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Building HVAC Requirements

Overview

Introduction and Organization

This chapter addresses the requirements for heating, ventilation, and air- conditioning (HVAC) systems, which include *space conditioning systems* and *indoor air quality systems* in the Energy Code, for newly constructed single-family residential buildings including single-family residences, duplexes, townhouses, and triplexes. The requirements are a source of information for the general public, mechanical system designers and installers, energy consultants, Energy Code Compliance (ECC)-Raters, and enforcement agency personnel.

Each section in this chapter outlines the mandatory measures and, when applicable, the prescriptive and performance compliance options pertaining to residential HVAC systems. If the overall home design does not achieve the minimum prescriptive requirements, the designer may use the performance compliance option that allows using higher performance measures in some areas to offset lower performance measures in other areas. See Chapter 1.6 for a more detailed discussion of the compliance process.

Each section of this chapter includes mandatory measures, prescriptive requirements, and performance compliance options.

Chapter 9 of the Residential Compliance Manual covers the heating and cooling requirements for additions to existing dwellings and for alterations to existing heating and cooling systems.

Chapter 10 of the Residential Compliance Manual covers the electric ready requirements including electric readiness for gas and propane furnaces and domestic hot water heaters.

What’s New for 2025

Mandatory Features and Devices – §150.0

- Adds the ASHRAE Handbook Fundamentals Volume and ACCA Manual J as sources for outdoor design conditions (§150.0(h)2).
- Provides guidance on how to use authorized load calculations in system sizing and selection. Specifically, states that heat pumps be sized to meet minimum requirements from the California Building Code without supplementary heating; clarifies that there is no limit on minimum cooling or maximum heating capacity, and furnace heating capacity is based on ACCA Manual S-2023, Table N2.5 (§150.0(h)5).
- Establishes defrost requirements. Specifically, if a heat pump is equipped with a installer-adjustable defrost delay timer, the delay timer shall be set to greater than or equal to 90 minutes. This setting shall be tested by the installer and certified on the Certificate of Installation (CF2R). Exceptions include homes in Climate Zones 6 and 7, and homes with a conditioned floor area of 500 square feet or less in Climate Zones 3, 5-10, and 15 (§150.0(h)6).
- Requires that heat pump supplementary heating (electric resistance or gas) shall only operate below an outdoor air temperature of 35°F, during defrost, or when the user selects emergency operation. This setting shall be tested by the installer and certified on the CF2R.

There are exceptions for room air-conditioner heat pumps, buildings in Climate Zones 7 and 15, and buildings with a conditioned floor area of less than 500 square (§150.0(h)7).

- Requires that electric resistance supplementary heat shall have a capacity no larger than the heat pump nominal cooling capacity (at 95°F ambient conditions) multiplied by 2.7 kW per ton, rounded up to the closest kW (§150.0(h)8).
- Requires that variable or multi-speed systems controlled by third-party thermostats shall be capable of responding to heating and cooling loads by modulating system compressor speed and meet thermostat requirements in §150.0(i)2. This control configuration shall be tested by the installer and certified on the CF2R (§150.0(h)9).
- Requires that thermostats controlling heat pumps with electric resistance or gas furnace supplementary heat shall receive outdoor air temperature from an outdoor air temperature sensor or from an internet weather service, display the outdoor air temperature, have an indicator to notify when supplementary heat or emergency heat is in use, and lock out supplementary heat when the outdoor temperature is above 35°F (alone or in conjunction with heat pump operation). This functionality shall be tested by the installer and certified on the CF2R. There are exceptions for room air-conditioner heat pumps (§150.0(i)).
- Allows ducts in unvented attics to be insulated to R-4.2, less than the mandatory minimum of R-6, provided certain other requirements are met (§150.0(m)1Bi).
- Allows multispeed or variable speed compressor systems with controls that vary fan speed with respect to the number of zones to demonstrate compliance with airflow and fan efficacy requirements by operating the system at maximum compressor capacity and system fan speed, with all zones calling for conditioning (§150.0(m)13).
- Revises requirements for new whole dwelling unit mechanical ventilation for detached and attached single-family dwellings (§150.0(o)1.C). The revision includes requirements for balanced and supply-only ventilation systems regarding accessibility of indoor air quality (IAQ) filters and HRV/ERV, IAQ System components, outdoor air intake design, and outdoor air intake location and accessibility.

Prescriptive and Performance Compliance Approaches – §150.1

- Heat pumps are required for prescriptive compliance in all climate zones (§150.1(c)6, Table 150.1-A).
- The energy budget for the performance approach uses Long-Term System Cost (LSC) instead of Time Dependent Valuation (TDV) energy (§150.1(b)).
- Refrigerant charge verification is now required for Heat Pumps in all Climate Zones (§150.1(c)7A, Table 150.1-A).
- Fault indicator displays have been removed as an available method for refrigerant charge verification (Section 150.1(c)7A).
- Fault Indicator Displays have been removed as an available method for Refrigerant Charge Verification (§150.1(c)7AicII).
- All HRV/ERV systems serving individual dwelling units shall have a Fault Indicator Display (FID) as specified in Joint Reference Appendix JA17. The FID shall also be field verified by an ECC-Rater (§150.1(c)15).
- Performance compliance software validates that new construction projects use no more than 120% of the standard design building's peak cooling energy use in kWh . Peak cooling

is measured in cooling energy kWh used between the hours of 4 – 9 pm. To reduce Peak Cooling energy use, upgrades to the opaque envelope, fenestrations, HVAC efficiency, and HVAC distribution systems may be necessary (See Alternative Calculation Method Manual for more details).

California Appliance Standards and Equipment Certification

Please refer to Chapter 4.1.3.1 of the 2022 Single-family Residential Compliance Manual.

Plan Review (Compliance)

Please refer to Chapter 4.1.3.2 of the 2022 Single-family Residential Compliance Manual.

Heating Equipment

Please refer to Chapter 4.2 of the 2022 Single-family Residential Compliance Manual.

Mandatory Measures for Heating Equipment

Equipment Efficiency

Reference: §110.1 and §110.2(a)

The efficiency of most heating equipment is regulated by the National Appliance Energy Conservation Act of 1987 (NAECA, the federal appliance standard) and the California Appliance Efficiency Regulations. These regulations are not contained in the Energy Code but are published separately. These regulations are referenced in §110.1. The heating efficiencies are generally reported in terms of annual fuel utilization efficiency (AFUE), thermal efficiency, combustion efficiency, heating seasonal performance factor (HSPF2), and coefficient of performance (COP). 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.

The energy efficiency of other equipment is regulated by §110.2(a). Also, see the *Nonresidential Compliance Manual* for more information on larger equipment.

Gas and Oil-Fired Furnaces

The *Appliance Efficiency Regulations* require gas- and oil-fired central furnaces with outputs less than 225,000 Btu/h 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/h are rated according to the respective thermal (or steady-state) efficiency. Refer to Table 4-1: Minimum Efficiency for Gas- and Oil-Fired Central Furnaces for the applicable efficiency requirements.

Table 4-1: Minimum Efficiency for Gas- and Oil-Fired Central Furnaces

Appliance	Rated Input (Btu/h)	Minimum Efficiency (%) AFUE	Minimum Efficiency (%) Thermal Efficiency
Weatherized gas central furnaces with single phase electrical supply	< 225,000	81	NA
Non-weatherized gas central furnaces with single phase electrical supply	< 225,000	80	NA
Weatherized oil central furnaces with single phase electrical supply	< 225,000	78	NA
Non-weatherized oil central furnaces with single phase electrical supply	< 225,000	83	NA
Gas central furnaces	≥ 225,000	NA	81
Oil central furnaces	≥ 225,000	NA	82

Source: California Appliance Efficiency Regulations Title-20 - Table E-5 and E-6

Noncentral gas furnaces and space heaters manufactured on or after April 16, 2013, shall be certified to have AFUE values greater than or equal to those listed in Table 4-2: Minimum Heating Efficiency for Non-ducted, Noncentral, Gas- Fired Heating Equipment.

Table 4-2: Minimum Heating Efficiency for Non-ducted, Noncentral, Gas- Fired Heating Equipment

Type	Capacity (Btu/h)	AFUE
Wall Furnace (fan type)	≤ 42,000	75%
Wall Furnace (fan type)	> 42,000	76%
Wall Furnace (gravity type)	≤ 27,000	65%
Wall Furnace (gravity type)	> 27,000 to ≤ 46,000	66%
Wall Furnace (gravity type)	> 46,000	67%
Floor Furnace	≤ 37,000	57%
Floor Furnace	> 37,000	58%
Room Heater	≤20,000	61%
Room Heater	> 20,000 to ≤ 27,000	66%
Room Heater	> 27,000 to ≤ 46,000	67%
Room Heater	> 46,000	68%

Source: California Appliance Efficiency Regulations Title 20 - Table E-2

Heat Pumps and Electric Heating

Heat pumps shall be certified to have a HSPF2 or coefficient of performance (COP) equal to or better than those listed in Table 4-3: Minimum Heating Efficiency for Heat Pumps.

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

Note: Minimum Cooling Efficiency for Heat Pump equipment types are in the Cooling Equipment section.

Table 4-3: Minimum Heating Efficiency for Heat Pumps

Equipment Type	Configuration/Size	Minimum Heating Efficiency
Packaged terminal heat pumps (heating mode)	Newly constructed or newly conditioned buildings or additions	3.7-(0.052 x Cap[1]/1000) = COP
Packaged terminal heat pumps (heating mode)	Replacements	2.9-(0.026 x Cap[1]/1000) = COP
Single-phase air source heat pumps (NAECA)	< 65,000 Btu/h cooling capacity	Packaged 6.7 HSPF2 Split 7.5 HSPF2
Single-phase air source heat pumps (NAECA)	Space constrained < 65,000 Btu/h cooling capacity	6.3 HSPF2
Single-phase air source heat pumps (NAECA)	Small duct, high velocity < 65,000 Btu/h cooling capacity	6.1 HSPF2
Three-phase air source heat pumps	Split-system < 65,000 Btu/h	7.5 HSPF2
Three-phase air source heat pumps	≥ 65,000 and <135,000	3.4 COP
Three-phase air source heat pumps	≥ 135,000 and <240,000	3.3[2] COP
Three-phase air source heat pumps	≥ 240,000 and <760,000	3.2 COP

Equipment Type	Configuration/Size	Minimum Heating Efficiency
Water-source heat pumps	≥ 65,000 and < 135,000 Btu/h	4.3 COP
Single package vertical heat pumps	< 65,000 single-phase and 3-phase	3.3 COP
Single package vertical heat pumps	≥ 65,000 and < 135,000	3.0 COP
Single package vertical heat pumps	≥ 135,000 and < 240,000	3.0 COP

1. Cap = Cooling Capacity of the product in Btu/h. If the unit's capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.
2. Electric resistance heating or no heating
3. All other types of heating

Source: California Appliance Efficiency Regulation Title 20 and Energy Code

Gas- and Oil-Fired Central Boilers and Electric Boilers

Gas- and oil-fired central boilers shall be certified to have and AFUE or *Combustion Efficiency* equal to or better than those listed in Table 4-4: Minimum Efficiency for Gas- and Oil-Fired Central Boilers.

Table 4-4: Minimum Efficiency for Gas- and Oil-Fired Central Boilers

Appliance	Rated Input (Btu/h)	Minimum Efficiency (%)	Efficiency Metric
Gas steam boilers with single-phase electrical supply	< 300,000	82 [1]	AFUE
Gas hot water boilers with single-phase electrical supply	< 300,000	84 [1,2]	AFUE
Oil steam boilers with single-phase electrical supply	< 300,000	85	AFUE
Oil hot water boilers with single-phase electrical supply	< 300,000	86 [2]	AFUE
Electric steam residential boilers	< 300,000	NA	NA
Electric hot water residential boilers	< 300,000	NA	NA
All other boilers with single-phase electrical supply	< 300,000	NA	NA

1. No constant burning pilot light design standard.
2. Automatic means for adjusting water temperature design standard.

Source: California Appliance Efficiency Regulations Title 20 Table E-3

Table 4-5: Minimum Efficiency for Gas- and Oil-Fired Central Boilers

Appliance	Rated Input (Btu/h)	Minimum Thermal Efficiency (%)	Minimum Combustion Efficiency (%)
Steam boilers; gas-fired, except natural draft;	≥ 300,000	79	81
Steam boilers; gas-fired, natural draft	≥ 300,000	79	81
Steam boilers; oil-fired	≥ 300,000	81	82

Source: California Appliance Efficiency Regulations Title 20 Table E-4

Heating System Controls

Reference: §150.0(i), §110.2(b), Exceptions to §110.2(b), §110.2(c), Exception to §110.2(c), §150.0(h)

Heating systems must be controlled by a central energy management control system (EMCS) or by a setback thermostat.

The setback thermostat must be capable of allowing the occupant to program temperature set points for at least four periods within a 24-hour time span (§110.2(c)). The exception to this requirement is for gravity gas wall heaters, floor heaters, room heaters, fireplaces, wood stoves, and noncentral electric heaters.

There are thermostat requirements for heat pump systems with electric resistance or gas furnace supplementary heat (§150.0(i)). For these systems, thermostats must be able to control the use of the supplementary heating. These features include the ability to monitor and display the outdoor air temperature either through an outdoor temperature sensor or from an internet weather service. The thermostat must also be capable of notifying the occupant when the supplementary heater is in use.

Per Section 150.0(h)7, heat pumps with supplementary heat, including, but not limited to, electric resistance heaters or gas furnace supplementary heating, shall lock out supplementary heating any time the outdoor air temperature is above a setpoint of no more than 35°F. This control can be on the heat pump or the thermostat, and there are additional thermostat requirements in Section 150.0(i)2. The installer must test this configuration using a procedure found on the Certificate of Installation, and certify that it meets these requirements.

The controls may allow supplementary heater operation above 35°F only during defrost; or when the user selects emergency operation.

Room air-conditioner heat pumps are an exception to the above requirements. For buildings with a conditioned floor area less than 500 square feet, and for buildings of any size in climate zones 7 and 15, heat pumps with supplementary heaters shall have controls that meet Option A or Option B below:

Option A:

- Prevent supplementary heater operation when the heating load can be met by the heat pump alone; and
- 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.

Option B:

- The controls may allow supplementary heater operation during defrost mode and transient periods, such as start-ups and following a room thermostat setpoint advance, if the controls prevent the unnecessary operation of supplementary heating.

Some heat pumps are equipped with a field-adjustable defrost delay timer, with delay settings of 30, 60, 90, or 120 minutes (for example). The longer this delay is set for, the less frequently the defrost mode will be enabled. When these heat pumps are used, the delay timer must be set to at least 90 minutes. The installer must test this configuration using a procedure found on the Certificate of Installation, and certify that it meets these requirements. Exceptions include homes in climate zones 6 and 7, and homes with a conditioned floor area of 500 square feet or less in climate zones 3, 5 – 10, and 15 (§150.0(h)6). Note that this requirement does not apply to heat pumps with more sophisticated types of defrost control, or systems with automatic timer settings.

Variable or multi-speed heat pumps, even when they are controlled by third-party thermostats (thermostats that are made to be used with any system, and are not proprietary to the HVAC manufacturer), must be capable of modulating system compressor speed in response to varying loads. In some cases, this may require special adapters that are provided by the HVAC manufacturer and must be configured by the installer. Thermostats used in these applications must also meet the thermostat requirements described above (§150.0(i)2). The installer must test this configuration using a procedure found on the Certificate of Installation, and certify that it meets these requirements. (§150.0(h)9).

Equipment Sizing

Reference: §150.0(h)1, 2, 5 and 8

Inappropriately sized equipment typically operates less efficiently and can create comfort problems due to excessive cycling and improper airflow. Ensuring appropriate sizing requires attention in two areas: 1) Load Calculation, and 2) System Selection.

The Energy Code requires that heating loads be calculated for new space heating systems.

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

- ACCA Manual J
- The SMACNA Residential Comfort System Installation Manual
- The ASHRAE Handbook – Equipment, Applications, and Fundamentals Volumes

Load Calculations are sensitive to the appropriate selection of outdoor and indoor Design Conditions. The Energy Code requires that the indoor design temperature for heating load calculations shall be 68°F.

The outdoor design conditions for load calculations are to be selected from one of the following sources:

- Reference Joint Appendix (JA) JA2,
- The ASHRAE Handbook, Fundamentals Volume, or
- ACCA Manual J.

The outdoor design temperature for heating must be no lower than the 99.0 percent Heating Dry Bulb or the Heating Winter Median of Extreme values for the project city. If the actual city location for a project is not included in Joint Appendix (JA) 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.

According to Section 150.0(h)8, if a heat pump has electric resistance supplementary heat, the capacity of that supplementary heater cannot be larger than the heat pump nominal cooling capacity (at 95°F ambient conditions) multiplied by 2.7 kW per ton, rounded up to the closest kW. For example, a heat pump with a nominal cooling capacity of 3 tons, the maximum allowed electric resistance allowed would be:

3 tons x 2.7 kW/ton = 8.1 kW rounded to the nearest kW would be 8 kW.

The load calculations may be prepared by 1) a mechanical engineer, 2) the mechanical contractor who is installing the equipment, or 3) someone who is qualified to do so in the

State of California according to Division 3 of the Business and Professions Code, such as an energy consultant.

The California Business and Professions Code allows unlicensed persons to prepare plans, drawings, or specifications for wood-framed single-family residential buildings if the dwellings are no more than two stories high, not counting a possible basement, or for certain buildings containing no more than four dwelling units of wood-frame construction not more than two stories and basement in height.

System Selection

To meet the minimum requirements of the CBC, selected heating systems must meet the heating loads of Section 150.0(h)1 and 2. In general, ACCA Manual S-2023 shall be used for system selection. For example, furnaces shall be sized based on ACCA Manual S-2023, Table N2.5. There are some important differences between ACCA Manual S-2003 and the Energy Code. Notably, heating systems are required to meet this minimum capacity *not including* any supplementary heating provided. Also, for the Energy Code, there is no limit on the maximum heating capacity for heat pumps.

For example, in a very cold climate, the heating load will be much larger than the cooling load. ACCA Manual S-2003 would allow sizing a heat pump system to the cooling load and making up the difference with supplementary heating. The Energy Code, however, requires designers to select a system that meets the larger heating load without use of supplementary heating. (Supplementary heating can still be used, but it should not be used to meet the design load, only to meet the load during defrost, morning warmup, or emergency situations). This system will be oversized for cooling, but the inefficiency introduced for cooling during the typically much smaller number of cooling hours in these climates is overshadowed by avoiding the inefficiency of using supplementary heating for a large number of heating hours.

When an addition is served by an existing HVAC system, load calculations per 150.0(h)1 should include the entire area served by the HVAC system. This will ensure that the system can properly serve the existing building area and addition.

Standby Losses and Pilot Lights

Please refer to Chapter 4.2.1.4 of the 2022 Single-family Residential Compliance Manual.

Pipe Insulation

Please refer to Chapter 4.2.1.5 of the 2022 Single-family Residential Compliance Manual.

Prescriptive Requirements for Heating Equipment

Reference: §150.1(c)6

Prescriptive compliance requires the installation of a heat pump as the main heating system. The heat pump shall meet minimum energy efficiency ratings (See Table 4-1 through Table 4-4: Minimum Efficiency for Gas- and Oil-Fired Central Boilers).

