the most remote heat exchanger or the heat exchanger requiring the greatest differential pressure.

d. For systems with direct digital control of individual coils with a central control panel, the static pressure setpoint shall be reset based on the valve requiring the most pressure, and the setpoint shall be no less than 80 percent open. Pressure sensors may be mounted anywhere.

Exception 1 to Section 170.2(c)4Ivi: Heating hot water systems.

Exception 2 to Section 170.2(c)4Ivi: Condenser water systems serving only water-cooled chillers.

vii. **Hydronic heat pump (WLHP) controls.** Hydronic heat pumps connected to a common heat pump water loop with central devices for heat rejection and heat addition shall have controls that are capable of providing a heat pump water supply temperature deadband of at least 20°F between initiation of heat rejection and heat addition by the central devices.

Exception to Section 170.2(c)4Ivii: Where a system loop temperature optimization controller is used to determine the most efficient operating temperature based on real-time conditions of demand and capacity, deadbands of less than 20°F shall be allowed.

J. Reserved.

K. **Fan control.** Each cooling system listed in Table 170.2-H shall be designed to vary the indoor fan airflow as a function of load and shall comply with the following requirements:

i. DX and chilled water cooling systems that control the capacity of the mechanical cooling directly based on occupied space temperature shall (i) have a minimum of two stages of fan control with no more than 66 percent speed when operating on stage 1; and (ii) draw no more than 40 percent of the fan power at full fan speed, when operating at 66 percent speed.

ii. All other systems, including but not limited to DX cooling systems and chilled water systems that control the space temperature by modulating the airflow to the space, shall have proportional fan control such that at 50 percent air flow the power draw is no more than 30 percent of the fan power at full fan speed.

iii. Systems that include an air side economizer to meet Section 170.2(c)4Ci shall have a minimum of two speeds of fan control during economizer operation.

Exception to Section 170.2(c)4K: Modulating fan control is not required for chilled water systems with all fan motors <1 HP, or for evaporative systems with all fan motors < 1 HP, if the systems are not used to provide ventilation air and all indoor fans cycle with the load.

L. **Mechanical system shut-off.** Any directly conditioned common use area space with operable wall or roof openings to the outdoors shall be provided with interlock controls that disable or reset the temperature setpoint to 55°F for mechanical heating and disable or reset the temperature setpoint to 90°F for mechanical cooling to that space when any such opening is open for more than 5 minutes.

Exception 1 to Section 170.2(c)4L: Interlocks are not required on doors with automatic closing devices.

Exception 2 to Section 170.2(c)4L: Any space without a thermostatic control (thermostat or a space temperature sensor used to control heating or cooling to the space).

«» Commentary for Section 170.2(c)4L:

If a directly conditioned zone has a thermostat and one or more manually operable wall or roof openings to the outdoors, then the openings must all have sensors that communicate to the HVAC system. The HVAC controller must be capable of shutting off the heating or cooling to that zone if the sensor detects that the opening has remained open for more than five minutes. This can be accomplished by resetting the heating set point to 55 °F or the heating can be disabled altogether. If the HVAC system is in cooling mode, then similarly this requirement can be satisfied by resetting the cooling set point to 90 °F, unless the outside air temperature is less than the space temperature, in which case the cooling set point can be reset, or not. If the zone is in cooling and the outside air temperature is less than the space temperature, then additional infiltration from the opening provides economizer-free cooling and is not an additional cooling load on the mechanical system.

This requirement does not require any openings to the outdoors to be operable. However, if operable openings are present, then they must comply with this requirement.

Mechanical ventilation as required by Section 160.2(c)3 must still be provided. The mechanical system shut off pertains to the space conditioning equipment only. Mechanical ventilation must still be provided if the space does not fall under the natural ventilation criteria. Systems that meet the ventilation requirements with natural ventilation, rather than mechanical ventilation, are not exempt from the window/door switch requirement. Thus, in the same way that most homeowners typically choose between opening the windows and running the heating/cooling, window/door switches will now cause occupants to choose between opening windows/doors and allowing full heating/cooling.

Manually operable openings to the outdoors include manually operable windows, skylights, and doors that do not have automatic closing devices (e.g., sliding balcony doors). Motorized openings (e.g., motorized skylights) are still considered manually operable if occupants can move the openings as desired and they will stay open until manually closed.

If a zone serves more than one room, then only the openings in the room with the thermostat are required to be interlocked. For example, if three perimeter private offices are served by a single VAV box then only the operable openings in the office with the thermostat need to be interlocked. The windows in the offices that do not have a thermostat do not need to be interlocked.

If there is a large room with more than one zone, then only the zones with operable windows in them need to be interlocked. For example, if a large open office has a perimeter zone and an interior zone in the same room and there are operable windows in the perimeter zone but not the interior zone then only the perimeter zone thermostat needs to be interlocked to the windows.

Alterations to existing buildings are exempt from this requirement. Additions to existing buildings only have to comply if the operable opening(s) and associated zone are new. **«»**

M**. Exhaust system transfer air.** Conditioned supply air delivered to any space with mechanical exhaust shall not exceed the greater of:

i. The supply flow required to meet the space heating or cooling load; or

ii. The ventilation rate required by the authority having jurisdiction, the facility Environmental Health and Safety Department or Section 160.2(c)3; or

iii. The mechanical exhaust flow minus the available transfer air. Available transfer air shall be from another conditioned space or return air plenums on the same floor and same smoke or fire compartment, and that at their closest point are within 15 feet of each other.

Exception 1 to Section 170.2(c)4M: Spaces that are required by applicable codes and standards to be maintained at a positive pressure differential relative to adjacent spaces.

Exception 2 to Section 170.2(c)4M: Spaces where the highest amount of transfer air that could be used for exhaust makeup may exceed the available transfer airflow rate and where the spaces have a required negative pressure relationship.

«» Commentary for Section 170.2(c)4M:

The standard prescriptively requires the use of transfer air for exhaust air makeup in most cases. The purpose is to avoid supply air that requires increased outdoor air intake, which would require conditioning, for exhaust makeup when return or relief air from neighboring spaces can be used instead. The requirement limits the supply of conditioned air to not exceed the larger of the supply flow required for space heating or space cooling, the required ventilation rate, or the exhaust flow, minus the available transfer air from conditioned spaces or plenums on the same floor and within 15 ft and not in different smoke or fire compartments. Available transfer air does not include air required to maintain pressurization and air that cannot be transferred based on-air class as defined in Section 160.2(c)8. **«»**

N. **Dedicated outdoor air systems (DOAS).** HVAC systems that utilize a dedicated outdoor air system (DOAS) such as a DX-DOAS, HRV or ERV unit to condition, temper or filter 100 percent outdoor air separate from local or central space-conditioning systems serving the same space shall meet the following criteria:

1. DOAS unit fan systems with input power less than 1 kW shall not exceed a total combined fan power of 1.0 W/cfm. DOAS with fan power greater than or equal to 1 kW shall meet the requirements of Section 140.4(c).

2. The DOAS supply air shall be delivered directly to the occupied space or at the outlet of any terminal heating or cooling coils and shall cycle off any zone heating and cooling equipment fans, circulation pumps and terminal unit fans when there is no call for heating or cooling in the zone.

   Exception 1 to Section 170.2(c)4N2: Active chilled beam systems.

   Exception 2 to Section 170.2(c)4N2: Sensible-only cooling terminal units with pressure-independent variable-airflow regulating devices limiting the DOAS supply air to the greater of latent load or minimum ventilation requirements.

   Exception 3 to Section 170.2(c)4N2: Any configuration where a DOAS unit provides ventilation air to a downstream fan (a terminal box, air handling unit or other space-conditioning equipment) where the total system airflow can be reduced to ventilation minimum or the downstream fan power is no greater than 0.12 watts per cfm when space temperatures are within the thermostat deadband (at low speed per manufacturer's literature).

