Table of Contents

4. Building HVAC Requirements

4.1 Overview

4.1.1 Introduction and Organization

This chapter addresses the requirements for heating, ventilating, and air-conditioning (HVAC) systems. The requirements are presented in this chapter to serve as a source of information for mechanical system designers and mechanical system installers, as well as energy consultants, HERS Raters, and enforcement personnel.

Each section in this chapter outlines the mandatory measures and, when applicable, the prescriptive requirements or compliance options. These prescriptive requirements vary by climate zone. If the building design does not achieve the minimum prescriptive requirements, then the compliance options may be used under the performance approach to achieve compliance.

The chapter is organized under the following sections:

1. **Section 4.2** - Heating Equipment. This section addresses the requirements for heating equipment, including mandatory measures, prescriptive requirements, and compliance options.
2. **Section 4.3 -** Cooling Equipment. This section addresses cooling equipment requirements, including mandatory measures, prescriptive requirements, and compliance options.
3. **Section 4.4 -** Air Distribution System Ducts, Plenums, and Fans. This section covers mandatory requirements such as duct insulation, duct system construction practices, and duct diagnostic testing. This section also covers prescriptive requirements for duct location and duct insulation, and specifications for access holes in the supply and return plenums.
4. **Section 4.5 -** Controls. This section addresses mandatory requirements for thermostats and the compliance option for zonal controls.
5. **Section 4.6,** Indoor Air Quality and Mechanical Ventilation. This section covers mandatory requirements for indoor air quality, including mechanical ventilation.
6. **Section 4.7 -** Alternative Systems. This section covers several systems that are less common in California homes, including hydronic heating, radiant floor systems, evaporative cooling, gas cooling, ground-source heat pumps, and wood space heating.
7. **Section 4.8 -** Compliance and Enforcement. In this section the documentation requirements at each phase of the project are highlighted.
8. **Section 4.9 -** Refrigerant Charge. This section addresses the requirements for refrigerant charge verification including procedures, prescriptive requirements and compliance option

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

4.1.2 What's New for the 2016 Energy Standards

The following is a summary of the new HVAC measures for the *2016 Building Energy Efficiency Standards* (Energy Standards), including new compliance options that provide greater flexibility in complying with the Energy Standards when using the performance method. See sections of this manual for more detail.

4.1.2.1 **Mandatory Features and Devices - §150.0**

1. Liquid line filter driers are required to be installed on all air-conditioning condensers, as specified by the manufacturer (§150.0(h)3).
2. There are some changes to the tables specifying mandatory minimum insulation on air-conditioning refrigerant lines (§150.0(j)2C).
3. There are some changes to the mandatory insulation protection for insulated pipes found outside conditioned space (§150.0(j)3).
4. The term *directly conditioned space* was replaced with *conditioned space* to capture ducts located in indirectly conditioned spaces. The mandatory minimum R-value for duct located in conditioned spaces is now R-4.2 (§150.0(m)1).
5. Duct sealing and leakage testing for single-family dwellings and townhouses has a new target for total duct leakage, which has been reduced to 5 percent total leakage (§150.0(m)11).
6. There are new mandatory requirements for filtration of all air passing through a ducted space-conditioning system. The requirements affect the pressure drop and labeling of the filtration devices (§150.0(m)12C).

4.1.2.2 **Prescriptive and Performance Compliance Approaches − §150.1**

1. The refrigerant charge requirement was restructured to clearly state that minimum system airflow is required in conjunction with refrigerant charge verification (§150.1(c)7).
2. The exception to 150.1(c)7 for packaged systems was amended to allow the installer to certify that they installed a packaged system that was charged by the manufacturer (§150.1(c)7).
3. New requirements for duct insulation and duct system location depending on the location of ceiling or roof insulation were added. (§150.1(c)9).
4. The prescriptive requirements for ventilation cooling have been changed. The total airflow requirement was reduced from 2 CFM/ft^2 to 1.5 and the vent-free area was reduced from 1 ft^2/375 CFM to 1 ft^2/750 CFM (§150.1(c)12).

4.1.2.3 **Additions and Alterations − §150.2**

The Energy Standards requirements for HVAC systems in homes that are altered or added to are summarized and discussed in Chapter 9.

4.1.3 Common System Types

New California homes in the Central Valley and the desert typically have a gas furnace and split-system air conditioner that distributes heating and cooling to each room through forced air ducts. Most mandatory measures and prescriptive requirements are based on this type of system. In some areas, a heat pump provides both heating and cooling, eliminating the furnace. In coastal climates and in the mountains, air conditioning is rare, and most new homes are heated by gas furnaces.

Although the Energy Standards focus on the typical system, they also apply to other systems as well, including some radiant hydronic systems. These hydronic systems distribute hot water to parts of the home to provide heating to the conditioned spaces.

Electric resistance systems are used in some areas and applications, although it is difficult for them to comply under the Standards.

Ground-source or water-source heat pump (geo-exchange) systems are also used, especially in areas where there is no gas service. Unlike more typical air source systems, these systems use water circulated underground or in large ponds or lakes as the heat source (in heating mode) and heat sink (in cooling mode).

While the primary focus of this chapter is typical systems, a Section 4.7 discusses alternative systems.

4.1.4 California Appliance Standards and Equipment Certification

§110.0 and §110.1

Most heating and cooling equipment installed in new California homes is regulated by the National Appliance Efficiency Conservation Act (NAECA) and/or the California *Appliance Efficiency Regulations (Title 20)*. Both the federal and state appliance standards apply to the manufacturing of new equipment and are applicable for equipment used in replacements, repairs, or for any other purpose. The *Appliance Efficiency Regulations* are enforced at the point of sale (except central split system air conditioners and central single package air conditioners, see Table 4-6), while the Energy Standards explained in this compliance manual are enforced by local enforcement agencies.

The following types of equipment (in the list below) are covered by the *Appliance Efficiency Regulations*. For this equipment, the manufacturer must certify that the equipment complies with the current *Appliance Efficiency Regulations* at the time of manufacture.

Appliances covered by the *Appliance Efficiency Regulations* include:

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

The *Appliance Efficiency Regulations* do not require certification for:

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

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

Note: Equipment manufactured before the effective date of a new standard may be sold and installed in California indefinitely, as long as the performance and prescriptive approach demonstrates energy compliance of the building using the lower efficiency of the relevant appliances. However, the Department of Energy (DOE) requires that central split-system air conditioners and central single package air conditioners *installed* in California on or after January 1, 2015 must comply with the minimum efficiencies as specified in Table 4-6.