There are no restrictions on the type of heat pump that can be installed if it meets the minimum efficiency rating requirements.

Supplemental heating systems, which are independent from the primary heating system, are allowed under the Exception to 150.1(c)6, 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 directly or indirectly 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. This supplemental heating system should not be confused with the supplemental heat integrated into some heat pumps that is regulated under the mandatory sections 150.0(h)7 and 8.

Electric resistance and electric radiant heating installations are not allowed as the primary heating system when using the prescriptive compliance approach.

Performance Compliance Options for Heating Equipment

Please refer to Chapter 4.2.3 of the 2022 Single-family Residential Compliance Manual.

High-Efficiency Heating

Heating system efficiencies are explained in the Equipment Efficiency subsection of the Heating Equipment section. 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 by using heating equipment that exceeds minimum efficiency requirements 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 listed on the certificate of compliance (CF1R). See Reference Residential Appendix RA3.4 for more information about this ECC-Verification.

Cooling Equipment

Mandatory Measures for Cooling Equipment

Equipment Efficiency

Reference: §110.1 and §110.2(a)

The efficiency of most cooling equipment is regulated by NAECA (the federal appliance standard) and the California Appliance Efficiency Regulations. These regulations are not contained in the Energy Code but are referenced in §110.1. The energy efficiency of larger equipment is regulated by §110.2(a). The cooling efficiencies are generally reported in terms of seasonal energy efficiency ratio (SEER2) and energy efficiency ratio (EER2), except for Room air conditioner efficiencies, which are reported in combined energy efficiency ratio (CEER). See the *Nonresidential Compliance Manual* for information on larger equipment.

Central, Single-Phase Air Conditioners and Air Source Heat Pumps (Under 65,000 Btu/h)

The central, single-phase air conditioners and air source heat pumps that are most commonly installed in homes have a capacity less than 65,000 Btu/h. The *Appliance Efficiency Regulations* for this equipment require minimum seasonal energy efficiency ratios (SEER2).

The SEER2 of all new central, single-phase air conditioners and air source heat pumps with output less than 65,000 Btu/h shall be certified to the Energy Commission to have values no less than the values listed in Table 4-6: Minimum Cooling Efficiencies for Central Air Conditioners and Heat Pumps (Cooling Capacity Less Than 65,000 Btu/h) (NR = No Requirement).

Note: Minimum Heating Efficiency for Heat Pump equipment types are in the Heating Equipment section.

Table 4-6: Minimum Cooling Efficiencies for Central Air Conditioners and Heat Pumps (Cooling Capacity Less Than 65,000 Btu/h) (NR = No Requirement)

Appliance	Type	SEER 2	EER 2
Central Air Conditioners	Split-System <45,000 Btu/h	14.3	11.7
Central Air Conditioners	Split-System ≥45,000 Btu/h	13.8	11.2
Central Air Conditioners	Single-Package	13.4	10.6
Central Air Source Heat Pumps	Split-System	14.3	NR
Central Air Source Heat Pumps	Single-Package	13.4	NR
Space-Constrained Air Conditioner	Split-System	14.3	NR
Space-Constrained Air Conditioner	Single-Package	11.7	NR
Space-Constrained Heat Pump	Split-System	11.9	NR
Space-Constrained Heat Pump	Single-Package	11.9	NR
Small-Duct, High-Velocity Air Conditioner	All	12.0	NR
Small-Duct, High-Velocity Heat Pump	All	12.0	NR

Source: California Appliance Efficiency Regulations, Title 20, Table C-3 and Federal Appliance Standards (NAECA)

Other Air Conditioners and Heat Pumps

Appliance Efficiency Regulations

The current *Appliance Efficiency Regulations* for three-phase models, larger-capacity central air conditioners and heat pumps, and all room air conditioners and room air conditioner heat pumps shall be certified to the Energy Commission by the manufacturer to have values no less than the values listed in Table 4-7: Minimum Cooling Efficiency for Three-Phase Models and Larger Capacity Central Air Conditioners and Heat Pumps and Table 4-8: Minimum Cooling Efficiency for Noncentral Space-Cooling Equipment.

Table 4-7: Minimum Cooling Efficiency for Three-Phase Models and Larger Capacity Central Air Conditioners and Heat Pumps

Equipment Type	Size Category (Btu/h)	SEER2 or EER2
Central Air-Conditioners	≥65,000 but <135,000	10.8[1] EER2 10.6[2] EER2
Central Air-Conditioners	≥135,000 but <240,000	10.6[1] EER2 10.4[2] EER2
Central Air-Conditioners	≥240,000 but <760,000	9.6[1] EER2 9.4[2] EER2
Central Air-Source Heat Pumps	< 65,000 Split-System	14.3 SEER2
Central Air-Source Heat Pumps	< 65,000 Single-Packaged	14.3 SEER2
Central Air-Source Heat Pumps	≥ 65,000 but <135,000	10.6[1] EER2 10.4[2] EER2
Central Air-Source Heat Pumps	≥135,000 but <240,000	10.2[1] EER2 10[2] EER2
Central Air-Source Heat Pumps	≥240,000 but <760,000	9.1[1] EER2 8.9[2] EER2
Central Water-Source Heat Pumps	< 17,000	11.7 EER2
Central Water-Source Heat Pumps	≥ 17,000 and < 65,000	12.5 EER2
Central Water-Source Heat Pumps	≥ 65,000 and < 135,000	12.5 EER2
Central Water-Source Heat Pumps	≥ 135,000 and < 240,000	12.0 EER2
Central Water-Source Heat Pumps	≥ 240,000 and < 760,000	11.9 EER2
Water-Cooled Air Conditioners	< 17,000	11.7.2 EER2

Water-Cooled Air Conditioners	≥ 17,000 < 65,000	12.5 EER2
Water-Cooled Air Conditioners	≥ 65,000 and < 135,000	11.6[3] EER2
Water-Cooled Air Conditioners	≥ 135,000 and < 240,000	12.0[3] EER2
Water-Cooled Air Conditioners	≥ 240,000 and < 760,000	11.9[3] EER2

* Three-phase models only

1. Applies to equipment that has electric resistance heat or no heating.

2. Applies to equipment with all other heating-system types that are integrated into the unitary equipment.

3. Deduct 0.2 from the required EER for units with heating sections other than electric resistance heat.

Source: California Appliance Efficiency Regulations Table C-4, C-5

Table 4-8: Minimum Cooling Efficiency for Noncentral Space-Cooling Equipment

Equipment Type	Size Category (Input)	Minimum Efficiency
Room Air Conditioners, With Louvered Sides	< 6,000	13.1 CEER
Room Air Conditioners, With Louvered Sides	≥ 6,000 and < 7,900	13.7 CEER
Room Air Conditioners, With Louvered Sides	≥ 8,000 and < 13,900	16.0 CEER
Room Air Conditioners, With Louvered Sides	≥ 14,000 and < 19,900	16.0 CEER
Room Air Conditioners, With Louvered Sides	≥ 20,000 and < 27,900	13.8 CEER
Room Air Conditioners, With Louvered Sides	≥ 28,000	13.2 CEER
Room Air Conditioners, Without Louvered Sides	< 6,000	12.8 CEER
Room Air Conditioners, Without Louvered Sides	≥ 6,000 and < 7,900	12.8 CEER
Room Air Conditioners, Without Louvered Sides	≥ 8,000 and < 10,900	14.1 CEER
Room Air Conditioners, Without Louvered Sides	≥ 11,000 and < 13,900	13.9 CEER
Room Air Conditioners, Without Louvered Sides	≥ 14,000 and < 19,900	13.7 CEER
Room Air Conditioners, Without Louvered Sides	≥ 20,000	13.8 CEER
Room Air Conditioner Heat Pumps With Louvered Sides	< 20,000	14.4 CEER
Room Air Conditioner Heat Pumps With Louvered Sides	≥ 20,000	13.7 CEER
Room Air Conditioner Heat Pumps Without Louvered Sides	< 14,000	13.7 CEER
Room Air Conditioner Heat Pumps Without Louvered Sides	≥ 14,000	12.8 CEER

Casement-Only Room Air Conditioner	All Capacities	13.9 CEER
Casement-Slider Room Air Conditioner	All Capacities	15.3 CEER
Standard Sized PTAC (cooling mode)	All Capacities	13.4 - (0.300 x Cap/1000) = EER2
Non-Standard Sized PTAC (cooling mode)	All Capacities	10.5 - (0.213 x Cap/1000) = EER2
Standard Sized PTHP (cooling mode)	All Capacities	13.4 - (0.300 x Cap/1000) = EER2
Non-Standard Sized PTHP (cooling mode)	All Capacities	10.4 - (0.213 x Cap/1000) = EER2
SPVAC (cooling mode)	< 65,000	11.0 EER
SPVAC (cooling mode)	≥ 65,000 and < 135,000	10.0 EER
SPVAC (cooling mode)	≥ 135,000 and < 240,000	10.0 EER
SPVHP (cooling mode)	< 65,000 Btu/h	11.0 EER
SPVHP (cooling mode)	≥ 65,000 and < 135,000	10.0 EER
SPVHP (cooling mode)	≥ 135,000 and < 240,000	10.0 EER

Cap. = Cooling Capacity (Btu/h)

Note: Including room air conditioners and room air conditioner heat pumps, package terminal air conditioners (PTAC), package terminal heat pumps (PTHP), single-package vertical air conditioners (SPVAC), and heat pumps (SPVHP).

Source: California Appliance Efficiency Regulations Title 20, Table B-2, B-3, B-4; Energy Code

Insulation for Refrigerant Lines in Split-System Air Conditioners

Reference: 150.0(j)2, 150.0(m)9

Two refrigerant lines connect the indoor and outdoor units of split-system air conditioners and heat pumps. These are the liquid line (the smaller diameter tube) and the suction line (the larger diameter tube).

If the liquid line remains at an elevated temperature relative to outdoor and indoor temperatures, it should not be insulated. In this situation, the heat loss 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) as specified in Table 120.3-A-1 and 120.3-A-2 of the Energy Code.

Insulation used for refrigerant suction lines located outside a condition 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.

Figure 4-1: Refrigerant Line Insulation

Source: Airex Manufacturing Inc.

Outdoor Condensing Units

Reference: 150.0(h)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 shall not be placed within 5 feet of a dryer vent. This requirement is applicable to new installations and to replacements. Regardless of location, condenser coils should be cleaned regularly in all homes. 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 4-2: Refrigerant Line Insulation

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 contaminates 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, which makes it difficult for technicians to access. Because of this difficulty, manufacturers have begun changing this practice by installing liquid line filter dryers outside condensers, so that 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.

Cooling System Controls

Reference: §150.0(h)9, §150.0(i)2

Variable or multi-speed heat pumps and air conditioners, even when they are controlled by third-party thermostats (thermostats that are made to be used with any system, and are not proprietary to the HVAC manufacturer), must be capable of modulating system compressor speed in response to varying loads. In some cases, this may require special adapters that are provided by the HVAC manufacturer and must be configured by the installer. Thermostats used in these applications must meet thermostat requirements in §150.0(i)2. The intent of this requirement is to ensure 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. The installer must test this configuration using a procedure found on the Certificate of Installation, and certify that it meets these requirements.

Equipment Sizing

Reference: §150.0(h)1, 2, and 5

Similarly to heating systems, inappropriately sized cooling equipment typically operates less efficiently and can create comfort problems due to excessive cycling and improper airflow. Ensuring appropriate sizing requires attention in two areas: 1) Load Calculation, and 2) System Selection.

Load Calculation

The Energy Code requires that cooling loads be calculated for new space cooling systems. Acceptable load calculation procedures include methods described in the following publications:

- ACCA Manual J
- The SMACNA Residential Comfort System Installation Manual
- The ASHRAE Handbook – Equipment, Applications, and Fundamentals Volumes

Load Calculations are sensitive to the appropriate selection of outdoor and indoor Design Conditions. The Energy Code requires that the indoor design temperature for cooling load calculations shall be 75 °F.

The outdoor design conditions for load calculations are to be selected from one of the following sources:

- Reference Joint Appendix (JA) JA2,
- The ASHRAE Handbook, Fundamentals Volume, or
- ACCA Manual J.

The outdoor design temperature for cooling must be equal to the 1.0 percent Cooling Dry Bulb and Mean Coincident Wet Bulb values for the project city. If the actual city location for a project is not included in Joint Appendix (JA) 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 prepared by 1) a mechanical engineer, 2) the mechanical contractor who is installing the equipment or 3) someone who is qualified to do so in the State of California according to Division 3 of the Business and Professions Code, such as an energy consultant.

The California Business and Professions Code allows an unlicensed person to prepare plans, drawings, or specifications for wood-framed single-family residential buildings if the dwellings are no more than two stories, not counting a possible basement, or for certain buildings containing no more than four dwelling units of wood-frame construction not more than two stories and basement in height.

System Selection

Reference: §150.0(h)5

In general, ACCA Manual S-2023 shall be used for system selection. Note that there is no lower limit on the size of an air conditioner, since meeting cooling loads is not a requirement of the CBC.

Hole for Static Pressure Probe (HSPP) or Permanently Installed Static Pressure Probe (PSPP)

Reference: §150.0(m)13

Space-conditioning systems that use forced air ducts to cool occupiable space shall have a hole for the placement of a static pressure probe (HSPP) or permanently installed static pressure probe (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 (RA) RA3.3. The HSPP or PSPP is 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 ECC-Raters to drill holes in the supply plenum for placement of pressure measurement probes.

The size and placement of the HSPP/PSPP shall be in accordance with RA3.3.1.1 and shall be verified by an ECC-Rater. In the event that 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. Not installing an HSPP/PSPP will limit the airflow measurement method to either a powered flow hood or passive (traditional) flow hood.

When the mandatory measure for minimum system airflow rate is in effect (for entirely new systems), there must be a hole in the supply plenum, provided by the installing contractor, for the placement of a HSPP. Alternatively, a PSPP must be installed in the same location.

This 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 ECC-Rater.

See Air Distribution System Ducts, Plenums, Fans, and Filters for discussion regarding mandatory sizing/airflow requirements for ducted systems with cooling.

Prescriptive Requirements for Cooling Equipment

Reference: §150.1(c)7

Prescriptive compliance does not require that a cooling system be installed. However, if a cooling system is to be installed, the minimum cooling equipment efficiency requirements apply (See Mandatory Measures for Cooling Equipment).

Prescriptive requirements for air-cooled air conditioners in Climate Zones 2 and 8 – 15 and air-source heat pumps installed in any Climate Zone necessitate the installation of a measurement access hole (MAH), refrigerant charge verification (RCV), and minimum system airflow verification. The minimum system airflow installation and RCV must be performed by the installer and/or ECC-Rater. The MAH provides a nonintrusive means of measuring return air temperature, which is a parameter important to the RCV process.

Note: The refrigerant charge verification is discussed below (Refrigerant Charge Verification (RCV)) and in greater detail later in Refrigerant Charge.

Measurement Access Hole (MAH)

Please refer to Chapter 4.3.2.1 of the 2022 Single-family Residential Compliance Manual.

The MAH provides a nonintrusive means for refrigerant charge verification by ECC-Raters and other third-party inspectors. They eliminate the need for raters/inspectors to drill holes into the installed air conditioning equipment enclosures for placement of the temperature sensors required by the refrigerant charge verification test procedures described in 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 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)

Minimum System Airflow

Please refer to Chapter 4.3.2.2 of the 2022 Single-family Residential Compliance Manual.

Refrigerant Charge Verification (RCV)

Reference: Table 150.1-A

The prescriptive standards require that an ECC-Rater verify that ducted air-cooled air conditioners in climate zones 2 and 8 – 15, and ducted air-source heat pumps, small- duct high-velocity systems; and mini-split systems in all climate zones have the correct refrigerant charge. The RCV procedures are documented in RA1.2, RA2.4.4, and RA3.2.

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). *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.

Performance Compliance Options for Cooling Equipment

Please refer to Chapter 4.3.3 of the 2022 Single-family Residential Compliance Manual.

High-Efficiency Air Conditioner

Air conditioner efficiencies are explained in the Equipment Efficiency section of the Cooling Equipment section. 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 by using cooling equipment that exceeds the minimum efficiency requirements which can be used to offset less efficient building features.

The EER2 is the full-load efficiency at specific operating conditions. It is possible that two units with the same SEER2 can have different EER2s. In cooling-dominated 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 (Table 4-6: Minimum Cooling Efficiencies for Central Air Conditioners and Heat Pumps (Cooling Capacity Less Than 65,000

Btu/h) (NR = No Requirement)). When credit is taken for a high EER2 and/or SEER2, field verification by an ECC-Rater is required. (See RA3.4.4).

Air Handler Fan Efficacy and System Airflow

Please refer to Chapter 4.3.3.2 of the 2022 Single-family Residential Compliance Manual.

Whole-House Fan Ventilation Cooling

Please refer to Chapter 4.3.3.3 of the 2022 Single-family Residential Compliance Manual.

A whole-house fan (WHF) is not a mandatory requirement. It is required in some climate zones when using prescriptive compliance. The three performance compliance options are the following:

- No WHF is assumed in the performance compliance software (no ventilation cooling). Whether or not the applicable climate zone assumes the effects of a WHF will affect the energy usage simulated in the model.
- A default WHF means this proposed feature is equivalent to the standard feature used to establish the energy budget of the building (The performance of the fan is derated to account for deficiencies from installing undersized or inefficiently designed WHF).
- The ECC-verified WHF option allows for modeling the effects of the WHF without derating the system performance. The ECC-verified option also allows modeling a WHF with a higher airflow rate or lower fan efficacy than the default, which improves the compliance credit.

Central Fan Ventilation Cooling

Central fan ventilation cooling (CFVC) performs a function similar to a whole-house fan (WHF) using the central space-conditioning ducts to distribute outside air. When using the performance compliance approach, a CFVC system may be selected instead of a conventional whole-house fan in the compliance software. Three compliance options are:

- No CFVC is assumed in the performance compliance software (no ventilation cooling). Whether or not the applicable climate zone assumes the effects of a WHF will affect the energy usage simulated in the model.
- A default CFVC system means the proposed system is equivalent in size and features to a derated WHF.
- The ECC-verified CFVC system option allows system performance without derating. It also allows for modeling a system with greater capacity, a higher airflow rate or lower fan efficacy than default.

After installation, the contractor must test the actual fan power and airflow of the system using the procedure in RA3.3 and show that it is equal to or better than what was proposed in the compliance software analysis.

Field verification by an ECC-Rater is required. (See RA3.3.)

Air Distribution System Ducts, Plenums, Fans, and Filters

Air distribution system performance can have a big effect on overall HVAC system efficiency. Therefore, air distribution systems are required to meet several mandatory and prescriptive requirements as discussed below.

The 2025 Energy Code specifies mandatory requirements for air distribution ducts to be sealed and tested in all climate zones. There are also several compliance credits available related to duct system design.

Duct efficiency is affected by the following parameters:

- Duct location (e.g., attic, crawlspace, basement, inside conditioned space, etc.).
- Specific conditions in the unconditioned space, for example, presence of a radiant barrier.
- Duct insulation characteristics.
- Duct internal surface area.
- Air leakage of the duct system.

In performance calculations, duct efficiency can be calculated in one of two ways:

- Default input assumptions.
- Diagnostic measurement values.