3. DOAS supply and exhaust fans shall have a minimum of three speeds to facilitate system balancing.
4. DOAS with mechanical cooling providing ventilation to multiple zones and operating in conjunction with zone heating and cooling systems shall not use heating or heat recovery to warm supply air above 60°F when representative building loads or outdoor air temperature indicates that the majority of zones require cooling.

«» Commentary for Section 170.2(c)4N:

Under certain climate zones and air handler design scenarios, DOAS units may also require Exhaust Air Heat Recovery (EAHR) requirements under Section 170.2(c)4O. **«»**

O. **Exhaust air heat recovery.** Fan systems designed to operate to the criteria listed in either Table 170.2-I or Table 170.2-J shall include an exhaust air heat recovery system that meets the following:

i. A sensible energy recovery ratio of at least 60 percent or an enthalpy recovery ratio of at least 50 percent for both heating and cooling design conditions.

ii. Energy recovery bypass or control to disable energy recovery and to directly economize with ventilation air based on outdoor air temperature limits specified in Table 170.2-G. For energy recovery systems where the transfer of energy cannot be stopped, bypass shall prevent the total airflow rate of either outdoor air or exhaust air through the energy recovery exchanger from exceeding 10 percent of the full design airflow rate.

iii. For a DOAS unit and a separate independent space-conditioning system meeting the requirements of Section 170.2(c)4Nia, the design supply fan airflow rate shall be the total airflow of only the DOAS unit.

EXCEPTION 1 to Section 170.2(c)4Oii: DOAS units with the capability to shut off when a separate independent space-conditioning system meets the economizer requirements specified by section 170.2(c)4Cia is economizing.

Exception 1 to Section 170.2(c)4O: Systems meeting Section 140.9(c) prescriptive requirements for laboratory and factory exhaust systems.

Exception 2 to Section 170.2(c)4O: Systems serving spaces that are not cooled and that are heated to less than 60°F.

Exception 3 to Section 170.2(c)4O: Where more than 60 percent of the outdoor air heating energy is provided from site-recovered energy in Climate Zone 16.

Exception 4 to Section 170.2(c)4O: Sensible recovery ratio requirements at heating design conditions are not required for Climate Zone 15.

Exception 5 to Section 170.2(c)4O: Sensible recovery ratio requirements at cooling design conditions are not required for Climate Zone 1.

Exception 6 to Section 170.2(c)4O: Where the sum of the airflow rates exhausted and relieved within 20 feet of each other is less than 75 percent of the design outdoor airflow rate, excluding exhaust air that is either:

i. used for another energy recovery system;

ii. not allowed by the California Mechanical Code (Title 24, Part 4) for use in energy recovery systems with leakage potential; or

iii. of Class 4 as specified in Section 160.2(c)8.

Exception 7 to Section 170.2(c)4O: Systems expected to operate less than 20 hours per week.

«» Commentary for Section 170.2(c)4O:

HVAC systems (including DOAS) must comply with Exhaust Air Heat Recovery (EAHR) requirements if their air handling systems meet design specifications that trigger compliance. For most HVAC systems these requirements are triggered if the full design airflow meets the criteria in Table 170.2-J for air handlers designed to operate continuously or Table 170.2-I for all other air handlers.

These requirements are also triggered if a decoupled DOAS system is utilizing EAHR instead of meeting economizer requirements per Section 170.2(c)Nia.

Balanced ventilation must be used with HRV/ERV in climate zones 1, 2, 4, 11 – 14, and 16 under prescriptive requirements. FIDs are prescriptively required for HRV/ERV systems, or projects could choose to install an HERV/ERV without an FID and incur a penalty in the modeling software that assumes 10 percent lower ventilation fan efficacy and 10 percent lower SRE for an HRV/ERV. Thus, the three options for multifamily projects in climate zones 1, 2, 4, 11 – 14 and 16 are following the prescriptive path which calls for an HRV/ERV system with an FID, install an HRV/ERV system without an FID and incur an energy efficiency penalty, or do not install an HRV/ERV system but meet performance efficiency requirement under another measure. **«»**

TABLE 170.2-I: ENERGY RECOVERY REQUIREMENTS BY CLIMATE ZONE AND PERCENT OUTDOOR AIR AT FULL DESIGN AIRFLOW (<8,000 HOURS / YEAR)

% Outdoor Air at Full Design Airflow	**CZ 1**	**CZ 2**	**CZ 3**	**CZ 4**	**CZ 5**	**CZ 6**	**CZ 7**	**CZ 8**	**CZ 9**	**CZ 10**	**CZ 11**	**CZ 12**	**CZ 13**	**CZ 14**	**CZ 15**	**CZ 16**
≥10% and <20%	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
≥20% and <30%	≥15,000	≥20,000	NR	NR	NR	NR	NR	NR	NR	NR	≥18,500	≥18,500	≥18,500	≥18,500	≥18,500	≥18,500
≥30% and <40%	≥13,000	≥15,000	NR	NR	NR	NR	NR	NR	NR	NR	≥15,000	≥15,000	≥15,000	≥15,000	≥15,000	≥15,000
≥40% and <50%	≥10,000	≥12,000	NR	NR	NR	NR	NR	NR	NR	≥22,000	≥10,000	≥10,000	≥10,000	≥10,000	≥10,000	≥10,000
≥50% and <60%	≥9,000	≥10,000	NR	≥18,500	NR	NR	NR	NR	NR	≥17,000	≥8,000	≥8,000	≥8,000	≥8,000	≥8,000	≥8,000
≥60% and <70%	≥7,000	≥7,500	NR	≥16,500	NR	NR	NR	NR	≥20,000	≥15,000	≥7,000	≥7,000	≥7,000	≥7,000	≥7,000	≥7,000
≥70% and <80%	≥6,500	≥7,000	NR	≥15,000	NR	NR	NR	NR	≥17,000	≥14,000	≥5,000	≥5,000	≥5,000	≥5,000	≥5,000	≥5,000
≥80%	≥4,500	≥6,500	NR	≥14,000	NR	NR	NR	NR	≥15,000	≥13,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000

FOOTNOTES TO TABLE 170.2-I:

1. Flow rates in Table 140.4-G represent the design supply fan airflow rate in CFM.
2. For a DOAS unit providing outdoor air to another space-conditioning system, the full design supply fan airflow rate shall be the total airflow of only the DOAS unit.

TABLE 170.2-J: ENERGY RECOVERY REQUIREMENTS BY CLIMATE ZONE AND PERCENT OUTDOOR AIR AT FULL DESIGN AIRFLOW (≥8,000 HOURS / YEAR)

% Outdoor Air at Full Design Airflow	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
≥10% and <20%	≥10,000	≥10,000	NR	NR	NR	NR	NR	NR	NR	≥40,000	≥40,000	≥20,000	≥10,000	≥10,000	≥10,000	≥10,000
≥20% and <30%	≥2,000	≥5,000	≥13,000	≥9,000	≥9,000	NR	NR	NR	NR	≥15,000	≥15,000	≥5,000	≥5,000	≥5,000	≥5,000	≥5,000
≥30% and <40%	≥2,000	≥3,000	≥10,000	≥6,500	≥6,500	NR	NR	NR	≥15,000	≥7,500	≥7,500	≥3,000	≥3,000	≥3,000	≥3,000	≥3,000
≥40% and <50%	≥2,000	≥2,000	≥8,000	≥6,000	≥6,000	NR	NR	NR	≥12,000	≥6,000	≥6,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000
≥50% and <60%	≥2,000	≥2,000	≥7,000	≥6,000	≥6,000	NR	NR	≥20,000	≥10,000	≥5,000	≥5,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000
≥60% and <70%	≥2,000	≥2,000	≥6,000	≥6,000	≥6,000	NR	NR	≥18,000	≥9,000	≥4,000	≥4,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000
≥70% and <80%	≥2,000	≥2,000	≥6,000	≥5,000	≥5,000	NR	NR	≥15,000	≥8,000	≥3,000	≥3,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000

≥80%	≥2,000	≥2,000	≥6,000	≥5,000	≥5,000	NR	NR	≥12,000	≥7,000	≥3,000	≥3,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000

Footnotes to TABLE 170.2-J:

1. Flow rates in Table 140.4-G represent the design supply fan airflow rate in CFM.
2. For a DOAS unit providing outdoor air to another space-conditioning system, the full design supply fan airflow rate shall be the total airflow of only the DOAS unit.