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

4.1.4.1 **Plan Review (Compliance)**

During the plan review, the builder is responsible for demonstrating compliance with the *Appliance Efficiency Regulations* by providing the efficiency of the HVAC equipment that is to be installed. Typically the builder does not identify the exact make or model at this point of the process. The plans examiner is responsible for verifying that the specified equipment efficiency complies with the *Appliance Efficiency Regulations.*

4.1.4.2 **Field Inspection (Enforcement)**

It is the responsibility of the field inspector to visually verify that the product information on the installed HVAC equipment matches the efficiency that was approved by the plans examiner. To simplify the inspection, the field inspector may reference the CF2R-MCH-01-H form submitted by the builder/installing contractor. Moreover, the field inspector is responsible for verifying that the installed HVAC equipment is certified to the Energy Commission. The field inspector, at his or her discretion, may require the builder/installing contractor to provide a printout from the Energy Commission Appliance Efficiency Database of certified equipment listing the same make and model that is installed.

If the specifications labeled on the HVAC equipment do not match the equipment specifications on the Energy Commission Appliance Efficiency Database, the inspector is responsible for issuing a correction notice to the builder/installing contractor.

4.2 Heating Equipment

This section addresses the requirements for heating equipment, including furnaces, boilers, heat pumps, and electric resistance equipment.

4.2.1 Mandatory Measures for Heating Equipment

4.2.1.1 **Equipment Efficiency**

§110.1 and §110.2(a)

The efficiency of most heating equipment is regulated by NAECA (the federal appliance standard) and the California Appliance Efficiency Regulations. These regulations are not contained in the Energy Standards but are published separately. These regulations are referenced in §110.1. The Appliance Efficiency Regulations include definitions for all types of equipment and are regularly updated, which may change the minimum efficiencies of most equipment.

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.

A. Gas and Oil-Fired Furnaces

The Appliance Efficiency Regulations (Title 20) require gas and oil-fired central furnaces with outputs less than 225,000 Btu/hr to be rated according to the associated Annual Fuel Utilization Efficiency (AFUE). Gas and oil-fired central furnaces with outputs greater than or equal to 225,000 Btu/hr are rated according to the respective thermal (or steady-state) efficiency. Refer to Table 4-1 for the applicable efficiency requirements.

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

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

Source: *California Appliance Efficiency Regulations Title-20* - Table E-4 and E-6

Noncentral gas furnaces and space heaters shall be certified to have AFUE values greater than or equal to those listed in Table 4-2.

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

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

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

B. Heat Pumps and Electric Heating

Heat pumps shall be certified to have a HSPF or COP equal to or better than those listed in Table 4-3.

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

C. 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 4-3: Minimum Heating Efficiency for Heat Pumps

Equipment Type	Reference	Configuration/Size	Minimum Heating Efficiency
Packaged terminal heat pumps (heating mode)	Table 110.2 E	Newly constructed or newly conditioned buildings or additions	3.7-(0.052 x Cap[1]/1000) = COP
Packaged terminal heat pumps (heating mode)	Table 110.2 E	Replacements	2.9-(0.026 x Cap1/1000) = COP
Single-phase air source heat pumps (NAECA)	Table C-2	< 65,000 Btu/h cooling	Packaged 8.0 HSPF Split 8.2 HSPF
		Space constrained < 65,000 Btu/h cooling capacity	Packaged 7.4 HSPF Split 7.4 HSPF
		Small–duct, high-velocity < 65,000 Btu/h cooling capacity	7.7 HSPF
Three-phase air source heat pumps	Table C-3	< 65,000 Btu/h	Packaged 7.7 HSPF Split 7.7 HSPF
		≥ 65,000 and <135,000	3.3 COP
		≥ 135,000 and <240,000	3.2 COP
		≥ 240,000 and <760,000	3.2 COP
Water-source heat pumps	Table C-4	≥ 65,000 and < 135,000 Btu/h	4.2 COP
		≥ 135,000 Btu/h, < 240,000 Btu/h	2.9 COP
Single package vertical heat pumps	Table C-5	< 65,000 single-phase	3.0 COP
		< 65,000 3-Phase	3.0 COP
		≥ 65,000 and < 135,000	3.0 COP
		≥ 135,000 and < 240,000	2.9 COP

1. Cap = Cooling Capacity

Source: *California Appliance Efficiency Regulation Title 20 and Energy Efficiency Standards*

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

Appliance	Rated Input (Btu/hr)	Minimum Efficiency (%)	
Gas steam boilers with single-phase electrical supply	< 300,000	80 [1]	AFUE
Gas hot water boilers with single-phase electrical supply	< 300,000	82 [1,2]	AFUE
Oil steam boilers with single-phase electrical supply	< 300,000	82	AFUE
Oil hot water boilers with single-phase electrical supply	< 300,000	84 [2]	AFUE
Electric steam residential boilers	< 300,000	—	—
Electric hot water residential boilers	< 300,000	—	—
All other boilers with single-phase electrical supply	< 300,000	—	—
		Thermal Efficiency	Combustion Efficiency
Steam boilers; gas-fired, except natural draft;	≥ 300,000	79	80
Steam boilers; gas-fired, natural draft	≥ 300,000	77	80
Steam boilers; oil-fired	≥ 300,000	81	83

[1] No constant burning pilot light design standard.

[2] Automatic means for adjusting temperature design standard.

Source: *California Appliance Efficiency Regulations Title 20* Table E-3 and E-4

4.2.1.2 Heating System Controls

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

All unitary heating systems, including heat pumps, must be controlled by a setback thermostat. These thermostats must be capable of allowing the occupant to program temperature set points for at least four periods within a 24 hour time span. For example, the setback thermostat could be programmed with specific temperature set points starting at 6:30 a.m., 9 a.m., 4:30 p.m., and 9 p.m.

If the heating system is integrated into a central energy management control system (EMCS), then that system does not need to comply with the setback requirements. Furthermore, all gravity gas wall heaters, floor heaters, room heaters, fireplaces, decorative gas appliances, wood stoves, and noncentral electric heaters are not required to be controlled by a setback thermostat.

Any heat pump with supplementary electric resistance heating requires controls with two capabilities to limit the electric resistance heating. The first required capability is to set the cut-on and cut-off temperatures for the heat pump and supplementary electric resistance heating at different levels.