The computer program will use default assumptions for the proposed design when the user does not intend to make improvements in duct efficiency.

Mandatory Measures for Air Distribution System Ducts, Plenums, Fans, and Filters

Minimum Insulation

Reference: §150.0(m)1B

Space conditioning supply-air and return-air ducts and plenums are required to have a minimum duct insulation level of R-6, except for when the duct or plenum is located in conditioned space or in an unvented attic as described below.

For duct systems located entirely in conditioned space, the ducts do not require insulation. To determine whether ducts are entirely in conditioned space as defined in §100.1, a, ECC-Rater must field verify by visual inspection and by using the protocols of RA 3.1.4.3.8.

For duct systems located in unvented attics meeting the three requirements of Exception 2 to 150.0(m)1Bi, ducts must be insulated to a minimum of R-4.2. The three conditions that must be met in order to qualify for this exception are:

- Minimum R-30 insulation between the roof rafters in contact with the roof deck;
- Gable ends meet the wall insulation requirements of 150.1(c)1B; and,
- Dwelling unit meets 3.0 ACH50 air leakage or less, as confirmed by field verification and diagnostic testing with the attic hatch open in accordance with RA3.8.

For duct systems located in both unconditioned and conditioned space, the portions of the duct system located in conditioned space are not required to be insulated if all of the following conditions are met and visually confirmed by the building inspector:

- The non-insulated portion of the duct system is located below the ceiling that separates the occupiable space from the attic and is entirely inside the building’s thermal envelope.
- At all locations where the non-insulated portions of the duct system penetrate into unconditioned space, the penetration must be draft stopped in compliance with California Fire Code (CFC) Sections 703.1 and 704.1. The penetration must also be air-sealed to the

construction materials that are penetrated using materials compliant with California Mechanical Code (CMC) Section E502.4.2 to prevent air infiltration into the building cavity. Any connections in the unconditioned space must be insulated to a minimum R-6.

CFC sections 703.1 and 704.1 require that materials and firestop systems used through penetrations in fire-resistance-rated construction, construction installed to resist the passage of smoke, and materials and systems used to protect joints and voids in the following locations must be maintained.

- Joints in or between fire-resistance-rated walls, floors or floor/ceiling assemblies and roof or roof/ceiling assemblies.
- Joints in smoke barriers.
- Voids at the intersection of a horizontal floor assembly and an exterior curtain wall.
- Voids at the intersection of a horizontal smoke barrier and an exterior curtain wall.
- Voids at the intersection of a nonfire-resistance-rated floor assembly and an exterior curtain wall.
- Voids at the intersection of a vertical fire barrier and an exterior curtain wall.
- Voids at the intersection of a vertical fire barrier and a nonfire-resistance-rated roof assembly.

The materials and systems must be securely attached to or bonded to the construction being penetrated or the adjacent construction, with no openings visible through or into the cavity of the construction.

CMC E502.4.2 requires that all joints, seams, and penetrations of duct systems must be made airtight by means of mastics, gasketing, or other means.

RA 3.1.4.3.8 describes the test of duct leakage to outside that determines whether the ducts are within the pressure boundary of the space being served by the duct system. Also, a basic visual inspection of the ducts is required to ensure 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.

Exception to §150.0(m)1: Ducts and fans integral to a wood heater or fireplace are exempt from §150.0(m)1.

Reference: §150.0(m)5

For determining the installed R-value of duct insulation based on thickness, when not an integral part of a manufacturer-labeled, insulated duct product such as vinyl flex duct, the following shall be used:

For duct wrap, the installed thickness of insulation must be assumed to be 75 percent of the nominal thickness due to compression.

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

Connections and Closures

Please refer to Chapter 4.4.1.2 of the 2022 Single-family Residential Compliance Manual.

Factory-Fabricated Duct Systems

Please refer to Chapter 4.4.1.3 of the 2022 Single-family Residential Compliance Manual.

Field-Fabricated Duct Systems

Please refer to Chapter 4.4.1.4 of the 2022 Single-family Residential Compliance Manual.

Draw Bands Used With Flexible Duct

Please refer to Chapter 4.4.1.5 of the 2022 Single-family Residential Compliance Manual.

Aerosol-Sealant Closures

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

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

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

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 an ECC-Rater may examine ducts installed in these building spaces 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.

Reference: §150.0(m)2D, §150.0(m)3D

Duct systems may not use cloth-backed, rubber-adhesive duct tape (typical, "old fashioned," nonrated duct tape) unless it is installed in combination with mastic and draw bands. Mastic and draw bands alone are adequate for sealing most connections. Cloth–backed, rubber-adhesive duct tape may be used to hold the outer vapor barrier in place or for some purpose other than prevention of duct leakage. Cloth-backed rubber adhesive duct tape alone is not adequate to serve as an air-sealing method or as a mechanical connection.

The enforcement of these minimum standards is normally the responsibility of the building official; however, ECC-Raters will also verify compliance with this requirement in conjunction with duct leakage verification.

Product Markings

Please refer to Chapter 4.4.1.7 of the 2022 Single-family Residential Compliance Manual.

Dampers to Prevent Air Leakage

Please refer to Chapter 4.4.1.8 of the 2022 Single-family Residential Compliance Manual.

Protection of Insulation

Reference: Section 150.0(m)9

Insulation must be protected from damage, including damage from sunlight, moisture, equipment maintenance, and wind, but not limited to the following:

- Insulation exposed to weather must be suitable for outdoor service – for example, 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 shields from solar radiation that can degrade the material.

If ducts are in the soil beneath the slab or embedded in the slab, the insulation material should be designed and rated for such installation. Insulation installed in below-grade applications should resist moisture penetration. (Closed-cell foam is one moisture-resistant product.) Common premanufactured duct systems are not suitable for below-grade installations. If concrete is to be poured directly over the ducts, then the duct construction and insulation system should be sturdy enough to resist the pressure and not collapse. Insulation should be of a type that will not compress, or it should be inside a rigid duct enclosure. The only time that common flex ducts are suitable in a below-grade application is when a channel is provided in the slab.

Porous Inner Core Flex Duct

Please refer to Chapter 4.4.1.11 of the 2022 Single-family Residential Compliance Manual.

Duct System Sealing and Leakage Testing

Please refer to Chapter 4.4.1.12 of the 2022 Single-family Residential Compliance Manual.

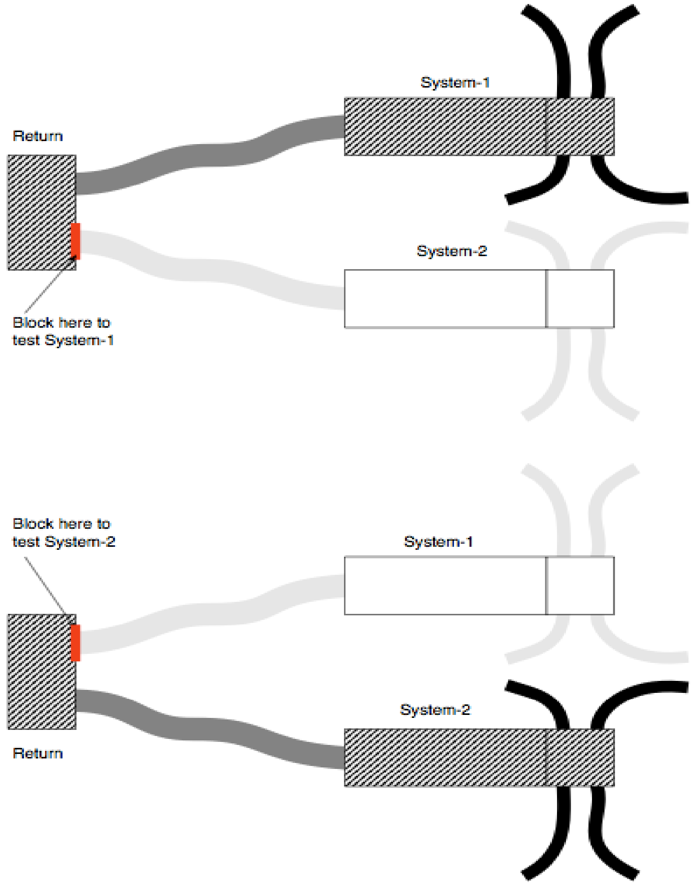
Duct Leakage Testing for Multiple Duct Systems With Common Return Ducts

If there are two or more duct systems in a building that are tied together at a common return duct, then each duct system should be tested separately, including the shared portion of the return duct system in each test. Under this scenario, the portions of the second duct system that is not being tested must be completely isolated from the portions of the ducts that are being tested, so the leakage from second duct system does not affect the leakage rate from the side that is being tested. Note that multiple dwelling units may not share ducted returns per CMC 311.4.

Figure 4-3: Two Duct Systems with a Common Return Duct represents the systems that are attached to a shared return boot or remote return plenum. In this case, the point in the return system that needs to be blocked off is readily accessible through the return grille.

The "duct leakage averaging," where both systems are tested together as though it is one large system and divided by the combined tonnage to get the target leakage, may not be used as it allows a duct system with more than 5 percent leakage to pass if the leakage of the combined system is 5 percent or less.

Figure 4-3: Two Duct Systems with a Common Return Duct



Source: California Energy Commission

Air Filtration

Please refer to Chapter 4.4.1.14 of the 2022 Single-family Residential Compliance Manual.

Air Filter Pressure Drop

Please refer to Chapter 4.4.1.14.1 of the 2022 Single-family Residential Compliance Manual.

Air Filter Particle Removal Efficiency Requirements – MERV 13

Please refer to Chapter 4.4.1.14.2 of the 2022 Single-family Residential Compliance Manual.

Air Filter Requirements for Space-Conditioning Systems

Reference: Section 150.0(m)12B

Space-conditioning systems may use any of the three following compliance approaches:

- Install a filter grille or accessible filter rack that accommodates a minimum 2-inch depth filter and install the appropriate filter.
- Install a filter grille or accessible filter rack that accommodates a minimum 1" depth filter and install the appropriate filter. The filter/grille must be sized for a velocity of ≤ 150 ft per minute. The installed filter must be labeled to indicate the pressure drop across the filter at the design airflow rate for that return is ≤ 0.1 inch water column (w.c. [25 PA]).
- Use the following method to calculate the 1" depth filter face area required. Divide the design airflow rate (ft^3/min) for the V filter grille/rack by the maximum allowed face velocity 150 ft/min. This yields a value for the face area in ft^2. Since air filters are sold

using nominal sizes in terms of inches, convert the face area to in^2 by multiplying the face area (ft^2) by a conversion factor of 144 in^2/ft^2. Summarizing:

Filter Nominal Face Area (in^2) = airflow (CFM) ÷ 150 x 144   Equation 4.4 1

Comply with Energy Code Tables 150.0-B and C, which prescribe the minimum total system nominal filter face area and return duct size(s). The installed filter must be labeled to indicate the pressure drop across the filter at the design airflow rate for that return is ≤ 0.1 inch w.c. (25 PA). This option is an alternative to the Section 150.0(m)13 requirement for ECC-verified fan efficacy and airflow rate but requires instead ECC-Verification of the return duct design.

Air Filter Requirements for Ventilation Systems

Please refer to Chapter 4.4.1.14.4 of the 2022 Single-family Residential Compliance Manual.

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

Please refer to Chapter 4.4.1.14.5 of the 2022 Single-family Residential Compliance Manual.

Air Filter Selection

Please refer to Chapter 4.4.1.14.6 of the 2022 Single-family Residential Compliance Manual.

Preventing Bypass

Please refer to Chapter 4.4.1.14.7 of the 2022 Single-family Residential Compliance Manual.

Forced-Air System Duct Sizing, Airflow Rate, and Fan Efficacy

Reference: Section 150.0(m)13

Adequate airflow is critical for cooling equipment efficiency. Further, it is important to maintain adequate airflow without expending excessive fan power.

Section150.0(m)13 requires system airflow and watt draw to be ECC-verified. See RA3.3 for the applicable ECC-verification procedures.

Forced-air systems that provide cooling must comply with either the airflow rate and fan efficacy verification, or may comply with the return duct design specifications given in Tables 150.0-B and C.

Airflow and watt draw measurement and determination of fan efficacy:

When using the airflow (CFM/ton) and fan efficacy (watt/CFM) method, the following criteria must be met:

- Provide airflow through the return grilles that is equal to or greater than
    - 350 CFM per ton of nominal cooling capacity for systems that are not small-duct high-velocity systems.
    - 250 CFM per ton for small duct, high velocity systems.

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 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.

- At the same time, the fan watt draw must be less than or equal to:
    - 0.45 watts per CFM for gas furnaces.
    - 0.58 watts per CFM for air handling units that are not gas furnaces.
    - 0.62 watts per CFM for small duct, high velocity systems.

The methods for measuring the air-handling unit watt draw are described in RA3.3. Three acceptable apparatuses are:

- A portable watt meter.
- An analog utility revenue meter.
- A digital utility revenue meter.

Note: When measuring fan watt draw in package air conditioners or heat pumps, it is recommended to use a portable true power clamp-on meter to

provide flexibility for isolating the correct fan wires. These meters may need to be high-voltage-capable.

There are three acceptable methods for determining compliance with the system airflow requirement. They are described in RA3.3 and use one of the following:

- An active or passive flow capture hood to measure the total airflow through the return grill(s).
- Flow grid device(s) at the return grill(s) or other location where all the central fan airflow passes through the flow grid.
- Fan flow meter device (also known as a duct blaster) to perform the plenum pressure matching procedure.

The flow grid and the fan flow meter methods both require access to static pressure measurements of the airflow exiting the cooling coil, which requires use of a HSPP or PSPP (Section RA3.3.1.1).

The contractor must install either a hole for the placement of a static pressure probe (HSPP) or provide a permanently installed static pressure probe (PSPP) as shown in RA3.3.

The HSPP or PSPP simplifies cooling coil airflow measurement when using devices/procedures that depend on supply plenum pressure measurements.

Return Duct System Design Method. This method allows the designer to specify, and the contractor to install, a system that does not have to be tested for airflow and fan efficacy. This method can be used for systems with either one, or two return grilles. Each return shall not exceed 30 feet 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 degrees of bend. To use this method, the designer and installer must provide return system sizing that meets the appropriate criteria in Energy Code Table 150.0-B and C.

Airflow and Fan Efficacy Testing Versus Return Duct Sizing

Please refer to Chapter 4.4.1.16 of the 2022 Single-family Residential Compliance Manual.

Return Duct Sizing Example

Please refer to Chapter 4.4.1.17 of the 2022 Single-family Residential Compliance Manual.

Zonally Controlled Central Forced-Air Heating and Cooling Systems

The primary purpose of zoning HVAC systems is to improve comfort. 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 house with room location, position of the sun, and occupancy. For example, it is common for two-story homes to be too hot on the second floor in summer and winter. Zoning has the capability of diverting more of the HVAC capacity to the area with the increased load. Another common example is a home with a significant area of west-facing and east-facing windows. In the summer, the east rooms overheat in the morning, and the west rooms overheat in the afternoon. Providing the most agreeable temperature to all the zones aids comfort and with proper equipment selection and design execution can save energy.

The typical way zone systems operate is when the temperature of any zone deviates from the zone thermostat setpoint, the zone control opens the damper, and the HVAC system is triggered to operate in the appropriate mode (heating or cooling). Adding zoning to single speed systems is problematic because if only one damper opens, the air handler will not be able to deliver all its air to that zone due to pressure restrictions, and blower motor energy use will likely increase. The reduced airflow also lowers the sensible efficiency of heat pumps and air conditioners, and elevated duct pressures can increase leakage.

Bypass ducts and dampers that connect the supply plenum to the return plenum are sometimes used in single speed zoned systems to maintain airflow through the blower, but they significantly compromise heat pump heating and air conditioner cooling efficiency. For example, in cooling mode the lower airflow will cause the indoor coil (evaporator) to be much colder. The compressor will not be able to deliver its maximum capacity and condensation on the coil may even freeze, blocking all airflow. For these reasons, compliance calculations penalize bypass ducts.

Section 150.1(c)13 of the standards prohibits the use of bypass ducts prescriptively. They may be used but compliance software will adjust simulated energy usage due to the reduced airflow.

A better alternative to bypass dampers for single-speed zoned systems is to provide a “dump zone” that does not include a zone damper, and to carefully design the duct system. The ducts with zone dampers can be oversized such that the system can deliver the required 350 cfm per ton and meet efficacy requirements (0.45 W/cfm for furnaces and air conditioners and 0.58 W/cfm for heat pumps). §150.0(m)13C requires that zonally controlled forced-air cooling systems be demonstrated to meet these efficacy requirements “in every zonal control mode”, meaning with only the damper in the smallest zone open.

Exception 1 to §150.0(m)13C allows airflow and fan efficacy to be tested in all zonal control modes if a variable speed compressor with controls that vary fan speed subject to the number of zones is installed. However, this exception also allows these systems to operate at maximum speed with all zones calling for conditioning. All major HVAC system manufacturers offer products that can vary fan speed in accordance with the number of zones calling. These systems deliver the greatest efficiency and quality.

Zonally Controlled Cooling Systems Compliance

Zoning Credit for Heating System

Compliance software allows for a "heating zonal control credit" if sleeping and living areas are separately zonally controlled. Non-closeable opening areas between living and sleeping zones must be less than 40 ft^2 and each zone must have a return air register. This credit applies only to furnaces, not heat pumps. Separate systems may be used to earn this credit.

If an air conditioner is installed that uses the furnace air handler to distribute heat, then the air handler and zonally controlled duct system must pass the efficacy testing described below. If tested airflow is lower than 350 cfm, then the heating credit for zoning referred to above will be adjusted based on the reduced cooling airflow.

Zoning with Air Conditioners and Heat Pumps

Recent studies have verified that zonally controlled cooling systems with or without bypass dampers using a single air handler usually do not meet the airflow and fan efficacy (AF/FE) requirements when fewer than all zones are calling. The resulting energy usage of the system can be greater than the benefit of having zonal control. Note that the energy usage adjustments in compliance software only applies to cooling systems, though it should also apply to heat pump heating systems because they are similarly affected by reduced airflow.

If zoning is accomplished by using two or more separate systems instead of one air handler with zone dampers, the software applies the most LSC energy-consuming system to both zones. Thus, it is unwise to install multiple heat pump systems that include an excessive amount of strip heat in any of the air handlers.

If the system is modeled by performance compliance software as a zoned system with a single-speed compressor, the airflow defaults to 150 CFM/ton. Because the standard house is assumed to have an airflow of 350 CFM/ton, there is an adjustment made to the compliance calculation unless the designer specifies a value of 350 CFM/ton or higher. Entering a value between 150 and 350 CFM/ton will result in changes in the simulated energy usage but the airflow must be ECC-verified. It is extremely important that the energy consultant model airflow and fan efficacy values that are reasonable and can be verified by an ECC-Rater. Otherwise, the system will fail verification, and the compliance calculations will have to be revised to include an airflow that is equivalent to the value that is measured by the ECC-Rater. For these reasons, energy consultants should coordinate with the HVAC designer before registering the certificate of compliance. For example,

- A home is to be built with a heat pump with a single-speed compressor, connected to a system with two zones and bypass ducts. From experience, the HVAC contractor knows that it will not be possible to meet the 350 CFM/ton requirement, but 275 CFM/ton is likely. 275 CFM/ton must be verified in all control modes.
- The energy consultant models the system in the proposed house with 275 CFM/ton and 0.45 W/CFM fan efficacy (0.45 W/cfm is standard for a gas furnace and 0.58 W/cfm for a heat pump). Because the standard house assumes 350 CFM/ton, there are adjustments made to simulated energy usage that must be made up by including other better-than-

standard features in the performance compliance input, but the changes in simulated energy usage are not as large as it would be with a default airflow of 150 CFM/ton.