TABLE 170.2-K MECHANICAL COMPONENT PACKAGE – Multifamily Standard Building Design

Component	CZ 1	CZ 2	CZ 3	CZ 4	CZ 5	CZ 6	CZ 7	CZ 8	CZ 9	CZ 10	CZ 11	CZ 12	CZ 13	CZ 14	CZ 15	CZ 16
Unitary[4] – Balanced Ventilation System[1] HRV/ERV Sensible Recovery Efficiency	0.67	0.67	NR	0.67	NR	NR	NR	NR	NR	NR	0.67	0.67	0.67	0.67	NR	0.67
Unitary[4] – Balanced Ventilation System[1] HRV/ERV Fan Efficacy (W/cfm)	0.6	0.6	1.0	0.6	1.0	1.0	1.0	1.0	1.0	1.0	0.6	0.6	0.6	0.6	1.0	0.6
Unitary[4] – Balanced Ventilation System[1] Non-HRV/ERV Fan Efficacy (W/cfm)	NR	NR	NR	NR	0.4	0.4	0.4	0.4	0.4	0.4	NR	NR	NR	NR	0.4	NR
Unitary[4] – Heat Pump[3], HSPF2[2]	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
Unitary[4] – Dual-Fuel Heat Pump[3], AFUE	MIN	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	MIN
Unitary[4] – Refrigerant Charge Verification or Fault Indicator Display	NR	REQ	NR	NR	NR	NR	NR	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	NR
Unitary[4] – SEER2	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
Central[5] - Balanced Ventilation Systems[1] Sensible Recovery Efficiency or Effectiveness	0.67	0.67	NR	0.67	NR	NR	NR	NR	NR	NR	0.67	0.67	0.67	0.67	NR	0.67
Central[5] - Balanced Ventilation Systems[1] Bypass Function	REQ	REQ	NR	REQ	NR	NR	NR	NR	NR	NR	REQ	REQ	REQ	REQ	NR	REQ
Central[5] – Central Fan Integrated Ventilation System Fan Efficacy	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ

Duct Insulation in Unconditioned Space	R 8	R 8	R 6	R 8	R 6	R 6	R 6	R 8	R 8	R 8	R 8	R 8	R 8	R 8	R 8	R 8
Water Heating - All Buildings System Shall meet Section 170.2(d)	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ	REQ

Footnotes to TABLE 170.2-K:

1. Requirements only apply when using Balanced Ventilation to meet 160.2(b)2Aivb.
2. HSPF2 means "heating seasonal performance factor."
3. A supplemental heating unit may be installed in a space served directly or indirectly by a primary heating system, provided that the unit thermal capacity does not exceed 2 kilowatts or 7,000 Btu/hr and is controlled by a time-limiting device not exceeding 30 minutes.
4. Unitary system serving one dwelling unit
5. Central system serving multiple dwelling units

«» Commentary for Table 170.2-K:

Table 170.2-K provides efficiency requirements for various mechanical components. Equipment used in multifamily standard building design not listed here must meet mandatory minimum requirements or federal minimum requirements. This includes room air conditioners which must meet minimum CEER requirements. «»

SECTION 180.1 – ADDITIONS

Additions to existing multifamily buildings shall meet the applicable requirements of Sections 110.0 through 110.9; Sections 160.0, 160.1, and 160.2(c) and (d); Sections 160.3 through 160.7; and either Section 180.1(a) or 180.1(b).

Exception 4 to Section 180.1: Space-conditioning system. When heating or cooling will be extended to an addition from the existing system(s), the existing heating and cooling equipment need not comply with Part 6. The heating system capacity must be adequate to meet the minimum requirements of CBC Section 1204.1.

Exception 5 to Section 180.1: Space-conditioning system ducts. When any length of duct is extended from an existing duct system to serve the addition, the existing duct system and the extended duct shall meet the applicable requirements specified in Sections 180.2(b)2Ai and 180.2(b)2Aii.

Exception 7 to Section 180.1: Dwelling unit space heating system. New or replacement space heating systems serving an addition may be a heat pump or gas heating system.

«» Commentary for Section 180.1:

New or altered mechanical systems serving alterations or additions for dwelling units or common use areas must meet all applicable mandatory requirements and comply with either the prescriptive or performance approach. If a building does not meet all applicable prescriptive requirements, then the performance method using an approved compliance software is the alternative.

All HVAC systems serving additions generally are required to meet the newly constructed building prescriptive requirements, with few exceptions. Table 4-6: HVAC Requirements for Prescriptive Additions summarizes the requirements.

Table 4-6: HVAC Requirements for Prescriptive Additions

Component	Additions
New or replaced space conditioning system(s)	All prescriptive requirements per Section 170.2 except the system may be a heat pump or gas heating system
Use existing space conditioning system(s)	No requirements for the heating/cooling equipment except that heating system must have adequate capacity
New duct system(s)	All prescriptive requirements per Section 170.2
Extend existing duct system(s)	Duct sealing and duct insulation per Section 180.2(b)2Aii

Source: California Energy Commission

If the heating and cooling system is unchanged as part of an addition or alteration, compliance for the HVAC system is not necessary. However, changing, altering, or replacing any component of a system triggers prescriptive requirements for that component. If the extended ducts are serving dwelling units, the combined new and existing duct system must meet the requirement to seal the ducts and verify that duct leakage is no greater than 15% of system airflow. If 15% leakage or lower cannot be attained, there are alternatives, including sealing all accessible leaks and confirming by a visual inspection.

When the HVAC system is entirely new or a complete replacement, then additional mandatory and prescriptive requirements apply.

The Energy Code makes a distinction between two HVAC changeout situations:

1. Entirely new or complete replacement space conditioning systems.
2. Altered space conditioning systems.

«»

(a) Prescriptive approach. The envelope and lighting of the addition; any newly installed space-conditioning or ventilation system, electrical power distribution system, or water-heating system; any addition to an outdoor lighting system; and any new sign installed in conjunction with an indoor or outdoor addition shall meet the applicable requirements of Sections 110.0 through 110.12**;** 160.0, 160.1, and 160.2(c) and (d); and 160.3 through 170.2.

2. **Mechanical ventilation for indoor air quality.** Additions to existing buildings shall comply with Section 160.2 subject to the requirements specified in Subsections A and B below. When field verification and diagnostic testing are required by Section 180.1(a)2, buildings with three habitable stories or less shall use the applicable procedures in the Residential Appendices, and buildings with four or more habitable stories shall use the applicable procedures in Nonresidential Appendices NA1 and NA2.

   Exception to Section 180.1(a)2: A dwelling unit air leakage test is not required for additions.

   A. **Whole-dwelling unit mechanical ventilation**.

      i. Dwelling units that meet the conditions in Subsection a or b below shall not be required to comply with the whole-dwelling unit ventilation airflow specified in Section 160.2(b)2Aiv or 160.2(b)2Av.

         a. Additions to an existing dwelling unit that increase the conditioned floor area of the existing dwelling unit by less than or equal to 1000 square feet.

b. Junior Accessory Dwelling Units (JADU) that are additions to an existing building.

ii. Additions to an existing dwelling unit that increase conditioned floor area by more than 1,000 square feet shall have mechanical ventilation airflow in accordance with Section 160.2(b)2Aiv or 160.2(b)2Av, as applicable. The mechanical ventilation airflow rate shall be based on the conditioned floor area of the entire dwelling unit comprising the existing dwelling unit conditioned floor area plus the addition conditioned floor area.