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

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

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

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

4.2.1.3 **Equipment Sizing**

§150.0(h)1 and 2

The Energy Standards do not set limits on the sizing of heating equipment, but they do require that heating loads be calculated for new heating systems. Oversized equipment typically operates less efficiently and can create comfort problems due to excessive cycling and high airflow.

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

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

The Energy Standards require that the outdoor design conditions for load calculations be selected from Reference Joint Appendix JA2 and that the indoor design temperature for heating load calculations be 68°F.

The outdoor design temperature must be no lower than the "heating winter median of extremes," as listed in the Reference Joint Appendix JA2.

If the actual city location for a project is not included in the Reference Joint Appendix JA2, or if the data given for a particular city does 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 must be submitted with the compliance documentation when requested by the building department.

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.

Note: The Business and Professions Code does not prohibit an unlicensed person from preparing plans, drawings, or specifications for single-family dwelling units of wood-frame construction not more than two stories and basement in height, or for certain buildings containing no more than four dwelling units of wood-frame construction not more than two stories and basement in height. However, licensure is required for apartment or condominium complexes.

4.2.1.4 Furnace Temperature Rise

§150.0(h)4

High temperature rise in a furnace is an indicator of low airflow and/or over specification firing rate. High temperature rise causes low efficiency and may potentially damage the furnace. Central forced-air heating furnace installations must be configured to operate at or below the furnace manufacturer's maximum inlet-to-outlet temperature rise specification.

4.2.1.5 Standby Losses and Pilot Lights

§110.5 and §110.2(d)

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

Larger gas-fired and oil-fired forced air furnaces with input ratings equal to or greater than 225,000 Btu/h (which is bigger than a typical residential furnace) must also have an intermittent ignition device (IID) and either power venting or a flue damper.

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

4.2.1.6 Pipe Insulation

§150.0(j)2C, §150.0(j)3, §120.3

The piping for heat pumps and for both steam and hydronic heating systems shall meet the insulation requirements provided below in Table 4-5 when the insulation is located outside conditioned space, it requires protection from damage caused by environmental conditions. The insulation must be rated for outdoor use or covered with a material that can withstand the outdoor conditions. Examples of these types of coverings are aluminum, sheet metal, painted canvas, plastic cover, or, if the insulation is cellular foam, a coating that is water-retardant and shields from solar radiation. Moreover, the insulation used for the refrigerant suction line of a heat pump must be Class I or Class II vapor retardant.

Table 4-5: Insulation Requirements for Heating System Piping

Fluid Temperature Range (^oF)	Conductivity Range (in Btu-inch per hour per square foot per (^oF)	Insulation Mean Rating Temperature(^oF)	Nominal Pipe Diameter (in inches)				
			1 and less	1 to <1.5	1.5 to <4	4 to <8	8 and larger
			Insulation Thickness Required (in inches)				
Space Heating, Hot Water Systems (Steam, Steam Condensate and Hot Water), Service Water Heating Systems							
Above 350	0.32-0.34	250	4.5	5.0	5.0	5.0	5.0
251-350	0.29-0.32	200	3.0	4.0	4.5	4.5	4.5
201-250	0.27-0.30	150	2.5	2.5	2.5	3.0	3.0
141-200	0.25-0.29	125	1.5	1.5	2.0	2.0	2.0
105-140	0.22-0.28	100	1.0	1.5	1.5	1.5	1.5
Heat Pump Suction Line							
40-60	0.21-0.27	75	0.75	0.75	1.0	1.0	1.0
Below 40	0.20-0.26	50	1.0	1.5	1.5	1.5	1.5

From Table 120.3 A of the *Building Energy Efficiency Standards*

4.2.2 Prescriptive Requirements for Heating Equipment

§150.1(c)6

Prescriptive Component Package A requires the installation of a gas heating system or heat pump that meet the required minimum energy efficiency. (See Table 4-1 through Table 4-4)

Supplemental heating systems are allowed prescriptively, and the designer may elect to provide supplemental heating to a space such as a bathroom. In this instance, the supplemental heating system must be installed in a space that is served by the primary heating system and must have a thermal capacity of less than 2 kilowatts (kW) or 7,000 Btu/hr while being controlled by a time-limiting device not exceeding 30 minutes. Electric resistance and electric radiant heating installation are allowed as the primary heating system only when using the performance compliance method.

When using the prescriptive compliance approach, no additional credit is given for selecting equipment that is higher than what is required by the prescriptive component package.

4.2.3 Compliance Options for Heating Equipment

There is one option for receiving compliance credit related to the heating system. This credit is available through the performance compliance method.

4.2.3.1 High-Efficiency Heating

Heating system efficiencies are explained in Section 4.2.1.1. The minimum efficiency is required according to the prescriptive package. When the performance compliance approach is used, additional compliance credit may be available when higher efficiency heating equipment, such as a high-efficiency furnace or heat pump, is modeled. For example, selecting a nonweatherized furnace with an AFUE higher than 81 will result in a compliance credit, which can be used to offset other building features that do not meet the prescriptive requirements. However, all mandatory requirements must be complied with.

4.3 Cooling Equipment

This section addresses the requirements for space-cooling equipment.

4.3.1 Mandatory Measures for Cooling Equipment

4.3.1.1 Equipment Efficiency

§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 Standards but are referenced in §110.1. The energy efficiency of larger equipment is regulated by §110.2(a). See the *Nonresidential Compliance Manual* for information on larger equipment.

A. 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 residences have a capacity less than 65,000 Btu/h. The *Appliance Efficiency Regulations* for this equipment require minimum seasonal energy efficiency ratios (SEER).

The SEER 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.

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

Appliance	Type	SEER Effective 1/1/2015	EER Effective 1/1/2015
Central Air Conditioners[1]	Split System <45,000 Btuh	14	12.2
	Split System ≥45,000 Btuh	14	11.7
	Single Package	14	11.0
Central Air Source Heat Pumps	Split System	14	NR
	Single Package	14	NR
Space Constrained Air Conditioner	Split System	12	NR
	Single Package	12	NR
Space-Constrained Heat Pump	Split System	12	NR
	Single Package	12	NR
Small-Duct, High-Velocity Air Conditioner	All	12	NR
Small-Duct, High-Velocity Heat Pump	All	12	NR

1. Central split system air conditioners and central single package air conditioners *installed* on or after January 1st, 2015 must comply with the minimum SEER and EER requirements of this table regardless of date of manufacturer.