- The home is built, and the system is verified to have an airflow of 287 CFM/ton with one zone calling and 372 CFM/ton with both zones calling. With one zone calling the fan energy is measured to be 165 Watts and an efficacy of 0.575 W/cfm is calculated. The system meets both the 350 CFM/ton total airflow and 0.58 W/cfm requirement when operated with one zone open.
- If this same home was to be built with a multispeed compressor, it would be tested only with all zones calling, and the target airflow would be no less than the mandatory 350 CFM/ton. Compliance credit can be achieved by modeling airflows greater than the mandatory CFM/ton and/or fan efficacies less than the mandatory watts/CFM.

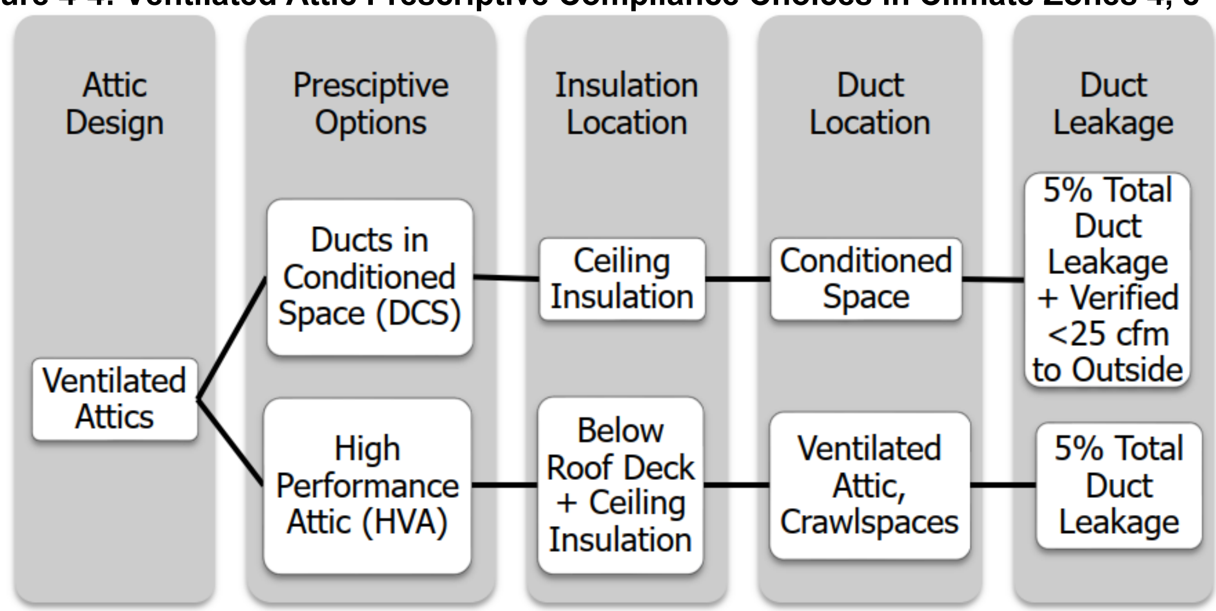
Indoor Air Quality and Mechanical Ventilation

Please refer to Chapter 4.4.1.20 of the 2022 Single-family Residential Compliance Manual.

Prescriptive Requirements for Air Distribution System Ducts, Plenums, and Fans

The Energy Code is designed to offer flexibility to the builders and designers of residential newly constructed buildings in achieving the intended energy efficiency targets. As such, several options are offered for achieving one of two design objectives related to improving energy performance of homes built with ventilated attics in Climate Zones 4, and 8 – 16, as shown in Figure 4-2: Ventilated Attic Prescriptive Compliance Choices in Climate Zones 4, 8 – 16.

Figure 4-4: Ventilated Attic Prescriptive Compliance Choices in Climate Zones 4, 8 – 16



Source: California Energy Commission

A high-performance attic (HPA) implements measures that minimize temperature difference between the attic space and the conditioned air being transported through ductwork in the attic. The package consists of insulation below the roof in addition to insulation at the ceiling, R-8 duct insulation, and 5 percent total duct leakage of the nominal air handler airflow. These requirements and approaches to meet the requirements are explained in Chapter 3 of this manual.

Ducts in conditioned space (DCS) is achieved when the ducts and air handler(s) are within the thermal envelope and air barrier of the building. This DCS option requires field verification to meet the prescriptive requirement. The following sections describe the duct related requirements for DCS.

Duct Location

Reference: §150.1(c)9

A typical residential construction practice in California is to place ducts and associated air handling equipment in the attic. When meeting the prescriptive requirements, there are two options for where this equipment can be located:

- If meeting the prescriptive requirements for a high-performance attic (HPA) as explained above, the duct system and air handlers of HVAC systems are allowed to be located in the attic.
- If meeting the prescriptive requirements for ducts in conditioned space (DCS) as explained above, the duct system and air handlers of HVAC systems must be located in entirely conditioned space, which includes a joist cavity between conditioned floors, or in a sealed cavity below attic insulation. For dwelling units with attics, the duct system and air handlers of HVAC systems shall be located below the ceiling separating the occupiable space from the attic.

If the DCS requirements are to be met, additional requirements apply:

- Air handlers containing a combustion component should be direct-vent (sealed combustion chambers) and shall not use air from conditioned space as combustion air. Other types of combustion heating systems are possible given the system installer adheres to the combustion air requirements found in Chapter 7 of the California Mechanical Code.
- Duct leakage to outside needs to be confirmed by field verification and diagnostic testing in accordance with RA3.1.4.3.8.
- Ducts are insulated to a level required in Table 150.1-A.

Figure 4-5: Checklist for Prescriptive Requirement − Option C DCS (§ 150.1(c)1)

§150.1(c)1
Option C

- ☐ Vented attic
- ☐ R30 or R38 ceiling insulation (climate zone specific)
- ☐ R6 ducts (climate zone specific)
- ☐ Radiant Barrier
- ☐ Verified ducts in conditioned space

Source: California Energy Commission

The checklist in Figure 4-3: Checklist for Prescriptive Requirement – Option C DCS (§ 150.1(c)1) lists all the requirements for complying prescriptively using a DCS strategy. It is not enough to locate ducts in conditioned space, the insulation must also meet prescriptive values. If a building is not able to meet all of the requirements in this checklist, it must use the performance approach or Option B from Section 150.1(c).1. Refer to Chapter 3 for more information on these options.

There are several methods of achieving the goal of DCS including:

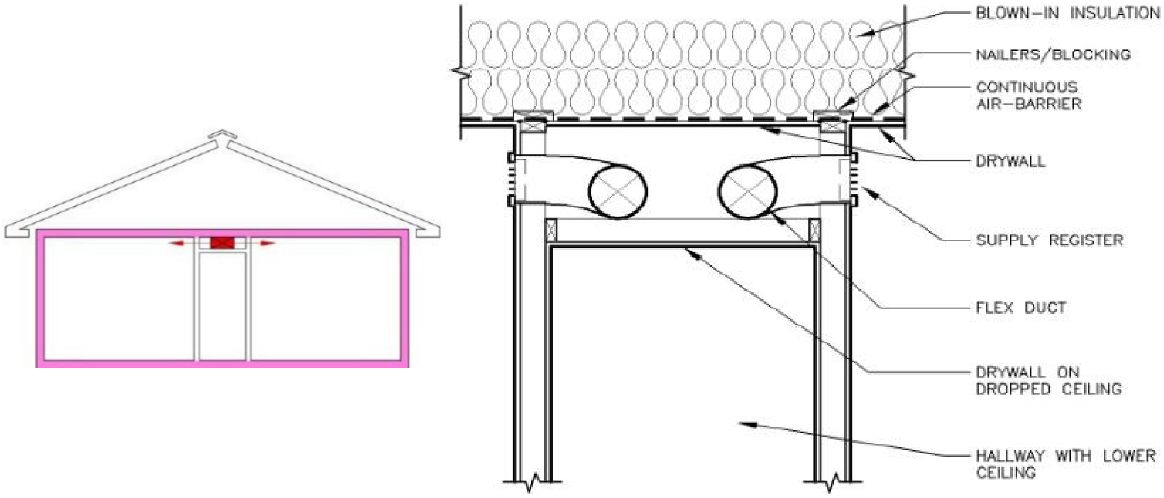
- Vented Attic, Dropped Ceiling,
- Vented Attic, Conditioned Plenum Space, and,
- Vented Attic, Open Web Floor Truss.

An overview of the strategies, related benefits, challenges, and potential solutions to those challenges are outlined below.

Vented Attic, Dropped Ceiling

This strategy places ducts within the thermal envelope without affecting the standard construction of the attic space. This strategy works well in linear plans where rooms branch out from a central hallway with a dropped ceiling.

Figure 4-6: Ducts in Conditioned Space Using a Dropped Ceiling



Source: www.ductsinside.org/

Figure 4-7: Ducts Routed Through a Dropped Ceiling

Source: BIRA Energy

Benefits of selecting this strategy include the following:

- Attic ventilation remains the same as standard practice.
- This strategy does not affect attic assembly or insulation; there are no changes to truss design.
- The strategy works with simple and linear designs with rooms off the main hallway but can also work with more complex plans.
- The strategy can be integrated into architectural accents.

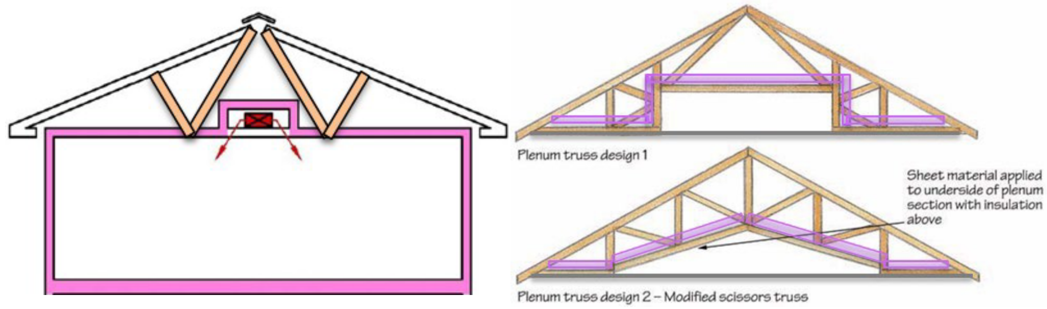
There are challenges associated with this strategy as outlined below, but they can be overcome with good design and installation practices.

- Air handler location – there may not be sufficient space (height, width) in the dropped ceiling to accommodate the air handler. In this case, the air handler would need to be installed in a separate closet within the thermal boundary of the home.
- Coordination needed between trades – installation of the ducts and air handlers and with isolating and sealing the dropped ceiling requires coordination between different trades (HVAC installer, drywall, framing, and electrical contractors) to ensure thermal integrity of the dropped ceiling.

Vented Attic, Conditioned Plenum Space

A conditioned plenum is created when a space within the attic is sealed off and insulated from the rest of the attic. To use this design option, a builder can specify two types of modified trusses: either scissor trusses or a truss configuration that creates a plenum box. Another way to create a conditioned plenum does not involve modified trusses, but rather creates the space by framing, sealing and insulating the plenum space above the ceiling plane.

Figure 4-8: Plenum Truss Design Example



Source: www.ductsinside.org

Similar to a dropped ceiling, this design is easier with a linear plan that allows the conditioned space in the attic to cover a central "spine" throughout the floor plan that can reach all spaces in need of supply registers. This design option allows for ducts in the attic space and does not affect aesthetics of the home.

Benefits of selecting this strategy include the following:

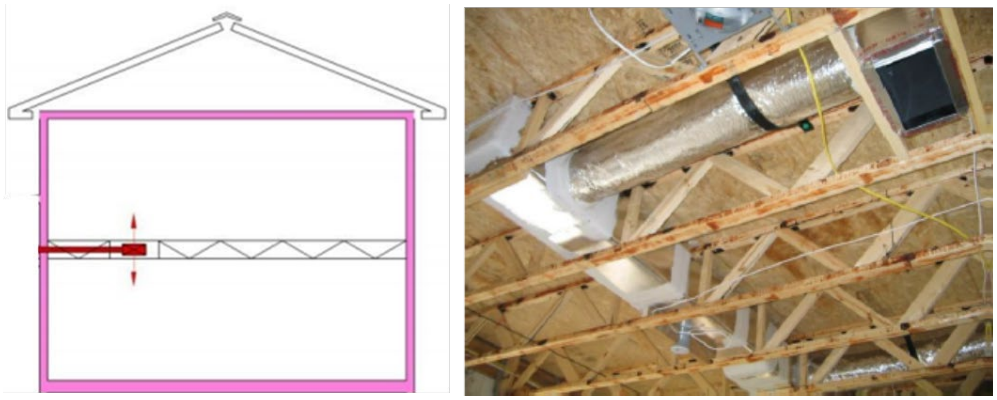
- Vented attic space, same as standard construction.
- Aesthetically less disruptive than a dropped ceiling.
- Works with simple and linear designs with rooms off main hallway.

There are challenges associated with this strategy as outlined below, but they can be overcome with good design and installation practices.

- Need to seal the plenum from attic – as with most of the DCS strategies, it is important that care and attention are provided to air-sealing the plenum space from the attic space.
- May require modified trusses, in which case manufacturers need to be provided with specifications that can be met.

Vented Attic, Open Web Floor Truss

Figure 4-9: Open Web Floor Truss Example



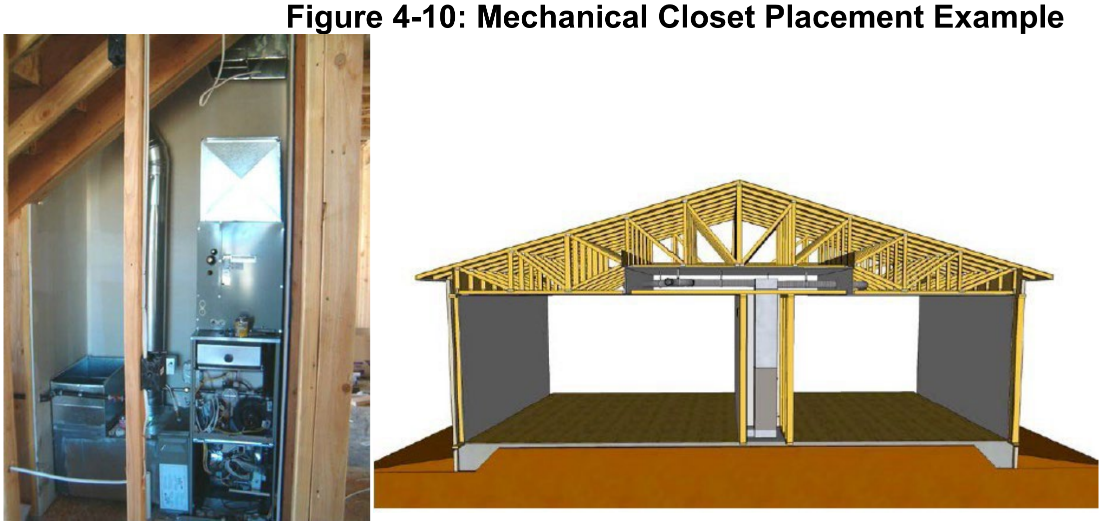
Source: www.ductsinside.org

This option can work for two-story construction and makes use of the space between floors to house ducts. Open-web floor trusses are uncommon in residential construction but are available from several floor joist manufacturers. The depth of floor joists may need to be increased to create a large enough space for supply ducts. The increased joist depth may affect interior details and wall heights. Because of the size constraints from using the floor truss, there is a need to preserve construction quality and prevent undesirable construction practices such as forcing 14-inch ducts into 12-inch joist spaces. Another option is to use alternatives to wire helix plastic flexible ducts that take up less space. Coordination between the architect and the HVAC engineer and/or contractor is needed to ensure that ducts are correctly sized and truss depths are appropriately selected.

Using the area between floors to house ducts prescribes that supply registers be at the floor or lower wall in the second story and the ceiling or upper wall in the first story.

Mechanical Closet and Placement of Sealed Combustion Furnace

Figure 4-10: Mechanical Closet Placement Example



Source: IBACOS 2013

As part of the requirement for moving the duct system and air handler into a conditioned space, construction of a mechanical closet is necessary with some DCS strategies. For example, if ducts are placed in dropped ceiling space but there is not enough room to accommodate the air handler in that space, the mechanical closet could be placed inside the thermal boundary of the building. A conditioned plenum could provide enough space for ducts and equipment; in which case, a mechanical closet may not be needed.

One potential location for a mechanical closet is within the garage or other normally unconditioned spaces. In such instances, the air handler must be located within a specially built closet that is insulated to the same level as the exterior of the house so that the closet is not a part of the unconditioned space. Combustion air for the air handler must be taken directly from the outside through a direct vent to the outside.

Duct Insulation

Reference: Section 150.1(c)9

All ducts shall be insulated to a minimum installed level as specified by Table 150.1- A, which requires either R-6 or R-8 depending on the climate zone and whether Option B or Option C is chosen for roof/ceiling Insulation. The prescriptive duct insulation requirement can be opted out by using the performance approach and trading off increased energy usage against some other features.

Central Fan-Integrated (CFI) Ventilation

Please refer to Chapter 4.4.2.3 of the 2022 Single-family Residential Compliance Manual.

Compliance Options for Air Distribution System Ducts, Plenums, and Fans

Please refer to Chapter 4.4.3 of the 2022 Single-family Residential Compliance Manual.

System Airflow and Fan Efficacy

A performance compliance credit is available for ECC verification of the installation of a high-efficiency air handler and duct system that performs better than the applicable mandatory requirements for minimum system airflow (CFM/ton) and maximum system fan efficacy (W/CFM). The performance compliance method allows the user's proposed airflow and fan efficacy to be entered into the program, and credit will be earned if the airflow is greater than the minimum required, and fan efficacy is lower than the default. After installation, the contractor must test the actual fan efficacy of each system using the procedure in RA3.3 and show that it is equal or less than what was proposed in the compliance software analysis.

The fan efficacy and airflow must also be verified by an ECC-Rater.

Duct Location

There are three ways to achieve credit for favorable duct location when using the performance compliance method:

- Credit is available if no more than 12 linear feet (LF) of duct are outside the conditioned space and the user chooses the high-performance attic (HPA) as explained in Chapter 3. This total must include the air handler and plenum lengths. This credit results in a reduction of duct surface area in the computer compliance programs. This option requires certification by the installer and field verification by an ECC-Rater.
- The second alternative applies when 100 percent of the ducts are located in conditioned space and the user chooses high-performance attic (HPA) as explained in Chapter 3. This credit results in eliminating the conduction losses associated with the return and supply

ducts; however, leakage rates still apply. This option requires field verification of the duct system by means of a visual inspection by an ECC-Rater.