Exception to Section 180.1(a)2Aii: Mechanical ventilation systems in additions shall be supply, balanced or the existing ventilation type.

iii. New dwelling units that are additions to an existing building shall have mechanical ventilation airflow provided in accordance with Section 160.2(b)2Aiv or 160.2(b)2Av as applicable. The mechanical ventilation airflow rate shall be based on the conditioned floor area of the new dwelling unit.

«» Commentary for Section 180.1(a)2A:

Additions

The whole-dwelling unit ventilation requirements in Section 160.2(b)2Aiv or Section 160.2(b)2Av apply to additions greater than 1,000 square feet and additions that add a new dwelling unit.

1. An addition to an existing dwelling unit that increases the conditioned floor area by more than 1,000 square feet must have the required whole-dwelling unit ventilation airflow calculated by using the entire dwelling unit conditioned floor area. This is the existing conditioned floor area plus the added conditioned floor area. For additions, mechanical ventilation systems may be supply, balanced or the existing ventilation type. This allows additions to use exhaust ventilation systems if it is used in the existing dwelling unit. Newly constructed dwelling units require the mechanical ventilation system to only be either supply system or balanced system under 160.2(b)2Aiv.
2. An addition that adds a new dwelling unit to an existing building must have the required whole-dwelling unit ventilation airflow calculated by using the conditioned floor area of the new dwelling unit.

Additions less than 1,000 square feet of conditioned floor area and additions that add a junior accessory dwelling unit (JADUs) do not need to meet the whole-dwelling unit ventilation requirements. «»

B. **Local mechanical exhaust**. Additions to existing buildings shall comply with all applicable requirements specified in Sections 160.2(b)2Avi and 160.2(b)2B.

(b) Performance approach. Performance calculations shall meet the requirements of Sections 170.0 through 170.2(a), pursuant to the applicable requirements in Items 1, 2 and 3 below.

1. **For additions alone.** The addition complies if the addition alone meets the energy budgets expressed in terms of Long-Term System Cost (LSC) energy.

2. **Existing plus alteration plus addition.** The standard design for existing plus alteration plus addition energy use is the combination of the existing building's unaltered components to remain; existing building altered components that are the more efficient, in LSC energy, of either the existing conditions or the requirements of Section 180.2(c); plus the proposed addition's energy use meeting the requirements of Section 180.1(a). The proposed design energy use is the combination of the existing building's unaltered components to remain and the altered components' energy features, plus the proposed energy features of the addition.

   Exception to Section 180.1(b)2: Existing structures with a minimum R-11 insulation in framed walls showing compliance with Section 180.1(b) are not required to show compliance with Section 160.1(b).

«» Commentary for Section 180.1(b)2:

Additions

New or altered mechanical systems serving additions for dwelling units or common use areas must meet all applicable mandatory requirements and comply with either the prescriptive or performance approach. If a building does not meet all applicable prescriptive requirements, then the performance method using an approved compliance software is the alternative.

All HVAC systems serving additions generally are required to meet the newly constructed building prescriptive requirements, with few exceptions. Table 4-7 summarizes the requirements.

Table 4-7: HVAC Requirements for Prescriptive Additions

Component	Additions
New or replaced space conditioning system(s)	All prescriptive requirements per Section 170.2 except the system may be a heat pump or gas heating system
Use existing space conditioning system(s)	No requirements for the heating/cooling equipment except that heating system must have adequate capacity

New duct system(s)	All prescriptive requirements per Section 170.2
Extend existing duct system(s)	Duct sealing and duct insulation per Section 180.2(b)2Aii

Source: California Energy Commission

If the heating and cooling system is unchanged as part of an addition, compliance for the HVAC system is not necessary. However, changing, altering, or replacing any component of a system triggers prescriptive requirements for that component. If the extended ducts are serving dwelling units, the combined new and existing duct system must meet the requirement to seal the ducts and verify that duct leakage is no greater than 15% of system airflow. If 15% leakage or lower cannot be attained, there are alternatives, including sealing all accessible leaks and confirming by a visual inspection.
«»

3. **Mechanical ventilation for indoor air quality**. Additions to existing buildings shall comply with Section 160.2 subject to the requirements specified in Subsections A and B below. When field verification and diagnostic testing are required by Section 180.1(b)3, buildings with three habitable stories or less shall use the applicable procedures in the Residential Appendices, and buildings with four or more habitable stories shall use the applicable procedures in Nonresidential Appendices NA1 and NA2.

   A. **Whole-dwelling unit mechanical ventilation**.

      i. Dwelling units that meet the conditions in Subsection a or b below shall not be required to comply with the whole-dwelling unit ventilation airflow specified in Section 160.2(b)2Aiv or 160.2(b)2Av.

         a. Additions to an existing dwelling unit that increase the conditioned floor area of the existing dwelling unit by less than or equal to 1,000 square feet.

         b. Junior Accessory Dwelling Units (JADU) that are additions to an existing building.

      ii. Additions to an existing dwelling unit that increase the conditioned floor area of the existing dwelling unit by more than 1,000 square feet shall have mechanical ventilation airflow in accordance with Section 160.2(b)2Aiv or 160.2(b)2Av as applicable. The mechanical ventilation airflow rate shall be based on the conditioned floor area of the entire dwelling unit comprised of the existing dwelling unit conditioned floor area plus the addition conditioned floor area.

      iii. New dwelling units that are additions to an existing building shall have mechanical ventilation airflow provided in accordance with Section

160.2(b)2Aiv or 160.2(b)2Av as applicable. The mechanical ventilation airflow rate shall be based on the conditioned floor area of the new dwelling unit.

B. **Local Mechanical Exhaust**. Additions to existing buildings shall comply with all applicable requirements specified in 160.2(b)2Avi and 160.2(b)2B.

«» Commentary for Section 180.1(b)3B:

Additions

The whole-dwelling unit ventilation requirements in Section 160.2(b)2Aiv or Section 160.2(b)2Av apply to additions greater than 1,000 square feet and additions that add a new dwelling unit.

1. An addition to an existing dwelling unit that increases the conditioned floor area by more than 1,000 square feet must have the required whole-dwelling unit ventilation airflow calculated by using the entire dwelling unit conditioned floor area. This is the existing conditioned floor area plus the added conditioned floor area.
2. An addition that adds a new dwelling unit to an existing building must have the required whole-dwelling unit ventilation airflow calculated by using the conditioned floor area of the new dwelling unit.

Additions less than 1,000 square feet of conditioned floor area and additions that add a junior accessory dwelling unit (JADUs) do not need to meet the whole-dwelling unit ventilation requirements. «»

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

SECTION 180.2 – ALTERATIONS

Alterations to components of existing multifamily buildings, including alterations made in conjunction with a change in building occupancy to a multifamily occupancy, shall meet Item (a), and either Item (b) or (c) below:

Exception 1 to Section 180.2: When heating, cooling or service water heating for an alteration is provided by expanding existing systems, the existing systems and equipment need not comply with Sections 110.0 through 110.10; Sections 160.0 through 160.7; and Section 170.2(c) or 170.2(d).

Exception 2 to Section 180.2: When existing heating, cooling or service water-heating systems or components are moved within a building, the existing systems or components need not comply with Sections 110.0 through 110.10; Sections 160.0 through 160.7; and Section 170.2(c) or 170.2(d).

Exception 3 to Section 180.2: Where an existing system with electric reheat is expanded when adding variable air volume (VAV) boxes to serve an alteration, total electric reheat capacity may be expanded not to exceed 20 percent of the existing installed electric capacity in any one permit and the system need not comply with Section 170.2(b)4E. Additional electric reheat capacity in excess of 20 percent may be added subject to the requirements of Section 170.2(b)4E.

Exception 4 to Section 180.2: The requirements of Section 160.3(a)2H shall not apply to alterations of space-conditioning systems or components.