Source: *California Appliance Efficiency Regulations*, *Title 20,* Table C-2 and Federal Appliance Standards (NAECA)

B. 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 and Table 4-8.

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

Equipment Type	Size Category	SEER or EER
Central Air Conditioners	< 65,000 Split System*	13.0 SEER
	< 65,000 Single Packaged*	13.0 SEER
	≥65,000 Btu/h but <135,000 Btu/h	11.2[1] EER 11.0[2] EER
	≥135,000 Btu/h but <240,000 Btu/h	11.0[1] EER 10.8[2] EER
	≥240,000 Btu/h but <760,000 Btu/h	10.0[1] EER 9.8[2] EER
Central Air Source Heat Pumps	< 65,000 Split System*	13.0 SEER
	< 65,000 Single Packaged*	13.0 SEER
	≥ 65,000 Btu/h but <135,000 Btu/h	11.0[1] EER 10.8[2] EER
	≥135,000 Btu/h but <240,000 Btu/h	10.6[1] EER 10.4[2] EER
	≥240,000 Btu/h but <760,000 Btu/h	9.5[1] EER 9.3[2] EER
Central Water Source Heat Pumps	< 17,000 Btu/h	11.2 EER
	≥ 17,000 Btu/h and < 65,000 Btu/h	12.0 EER
	≥ 65,000 Btu/h and < 135,000 Btu/h	11.9 EER
	≥ 135,000 Btu/h and < 240,000 Btu/h	12.3 EER
	≥ 240,000 Btu/h and < 760,000 Btu/h	12.2 EER
Water-Cooled Air Conditioners	< 17,000 Btu/h	12.1 EER
	< 17,000 < 65,000 Btu/h	12.1 EER
	≥ 65,000 Btu/h and < 135,000 Btu/h	12.1[3] EER
	≥ 135,000 Btu/h and < 240,000 Btu/h	12.5[3] EER
	≥ 240,000 Btu/h and < 760,000 Btu/h	12.4[3] EER

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

Source: *California Appliance Efficiency Regulations* Table C-3, C-4

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 Btu/h	11.0 EER
	≥ 6,000 Btu/h and - 7,999 Btu/h	11.0 EER
	≥ 8,000 Btu/h and -13,999 Btu/h	10.9EER
	≥ 14,000 Btu/h and - 19,999 Btu/h	10.7 EER
	≥ 20,000 Btu/h and 27,999 Btu/h	9.4 EER
	≥ 28,000 Btu/h	9.0 EER
Room Air Conditioners, Without Louvered Sides	< 6,000 Btu/h	10.0 EER
	≥ 6,000 Btu/h and - 7,999 Btu/h	10.0 EER
	≥ 8,000 Btu/h and - 10,999 Btu/h	9.6 EER
	≥ 11,000 Btu/h and - 13,999 Btu/h	9.5 EER
	≥ 14,000 Btu/h and - 19,999 Btu/h	9.3 EER
	≥ 20,000 Btu/h	9.4 EER
Room Air Conditioner Heat Pumps With Louvered Sides	< 20,000 Btu/h	9.8 EER
	≥ 20,000 Btu/h	9.3 EER
Room Air Conditioner Heat Pumps Without Louvered Sides	< 14,000 Btu/h	9.3 EER
	≥ 14,000 Btu/h	8.7 EER
Casement-Only Room Air Conditioner	All Capacities	9.5 EER
Casement-Slider Room Air Conditioner	All Capacities	10.4 EER
PTAC (cooling mode) Newly Constructed or Newly Conditioned Buildings or Additions	All Capacities	14.0-(0.300 x Cap/1000) = EER
PTAC (cooling mode) Replacements	All Capacities	10.9-(0.213 x Cap/1000) = EER
PTHP (cooling mode) Newly Constructed or newly conditioned buildings or Additions	All Capacities	14.0-(0.300 x Cap/1000) = EER
PTHP (cooling mode) Replacements	All Capacities	10.8-(0.213 x Cap/1000) = EER
SPVAC (cooling mode)	< 65,000 Btu/h	10.0 EER
	≥ 65,000 Btu/h and < 135,000 Btu/h	10.0 EER
	≥ 135,000 Btu/h and < 240,000 Btu/h	10.0 EER
SPVHP (cooling mode)	< 65,000 Btu/h	10 EER
	≥ 65,000 Btu/h and < 135,000 Btu/h	10 EER
	≥ 135,000 Btu/h and < 240,000 Btu/h	10 EER
Cap. = Cooling Capacity (Btu/hr)		
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, the Energy Standards Table 110.2-E

4.3.1.2 Insulation for Refrigerant Lines in Split-System Air Conditioners

§150.0(j)2 and 3, §150.0(m)9

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

If the liquid line is at an elevated temperature relative to outdoor and indoor temperatures, it should not be insulated. In those areas, heat escaping from it is helpful. When the liquid line runs through the attic, the attic temperature is higher than the liquid line temperature, so liquid lines running through attics should be insulated to reduce heat transfer from the surrounding environment into the refrigeration system.

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 4-9.

Table 4-9: Insulation Requirements for Split-System Refrigerant Piping

Fluid Temperature Range (°F)	Conductivity Range (in Btu-inch per hour per square foot per °F	Insulation Mean Rating Temperature(°F)	Nominal Pipe Diameter (in inches)				
			1 and less	1 to <1.5	1.5 to <4	4 to <8	8 and larger
			Insulation Thickness Required (in inches)				
Space cooling systems suction line							
40-60	0.21-0.27	75	0.75	0.75	1.0	1.0	1.0
Below 40	0.20-0.26	50	1.0	1.5	1.5	1.5	1.5

From Table 120.3-A of the Energy Standards

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.

4.3.1.3 **Outdoor Condensing Units**

§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. 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 Standards.

Figure 4-2: Noncompliant Condensing Unit Clearance From Dryer Vents

Source: California Energy Commission

Liquid line filter driers are components of split system air-conditioners and split system heat pumps that are installed in the refrigerant line to remove noncondensables, like moisture and particles, from the refrigerant stream. These noncondensables may appear in the refrigerant line due to improper charging procedures and result in reduced efficiency and capacity for the air conditioner. 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 HERS Raters.