- Credit for a high-efficiency duct design is available. This option requires field verification of the duct design layout drawing(s) by an ECC-Rater. Verified duct design, when required, will be included in the ECC Required Verification list on the certificate of compliance (CF1R). This approach provides energy savings credits for having shorter duct runs, fewer ducts, ducts in beneficial locations of ductwork, and other benefits of a well-designed duct system. This credit is available regardless of whether a high-performance attic (HPA) or ducts in conditioned space (DCS) option is chosen, as explained in Chapter 3.

There is no compliance credit provided for choosing a heating system such as a wall furnace, floor heater, or room heater, even though those systems typically have no ducts. For these cases, the standard design in the compliance calculation uses the same type of system and has no ducts. However, other systems, such as hydronic heating systems with a central heater or boiler and multiple terminal units, are considered central HVAC systems that are compared to a ducted system in the standard design. If the hydronic system has no ducts, there may be a significant energy credit through the performance method.

Duct Insulation

Please refer to Chapter 4.4.3.3 of the 2022 Single-family Residential Compliance Manual.

Diagnostic Duct Location, Surface Area, and R-value

This compliance option allows the designer to take credit for a high-efficiency duct design that incorporates duct system features that may not meet the criteria for the duct location and/or insulation compliance options described above. This method requires that the designer must enter the design characteristics of all ducts that are not within the conditioned space. The information required as input to the compliance software includes the length, diameter, insulation R-value, and location of all ducts. This method will result in a credit if the proposed duct system outperforms the standard design.

To claim this credit, the duct system design must be documented on plans that are submitted to the enforcement agency and posted at the construction site for use by the installers, the enforcement agency field inspector, and the ECC-Rater. The duct system must be installed in accordance with the approved duct system plans, and the duct system installation must be certified by the installer on the CF2R form and verified by an ECC-Rater on the CF3R. Details of this compliance option are described in the *Residential Alternative Calculation Method (ACM) Reference Manual*, and verification procedures are described in RA3.1.

Buried and Deeply Buried Ducts

Please refer to Chapter 4.4.3.5 of the 2022 Single-family Residential Compliance Manual.

Ducts in Attics with Radiant Barriers

Installation of a radiant barrier in the attic increases the duct efficiency by lowering attic summer temperatures. Compliance credit for radiant barriers is available in cases where the prescriptive standard does not require radiant barriers and requires listing of the radiant barrier in the special features and modeling assumptions to aid the local enforcement agency's inspections. Compliance credit for a radiant barrier does not require ECC-Rater verification.

Radiant barrier must be installed with the appropriate clearance and/or air gap as specified by the manufacturer. Insulation products installed in direct contact with the radiant barrier may negatively affect the performance of the radiant barrier. When a

credit is taken for radiant barrier, an improperly installed radiant barrier assembly will require revision of the CF1R compliance document to remove the energy compliance credit taken.

Duct Installation Standards

Please refer to Chapter 4.4.4 of the 2022 Single-family Residential Compliance Manual.

Tapes and Clamps

Please refer to Chapter 4.4.4.1 of the 2022 Single-family Residential Compliance Manual.

All Joints Must Be Mechanically Fastened

Please refer to Chapter 4.4.4.2 of the 2022 Single-family Residential Compliance Manual.

All Joints Must Be Made Airtight

Please refer to Chapter 4.4.4.3 of the 2022 Single-family Residential Compliance Manual.

Controls

Thermostats

Automatic setback thermostats can add comfort and convenience to a home. Occupants can wake up to a warm house in the winter and come home to a cool house in the summer without using unnecessary energy. See Heating System Controls and Cooling System Controls for more details.

Example 4-1

Question:

Am I exempt from the requirement for a thermostat if I have a gravity wall heater or any of the equipment types listed in the exception to §110.2(c)?

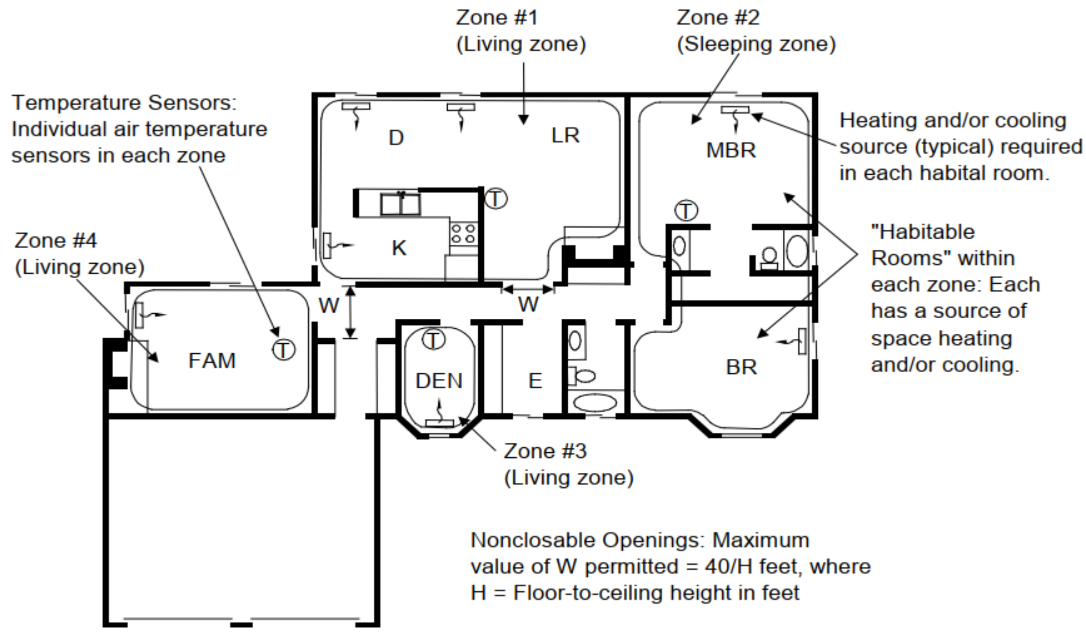
Answer:

Yes.

Zonal Control for Compliance Credit

An energy compliance credit is provided for zoned heating systems, which save energy by providing selective conditioning for only the occupied areas of a house. A house having at least two zones (living and sleeping) may qualify for this compliance credit. The equipment may consist of one heating system for the living areas and another system for sleeping areas or a single system with zoning capabilities, set to turn off the sleeping area zones in the daytime and the living area zones at night. (See Figure 4-9: Zonal Control Example)

Figure 4-11: Zonal Control Example



Source: Richard Heath & Associates/Pacific Gas and Electric Company

There are unique eligibility and installation requirements for zonal control to qualify under the Energy Code. The following steps must be taken for the building to show compliance with the Energy Code under this exceptional method:

- **Temperature Sensors**. Each thermal zone, including a living zone and a sleeping zone, must have air temperature sensors that provide accurate temperature readings of the typical condition in that zone.
- **Habitable Rooms**. For systems using central forced-air or hydronic heating, each habitable room in each zone must have a source of space heating, such as forced-air supply registers, radiant tubing, or a radiator. For systems using a combination of a central system and a gas-vented fireplace or other conditioning units, the zone served by the individual conditioning unit can be limited to a single room. Bathrooms, laundry, halls and/or dressing rooms are not habitable rooms.
- **Noncloseable Openings**. The total noncloseable opening area (W) between adjacent living and sleeping thermal zones (such as halls, stairwells, and other openings) must be less than or equal to 40 ft^2. All remaining zonal boundary areas must be separated by permanent floor-to-ceiling walls and/or fully solid, operable doors capable of restricting free air movement when closed.
- **Thermostats**. Each zone must be controlled by a central automatic dual-setback thermostat that can control the conditioning equipment and maintain preset temperatures for varying periods in each zone independent of the other. Thermostats controlling vented gas fireplace heaters that are not permanently mounted to a wall are acceptable as long as they have the dual- setback capabilities.

Other requirements specific to forced-air-ducted systems include the following:

- Each zone must be served by a return air register located entirely within the zone. Return air dampers are not required.
- Supply air dampers must be manufactured and installed so that when they are closed, there is no measurable airflow at the registers.

- The system must be designed to operate within the equipment manufacturer's specifications.
- Air is to positively flow into, though, and out of a zone only when the zone is being conditioned. No measurable amount of supply air is to be discharged into unconditioned or unoccupied space to maintain proper airflow in the system.

Although multiple thermally distinct living and/or sleeping zones may exist in a residence, the correct way to model zonal control for credit requires only two zones: a living zone and a sleeping zone. All separate living zone components must be modeled as one living zone; the same must be done for sleeping zones

As with cooling systems, zonally-controlled heat pump or furnace systems must be ECC verified to confirm they meet the mandatory fan efficacy and airflow requirements. Single-speed systems and variable-speed systems that do not have integrated controls must test in all zonal control modes. Variable-speed systems that utilize integrated controls that vary fan speed with respect to the number of zones calling for air may do these tests with the compressor on high speed and all zones calling for cooling.

Example 4-2

Question:

In defining the living and sleeping zones for a home with a zonally controlled HVAC system, can laundry rooms and bathrooms (which are not habitable spaces) be included on whichever zone they are most suited to geographically (for example, a bathroom located near bedrooms)?

Answer:

Yes. For computer modeling, include the square footage of any not habitable or indirectly conditioned spaces with the closest zone.

Example 4-3

Question:

I have two HVAC systems and want to take zonal control credit. Can the return air grilles for both zones be located next to each other in the 5 ft. wide by 9 ft. high hallway (in the same zone)?

Answer:

No. Because of the need to prevent mixing of air between the conditioned zone and the unconditioned zone, it is necessary to (1) have the return air for each zone within that zone, and (2) limit any noncloseable openings between the two zones to 40 ft^2 or less. Unless these criteria and the other criteria listed in this chapter can be met, credit for a zonally controlled system cannot be taken.

Example 4-4

Question:

Can a gas-vented fireplace be used for zonal control heating, and qualify for the zonal control credit?

Answer:

Gas-vented fireplaces that meet zonal control requirements may qualify for the zonal control credit.

Example 4-5

Question:

Does a gas-vented fireplace with a handheld remote thermostat meet the thermostat requirement for the two-zone modeling credit?

Answer:

Yes, as long as the thermostat has manual "on" to start, automatic setback capability, and temperature preset capability, it does not have to be permanently wall-mounted.

Indoor Air Quality and Mechanical Ventilation

Please refer to Chapter 4.6 of the 2022 Single-family Residential Compliance Manual.

Continuous Mechanical Ventilation for Indoor Air Quality

ASHRAE *Standard 62.2–Ventilation for Acceptable Indoor Air Quality in Residential Buildings* recognizes the need for controlled mechanical outdoor air supply in homes that are built tight for efficient space conditioning. Infiltration, or uncontrolled air leakage through the building, is highest during winter and lowest in mild weather, and too inconsistent to rely on for air exchange.

California's 2008 Energy Code adopted Standard 62.2-2007 with exceptions, and the 2013 Energy Code began requiring ECC field verification of airflow rates of residential indoor-outdoor (I-O) ventilation systems installed to meet this requirement. The 2025 Energy Code incorporates updated versions of Standard 62.2 and extends its requirements to multifamily and high-rise residential buildings.

Standard 62.2 requires two residential mechanical ventilation functions:

- Local exhaust fans in bathrooms and kitchens to remove most occupant-generated moisture and odors where and when they are generated.
- Whole-dwelling ventilation systems to automatically ensure an adequate amount of I-O air exchange year-round, regardless of window operation.

It also discusses the need for tightening building envelopes and preventing habitable spaces from drawing air from polluted spaces such as garages, attics, crawlspaces, adjacent dwellings, and other sources of outdoor air pollution.

Since the Energy Code requirement for mechanical ventilation is a continuous electrical end use in new homes, fan efficacy (in W/cfm fan flow) is one factor to consider when selecting a ventilation system.

Types of Mechanical Ventilation Systems

There are three basic ways to meet the whole-dwelling ventilation requirement.

- Exhaust-only systems remove indoor air and create some degree of negative indoor pressure (depressurization) that induces air infiltration of the building envelope through the paths of least resistance.
- Supply-only systems filter outdoor air from a known location before delivering it to a home; this creates some degree of positive pressure (pressurization) that can serve to both prevent infiltration and buffer against depressurization.
- Balanced ventilation systems use an exhaust fan and a supply fan that move approximately the same amount of air at the same time; these opposite airflows have little effect on indoor pressure, and cannot prevent the forces of wind, stack effect, and other fans from pressurizing or depressurizing a home.

Indoor pressures cannot be avoided. In fact, the tighter and more energy-efficient the building envelope, the higher indoor pressures can and will be. Airflow requires both a driving force and a pathway. Regardless of the degree of indoor pressure, infiltration cannot occur unless there are leakage sites or designated pathways for air to flow.

The building science principle “Build Tight, Ventilate Right” acknowledges that energy efficient homes require tight building envelopes that make it possible for a continuous low-cfm ventilation system to control indoor-outdoor air exchange.

Balanced systems do not create indoor pressure or neutralize indoor pressure. The advantage of a balanced mechanical ventilation system is the ability to incorporate an engineered heat exchanger core that passively transfers thermal energy between the outgoing exhaust airstream and incoming supply airstream. This reduces the cost of heating and cooling the incoming supply ventilation air.

However, balanced heat or energy recovery ventilation (HRV, ERV) systems cannot recover heat from air that infiltrates the home and bypasses the system’s core.

The remainder of this section describes minimum requirements for residential mechanical ventilation, which can be readily exceeded or improved upon by:

- Using local exhaust fans as needed to remove moisture and odors.
- Using source control to minimize air pollutants within the building.
- Operating the whole-dwelling fan continuously to minimize volatile organic compound (VOC) levels.

As residential buildings are tightened to improve energy performance, the dilution of indoor air through natural ventilation and infiltration has been reduced. As a result, the importance of controlling indoor pollutants and moisture generated and volatile organic compounds (VOCs) in homes has increased.

Energy Commission sponsored field research revealed that indoor concentrations of pollutants such as formaldehyde are higher than expected, and that many occupants do not open windows regularly for ventilation.

The Energy Code includes mandatory requirements for local mechanical exhaust and whole-dwelling unit mechanical ventilation to improve indoor air quality (IAQ) in homes and MERV 13 air filtration requirements for ventilation systems. As specified by §150.0(o), dwelling units must meet the requirements of ASHRAE Standard 62.2- 2019 including Addenda v and d (ASHRAE 62.2), subject to the amendments specified in Section 150.0(o)1. A copy of this version of ASHRAE 62.2 may be obtained at https://store.accuristech.com/ashrae/standards/california-energy-commission-adopted-version-of-ansi-ashrae-standard-62-2-2019?product_id=2033702.

Opening and closing windows and continuous operation of central fan-integrated ventilation systems are not allowable options for meeting dwelling unit ventilation requirements. The requirements of ASHRAE Standard 62.2 focus on providing continuous dwelling unit mechanical ventilation, as well as local exhaust ventilation at known sources of pollutants or moisture, such as kitchens, bathrooms, and laundries. The California Air Resources Board (CARB) provides guidance for reducing indoor air pollution in homes by selecting low-VOC building materials, finishes, and furnishings. For more information, see the CARB Indoor Air Quality Guidelines at https://ww2.arb.ca.gov/our-work/topics/indoor-air-quality-exposure.

This section covers mandatory requirements for mechanical ventilation of homes, the process of compliance and enforcement, including ECC-Verifications, and requirements specified by ASHRAE 62.2 as amended in the Energy Code.

Compliance with the whole-dwelling unit ventilation airflow specified in ASHRAE 62.2 is required in new dwelling units, in new dwelling units that are additions to an existing building except for junior accessory dwelling units, and in additions to existing dwelling units that increase the conditioned floor area of the existing dwelling unit by more than 1,000 square feet. Alterations to components of existing buildings that previously met any requirements of ASHRAE 62.2 must continue to meet requirements upon completion of the alteration(s).

The key requirements for most newly constructed buildings are summarized below:

- A whole-dwelling unit mechanical ventilation system shall be provided. Typical solutions are described in the Typical Solutions for Single-Family Dwelling Unit Ventilation section below. The airflow rate provided by the system shall be confirmed through field verification and diagnostic testing in accordance with the applicable procedures specified in RA3.7.
- Kitchens and bathrooms must have local exhaust systems vented to outdoors.
- Clothes dryer exhaust shall be vented to outdoors.

Additional indoor air quality design requirements include:

- Ventilation air shall come from outdoors and shall not be transferred from adjacent dwelling units, garages, unconditioned attics, or crawl spaces.
- Ventilation system controls shall be labeled, and the homeowner shall be provided with instructions on how to operate the system.
- Combustion appliances shall be properly vented to outdoors and exhaust systems shall be designed to prevent back drafting.
- Walls and openings between the house and attached garage shall be sealed or gasketed to prevent air exchange between the house and garage.
- Habitable rooms shall have operable windows with a free opening area of at least 4 percent of the floor area.
- Mechanical systems including space conditioning systems that supply air to habitable spaces shall have a MERV 13 or better filter and be designed to accommodate the air filter’s rated pressure drop at the designed airflow rate.

- Dedicated outdoor air inlets that are part of the ventilation system design shall be located away from known sources of outdoor contaminants.
- A carbon monoxide alarm shall be installed in each dwelling unit in accordance with the National Fire Protection Association (NFPA) Standard 720.
- Air-moving equipment used to meet the whole-dwelling unit ventilation requirement and local exhaust requirement shall be rated for airflow and sound:
  - Whole-dwelling unit ventilation and continuously operating local exhaust fans must be rated at a maximum of 1.0 sone.
  - Demand-controlled local exhaust fans must be rated at a maximum of 3.0 sones.
  - Kitchen exhaust fans must be rated at a maximum of 3.0 sones at one or more airflow settings greater than or equal to 100 CFM.
  - Remotely located air-moving equipment (mounted outside habitable spaces) are exempt from the sound requirements provided there is at least 4 feet of ductwork between the remote fan and interior grille.

Compliance and Enforcement

Compliance with ASHRAE 62.2 requirements must be verified by the enforcement agency, except for the following requirements that must be ECC verified in accordance with the procedures in Residential Appendix RA3.7:

- Whole-dwelling unit ventilation airflow rate.
- Home Ventilating Institute (HVI) or Association of Home Appliance Manufacturers (AHAM) ratings for kitchen local mechanical exhaust fan airflow or capture efficiency, and sound.

All applicable certificates of compliance, installation, and verification must be registered with an approved ECC-Provider.

Title 24 Part 6 amendments to ASHRAE 62.2 do not require a blower door measurement when calculating the dwelling unit mechanical ventilation rate (Qfan). Instead, the Qfan calculation applies a default infiltration leakage rate of 2 ACH50 (air changes per hour at 50 Pascals). Blower door measurement of actual dwelling unit enclosure leakage is required only when performance compliance modeling uses an infiltration leakage rate less than 2 ACH50 - which requires ECC-Verification of enclosure leakage for energy compliance and for determining Qfan.

If a central heating/cooling system air-handler fan is used to ventilate the dwelling (central fan-integrated ventilation, also known as CFI ventilation), the air-handler must be less than or equal to the mandatory fan efficacy criteria. This requires the installer to perform the test given in Reference Appendix RA3.3 and an ECC-Rater to verify the efficacy (W/CFM) of the central air-handler fan.