(b) Prescriptive approach. The altered component and any newly installed equipment serving the alteration shall meet the applicable requirements of Sections 110.0 through 110.9 and all applicable requirements of Sections 160.0, 160.1, 160.2(c) and (d), 160.3(a) through 160.3(b)5J, 160.3(b)6, 160.3(c) and 160.5; and

2. **Space-conditioning systems**.

   A. Space-conditioning systems serving dwelling units.

      i. **Entirely new or complete replacement space-conditioning systems** installed as part of an alteration shall include all the system heating or cooling equipment, including but not limited to: condensing unit, cooling or heating coil, and air handler for split systems; or complete replacement of a packaged unit; plus entirely new or replacement duct system [Section 180.2(b)2Aiib]. Entirely new or complete replacement space-conditioning systems shall meet the requirements of Sections 160.2(a)1, 160.3(a)1, 160.3(b)1 through 3, 160.3(b)5, 160.3(b)6, 160.3(c)1, 170.2(c)3B, 180.2(b)2Av, and Table 180.2-C.

«» Commentary for Section 180.2(b)2Ai:

An entirely new or complete replacement must meet all applicable mandatory and prescriptive requirements as described below.

1. Section 160.2(b)1: Air filtration requirements.
2. Section 160.3(a)1: Setback thermostats or controlled by EMCS.
3. Section 160.3(b)1-2: Cooling and heating load calculations.
4. Section 160.3(b)3: Outdoor condensing unit requirements.
5. Section 160.3(b)4: Heating furnace temperature rise requirements.
6. Section 160.3(b)5A-J: Duct insulation, labeling, & damper requirements.
7. Section 160.3(b)5L: Static pressure probe, airflow, and fan efficacy requirements (or alternative return duct sizing as per Table 160.3-A and B). Multifamily buildings in Climate Zone 1 with four or more habitable stories are exempt from this requirement.
8. Section 160.3(b)6: Pipe insulation.
9. Section 170.2(c)3A: Prescriptive heating system type: the new or complete replacement space-conditioning system may be a heat pump or gas heating system.
10. Section 170.2(c)3Bi: Prescriptive refrigerant charge verification.
11. Section 170.2(c)3Biii: Prescriptive central fan integrated ventilation system airflow and fan efficacy.
12. Table 180.2-C: Prescriptive duct insulation.

A system installed in an existing dwelling unit as part of an alteration must be considered entirely new when both of the following conditions are met:

1. The air handler and all the system heating/cooling equipment (e.g., outdoor condensing unit and indoor cooling or heating coil for split systems; or complete replacement of a package unit), are new.
2. The duct system is entirely new (including systems with less than 40 ft. in length).

An entirely new duct system may be part of an entirely new space conditioning system, or it may be connected to an existing space conditioning system. Duct systems are classified as entirely new when:

1. At least 75% of the duct material is new. Up to 25% may be composed of reused parts from the existing duct system.
2. All remaining components from the previous system are accessible and can be sealed.

In addition, entirely new duct systems must meet the following mandatory requirements:

1. Section 160.2(b)1: Air filtration requirements.
2. Section 160.3(b)5L: Static pressure probe, airflow, and fan efficacy requirements (or alternative return duct sizing as per Table 160.3-A and B). Multifamily buildings in Climate Zone 1 with four or more habitable stories are exempt from this requirement.

When an entirely new duct system and the furnace or air handler it is connected to are in a vented attic the following prescriptive requirements also must be met.

1. Section 180.2(b)1Bi: Attic insulation and air sealing requirements.

Altered duct systems that are not entirely new or complete replacements are treated as an extension of an existing system. «»

ii. **Altered duct systems—duct sealing**: In all climate zones, when more than 25 feet of new or replacement space-conditioning system ducts are installed, the ducts shall comply with the applicable requirements of Subsections a and b below. New ducts located in unconditioned space shall meet the applicable requirements of Sections 160.3(b)5A through J and the duct insulation requirements of Table 180.2-C, and

   a. The altered duct system, regardless of location, shall be sealed as confirmed through field verification and diagnostic testing in accordance with all applicable procedures for duct sealing of altered existing duct systems as specified in Reference Residential Appendix RA3.1, utilizing the leakage compliance criteria specified in Subsection I or II below.

TABLE 180.2-C DUCT INSULATION R-VALUE

Climate Zones 3, 5 through 7	Climate Zones 1, 2, 4, 8 through 16
R-6	R-8

«» Commentary for Section 180.2(b)2Aii:

New and Altered Duct System – Insulation

When more than 25 linear ft. of new ducts are installed in an unconditioned space, the new ducts must be insulated per Table 180.2-C. When 25 ft. or less of ducts are installed in an unconditioned space, they must be insulated to the minimum mandatory insulation level of R-6 in all climate zones.

When new ducts are installed in conditioned space, the ducts must be insulated to the minimum mandatory insulation level of R-6 unless an exception or alternative mandatory minimum applies. For multifamily buildings four habitable or more stories, this can be confirmed by visual verification of the enforcement agency. For multifamily buildings up to three habitable stories, the entire duct system must be tested and confirmed to be in conditioned space by a ECC-Rater per RA3.1.4.3.8.

Altered System Duct Sealing

In all climate zones, altered existing duct systems must be sealed and tested. An existing duct system is considered altered under any of the following conditions:

1. An outdoor condensing unit of a split system air conditioner or heat pump is installed or replaced.
2. A packaged system is completely replaced.
3. A cooling or heating coil is installed or replaced.
4. An air handler is installed or replaced.
5. More than 25 ft. of new or replacement ducts are installed.
6. The ducts are extended to serve an addition, regardless of the length of duct.

If a dwelling unit has more than one duct system, only the altered ducts or ducts connected to the altered equipment need to be sealed and verified.

There are three options for showing compliance for altered existing duct systems listed below. Compliance must at least be attempted with one of the first two options (15% total leakage or 10% leakage to outside); then the third option (sealing all accessible leaks) any of the other options can be used.

1. Total leakage is less than 15% of nominal system fan airflow (RA3.1.4.3.1).
2. Leakage to the outside is less than 10% of system fan airflow (RA3.1.4.3.4).
3. If the first two option leakage targets cannot be met, then compliance can be achieved by sealing all accessible leaks and conducting a smoke test (RA3.1.4.3.7).

Some judgment is required in determining if ducts are accessible. The local code enforcement agency will make a determination when it is not immediately obvious. «»

I. **Entirely new or complete replacement duct system.** If the new ducts form an entirely new or complete replacement duct system directly connected to the air handler, the duct system shall meet one of the following requirements:

   A. The total leakage of the duct system shall not exceed 12 percent of the air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1, or

   B. The duct system leakage to outside shall not exceed 6 percent of the air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.4.

   Entirely new or complete replacement duct systems installed as part of an alteration are constructed of at least 75 percent new duct material, and up to 25 percent may consist of reused parts from the dwelling unit's existing duct system, including but not limited to registers, grilles, boots, air handler, coil, plenums and duct material, if the reused parts are accessible and can be sealed to prevent leakage.

Entirely new or complete replacement duct systems shall also conform to the requirements of Sections 160.2(a)1 and 160.3(b)5L. If the air handler and ducts are located within a vented attic, the requirements of Section 180.2(b)1Bi shall also be met.

«» Commentary for Section 180.2(b)2AiiaI:

New and Altered Duct System – Insulation

An entirely new duct system may be part of an entirely new space conditioning system, or it may be connected to an existing space conditioning system. Duct systems are classified as entirely new when:

1. At least 75% of the duct material is new. Up to 25% may be composed of reused parts from the existing duct system.
2. All remaining components from the previous system are accessible and can be sealed.