The quality of installation is important to 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, the orientation of the liquid line filter dryer will matter.

4.3.1.4 **Equipment Sizing**

§150.0(h)

Similar to heating equipment, the Energy Standards do not set limits on the size of cooling equipment, but they do require that cooling loads be calculated for new cooling systems. Avoid oversizing the cooling components since oversizing may adversely affect the efficiency of the system. Ducts must be sized correctly, otherwise the system airflow rate may be restricted, adversely affecting the efficiency of the system and preventing the system from meeting the mandatory minimum airflow rate requirements.

The outdoor design conditions for load calculations must be selected from Reference Joint Appendix JA2, Table 2-3, using values no greater than the “1.0 percent cooling dry bulb” and “mean coincident wet bulb” values listed. The indoor design temperature for cooling load calculations must be 75°F. Acceptable load calculation procedures include methods described in:

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

Cooling load calculations must be submitted with compliance documentation when requested by the building department. 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.

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

§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 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 HERS Raters to perform the required diagnostic airflow testing in a nonintrusive manner, by eliminating the necessity for the Raters to drill holes in the supply plenum for placement of pressure measurement probes.

The size and placement of the HSPP/PSPP shall be in accordance with RA3.3.1.1 and shall be verified by a HERS Rater. In the event that the HSPP/PSPP cannot be installed as shown in Figure RA3.3-1, due to 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 HERS 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 (entirely new systems), there must be a hole in the supply plenum, provided by the installing contractor, for the placement of a static pressure probe (HSPP). Alternatively, a permanently installed static pressure probe (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 Rater.

See Air Distribution Ducts, Plenums, and Fans Section 4.4 for discussion regarding mandatory sizing/airflow requirements for ducted systems with cooling.

4.3.2 Prescriptive Requirements for Cooling Equipment

§150.1(c)7

Prescriptive Component Package A does not require that a cooling system be installed. However if one is to be installed, the cooling equipment efficiency requirements are specified by the mandatory measures (See Section 4.3.1 above)

Using the prescriptive compliance approach, no additional credit is given for selecting equipment that is higher than what is required by the prescriptive component package.

Prescriptive Component Package A, for air-cooled air conditioners and air-source heat pumps installed in Climate Zones 2 and 8 through 15, requires 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 HERS Rater. The MAH provides a nonintrusive means of measuring return air temperature, which is a parameter important to the RCV process. The alternative to RCV by a HERS Rater is the installation of a refrigerant fault indicator display. When installing a fault indicator display, the installer must still perform a RCV.

Note: The refrigerant charge verification is discussed in greater detail later in Section 4.9.

4.3.2.1 **Measurement Access Hole (MAH).**

The MAH provides a nonintrusive means for refrigerant charge verification by HERS 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 the Reference Residential Appendix RA3.2.

Installation of MAH must be performed by the installer of the air conditioner or heat pump equipment according to the specifications given in Reference Residential Appendix RA3.2.

The MAH feature consists of one 5/8-inch (16 mm) diameter hole in the return plenum, upstream from the evaporator coil. (See figure RA3.2-1 in Reference Residential Appendix RA3.2.)

4.3.2.2 **Minimum System Airflow**

Ducted forced air systems must comply with the minimum system airflow rate of greater than or equal to 350 cfm per ton when performing the refrigerant charge verification. The airflow is important when performing the refrigerant charge verification to validate the measured values for pressure and temperature. The correct airflow will also improve the performance of the air-conditioning equipment.

The airflow verification procedure is documented in Reference Residential Appendix RA3.3.

4.3.2.3 **Refrigerant Charge Verification (RCV)**

The prescriptive standards require that a HERS Rater verify that air-cooled air conditioners and air-source heat pumps have the correct refrigerant charge. The RCV procedures are documented in Reference Residential Appendix RA1.2, RA2.4.4, and RA3.2.

Refrigerant charge refers to the actual amount of refrigerant present in the system. Excessive refrigerant charge (overcharge) reduces system efficiency and can lead to premature compressor failure. Insufficient refrigerant charge (undercharge) also reduces system efficiency and can cause compressors to overheat. Ensuring correct refrigerant charge can significantly improve the performance of air-conditioning equipment. *Refrigerants* are the working fluids in air-conditioning and heat-pump systems that absorb heat energy from one area (the evaporator), transfer, and reject it to another (the condenser).

4.3.2.4 **Fault Indicator Display**

The installation of a fault indicator display (FID) may be used as an alternative to the prescriptive requirement for HERS diagnostic testing of the refrigerant charge in air conditioners and heat pumps. The installation of a FID does not preclude the HVAC installer from having to properly charge the system with refrigerant. The FID provides real-time information to the building occupant about the status of the system refrigerant charge, metering device, and system airflow. The FID will monitor and determine the operating performance of air conditioners and heat pumps and provide visual indication to the system owner or operator if the refrigerant charge, airflow, or metering device performance of the system does not conform to approved target parameters for minimally efficient operation. Thus, if the FID signals the owner/occupant that the system requires service or repair, the occupant can immediately call for a service technician to make the necessary adjustments or repairs. A FID can provide significant benefit to the owner/occupant by alerting the owner/occupant to the presence of inefficient operation that could result in excessive energy use/costs over an extended period. A FID can also indicate system performance faults that could result in system component damage or failure if not corrected, thus helping the owner/occupant avoid unnecessary repair costs.

Fault indicator display technologies shall be installed in the factory or the field according to manufacturer's specifications. Reference Joint Appendix JA6 contains more information about FID technologies.

The presence of a FID on a system must be field-verified by a HERS Rater. See Reference Residential Appendix RA3.4.2 for the HERS verification procedure, which consists of a visual verification of the presence of the installed FID technology. The Rater must inspect to see that the visual indication display component of the installed FID technology is mounted adjacent to the thermostat of the split system. When the outdoor temperature is greater than

55°F, the rater must also observe that the system reports no system faults when the system is operated continuously for at least 15 minutes when the indoor air temperature returning to the air conditioner is at or above 70°F. When the outdoor temperature is below 55°F, the Rater must observe that the FID does a self-diagnosis and indicates that the sensors and internal processes are operating properly.

4.3.3 Performance Compliance Options for Cooling Equipment

There are several options for receiving compliance credit related to the cooling system. These credits are available through the performance compliance method.