Certificate of Compliance Reporting Requirements

When using the prescriptive compliance approach, the mechanical ventilation rate (Qfan) must be calculated using the applicable equations in Energy Code Section 150.0(o)1, also shown in Typical Solutions for Single-Family Dwelling Unit Ventilation below. The value for Qfan must be reported on the CF1R. When using the performance compliance approach, the compliance model automatically calculates Qfan based on inputs for conditioned floor area, number of bedrooms, and climate zone, and uses the Qfan ventilation airflow value when calculating the building energy use. The performance certificate of compliance (CF1R-PRF-01) will report the following parameters for the whole- dwelling unit ventilation system:

- Minimum mechanical ventilation airflow rate (calculated value) that must be delivered by the system.
- Type of ventilation system (exhaust, supply, balanced, CFI).
- Fan efficacy (W/CFM) for the selected system.
- Recovery efficiency (%) applicable only to HRV or ERV systems.
- For CFI systems—ECC-Verification of air handler fan efficacy is required.

The installed dwelling unit ventilation system must conform to the performance requirements on the CF1R.

The local enforcement agency may require additional information/documentation describing the ventilation systems be submitted along with the CF1R at plan check.

Certificates of Installation and Verification Reporting Requirements

The builder/installer must complete two certificates of installation (CF2R-MCH-27 and CF2R-MCH-32) for the dwelling. The ECC-Rater must complete a certificate of verification (CF3R-MCH-27) for the dwelling.

CF2R-MCH-27

The following information must be provided on the CF2R-MCH-27 for each ventilation fan/system in the dwelling that will require ECC-Verification.

For dwelling unit ventilation systems:

- System type, name, and location.
- Control type.
- Minimum required continuous airflow rate.
- Ventilation fan or system manufacturer, and model number.
- Energy Commission certification number for variable system/control (if any).

For kitchen exhaust ventilation systems:

- Type of exhaust fan control (intermittent, demand-controlled, or continuous).
- Type of exhaust fan (range hood, over-the-range microwave, downdraft, other).
- Required airflow or capture efficiency.
- Manufacturer name and model number.

CF3R-MCH-27

Please refer to Chapter 4.6.3.2.3 of the 2022 Single-family Residential Compliance Manual.

Typical Solutions for Single-Family Dwelling Unit Ventilation

Please refer to Chapter 4.6.4 of the 2022 Single-family Residential Compliance Manual.

Exhaust Ventilation

Please refer to Chapter 4.6.4.1 of the 2022 Single-family Residential Compliance Manual.

Supply Ventilation

Please refer to Chapter 4.6.4.2 of the 2022 Single-family Residential Compliance Manual.

Central Fan-Integrated (CFI) Ventilation

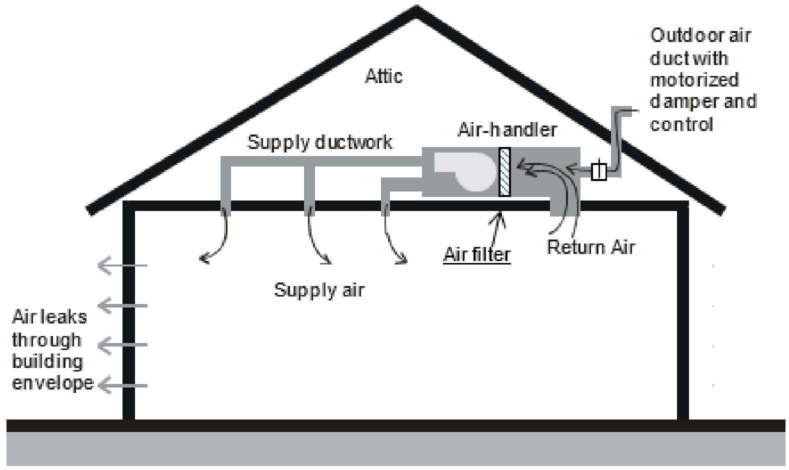
A central fan integrated (CFI) ventilation system is a configuration where the ventilation ductwork is connected to the space conditioning duct system, to enable distribution of ventilation air to the dwelling unit when the space conditioning system air handler is operating. This strategy mixes the outdoor 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. CFI ventilation systems are considered intermittent mechanical ventilation systems and must be certified to the Energy Commission as capable of meeting the minimum whole-dwelling unit ventilation requirements of Section 150.0(o).

A listing of certified CFI ventilation systems is posted at https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment.

The Energy Code includes the following requirements specific to CFI ventilation systems:

- Continuous Operation is Prohibited – The continuous operation of a space conditioning air handler is prohibited in providing whole-dwelling unit ventilation.
- 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.
- 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 either 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 4-12: Central Fan-Integrated (CFI) Ventilation Example



Source: California Energy Commission

Section 150.0(m)12 requires that outside air be filtered using MERV 13 (or greater) 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. 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 where the outside air enters the return plenum of the central fan.

When considering system design and ECC verification compliance for CFI ventilation systems, it is important to distinguish between the central forced-air system fan total airflow and the much smaller outdoor ventilation airflow rate. Both of these airflows must be verified by an ECC-Rater. Figure 4-10: Central Fan-Integrated (CFI) Ventilation Example. The total airflow through the air handler is the sum of the return airflow and the ventilation airflow. 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.

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 is required to have controlled motorized dampers that open only when outdoor air ventilation is required and close when outdoor air ventilation is not required. These dampers may be closed during duct leakage testing. See RA3.1.4.3 for duct leakage verification and diagnostic test protocols.

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.

Balanced Ventilation

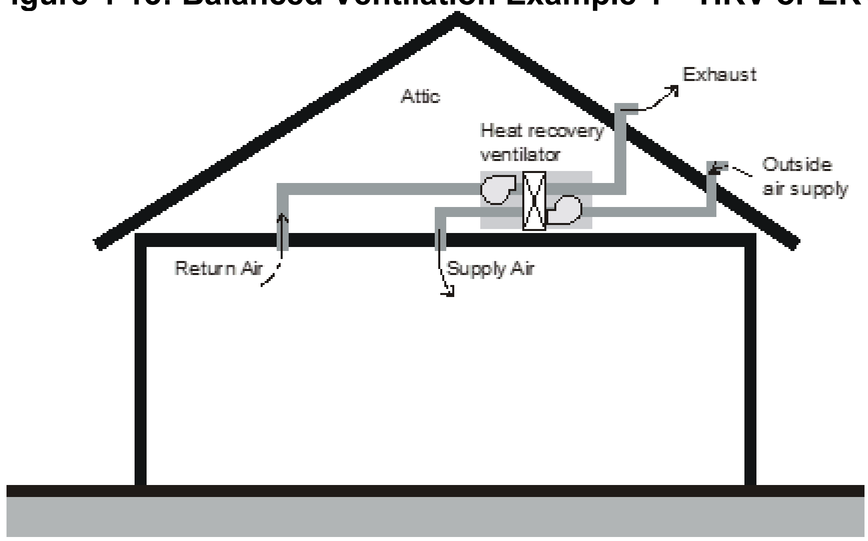
Balanced systems use an exhaust fan and a supply fan to move approximately the same volume of air into and out of a dwelling unit. To be considered a balanced ventilation system, the total supply airflow and the total exhaust airflow from all fans must be within 20 percent of each other. For determining compliance, the average of the supply and exhaust airflows is equal to the balanced system airflow rate. (Refer to RA3.7.4.1.2.)

A balanced system may include an indoor-outdoor air heat exchanger. This is called a Heat Recovery Ventilator (HRV). Another balanced system type that also exchanges moisture (humidity) is called an Energy Recovery Ventilator (ERV). These systems indirectly or directly temper incoming air with outgoing air, which reduces the thermal effect of ventilation on heating and cooling loads, but the dual fans also increase electrical energy use. They are most practical for use in tightly sealed houses and in multifamily units where exhaust type systems have difficulty drawing adequate outside air due to limited exterior wall area. Fault Indicator Displays (FID) are prescriptively required for HRV and ERV systems serving individual dwelling units with ECC-rater verification per Joint Reference Appendix JA17. An HRV or ERV without an FID may be used via the performance compliance method, but will receive less compliance credit than an HRV/ERV equipped with an FID.

Section 150.0(m)12 requires that outside air be filtered using MERV 13 (or greater) air filters. The filters must be accessible to facilitate replacement. An example of a heat recovery ventilator is shown in Figure 4-11: Balanced Ventilation Example 1 – HRV or ERV.

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

Figure 4-13: Balanced Ventilation Example 1 – HRV or ERV

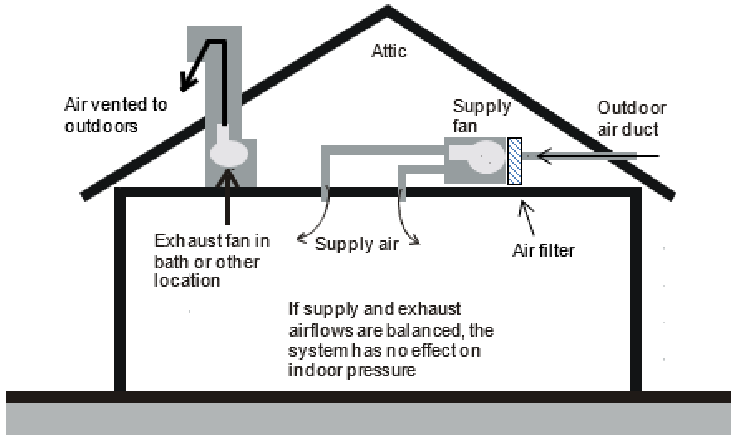


If supply and exhaust airflows are balanced, the system has no effect on indoor pressure

Source: California Energy Commission

Another balanced system configuration uses a stand-alone supply fan coupled with a stand-alone exhaust fan, both wired to a common switch or control to ensure they operate simultaneously. The controls must make it possible to adjust the speed of the fans for balancing the airflows within 20 percent. An example is shown in Figure 4-12: Balanced Ventilation Example 2 – Separate Supply and Exhaust Fan.

Figure 4-14: Balanced Ventilation Example 2 – Separate Supply and Exhaust Fan



Source: California Energy Commission

Source: California Energy Commission

Whole-Dwelling Unit Ventilation Airflow Measurement

Residential Appendix RA3.7.4 provides direction for field measurement of supply, exhaust, and balanced ventilation system types. These measurement procedures are applicable for ventilation systems that operate at a specific airflow rate or systems that are controlled to operate intermittently at a fixed speed (averaged over any three-hour period), according to a fixed schedule that is verifiable by an ECC-Rater on site. (Refer to ASHRAE 62.2 Section 4.5.1 Short Term Average Ventilation.)

Variable or intermittent operation that complies with ASHRAE 62.2 Sections 4.5.2 and 4.5.3 complies with the dwelling unit mechanical ventilation requirements by use of varying ventilation airflow rates based on calculations of relative exposure as specified in ASHRAE 62.2 Normative Appendix C. These calculation procedures provide the basis for "smart" ventilation controls implemented by use of digital controls that rely on the manufacturer's product-specific algorithms or software. Any ventilation system models that use these complex ventilation system controls in a ventilation product designed to be used to comply with Standards Section 150.0(o) must submit an application to the Energy Commission to have the ventilation technology approved. These manufacturers are expected to provide with their applications evidence that the system will perform to provide the required dwelling unit mechanical ventilation. The manufacturers are also expected to provide a method that could be used by an ECC-Rater to verify that an installed system is operating as designed.

Listings of systems approved by the Energy Commission are located at https://www.energy.ca.gov/rules-and-regulations/building-energy-efficiency/manufacturer-certification-building-equipment.

Dwelling Unit Ventilation Rate

Please refer to Chapter 4.6.6 of the 2022 Single-family Residential Compliance Manual.

Total Ventilation Rate (Qtot)

The total ventilation rate is the combined volume of ventilation air provided by infiltration and the mechanical ventilation provided from fans, as follows:

$$Q_{tot} = 0.03A_{Floor} + 7.5(N_{br} + 1)$$

Where,

- Q_tot = total required ventilation rate (CFM)
- A_floor = conditioned floor area (ft^2)
- N_br = number of bedrooms (not less than one)

Infiltration Rate (Qinf)

Please refer to Chapter 4.6.6.2 of the 2022 Single-family Residential Compliance Manual.

Required Mechanical Ventilation Rate (Qfan)

The required mechanical ventilation rate, Qfan is the total outside airflow required to be supplied to (or total indoor air required to be exhausted from) the building by fans. For balanced ventilation system, the average of the supply and exhaust airflows must be greater than or equal to Qfan.

Qfan is calculated using the equation below, which uses the values for Qtot and Qinf determined above. The equation below accounts for reduced exterior wall leakage area in attached units (e.g., townhomes and duplexes). It also accounts for the differences in ventilation effectiveness of balanced systems compared to exhaust/supply (unbalanced) systems due to varying dwelling infiltration leakage rates. If Qfan is less than 10 CFM, then no fan is required.

$$Q_{fan} = Q_{tot} - \varphi \times (Q_{inf} \times A_{ext})$$

Where,

- Q_{tot} = total required ventilation rate (CFM)
- Q_{inf}= effective annual average infiltration rate (CFM)
- φ = 1 for balanced ventilation systems or $\frac{Q_{inf}}{Q_{tot}}$ for other system types
- A_{ext} = 1 for single-family detached homes. For attached dwelling units not sharing ceilings or floors with other dwelling units, occupiable spaces, public garages, or commercial spaces (e.g., duplexes and townhomes), A_{ext} is the ratio of exterior envelope surface area that is not attached to garages or other dwelling units to total envelope surface area.

Example 4-6: Required Ventilation

Question:

What is the required continuous ventilation rate for a three-bedroom, 1,800 ft² 2-story townhouse located in climate zone 8 that has 9-foot ceilings, and where 25% of the exterior wall surface area adjoins another unit? Ventilation is provided by a bathroom exhaust fan. No extraordinary measures have been taken to seal the building.

Answer:

Equation 4-1 yields a total ventilation rate of 84 CFM.

$$Qtot = 0.03A_{floor} + 7.5(N_{br} + 1) = 0.03(1800) + 7.5(3 + 1) = 84\ CFM$$

The volume is 1,800 x 9 = 16,200 ft^3. Solving for Equation 4-2 results in a leakage rate of 540 CFM.

$Q_{50} = Vdu\ x\ \ 2\ ACH50/60 = 16{,}200\ x \frac{2}{60} = 540\ CFM$

Using Equation 4-3:

$Q_{inf} = 0.052\ x\ Q_{50}\ x\ wsf\ x\ (\frac{H}{H_r})^z = 0.052\ x\ 540\ x\ 0.36\ x\ (\frac{18}{8.2})^{0.4} = 14\ CFM$

The mechanical ventilation system must move 82 CFM.

$$Q_{fan} = Q_{tot} - \varphi \times (Q_{inf} \times A_{ext})$$

= 84 – (14/84)(14 x (1-0.25)) = 82 CFM

Due to the reduction in infiltration resulting from reduced exterior wall area and to the use of an exhaust fan instead of a balanced system, the effective infiltration credit is only 2 CFM.

Example 4-7

Question:

The two-story house I am building in Climate Zone 12 has a floor area of 2,240 ft² and four bedrooms. I am using an HRV that delivers 80 CFM of outdoor air and exhausts 90 cfm of indoor air. My calculations for required mechanical ventilation rate (Qfan) come out to 86 CFM. Can I use this system?

Answer:

No. For balanced systems, the supply and exhaust airflows can be averaged, and in this case, they average 85 CFM, which is slightly less than the required 86 CFM.

The nominal rating of a fan can be different than what it actually delivers when installed and connected to ductwork, so designers should always include a safety margin when sizing equipment. The length and size of ducting should be used to calculate the pressure drop. This is why dwelling unit ventilation rates must be verified by an ECC-Rater.

Example 4-8

Question:

A 2,300 ft² house has exhaust fans running continuously in two bathrooms, providing a total exhaust flow rate of 90 CFM, but the requirement is 98 CFM. What are the options for providing the additional 8 CFM?

Answer:

Option 1: The required additional CFM could be provided either by increasing the size of either or both exhaust fans such that the combined airflow exceeds 98 CFM.

Option 2: Another solution would be to use a balanced system, which may reduce the airflow requirement to below 90 CFM. Adding another 8 CFM fan is not an acceptable solution.

Example 4-9

Question:

A CFI system is connected to the return air plenum of a furnace such that when operating, 10% of the air supplied by the furnace is outdoor air. The CFI control limits furnace fan operation to 30 minutes of every hour. If the house requires 100 CFM of continuous ventilation air, what volume of air must the furnace deliver?

Answer:

Since the furnace operates half the time, the volume of outside air delivered when it is operating must be 2 x 100 = 200 CFM. Therefore, the furnace must be able to deliver 200/0.1 = 2,000 CFM.

Example 4-10

Question:

Can an exhaust fan be used to supplement ventilation air provided by a CFI system?

Answer:

Yes. In the example above, if an exhaust fan is operated continuously to deliver 50 CFM, then the volume of air required of the CFI system is reduced to 100 CFM, or an average of 50 CFM over the hour such that the sum of ventilation air delivered averages 100 CFM. A 1,000 CFM furnace providing 10% outside air could be used in this case. Even though such a combined ventilation system is partially balanced, it would not qualify as a balanced system in the calculation of Qfan.

Example 4-11

Question:

I want to provide controls that disable the ventilation system so it does not bring in outside air during the hottest two hours of the day, and the calculations show I need 80 CFM continuous. How large must my fan be?

Answer:

If the average rate over three hours is 80 CFM and the fan only operates one hour, then it must be capable of delivering 3 x 80 = 240 CFM. ASHRAE 62.2 does not allow averaging ventilation over more than a three-hour period.

Control and Operation

Please refer to Chapter 4.6.6.4 of the 2022 Single-family Residential Compliance Manual.

Whole-Dwelling Unit Mechanical Ventilation Energy Consumption

For builders using the performance compliance approach, the energy use of whole-dwelling unit ventilation fans is factored into the compliance of the proposed building. Proposed designs with lower fan efficacy, higher W/CFM, than the energy usage in the standard design will be adjusted and proposed designs with higher fan efficacy will get a compliance credit. Whole-dwelling unit ventilation airflow rate is also a factor in the performance approach. Proposed designs exceeding the standard design ventilation airflow rate, higher CFM than the standard, will see an adjustment in energy usage due to the additional fan energy. In most cases the standard design will match the proposed design ventilation rate and compliance will be neutral for airflow rate. However, the standard design will only match the proposed design airflow rate up to a limit and additional airflow will count against the proposed design energy budget. More information on the standard design ventilation fan efficacy and airflow rate limit can be found in the *Residential ACM Reference Manual*. For balanced heat recovery or energy recovery ventilators (H/ERVs), the HVI rated heat recovery efficiency can help offset higher fan energy use for balanced ventilation systems.

The fan efficacy of the central air handler used for a CFI ventilation system must conform to the same fan watt draw (W/CFM) limit as for cooling systems in all climate zones as verified by an ECC-Rater in accordance with the diagnostic test protocols given in RA3.3. The RA3.3 verification of CFI systems determines the W/CFM of the total central system airflow, not the W/CFM of the ventilation airflow.

The Energy Code does not regulate the energy use of ventilation fans installed for other purposes, such as local exhaust.

Central Fan-Integrated Ventilation Systems – Watt Draw

Please refer to Chapter 4.6.7.1 of the 2022 Single-family Residential Compliance Manual.