«»

II. **Extension of an existing duct system.** If the new ducts are an extension of an existing duct system serving multifamily dwellings, the combined new and existing duct system shall meet one of the following requirements:

A. The measured duct leakage shall be equal to or less than 15 percent of air handler airflow as confirmed by field verification and diagnostic testing utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1; or

B. The measured duct leakage to outside shall be equal to or less than 10 percent of air handler airflow as confirmed by field verification and diagnostic testing utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.4; or

C. If it is not possible to meet the duct sealing requirements of either Section 180.2(b)2AiicI or II then all accessible leaks shall be sealed and verified through a visual inspection and a smoke test by a certified ECC-Rater utilizing the methods specified in Reference Residential Appendix RA3.1.4.3.5.

Exception to Section 180.2(b)2AiiaII: duct sealing. Existing duct systems that are extended, which are constructed, insulated or sealed with asbestos.

Exception 1 to 180.2(b)2Aii: The field verification and ECC-Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

«» Commentary for Section 180.2(b)2Aii:

New and Altered Duct System – Insulation

For multifamily buildings with up to three habitable stories, ECC-verification is required. For other multifamily buildings, testing only needs to be conducted and certified by the installing contractor, and neither a ECC-Rater nor registration with a ECC-Provider is required. «»

iii. **Altered space-conditioning system—duct sealing.** In all climate zones, when a space-conditioning system serving a multifamily dwelling is altered by the installation or replacement of space-conditioning system equipment, including replacement of the air handler, outdoor condensing unit of a split system air conditioner or heat pump, or cooling or heating coil, the duct system that is connected to the altered space-conditioning system equipment shall be sealed, as confirmed through field verification and diagnostic testing in accordance with the applicable procedures for duct sealing of altered existing duct systems as specified in Reference Residential Appendix RA3.1 and the leakage compliance criteria specified in Subsection a, b or c below.

A. The measured duct leakage shall be equal to or less than 15 percent of air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.1; or

b. The measured duct leakage to outside shall be equal to or less than 10 percent of air handler airflow as determined utilizing the procedures in Reference Residential Appendix Section RA3.1.4.3.4; or

c. If it is not possible to meet the duct sealing requirements of either Section 180.2(b)2Aiiia or b, then all accessible leaks shall be sealed and verified through a visual inspection and a smoke test by a certified ECC-Rater utilizing the methods specified in Reference Residential Appendix RA3.1.4.3.5.

Exception 1 to Section 180.2(b)2Aiii: duct sealing. Duct systems that are documented to have been previously sealed as confirmed through field verification and diagnostic testing in accordance with procedures in Reference Residential Appendix RA3.1.

Exception 2 to Section 180.2(b)2Aiii: duct sealing. Duct systems with less than 40 linear feet as determined by visual inspection.

Exception 3 to Section 180.2(b)2Aiii: duct sealing. Existing duct systems constructed, insulated or sealed with asbestos.

Exception 4 to Section 180.2(b)2Aiii: The field verification and ECC-Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

«» Commentary for Section 180.2(b)2Aiii:

New and Altered Duct System – Insulation

For multifamily buildings with up to three habitable stories, ECC-verification is required. For other multifamily buildings, testing only needs to be conducted and certified by the installing contractor, and neither a ECC-Rater nor registration with a ECC-Provider is required. «»

iv. **Altered space-conditioning system mechanical cooling.** When a space-conditioning system is an air conditioner or heat pump that is altered by the installation or replacement of refrigerant-containing system components such as the compressor, condensing coil, evaporator coil, refrigerant metering device or refrigerant piping, the altered system shall comply with the following requirements:

a. All thermostats associated with the system shall be replaced with setback thermostats meeting the requirements of Section 110.2(c).

«» Commentary for Section 180.2(b)2Aiva:

When an existing system has a refrigerant containing system component added or replaced, the thermostat must be upgraded to a setback type that meets Section 110.2(c). **«»**

b. In Climate Zones 2 and 8 through 15, air-cooled air conditioners and air-source heat pumps, including but not limited to ducted split systems, ducted package systems, small duct high velocity air systems, and minisplit systems, shall comply with Subsections I and II, unless the system is of a type that cannot be verified using the specified procedures. Systems that cannot comply with the requirements of Section 180.2(b)2Aivb shall comply with Section 180.2(b)2Aivc.

Exception to Section 180.2(b)2Aivb: Entirely new or complete replacement packaged systems for which the manufacturer has verified correct system refrigerant charge prior to shipment from the factory are not required to have refrigerant charge confirmed through field verification and diagnostic testing. The installer of these packaged systems shall certify that the packaged system was pre-charged at the factory and has not been altered in a way that would affect the charge. Ducted systems shall comply with the minimum system airflow rate requirement in Section 180.2(b)2AivbI, provided that the system is of a type that can be verified using the procedure specified in RA3.3 or an approved alternative in RA1.

I. The minimum system airflow rate shall comply with the applicable Subsection A or B below as confirmed through field verification and diagnostic testing in accordance with the procedures specified in Reference Residential Appendix Section RA3.3 or an approved alternative procedure as specified in Section RA1.

A. Small duct high velocity systems shall demonstrate a minimum system airflow rate greater than or equal to 250 cfm per ton of nominal cooling capacity; or

B. All other air-cooled air conditioner or air-source heat pump systems shall demonstrate a minimum system airflow rate greater than or equal to 300 cfm per ton of nominal cooling capacity.

Exception 1 to Section 180.2(b)2AivbI: Systems unable to comply with the minimum airflow rate requirement shall demonstrate compliance using the procedures in Section RA3.3.3.1.5, and the system's thermostat shall conform to the specifications in Section 110.12.

Exception 2 to Section 180.2(b)2AivbI: Entirely new or complete replacement space-conditioning systems, as specified by Section 180.2(b)2Ai, without zoning dampers may comply with the minimum airflow rate by meeting the applicable requirements in Table 160.3-A or 160.3-B as confirmed by field verification and diagnostic testing in accordance with the procedures in Reference Residential Appendix Sections RA3.1.4.4 and RA3.1.4.5. The design clean-filter pressure drop requirements of Section 160.2(a)1C for the system air filter device(s) shall conform to the requirements given in Tables 160.3-A and 160.3-B.

II. The installer shall charge the system according to manufacturer's specifications. Refrigerant charge shall be verified according to one of the following options, as applicable.

A. The installer and rater shall perform the standard charge verification procedure as specified in Reference Residential Appendix Section RA3.2.2, or an approved alternative procedure as specified in Section RA1; or

B. The installer shall perform the weigh-in charging procedure as specified by Reference Residential Appendix Section RA3.2.3.1, provided the system is of a type that can be verified using the RA3.2.2 standard charge verification procedure and RA3.3 airflow rate verification procedure or approved alternatives in RA1. The ECC-Rater shall verify the charge using RA3.2.2 and RA3.3 or approved alternatives in RA1.

Exception 1 to Section 180.2(b)2AivbII: When the outdoor temperature is less than 55 degrees F and the installer utilizes the weigh-in charging procedure in Reference Residential Appendix Section RA3.2.3.1 to demonstrate compliance, the installer may elect to utilize the verification procedure in Reference Residential Appendix Section RA3.2.3.2. If the verification procedure in Section RA3.2.3.2 is used for compliance, the system's thermostat shall conform to the specifications in Section 110.12. Ducted systems shall comply with the minimum system airflow rate requirements in Section 180.2(b)2AivbI.

EXCEPTION 2 to Section 180.2(b)2Aivb: The field verification and ECC-Provider data registry requirements of Reference Residential Appendix RA2 and RA3 are not required for multifamily dwelling units in buildings four stories and greater. The installer shall certify that diagnostic testing was performed in accordance with the applicable procedures.

«» Commentary for Section 180.2(b)2Aivb:

When refrigerant charge verification is required for compliance, the system must also comply with the minimum airflow of 300 CFM/ton according to the procedures specified in RA3.3.

Entirely new or complete replacement space-conditioning systems must meet the minimum 350 CFM/ton airflow rate compliance criterion or the duct design alternative along with the other prescriptive and mandatory requirements described above.