4.3.3.1 **High-Efficiency Air Conditioner**

Air conditioner efficiencies are determined according to federal test procedures. The efficiencies are reported in terms of seasonal energy efficiency ratio (SEER) and energy efficiency ratio (EER). Savings can be achieved by choosing an air conditioner that exceeds the minimum efficiency requirements.

The EER is the full load efficiency at specific operating conditions. It is possible that two units with the same SEER can have different EERs. In cooling climate zones of California, for two units with a given SEER, the unit with the higher EER is more effective in saving energy. Using the performance compliance method, credit is available for specifying an air conditioner with an EER greater than 10. (See the compliance program vendor's compliance supplement.) When credit is taken for a high EER and/or SEER, field verification by a HERS Rater is required. (See Reference Residential Appendix RA3.4.)

4.3.3.2 **Air Handler Watt Draw and System Airflow**

It is mandatory that central forced air systems produce fan watt draws less than or equal to 0.58 watts/CFM and flow at least 350 CFM per nominal cooling ton. Performance compliance credits are available for demonstrating the installation of a high-efficiency system with a lower fan wattage and/or higher airflow than the mandatory requirements. These credits can be achieved by selecting good duct design and can be assisted by a high-efficiency fan. There are two possible performance compliance credits:

1. The performance compliance method allows the user's proposed fan watt draw to be entered and credit earned if it is lower than the default of 0.58 watts per CFM of system airflow. To obtain this credit, the system airflow must meet the mandatory requirement of at least 350 CFM/ton of nominal cooling capacity.
2. The performance compliance method allows the user's proposed airflow to be entered and credit earned if it is higher than the default of 350 CFM/ton of nominal cooling capacity. To obtain this credit, the fan watt draw must meet the mandatory requirement of no more than 0.58 watts per CFM of nominal cooling capacity.

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

Field verification by a HERS Rater is required. (See Reference Residential Appendix RA3.3.)

4.4 Air Distribution System Ducts, Plenums, and Fans

Air distribution system performance can have a big effect on overall HVAC system efficiency. Therefore, air distribution systems face several mandatory measures and prescriptive requirements, discussed below.

The *2016 Energy Standards* specify 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:

1. Duct location (attic, crawlspace, basement, inside conditioned space, or other)
2. Specific conditions in the unconditioned space, for example, presence of a radiant barrier
3. Duct insulation characteristics
4. Duct surface area, and
5. Air leakage of the duct system

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

1. Default input assumptions; or
2. 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.

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

4.4.1.1 Minimum Insulation

§150.0(m)1

Ducts that are entirely in conditioned space must comply with an installed R-value of R-4.2. In all other cases, the minimum allowed duct insulation value is R-6. Higher values may be required by the prescriptive requirements, as described below.

To determine whether ducts are entirely in conditioned space as defined in §100.1, a Rater must field verify by visual inspection and by using the protocols of RA 3.1.4.3.8.

RA 3.1.4.3.8 describes the duct leakage to outside test to help ensure that the ducts are within the pressure boundary of the space being served by the duct system. Passing the test alone is not enough to establish that the ducts are entirely within conditioned space. The test procedure is in addition to a basic visual inspection of the ducts to ensure that no portion of the duct system is obviously outside the apparent pressure/thermal boundary. Once this has been established, the leakage to outside test verifies that the pressure boundary is intact and preventing leakage from escaping to the outside.

Applying this procedure to multifamily dwelling units poses a unique situation. In this case, leakage to “outside” means conditioned air leaking from the ducts to anywhere outside the pressure boundary of the space being served by the duct system, including adjacent dwelling units. Duct leakage to adjacent dwelling units is not desirable and should be eliminated. When performing the leakage-to-outside test, it is necessary only to pressurize the dwelling unit served by the duct system being tested.

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

§150.0(m)5

For determining 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:

1. For duct wrap, the installed thickness of insulation must be assumed to be 75 percent of the nominal thickness due to compression.
2. For duct board, duct liner, and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used.

4.4.1.2 **Connections and Closures**

§150.0(m)1 - §150.0(m)3

The Energy Standards set a number of mandatory measures related to duct connections and closures. These measures address both the materials and methods used for duct sealing. The following is a summary. Refer to the sections of the Energy Standards listed above for additional details.

4.4.1.3 **Factory-Fabricated Duct Systems**

Factory-fabricated duct systems must comply with the following requirements:

1. All factory-fabricated duct systems must comply with UL 181 for ducts and closure systems, including collars, connections, and splices, and be labeled as complying with UL 181. UL181 testing may be performed by UL laboratories or a laboratory approved by the Executive Director.
2. All pressure-sensitive tapes, heat-activated tapes, and mastics used in the manufacture of rigid fiberglass ducts must comply with UL 181 and UL 181A.
3. All pressure-sensitive tapes and mastics used with flexible ducts must comply with UL 181 and UL 181B.
4. Joints and seams of duct systems and related components cannot be sealed with cloth back rubber adhesive duct tapes unless such tape is used in combination with mastic and draw bands, or
5. It has on its backing the phrase "CEC approved," a drawing of a fitting to plenum joint in a red circle with a slash through it (the international symbol of prohibition), and a statement that it cannot be used to seal fittings to plenums and junction box joints.

4.4.1.4 **Field-Fabricated Duct Systems**

Field-fabricated duct systems must comply with the following requirements:

1. Factory-made rigid fiberglass and flexible ducts for field-fabricated duct systems must comply with UL 181. All pressure-sensitive tapes, mastics, aerosol sealants, or other closure systems used for installing field-fabricated duct systems shall meet the applicable requirements of UL 181, UL 181A, and UL 181B.
2. Mastic sealants and mesh:
   a. Sealants must comply with the applicable requirements of UL 181, UL 181A, and/or UL 181B and be nontoxic and water-resistant.

b. Sealants for interior applications must be tested in accordance with ASTM C731 and D2202.

c. Sealants for exterior applications must be tested in accordance with ASTM C731, C732, and D 2202.

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

3. Pressure-sensitive tapes must comply with the applicable requirements of UL 181, UL 181A, and UL 181B.
4. Joints and seams of duct systems and their components must not be sealed with cloth back rubber adhesive duct tapes unless such tape is used in combination with mastic and draw bands: or
5. It has on its backing the phrase "CEC approved," a drawing of a fitting to plenum joint in a red circle with a slash through it (the international symbol of prohibition), and a statement that it cannot be used to seal fittings to plenums or junction box joints.