Other Whole-Dwelling Unit Ventilation Systems – Watt Draw

Using the prescriptive or performance compliance approach, the maximum mandatory fan efficacy for HRVs and ERVs is 1.0 W/CFM. This must be ECC verified in accordance with RA3.7.4.4. For balanced systems without heat recovery, exhaust, or supply ventilation fans there are no mandatory or prescriptive fan efficacy requirements.

When using the performance compliance approach, the airflow rate and fan watt draw of the fan must be entered into the compliance software. Values for airflow and fan W/CFM information may be available from the HVI directory at https://www.hvi.org/hvi-certified-products-directory/. If HVI does not list fan energy for the installed model, use information from the manufacturer's published documentation. When fan energy is listed as CFM/W instead of W/CFM, it is necessary to invert the value to provide W/CFM as input to the compliance software (for example: 4 CFM/ W = 1/4 W/CFM = 0.25 W/CFM).

Dwelling unit ventilation is not compliance neutral and performance compliance will be affected by the proposed design W/CFM, ventilation airflow rate, and heat recovery if present. Installation of designs exceeding the standard design W/CFM or ventilation rate will receive adjusted energy usage in building model simulations. More information on the standard design ventilation fan W/CFM and airflow rate can be found in the *Residential ACM Reference Manual*.

If an H/ERV is specified, the heat recovery efficiency of the proposed system must be entered into the compliance software so that the heat recovery effect can be accounted for in the compliance simulation. Many factors affect the benefit of heat recovery on ventilation, like climate zone and building design, but in general heat recovery will increase building compliance.

Local Mechanical Exhaust

Please refer to Chapter 4.6.8 of the 2022 Single-family Residential Compliance Manual.

Demand-Controlled (Intermittent) Local Exhaust

The Energy Code requires that local exhaust fans be designed to be operated by the occupant. This usually means that a wall switch or some other control is accessible and obvious. There is no requirement to specify where the control or switch needs to be located, but bathroom exhaust fan controls are generally located next to the light switch, and kitchen exhaust fan controls are generally integrated into the range hood or mounted on the wall or counter adjacent to the range hood.

Bathrooms can use a variety of exhaust strategies. They can use ceiling-mounted exhaust fans or may use a remotely mounted fan ducted to two or more exhaust grilles. Demand-controlled local exhaust can be integrated with the dwelling unit ventilation system to provide both functions. Kitchens can have range hood exhaust fans, down-draft exhausts, ceiling- or wall-mounted exhaust fans, or pickups for remote-mounted inline exhaust fans. Generally, HRV and ERV manufacturers do not allow exhaust ducting from the kitchen because of the presence of heat, moisture, grease, and particulates that should not enter the heat exchange core. Building codes require kitchen exhaust fans to be connected to metal ductwork for fire safety.

Example 4-12: Ducting Kitchen Exhaust to the Outdoors

Question:

How do I know what kind of duct I need to use? I've been using recirculating hoods my entire career, now I need to vent to the outdoors. How do I do it?

Answer:

A kitchen range hood or downdraft duct is generally a smooth metal duct that is sized to match the outlet of the ventilation device. It is often a six-inch or seven-inch-round duct, or the range hood may have a rectangular discharge. If it is rectangular, the fan will typically have a rectangular-to-round adapter included. Always use a terminal device on the roof or wall that is sized to be at least as large as the duct. Try to minimize the number of elbows used.

Example 4-13

Question:

How do I know what the requirements are in my area?

Answer:

Ask your code enforcement agency for that information. Some enforcement agencies will accept metal flex; some will not.

Control and Operation for Intermittent Local Exhaust

The choice of control is left to the designer. It can be a manual switch or automatic control like an occupancy sensor. Some exhaust fans have multiple speeds, and some fan controls have a delay-off function that operates the exhaust fan for a set time after the occupant leaves the bathroom. New control strategies continue to come to the market. The only requirement is that there is a control.

Title 24, Part 11 may specify additional requirements for the control and operation of intermittent local exhaust.

Ventilation Rate for Demand-Controlled Local Exhaust

Cooking is a regularly occurring activity inside a home that causes indoor pollution. The most effective method of 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 2022 Energy Code incorporated a metric for local exhaust called capture efficiency. Capture efficiency is defined as the fraction of emitted tracer gas that is directly exhausted by a range hood.

To adequately capture the moisture, particulates, and other products of cooking and/or combustion in kitchens, the Energy Code requires minimum ventilation rates or capture efficiencies in Table 4-9: Demand-Controlled Local Ventilation Exhaust Airflow Rates (from Table 150.0 -E) and Table 4-10: Demand-Controlled Local Ventilation Exhaust Airflow Rates (from Table 150.0). Only in kitchens that are enclosed, 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 requirements of ASHRAE Standard 62.2.

Table 4-9: Demand-Controlled Local Ventilation Exhaust Airflow Rates (from Table 150.0 -E)

Application	Airflow
Enclosed Kitchen	• Vented range hood (including appliance-range hood combinations): capture efficiency or airflow rate specified in Table 4-10: Demand-Controlled Local Ventilation Exhaust Airflow Rates (from Table 150.0). • Other kitchen exhaust fans, including downdraft: 300 CFM (150 L/s)
Non-Enclosed Kitchen	• Vented range hood (including appliance-range hood combinations): capture efficiency or airflow rate specified in Table 4-10. • Other kitchen exhaust fans, including downdraft: 300 CFM (150 L/s)
Bathroom	• 50 CFM (25 L/s)

Source: California Energy Commission

Table 4-10: Demand-Controlled Local Ventilation Exhaust Airflow Rates (from Table 150.0-G)

Dwelling Unit Floor Area (ft^2)	Hood Over Electric Range	Hood Over 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: California Energy Commission

The Energy Code requires verification that range hoods are HVI or AHAM-certified to provide at least one speed setting at which they can deliver at least 100 CFM at a noise level of 3 sones or less. Verification must be in accordance with the procedures in RA3.7.4.3. Range hoods that have a minimum airflow setting exceeding 400 CFM are exempt from the noise requirement.

Ratings for Local Exhaust Fans are listed at the following web pages:

- Home Ventilating Institute (HVI) at https://www.hvi.org/hvi-certified-products-directory/
- Association of Home Appliance Manufacturers (AHAM) at https://www.aham.org/AHAM/What_We_Do/Kitchen_Range_Hood_Certification

ASHRAE Standard 62.2 limits exhaust airflow when atmospherically vented combustion appliances are located inside the pressure boundary. This is particularly important to observe when large range hoods are installed. Refer to Combustion and Solid-Fuel Burning Appliances below for more information.

Example 4-14: Ceiling or Wall Exhaust vs Demand-Controlled Range Hood in an Enclosed Kitchen

Question:

I am building a house with an enclosed kitchen that is 12 ft. x 14 ft. with a 10 ft. ceiling. What size ceiling exhaust fan or range hood fan is required?

Answer:

If a range hood exhaust is not used, either a minimum 300 CFM demand-controlled local ventilation exhaust airflow or a minimum 5 ACH continuous local ventilation exhaust airflow is required. The kitchen volume is 12 ft. x 14 ft. x 10 ft. = 1,680 ft^3. Five air changes requires a flow rate of 1,680 ft^3 x 5/ hr. ÷ 60 min/hr = 140 CFM. So, this kitchen must have a ceiling or wall exhaust fan of 140 CFM. Otherwise, a vented range hood fan that provides at least the required minimum air flow in Table 4-10: Demand-Controlled Local Ventilation Exhaust Airflow Rates (from Table 150.0) according to the dwelling unit size and the type of range is required.

Continuous Local Exhaust

Please refer to Chapter 4.6.8.2 of the 2022 Single-family Residential Compliance Manual.

Other Requirements (Section 6 of ASHRAE 62.2)

Adjacent Spaces and Transfer Air

Please refer to Chapter 4.6.9.1 of the 2022 Single-family Residential Compliance Manual.

Instructions and Labeling

Please refer to Chapter 4.6.9.2 of the 2022 Single-family Residential Compliance Manual.

Clothes Dryers

Please refer to Chapter 4.6.9.3 of the 2022 Single-family Residential Compliance Manual.

Combustion and Solid-Fuel Burning Appliances

Please refer to Chapter 4.6.9.4 of the 2022 Single-family Residential Compliance Manual.

Garages

Please refer to Chapter 4.6.9.5 of the 2022 Single-family Residential Compliance Manual.

Ventilation Opening Area

Please refer to Chapter 4.6.9.6 of the 2022 Single-family Residential Compliance Manual.

Habitable Spaces

Please refer to Chapter 4.6.9.7 of the 2022 Single-family Residential Compliance Manual.

Minimum Filtration

Please refer to Chapter 4.6.9.8 of the 2022 Single-family Residential Compliance Manual.

Air Inlets

Please refer to Chapter 4.6.9.9 of the 2022 Single-family Residential Compliance Manual.

Air-Moving Equipment (Section 7 of ASHRAE 62.2)

Please refer to Chapter 4.6.10 of the 2022 Single-family Residential Compliance Manual.

Selection and Installation

Please refer to Chapter 4.6.10.1 of the 2022 Single-family Residential Compliance Manual.

Sound Ratings for Fans

Please refer to Chapter 4.6.10.2 of the 2022 Single-family Residential Compliance Manual.

Airflow Measurements and Airflow Ratings

Please refer to Chapter 4.6.10.3 of the 2022 Single-family Residential Compliance Manual.

Exhaust Ducts

Please refer to Chapter 4.6.10.4 of the 2022 Single-family Residential Compliance Manual.

Supply Ducts

Please refer to Chapter 4.6.10.5 of the 2022 Single-family Residential Compliance Manual.

Alternative Systems

Hydronic Heating Systems

Please refer to Chapter 4.7.1 of the 2022 Single-family Residential Compliance Manual.

Mandatory Requirements

Please refer to Chapter 4.7.1.1 of the 2022 Single-family Residential Compliance Manual.

Prescriptive Requirements

Please refer to Chapter 4.7.1.2 of the 2022 Single-family Residential Compliance Manual.

Performance Compliance Options

Credit for choosing a hydronic heating system is possible using the performance compliance method. The standard design is assumed to have a heat pump in all climate zones. In all cases, the system is of minimum efficiency rating with a ducted air distribution system.

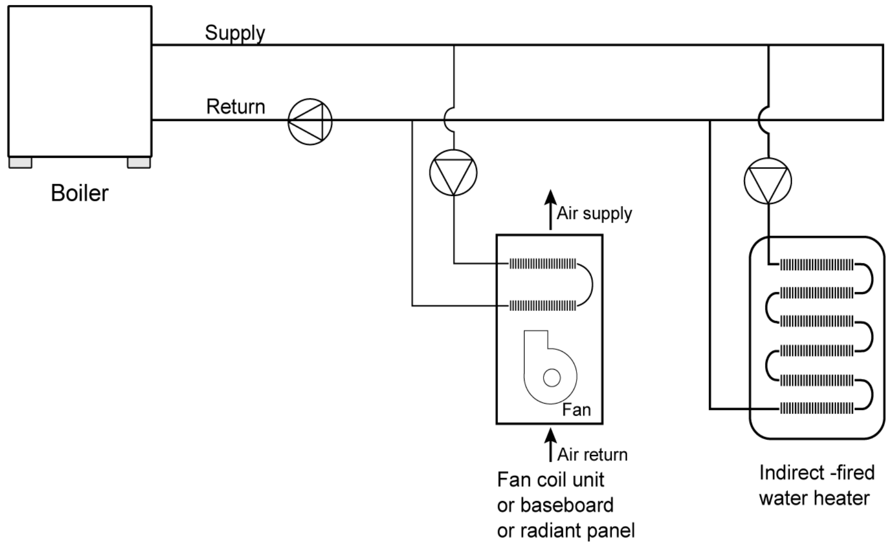
Therefore, hydronic systems without ducts can take credit for avoiding duct leakage. In addition, minimizing the amount of pipe outside conditioned space will provide some savings. Hydronic heating and cooling compliance calculations are described in the *Residential ACM Manual*.

If the proposed hydronic system includes ducted air distribution, then the associated compliance options described earlier in this chapter may apply, such as improved airflow (if there is air conditioning) and supply duct location.

A "combined hydronic" system is another compliance option that is possible when using the performance compliance method. *Combined hydronic heating* refers to the use of a single water heating device as the heat source for space and domestic hot water heating.

Combined hydronic systems may use either a boiler (as in the figure below), heat pump, or a water heater as a heat source. The boiler heats domestic water by circulating hot water through a heat exchanger in an indirect-fired water heater. The water heater provides domestic hot water as usual.

Figure 4-15: Combined Hydronic System With Boiler and Indirect Fired Water Heater



Source: Richard Heath & Associates/Pacific Gas and Electric Company

Space heating is accomplished by circulating water from the heat source through the space heating delivery system. Sometimes a heat exchanger is used to isolate potable water from the water circulated through the delivery system. Some water heaters have built-in heat exchangers for this purpose.

For performance compliance calculations, the water-heating function of a combined hydronic system is analyzed for water-heating performance as if the space-heating function were separate. For the space-heating function, an "effective" AFUE or HSPF2 rating is calculated. These calculations are performed automatically by the compliance software.

Radiant Floor System

Please refer to Chapter 4.7.2 of the 2022 Single-family Residential Compliance Manual.

Evaporative Cooling

Evaporative coolers cool a building by passing outdoor air through a wetted evaporative medium (direct evaporative cooler), by indirect cooling through a nonporous heat exchanger separating evaporatively cooled secondary air from outdoor air, or by a system that combines an indirect heat exchanger with a downstream direct evaporative process. Direct evaporative cooling is not allowed for compliance. The indirect and indirect-direct systems offer generally lower supply air temperatures with less moisture introduced to the indoor space. For the Energy Code, performance credit is allowed only for indirect and indirect-direct evaporative cooling systems. All coolers receiving credits within the *Residential ACM Manual* must be listed in the Energy Commission's Title 20 Evaporative Cooler appliance database at https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx.

Evaporative coolers may be used with any compliance approach. In the prescriptive compliance approach, all evaporative coolers are treated as a minimum efficiency 14.3 SEER2 air conditioner.

In the performance compliance approach, the compliance software uses an hourly model based on unit effectiveness, supply airflow, and power to determine the magnitude of the credit based on climate conditions and unit sizing relative to the loads. Typical cooling budget credits are 20-30 percent, depending upon these factors.

The evaporative cooling system must meet the following requirements to receive credit based on the hourly performance method described above. Indirect and indirect-direct coolers not meeting these criteria, shall be modeled as a minimum efficiency (14.3 SEER2) central air conditioner.

- The equipment manufacturer shall certify to the Energy Commission that water use does not exceed 7.5 gallons per ton hour based on the Title 20 Appliance Efficiency Regulations testing criteria.
- Equipment shall be permanently installed (no window or portable units).
- Installation shall provide for automatic relief of supply air from the house with maximum air velocity through the relief dampers not exceeding 800 feet per minute (at the Title 20 rated airflow). Pressure relief dampers and ductwork shall be distributed to provide adequate airflow through all habitable rooms. For installations with an attic, ceiling dampers shall be installed to relieve air into the attic and then outside through attic vents. For installations without an attic, sidewall relief dampers are acceptable.
- To minimize water consumption, bleed systems are not allowed.
- A water quality management system (either "pump down" or conductivity sensor) is required. "Pump down" systems can either be integral to the evaporative cooler or they can be accessories that operate on a timed interval. The time interval between pumps shall be set to a minimum of 6 hours of cooler operation. Longer intervals are encouraged if local water quality allows. Automatic systems that use conductivity sensors provide the best water efficiency compared to a timed pump down system. These sensors monitor the water quality and don't unnecessarily drain the water based on elapsed time.
- Automatic thermostats are required. Manual on/off controls are not allowed.
- If the evaporative cooler duct system is shared with a heating and/or cooling system, the installed duct system shall employ backdraft dampers at the evaporative cooler supply.
- The installing contractor must provide a winter closure device that substantially blocks outdoor air from entering the indoor space.
- The size of the water inlet connection at the evaporative cooler shall not exceed 3/8 inch.
- Unless prohibited by local code, the sump overflow line shall not be directly connected to a drain and shall terminate in a location that is normally visible to the building occupants.

Example 4-15

Question:

How are applications with vapor compression cooling systems and evaporative cooling systems handled?

Answer:

In situations where evaporative cooling system(s) and vapor compression system(s) are installed in a house, the size of the evaporative cooler will dictate the magnitude of the credit. The performance approach will ensure that an evaporative cooler sized to meet most of the cooling loads will generate a higher credit than one sized to meet a fraction of the design cooling load.

Example 4-16

Question:

How do you model multiple evaporative coolers on one house?

Answer:

In situations with multiple evaporative coolers, effectiveness inputs should be averaged, and airflow and power inputs should be totaled. Performance characteristics of each piece of equipment should be listed on the compliance forms.

Ground-Source Heat Pumps

Table 4-11: Standards for Ground Water-Source and Ground-Source Heat Pumps

Appliance	Rating Condition	Minimum Standard
Ground water-source heat pumps (cooling)	59º F entering water temperature	16.2 EER
Ground water-source heat pumps (heating)	50º F entering water temperature	3.6 COP
Ground-source heat pumps (cooling)	77º F entering brine temperature	13.4 EER
Ground-source heat pumps (heating)	32º F entering brine temperature	3.1 COP

Source: Section 1605.3 of the California Appliance Efficiency Regulations

A geothermal or ground-source heat pump uses the earth as a source of energy when heating the home and as a heat sink for energy when cooling. Some systems pump water from an aquifer in the ground and return the water to the ground after exchanging heat with the water. A few systems use refrigerant directly in a loop of piping buried in the ground. Those heat pumps that either use a water loop or pump water from an aquifer have efficiency test methods that are accepted by the Energy Commission.

The mandatory minimum efficiencies for ground water-source heat pumps shown in Table 4-11: Standards for Ground Water-Source and Ground-Source Heat Pumps are certified to the Energy Commission by the manufacturer and are expressed in terms of coefficient of performance (COP) for heating and EER for cooling.

Verify that the system will meet local code conditions before choosing this type of system to comply with the Energy Code.

Solar Space Heating

Please refer to Chapter 4.7.5 of the 2022 Single-family Residential Compliance Manual.

Wood Space Heating

Please refer to Chapter 4.7.6 of the 2022 Single-family Residential Compliance Manual.

Prescriptive Approach

Please refer to Chapter 4.7.6.1 of the 2022 Single-family Residential Compliance Manual.

Performance Approach

Please refer to Chapter 4.7.6.2 of the 2022 Single-family Residential Compliance Manual.

Wood Heater Qualification Criteria

Please refer to Chapter 4.7.6.3 of the 2022 Single-family Residential Compliance Manual.

Gas Appliances

Please refer to Chapter 4.7.7 of the 2022 Single-family Residential Compliance Manual.

Evaporatively Cooled Condensers

Evaporatively cooled condenser air conditioners are a type of air-conditioning system that can provide significant space-cooling savings, especially in hot, dry climates.

The equipment minimal efficiencies are determined according to federal test procedures. The efficiencies of these air conditioners are reported in terms of energy efficiency rating (EER2).

If credit is taken for a high EER2, field verification by an ECC-Rater is required. Other ECC verified measures are also required, including duct sealing, airflow, fan efficacy, and refrigerant charge or fault indicator display.