Verification of refrigerant charge and airflow must be conducted by a ECC-Rater for multifamily buildings with up to three habitable stories. For other multifamily buildings, testing only needs to be conducted and certified by the installing contractor and neither a ECC-Rater nor registration with a ECC-Provider is required. **«»**

v. **Altered Space-Heating System.** Altered or replacement space-heating systems shall not use electric resistance as the primary heat source.

EXCEPTION 1 to Section 180.2(b)2Av: Non-ducted electric resistance space heating systems if the existing space heating system is electric resistance.

EXCEPTION 2 to Section 180.2(b)2Av: Ducted electric resistance space heating systems if the existing space heating system is electric resistance and a ducted space cooling system is not being replaced or installed.

EXCEPTION 3 to Section 180.2(b)2Av: Electric resistance space heating systems, if the existing space heating system is electric resistance in Climate Zones 6, 7, 8, or 15.

«» Commentary for Section 180.2(b)2Av:

Heating System Replacements

Prescriptive compliance requires new heating systems be limited to a heat pump or a gas or propane system. Altered systems must not use electric resistance as the primary heat source unless the existing space heating system is electric resistance and one of the following conditions are met:

1. Non-ducted electric resistance system when the existing system is electric resistance.
2. Ducted electric resistance systems only when a ducted space cooling system is not being replaced or installed as part of the alteration.
3. Any electric resistance systems in climate zones 6, 7, 8 or 15.

«»

B. **Common Use Area Space Conditioning Systems**

i. New or Replacement Space-Conditioning Systems or Components other than new or replacement space-conditioning system ducts shall meet the requirements of Sections 170.2(c)1, 2, and 4, applicable to the systems or components being altered. For compliance with Section 170.2(c)4A, additional fan power adjustment credits are available as specified in TABLE 180.2-D.

TABLE 180.2-D Fan Power Limitation Pressure Drop Adjustment

Airflow	**Multi-Zone VAV Systems[1] ≤5,000 cfm**	**Multi-Zone VAV Systems[1] >5,000 and ≤10,000 cfm**	**Multi-Zone VAV Systems[1] >10,000 cfm**	**All Other Fan Systems ≤5,000 cfm**	**All Other Fan Systems >5,000 and ≤10,000 cfm**	**All Other Fan Systems >10,000 cfm**
Supply Fan System Additional Allowance	0.135	0.114	0.105	0.139	0.12	0.107
Supply Fan System Additional Allowance In Unit with Adapter Curb	0.033	0.033	0.043	0.000	0.000	0.000
Exhaust/ Relief/ Return/ Transfer Fan System Additional Allowance	0.07	0.061	0.054	0.07	0.062	0.055
Exhaust/ Relief/ Return/ Transfer Fan System Additional Allowance In Unit with Adapter Curb	0.016	0.017	0.022	0.000	0.000	0.000

Footnotes to Table 180.2-D:

1. See FAN SYSTEM, MULTI-ZONE VARIABLE AIR VOLUME (VAV) for the definition of a Multi-Zone VAV System.

Exception 1 to Section 180.2(b)2Bi: Section 180.2(b)2Av does not apply to replacement of electric reheat of equivalent or lower capacity electric resistance space heaters when natural gas is not available.

Exception 2 to Section 180.2(b)2Bi: Operable wall or roof openings that have been previously installed without interlock controls are exempt from complying with Section 170.2(c)4L.

Exception 3 to Section 180.2(b)2Bi: Section 170.2(c)4Ci is not applicable to systems that meet both of the following:

The system is not a single package air-cooled commercial unitary air conditioner or heat pump; and

The cooling capacity of the system is less than 54,000 Btu/h.

«» Commentary for Section 180.2(b)2Bi:

Multifamily HVAC Alterations

An economizer is required for replacement of HVAC single packaged units per Section 170.2(c)4. Exception 3 to Section 180.2(b)2Bi requires single packaged air-cooled commercial unitary air conditioners or heat pumps with cooling capacity less than 54,000 Btu per hour to meet the economizer requirements in Section 170.2(c)4Ci. This exception does not require economizers for replacements of VRF, split systems, or systems that are not single packaged units. **«»**

ii. **Altered duct systems.** When new or replacement space-conditioning system ducts are installed to serve an existing building, the new ducts shall meet the requirements of Section 160.3(c)2 and meet a or b below:

   a. Reserved.

   b. Entirely new or replacement duct systems installed as part of an alteration shall be leakage-tested in accordance with Section 160.2(c)2H. Entirely new or replacement duct systems installed as part of an alteration shall be constructed of at least 75 percent new duct material, and up to 25 percent may consist of reused parts from the building's existing duct system, including registers, grilles, boots, air handlers, coils, plenums, and ducts, if the reused parts are accessible and can be sealed to prevent leakage.

   EXCEPTION 1 to Section 180.2(b)2Biib: When it is not possible to achieve the duct leakage criteria in Section 180.2(b)2Biib, all accessible leaks shall be sealed and verified through a visual inspection and a smoke test performed by a certified mechanical acceptance test technician utilizing the methods specified in Reference Nonresidential Appendix NA7.5.3.

   EXCEPTION 2 to Section 180.2(b)2Biib: Duct Sealing. Existing duct systems that are extended, which are constructed, insulated or sealed with asbestos are not required to comply with subsection 180.2(b)2Biib.

c. If the new ducts are an extension of an existing duct system, the combined new and existing duct system meets the criteria in Subsections I, II, and III below. The duct system shall be sealed to a leakage rate not to exceed 15 percent of the nominal air handler airflow rate as confirmed through acceptance testing, in accordance with Reference Nonresidential Appendix NA7.5.3:

I. The duct system provides conditioned air to an occupiable space for a constant volume, single zone, space-conditioning system; and

II. The space conditioning system serves less than 5,000 square feet of conditioned floor area; and

III. The combined surface area of the ducts located in the following spaces is more than 25 percent of the total surface area of the entire duct system:

A. Outdoors;

B. In a space directly under a roof that

C. Has a U-factor greater than the U-factor of the ceiling, or if the roof does not meet the requirements of Section 170.2(a)1B, or

D. Has fixed vents or openings to the outside or unconditioned spaces; or

E. In an unconditioned crawl space; or

F. In other unconditioned spaces.

«» Commentary for Section 180.2(b)2Bii:

Once the ducts have been sealed and tested to leak less than the amounts required in Section 180.2(b)2Bii, a ECC-rater will be contacted by the contractor to validate the accuracy of the duct sealing measurement on a sample of the systems repaired as described in Reference Nonresidential Appendix NA1. Certified ATTs may perform these field verifications only if the ATTCP has been approved to provide this service. **«»**

iii. **Altered space-conditioning systems.** When a space-conditioning system is altered by the installation or replacement of space-conditioning system equipment (including replacement of the air handler, outdoor condensing unit of a split system air conditioner or heat pump, or cooling or heating coil:

a. For all altered units where the existing thermostat does not comply with the requirements for demand responsive controls specified in Section 110.12, the existing thermostat shall be replaced with a demand responsive thermostat that complies with Section 110.12. All newly installed space-conditioning systems requiring a thermostat shall be equipped with a demand responsive thermostat that complies with Section 110.12; and

b. The duct system that is connected to the new or replaced space-conditioning system equipment shall be sealed, if the duct system meets the criteria of Section 120.4(g), as confirmed through acceptance testing, in accordance with the applicable procedures for duct sealing of altered existing duct systems as specified in Reference Nonresidential Appendix NA7.5.3, and conforming to the applicable leakage compliance criteria in Section 180.2(b)2Bii.

Exception 1 to Section 180.2(b)2Biiib: duct sealing. Buildings altered so that the duct system no longer meets the criteria of Section 170.2(c)4Ji are not required to comply with Subsection 180.2(b)2Biiib.

Exception 2 to Section 180.2(b)2Biiib: duct sealing. Duct systems that are documented to have been previously sealed as confirmed through acceptance testing in accordance with procedures in the Reference Nonresidential Appendix NA7.5.3 are not required to comply with Subsection 180.2(b)2Biiib.