4.4.1.5 **Draw Bands Used With Flexible Duct**

1. Draw bands must be either stainless-steel worm-drive hose clamps or UV-resistant nylon duct ties.
2. Draw bands must have a minimum tensile strength rating of 150 pounds.
3. Draw bands must be tightened as recommended by the manufacturer with an adjustable tensioning tool.

4.4.1.6 **Aerosol-Sealant Closures**

1. Aerosol sealants shall meet the requirements of UL 723 and be applied according to manufacturer specifications.
2. 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 a HERS Rater may examine this as a part of his or her responsibilities when involved in a project, the enforcement of these minimum standards for ducts is the responsibility of the building official.

§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 drawbands alone are adequate for sealing most connections. Cloth–backed, rubber-adhesive duct tape would then be used only to hold the outer vapor barrier in place or for some other superfluous purpose. It 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, HERS Raters will also verify compliance with this requirement in conjunction with duct leakage verification.

4.4.1.7 **Product Markings**

§150.0(m)2A, §150.0(m)6

All factory-fabricated duct systems must meet UL 181 for ducts and closure systems and be labeled as complying with UL 181. Collars, connections, and splices are considered to be factory-fabricated duct systems and must meet the same requirement.

Insulated flexible duct products installed to meet this requirement must include labels, in maximum intervals of 3 ft, showing the R-value for the duct insulation (excluding air films, vapor barriers, or other duct components), based on the tests and thickness specified in §150.0(m)4 and §150.0(m)5C.

4.4.1.8 **Dampers to Prevent Air Leakage**

§150.0(m)7

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

§150.0(m)8

Gravity ventilating systems must have an automatic or readily accessible, manually operated damper in all openings to the outside, except combustion inlet and outlet air openings and elevator shaft vents. This includes clothes dryer exhaust vents when installed in conditioned space.

4.4.1.9 **Protection of Insulation**

§150.0(m)9

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

1. Insulation exposed to weather must be suitable for outdoor service − for example, protected by aluminum, sheet metal, painted canvas, or plastic cover.
2. 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.

4.4.1.10 **Ducts in Concrete Slab**

Ducts located in a concrete slab must have R-6 insulation, but other issues will come into play. 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 located 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.

4.4.1.11 **Porous Inner Core Flex Duct**

§150(m)10

Over time, the outer vapor barrier of flex duct can be compromised. Therefore, porous inner core flex duct is not allowed.

4.4.1.12 **Duct System Sealing and Leakage Testing**

§150(m)11

Duct system sealing and leakage testing is mandatory in all climate zones. Duct systems in newly constructed single-family dwellings, townhouses, and multifamily dwellings are required to comply with the requirements. For single-family dwellings and townhouses where the air-handling unit is installed and ducts are connected directly to the air handler, the total leakage of the duct system needs to be 5 percent or less of the nominal system air handler airflow. For single-family dwellings and townhouses where the air-handling unit is not installed, the total leakage of the duct system shall not exceed 4 percent of the nominal systems air handler airflow.

For multifamily dwellings with the air-handling unit installed and the ducts connected directly to the air handler, the total leakage of the duct system shall not exceed 12 percent of the nominal system air handler airflow or the duct system leakage to outside shall not exceed 6 percent of the nominal system air handler airflow.

The duct system leakage needs to be verified per the applicable procedures outlined in Reference Residential Appendix Section RA3.1.4.3.1 through RA3.1.4.3.4.

Alterations and additions to ducted systems in existing buildings in all climate zones are also required to comply with applicable maximum leakage criteria. Refer to Chapter 9 for more information on duct sealing and leakage testing for existing buildings.

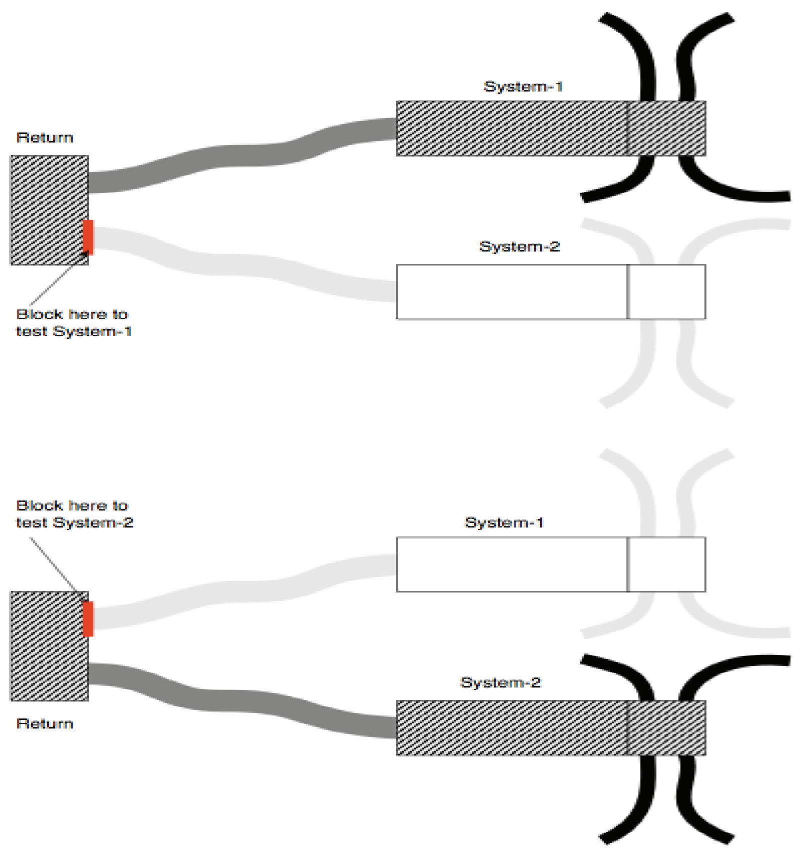
A. Duct Leakage Testing for Multiple Duct Systems With Common Return Ducts

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.

Figure 4-3 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 the 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

4.4.1.13 Air Filtration

§150.0(m)12

Air filtration is present in forced air systems to protect the equipment and may provide health benefits to building occupants. In addition to filtering particulates from the airstream, filters add flow resistance to the forced air system, potentially lowering the efficiency of the heating/cooling equipment. Flow resistance is measured as a pressure drop at a specific airflow.