Besides the ECC-Verification, there are additional special requirements for evaporatively cooled condensing air conditioners. These include that the manufacturer provide certification that water use is limited to no more than 0.15 gallon per minute per ton of capacity and that the supply line be no larger than ¼- inch in diameter. For a listing of all the requirements for evaporatively cooled condensing air conditioners, see the CF2R compliance form.

Variable Capacity Heat Pump Systems

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.

Compliance with ductless VCHP systems requires that all indoor units be located entirely in conditioned space with wall-mounted thermostats in zones over 150 square feet and air flow to all habitable spaces. Refrigerant charge verification is also required.

Ducted VCHP systems do not need to meet the mandatory duct system sealing and leakage (Section 150.0(m)11) and fan airflow rate and fan efficacy testing (Section 150.0(m)13). However, there are requirements to verify that VCHP system indoor unit ducts are located entirely in conditioned space, that ducted indoor units are low-static certified, and additional requirements for this compliance option listed below. The list of low-static ducted VCHP system 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/ducted-vchp.

Additional verification requirements apply depending on the system type, see below.

- Low-Static Certification for Ducted Systems
- Non-Continuous Indoor Unit Fan Operation
- Refrigerant Charge Verification

- Ducts Located Entirely in Conditioned Space
- Indoor Units Located Entirely in Conditioned Space
- Supply to All Habitable Spaces
- Wall-Mounted Thermostat
- Space-Conditioning System Airflow
- Air Filter Sizing
- Air Filter Pressure Drop Rating

Ventilation Cooling

Please refer to Chapter 4.7.10 of the 2022 Single-family Residential Compliance Manual.

Whole-House Fans

Please refer to Chapter 4.7.10.1 of the 2022 Single-family Residential Compliance Manual.

Central Fan Ventilation Cooling Systems

Please refer to Chapter 4.7.10.2 of the 2022 Single-family Residential Compliance Manual.

Prescriptive Requirements

Please refer to Chapter 4.7.10.3 of the 2022 Single-family Residential Compliance Manual.

Eligibility Criteria for Whole-House Fans

Please refer to Chapter 4.7.10.3.1 of the 2022 Single-family Residential Compliance Manual.

Refrigerant Charge

Refrigerant Charge Verification

This section summarizes the procedures for verifying refrigerant charge for heat pumps and air-conditioning systems as required in 150.1(c)7A and specified in RA3.2.

Overview

The refrigerant charge in all split-system heat pumps and air conditioners undergoes a final adjustment at installation. This refrigerant charge adjustment of heat pumps in all Climate Zones and split-system air conditioners in climate zones 2 and 8 – 15 must be verified to ensure proper performance. Important factors that affect performance include the amount of refrigerant in the system (the charge) and the proper functioning of the metering device. Energy efficiency suffers if the refrigerant charge is either too low or too high and if the metering device (thermostatic expansion valves (TXV) or electronic expansion valves (EXV)) is not functioning properly. In addition to a loss of efficiency and capacity, errors in these areas can lead to premature compressor failure.

To help avoid these problems, the prescriptive standards require that heat pump systems be correctly installed and field-verified in all climate zones. This installation and field-verification is required for air conditioners in climate zones 2 and 8 – 15. Refrigerant charge verification is also required for air conditioners in any climate zone when chosen as a compliance feature using the performance compliance approach.

The requirement to verify the refrigerant charge after installation does not apply to new packaged systems, where the installer certifies the package system came factory-charged and did not alter the system in any way that would affect the refrigerant level. The ECC-Rater does not verify this method of RCV but may review that the CF2R accurately documented the packaged system. Airflow and other requirements must still be verified.

The prescriptive standards regarding verification of refrigerant charge do apply to altered package systems in all climate zones.

There are two methods of verifying that the charge level is appropriate: 1) testing the charge level, and 2) weighing-in of refrigerant. Installers must confirm that the charge level is correct and ECC-Raters must independently verify the charge.

Example 4-17: "DIY" HVAC Installation

Question:

Does a "do-it-yourself" (DIY) split system require refrigerant charge verification?

Answer:

Yes, for multiple reasons that may appear to conflict with the manufacturer's claims about easy, leak-proof installation. Installation of a space conditioning appliance (other than a plug-in room appliance) requires a building permit. It also requires wall penetrations and sturdy mounting to support the indoor fan-coil unit. New HVAC systems require load calculations. If the new system is replacing an old system (an alteration), then removal of the old system requires refrigerant recovery by a technician that holds an EPA 608 Type II or Universal certificate.

Even though the DIY system is charged at the factory, it must be altered by connecting the indoor unit(s), outdoor unit, and the charged line set at the home to complete the installation. This disqualifies it from the Exception to Section 150.1(c)7A.

The appropriate RCV protocol is the weigh-in method. This allows the installer and rater to document the installation and certify that no refrigerant adjustment was necessary.

Charge Test

Verification of proper refrigerant charge must occur after the HVAC contractor has installed the system in accordance with the manufacturer's specifications, which may include nominally evacuating and charging the system. The standard procedure requires properly calibrated digital refrigerant gauges, thermocouples, and digital thermometers. Multiple systems in a home that require verification must be verified individually. For a heat pump, refrigerant charge verification can only be done with the system operating in cooling mode.

In a typical home HVAC 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 temperature-dependent. This is why heat pumps can only be tested in cooling mode.

A note about flammable refrigerants: Residential HVAC equipment has typically contained R-22, R-410A, or R-408A, which are not flammable but have high global warming potential (GWP) characteristics. Low-GWP refrigerants such as R-454B, R-32 and R-1234yf, are appearing on the market and are classified in the ASHRAE Safety Group A2L for "Slight Flammability."

This presents a safety concern that requires personnel to consider the size of any enclosed workspace and availability of ventilation or refrigerant detection. A series of fact sheets, articles, and guidance materials may be found on the AHRI Safe Refrigerant Transition Task Force webpage at https://www.ahrinet.org/safe-refrigerant-task-force.

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.

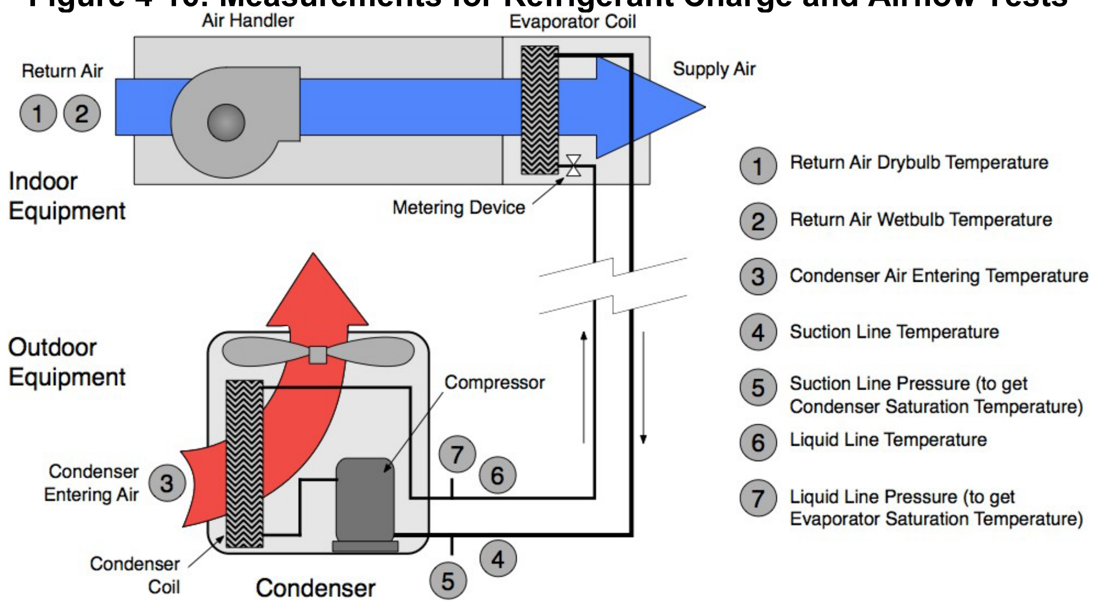
If an altered system does not meet the minimum airflow requirements, remedial steps are required to increase system airflow. More airflow is generally better for systems with air conditioning. Not only does this allow proper refrigerant charge to be verified, but it improves the overall performance of the system. When possible, 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 case (RA3.3.3.1.5). When this option is used, verification by sample groups is not allowed. Minimum airflow is critical to proper heat pump and air-conditioner operation. Reducing airflow reduces 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 minimum airflows 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 confirm that the outdoor conditions are warm enough to conduct the test, and warm enough for the system to run properly, typically at least 50°F. Turn on the 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 4-16: Measurements for Refrigerant Charge and Airflow Tests



Source: California Energy Commission

The following measurements shall be taken by the technician or ECC-Rater, when applicable.

- 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 4-14: Measurements for Refrigerant Charge and Airflow Tests). See Figure RA 3.2-1 for more information on the placement of the MAH.

- 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 4-14: 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.

- 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 4-14: Measurements for Refrigerant Charge and Airflow Tests)
- The second measurement determines the saturation temperature of the refrigerant in the evaporator coil. (See Point 5 in Figure 4-14: 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:

- 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 Figure 4-14: Measurements for Refrigerant Charge and Airflow Tests)
- 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 4-14: 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 TXV or 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 (TSuction, db) minus the evaporator saturation temperature (TEvaporator, 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)

Please refer to Chapter 4.8.1.5 of the 2022 Single-family Residential Compliance Manual.

Weigh-In Charging Procedure (RA3.2.3)

When the conditions are not conducive to conducting a charge test, a Weigh-In Charge Verification must be completed. This may only be performed by the installer, and it must be verified by the ECC-Rater either by simultaneous observation or by using the standard method when conditions permit.

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 installing technician may perform any kind of weigh-in procedure. The ECC-Rater may only verify compliance of the weigh-in method if the installer performed a weighed-in verification (with rater observation) and the system is incompatible with the standard procedure (e.g., ductless mini-split system).

Per RA 3.2.3.1.5, the weigh-in procedure shall be performed in accordance with all manufacturer specifications. The HVAC Installer shall document and confirm the following, and certify on the Certificate of Installation that the manufacturer's specifications for these procedures have been met.

- Liquid line filter drier has been installed if required per outdoor condensing unit manufacturer's instructions, and installed with the proper orientation with respect to refrigerant flow.
- If refrigerant line connections require welding, the system is braised with dry nitrogen in the lines and indoor coil.
- In all cases where the equipment manufacturer's instructions call for checking for gas leaks with vacuum, the system is evacuated to 500 microns or less and, when isolated, rises no more than 300 microns over five minutes.
- In all cases where the equipment manufacturer's instructions call for checking for gas leaks with nitrogen gas, the system is pressurized to the manufacturer's specified pressure and if the pressure cannot be maintained, leaks shall be located and fixed.
- The calculated weight adjustment for lineset length is based on the length and diameter of the lineset.
- The calculated weight adjustment for coil size is based on equipment manufacturer's instructions.

- The actual total weight adjustment is equal to the sum of the calculated weight adjustments for lineset and coil size.
- The calculated and actual total weights of refrigerant in the system are recorded on or near the nameplate label, in indelible ink or other permanent means.

These requirements shall also be verified through ECC-Rater on-site observation, and per RA 3.2.3.2, the ECC-Rater shall observe and confirm, and document on a Certificate of Verification:

- The calculated weight adjustment for lineset length was based on the length and diameter of the lineset.
- The calculated weight adjustment for coil size was based on the equipment manufacturer's instructions.
- The actual charge adjustment was equal to the sum of the calculated weight adjustments for lineset and coil size.
- The calculated and actual total weights of refrigerant in the system were recorded on or near the nameplate label, in indelible ink or other permanent means.
- One of the following:
    - In all cases where the equipment manufacturer's instructions call for checking for gas leaks with vacuum, the system is evacuated to 500 microns or less and, when isolated, rises no more than 300 microns over five minutes.
    - In all cases where the equipment manufacturer's instructions call for checking for gas leaks with nitrogen gas, the system was pressurized to the manufacturer's specified pressure and if the pressure could not be maintained, leaks were located and fixed.
    - Confirm that no fittings (other than the fitting to the compressor) are compression or flare fittings.

General Requirements

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 Energy Commission. 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.

ECC-Verification Procedures

When required by the CF1R, ECC-Raters must perform field verification and diagnostic testing of the refrigerant charge, including verification of minimum system airflow and verification of installation of the measurement access hole.

The verification procedures are essentially identical for the ECC-Rater and the installer except that the tolerances for passing the superheat and subcooling tests are less stringent for the ECC-Rater's test. This is to allow for some variations in measurements due to instrumentation or test conditions (for example, weather).

The following conditions prohibit verification using sample groups:

- When the weigh-in method is used.
- When the minimum airflow cannot be met despite reasonable remediation attempts. (See RA3.3.3.1.5).

As always, to be eligible for sampling, the installer must first verify and pass the system. If sampling is not being used, the ECC-Rater will perform the verification only after the installer has charged the system according to manufacturer's specifications.

Winter Setup Procedures

Reference Appendix RA1 provides for the approval of special case refrigerant charge verification procedures. These protocols may be used only if the manufacturer has approved use of the procedure for their equipment.

One such procedure is found in RA1.2 Winter Setup for the standard charge verification procedure (winter charge setup). It provides for a modification to the standard charge procedure when temperature conditions do not allow use of the RA3.2.2 standard charge verification procedure.

The winter charge setup allows both installers and ECC-Raters to verify the charge when outdoor temperatures are below the manufacturer's allowed temperature, or the outdoor temperature is less than 55°F. The Weigh-in Charging Procedure specified in Section RA3.2.3 may also be used for air conditioners or heat pumps in cooling mode when the outdoor temperatures are below the manufacturer's allowed temperature or below 55°F but may be used only by the installer.

The winter charge setup procedure allows the system to operate in the same range of pressure differences between the low-side pressure and the high-side pressure as occurs during warm outdoor temperatures, by restricting the airflow at the condenser fan outlet. The winter charge setup is used only for air conditioners or heat pumps in cooling mode, and only for units equipped with variable metering devices, which include TXV and EXV for which the manufacturer specifies subcooling as the means for determining the proper charge for the unit, including units equipped with microchannel heat exchangers. Once this pressure differential is achieved, the variable metering device calculations are conducted in the same way as the variable metering device procedures described in RA3.2.2.6.2. All other applicable requirements of Section RA3.2.2 remain the same and must be completed when using the winter charge setup.

Using Weigh-In Charging Procedure at Low Outdoor Temperatures

When a new HVAC system is installed, the HVAC installer must check the refrigerant charge, and an ECC-Rater must verify the correct charge; however, an exception to §150.1(c)7Aic provides for an alternative third-party ECC verification if the weigh-in method is used when the outdoor temperature is less than 55 degrees F.

Typically, when the weigh-in method is used by the installing contractor, an ECC-Rater must perform a charge verification in accordance with the RA3.2. standard charge procedure. However, because the RA3.2.2 procedures cannot be used when the outdoor temperatures are less than 55 degrees, the Energy Code provides the installer with two choices:

- Use the RA3.2.3.1 Installer Weigh-In Charging Procedure to demonstrate compliance and install an occupant-controlled smart thermostat (OCST).
- Wait for warmer temperatures then perform the standard charge verification procedure. In this case, the installer must agree to return to correct refrigerant charge if an ECC-Rater determines later, when the outside temperature is 55 degrees F or above, that correction is necessary as described in Residential Appendix RA 2.4.4. The installer must also provide written notice to the homeowner and enforcement agency that the charge has not yet been verified.

Compliance and Enforcement

Please refer to Chapter 2 of the 2025 Single-family Residential Compliance Manual.

Design-Phase Documentation

The initial compliance documentation consists of the certificate of compliance (CF1R). It lists the features that the house needs for compliance with the prescriptive or performance compliance requirements.

For the prescriptive compliance approach, the required features are based on the Prescriptive Component Package, shown in Tables 150.1-A and 150.1-B.

For the performance compliance approach, the required features are based on a set of features that the designer has documented to result in a level of efficiency at least as good as the prescriptive standard design for single-family houses and townhouses. The calculations for documenting this performance are done using the approved performance compliance software at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency. The calculation approach is described in the *Residential ACM Reference Manual.*

The performance compliance approach provides maximum design flexibility. It also allows compliance credit for special additional features to be quantified.

The CF1R lists special features for which compliance credit was taken using the performance compliance approach. These features require additional visual verification by the enforcement agency to ensure proper installation. Some require field verification and diagnostic testing by an ECC-Rater. These will be listed separately on the CF1R under the following headings. For the purposes of this manual, only HVAC-related features are listed below.

Special Features Not Requiring ECC-Rater verification:

- Ducts in a basement
- Ducts in a crawlspace
- Ducts in an attic with a radiant barrier

- Hydronic heating and system design details
- Gas-fired absorption cooling
- Zonal control
- Ductless wall heaters

Special features requiring ECC-Rater verification:

- Duct sealing
- Verified duct design – for reduced duct surface area and ducts in conditioned space
- Low-leakage ducts in conditioned space
- Low-leakage air handlers
- Verification of return duct design
- Verification of air filter device design
- Verification of bypass duct prohibition
- Refrigerant charge verification
- Verified system airflow
- Air handler fan watt draw
- High energy efficiency ratio (EER2)
- Verified seasonal energy efficiency ratio (SEER2)
- Heating seasonal performance factor (HSPF2)
- Heat pump - rated heating capacity
- Continuous whole-dwelling unit mechanical ventilation airflow for IAQ
- Intermittent dwelling unit mechanical ventilation airflow for IAQ
- Kitchen exhaust fan verification for IAQ (Local Mechanical Exhaust)
- Whole-house fan (WHF) airflow and fan efficacy
- Central fan ventilation cooling system (CFVCS)
- Variable capacity heat pump (VCHP)

HRV or ERV fan efficacy and fault indicator display (FID)

Information summarizing measures requiring field verification and diagnostic testing is presented in Table RA2-1. The field verification and diagnostic testing protocols that must be followed to qualify for compliance credit are described in RA3.

Registration of the CF1R with an approved ECC Provider is required. The building owner or the person responsible for the design must submit the CF1R to an ECC Data Registry for retention according to the procedures described in Section 10-103 and RA2. Registration ensures that the project follows the appropriate verification process, provides tracking, and provides electronic access to authentic documentation.

Construction-Phase Documentation

During construction, the general contractor or specialty subcontractors must complete all applicable CF2Rs for the building design special features specified on the CF1R.

Registration of the CF2R is required. The licensed contractor responsible for the installation must submit the CF2R information that applies to the installation to an ECC-Provider Data registry using procedures described in Section 10-103 and RA2. CF2R documents corresponding to the list of special features requiring ECC-Rater verification in Design-Phase Documentation are required.

Field Verification and Diagnostic Testing

When the CF1R and CF2Rs require ECC verification, an ECC-Rater must visit the site to perform the tests necessary to complete the applicable heating and cooling system certificates of verification (CF3R). A CF3R is available for each special feature requiring ECC-Rater verification given in Section 4.9.1.

Field verification for nonmandatory features is necessary only when performance credit is taken for the measure. Some field verifications are mandatory in all homes unless they are exempted in the Energy Code by specific exceptions.

Registration of the CF3R is required. The ECC-Rater must submit the field verification and diagnostic testing information to the ECC Data Registry as described in Chapter 2. For additional details describing ECC-Verification and the registration procedure, refer to RA2.