Exception 3 to Section 180.2(b)2Biiib: duct sealing. Existing duct systems constructed, insulated or sealed with asbestos are not required to comply with the requirements of Subsection 180.2(b)2Biiib.

5. **Mechanical ventilation and indoor air quality for dwelling units.** Alterations to existing buildings shall comply with Subsections A and B below as applicable. When field verification and diagnostic testing are required by Section 180.2(b)5, buildings with three habitable stories or less shall use the applicable procedures in the Residential Appendices, and buildings with four or more habitable stories shall use the applicable procedures in Nonresidential Appendices NA1 and NA2.

Exception to Section 180.2(b)5: A dwelling unit air leakage test is not required for alterations.

A. **Entirely new or complete replacement ventilation systems.** Entirely new or complete replacement ventilation systems shall comply with all applicable requirements in Section 160.2(b)2. An entirely new or complete replacement ventilation system includes a new ventilation fan component and an entirely new duct system. An entirely new or complete replacement duct system is constructed of at least 75 percent new duct material, and up to 25 percent may consist of reused parts from the dwelling unit's existing duct system, including but not limited to registers, grilles, boots, air filtration devices and duct material, if the reused parts are accessible and can be sealed to prevent leakage.

Exception: to Section 180.2(b)5A: The new or replacement ventilation type shall be supply, balanced, or the existing ventilation type being replaced.

B. **Altered ventilation systems**. Altered ventilation system components or newly installed ventilation equipment serving the alteration shall comply with Section 160.2(b)2 as applicable subject to the requirements specified in Subsections i and ii below.

i. **Whole-dwelling unit mechanical ventilation**.

a. **Whole-dwelling unit ventilation strategy.** The altered ventilation system shall be supply, balanced, or the existing ventilation type being altered.

b. **Whole-dwelling unit airflow**. If the whole-dwelling ventilation fan is altered or replaced, then one of the following Subsections 1 or 2 shall be used for compliance as applicable.

1. Dwellings that were required by a previous building permit to comply with the whole-dwelling unit airflow requirements in Section 160.2(b)2, 120.1(b) or 150.0(o) shall meet or exceed the whole-dwelling unit mechanical ventilation airflow specified in Section 160.2(b)2Aiv or 160.2(b)2Av as confirmed through field verification and diagnostic testing in accordance with the applicable procedures specified in Reference Appendix RA3.7 or NA2.2.

2. Dwellings that were not required by a previous building permit to have a whole-dwelling unit ventilation system to comply with Section 160.2(b)2, 120.1(b) or 150.0(o) shall not be required to comply with the whole-dwelling unit ventilation airflow specified in Section 160.2(b)2Aiv or 160.2(b)2Av.

c. **Replacement ventilation fans.** Whole-dwelling unit replacement ventilation fans shall be rated for airflow and sound in accordance with the requirements of ASHRAE 62.2 Sections 7.1 and 7.3. Additionally, when conformance to a specified whole-dwelling unit airflow rate is required for compliance, the replacement fans shall be rated at no less than the airflow rate required for compliance.

d. **Air filters**. If the air filtration device for a whole-dwelling unit ventilation system is altered or replaced, then one of the following Subsections 1 or 2 shall be used for compliance.

1. Dwellings that were required by a previous building permit to comply with the ventilation system air filtration requirements in Section 160.2(b)1, 120.1(b)1 or 150.0(m)12 shall comply with the air filtration requirements in Section 160.2(b)1.

2. Dwellings that were not required by a previous building permit to comply with the ventilation system air filtration requirements in Section 160.2(b)1, 120.1(b)1 or 150.0(m)12 shall not be required to comply with the air filtration requirements specified in Section 160.2(b)1.

ii. **Local mechanical exhaust**.

a. **Bathroom local mechanical exhaust**. Altered bathroom local mechanical exhaust systems shall comply with the applicable requirements specified in Section 160.0(b)2Avi.

b. **Kitchen local mechanical exhaust**. If the kitchen local ventilation fan is altered or replaced, then one of the following Subsections 1, 2 or 3 shall be used for compliance.

1. Dwellings that were required by a previous building permit to comply with the kitchen local exhaust requirements in Section 160.0(b)2Avi, 120.1(b)2vi or 150.0(o)1G shall meet or exceed the applicable airflow or capture efficiency requirements in Section 160.0(b)2Avi.

2. Dwellings that were required by a previous building permit to install a vented kitchen range hood or other kitchen exhaust fan shall install a replacement fan that meets or exceeds the airflow required by the previous building permit, or 100 cfm, whichever is greater.

«» Commentary for Section 180.2(b)5Biib:

Kitchen local mechanical exhaust systems that previously met indoor air quality requirements must continue to meet indoor air quality requirements after the additions or alterations are completed. They must either 1) meet or exceed the airflow and capture efficiency requirements in Sections 160.0(b)2Avi if a previous building permit required compliance with Section 160.0(b)2Avi, 120.1(b)2vi or 150.0(o)1G, or 2) meet or exceed the greater of airflow requirement by the previous building permit or 100 cfm if the previous permit required installing a vented kitchen range hood. **«»**

3. Dwellings that were not required to have a kitchen local ventilation exhaust system according to the conditions in either Subsection 1 or 2 above shall not be required to comply with the requirements of Section 160.0(b)2Avi.

c. **Replacement ventilation fans.** New or replacement local mechanical exhaust fans shall be rated for airflow and sound in accordance with the requirements of ASHRAE 62.2 Section 7.1 and Title 24, Part 6, Section 160.0(b)2Avif. Additionally, when compliance with a specified exhaust airflow rate is required, the replacement fan shall be rated at no less than the airflow rate required for compliance.

(c) Performance approach. The altered component(s) and any newly installed equipment serving the alteration shall meet the applicable requirements of Subsections 1, 2 and 3 below. The energy budget for alterations is expressed in terms of Long-Term System Cost (LSC) energy.

1. The altered components shall meet the applicable requirements of Sections 110.0 through 110.9, 160.0, 160.1, 160.2(c) and (d), 160.3(a) through 160.3(b)5J, 160.3(b)6, 160.3(c), and 160.5. Entirely new or complete replacement mechanical ventilation systems as these terms are used in Section 180.2(b)5A shall comply with the requirements in Section 180.2(b)5A. Altered mechanical ventilation systems shall comply with the requirements of Sections 180.2(b)5B. Entirely new or complete replacement space-conditioning systems, and entirely new or complete replacement duct systems, as these terms are used in Sections 180.2(b)2Ai and 180.2(b)2Aiia, shall comply with the requirements of Sections 160.2(a)1 and 160.3(b)5L.
2. The standard design for an altered component shall be the higher efficiency of existing conditions or the requirements of Section 180.2(b). For components not being altered, the standard design shall be based on the unaltered existing conditions such that the standard and proposed designs for these components are identical. When the third-party verification option is specified, all components proposed for alteration for which the additional credit is taken, must be verified by a certified ECC-rater.
3. The proposed design shall be based on the actual values of the altered components.

NOTES TO SECTION 180.2(c):

1. If an existing component must be replaced with a new component, that component is considered an altered component for the purpose of determining the standard design altered component energy budget and must meet the requirements of Section 180.2(c)2.
2. The standard design shall assume the same geometry and orientation as the proposed design.
3. The "existing efficiency level" modeling rules, including situations where nameplate data is not available, are described in Section 10-109(c) and Section 10-116.

EXCEPTION 1 to Section 180.2(c): Any dual-glazed greenhouse or garden window installed as part of an alteration complies with the U-factor requirements in Section 170.2.

EXCEPTION 2 to Section 180.2(c): Where the space in the attic or rafter area is not large enough to accommodate the required R-value, the entire space shall be filled with insulation provided such installation does not violate Section 1203.2 of Title 24, Part 2.

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