Except for evaporative coolers, any mechanical forced air heating and/or cooling system with more than 10 feet of duct must meet four sets of criteria:

1. System Design Criteria:
   a. All recirculated and outdoor air passing through the heating/cooling device must first pass through the filter.
   b. The system design must accommodate the pressure drop through the filter at the designed airflow. To accomplish this, the design airflow and the design pressure drop through the filter must be determined by the designer. The design pressure drop will determine the size and depth of the filter media required for the device (return filter grille or filter rack).
   c. If the system design elects compliance using the return duct design alternative specified in Tables 150.0-B and C (see Table 4-10 and Table 4-11), then the

designer must assume a design filter pressure drop of 0.05 IWC at the applicable design airflow rate.

d. Replacing the filters, like for like, when they become dirty brings the resistance to airflow back to the design condition. Therefore, the filters must be located to allow access for regular service by the occupants.

e. To maintain the energy efficiency of the system, it is necessary for the occupants to know which filters to select that will provide the designed airflow. Therefore, a clearly legible label, such as shown in Figure 4-4, shall be permanently placed in a location visible to a person changing the filter. As shown in Figure 4-4, the label shows the allowable maximum resistance at the airflow rate closest to the design airflow for that filter location. For example, Figure 4-4 is a label for a filter location designed for 400 CFM at 0.03 IWC. On air filter media product labeling, the AHRI Standard 680 test procedure reports pressure drop at airflow values in 400 CFM increments, and the ASHRAE Standard 52.2 test procedure reports pressure drop at five airflow values within the manufacturer's rated range of performance. Therefore values for air filter media pressure drop for airflow rates that fall between the reported cfm increments must be determined by interpolation of the values reported on the manufacturer's air filter product label, or by lookup methods made available by the filter media vendor or manufacturer.

Figure 4-4: Example of Filter Location Label

Air Filter Performance Requirement		**Maintenance Instructions**
Airflow (CFM)	Initial Resistance (inch WC)	USE ONLY REPLACEMENT FILTERS WITH AN INTIAL RESISTANCE LESS THAN 0.032 AT 400 CFM AIRFLOW RATE
400	0.03	

Source: California Energy Commission

2. Air Filter Media Efficiency Criteria: The filter media shall be MERV 6 or better to protect the equipment and to potentially provide health benefits. Filter media that provide at least 50% percent particle efficiency in the 3.0–10 μm range in AHRI 680 are considered to meet the MERV 6 criterion.
3. Air Filter Media Pressure Drop Criteria: To ensure airflow for efficient heating and cooling equipment operation, the installed filter media must conform to the design pressure drop specification shown in the Filter Location Label described in Item 1e above.
4. Air Filter Media Labeling Criteria: The filter device must be provided with a filter media product that has been labeled by the manufacturer to disclose performance ratings that meet both the Efficiency and Pressure drop criteria described in 2 and 3 above and as shown in the Filter Location Label described in Item 1.e above.

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

§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. §150.0(m)13 requires system airflow and watt draw to be HERS-verified. See Reference Residential Appendices RA3.3 for the applicable HERS verification procedures.

Except for heating only systems, systems must comply with one of the following two methods:

1. 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:

   a. Provide airflow through the return grilles that is equal to or greater than 350 CFM per ton of nominal cooling capacity.

   b. At the same time, the fan watt draw must be less than or equal to 0.58 watts per CFM.

   The methods of measuring the watt draw are described in Reference Residential Appendix RA3.3. Three acceptable apparatuses are:

   a. A portable watt meter,

   b. An analog utility revenue meter, or

   c. A digital utility revenue meter.

   Note: When required to measure 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 to determine compliance with the system airflow requirement. They are described in Reference Residential Appendix RA3.3 and use one of the following:

   a. An active or passive flow capture hood to measure the total airflow through the return grill(s)

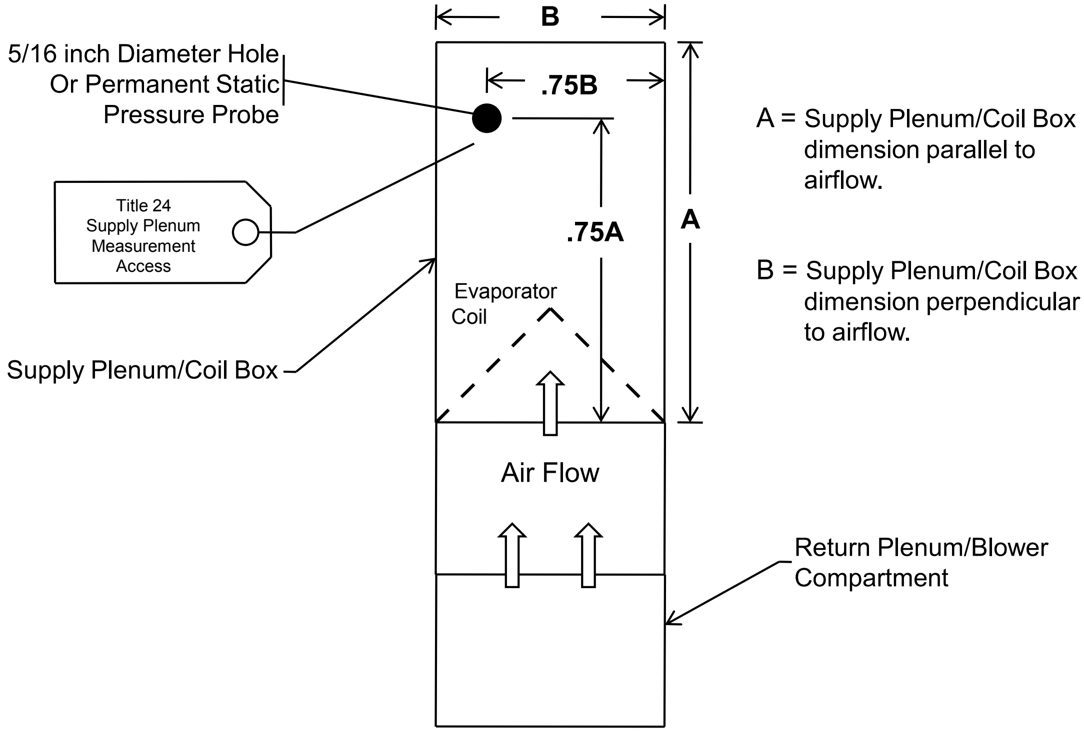
   b. Flow grid device(s) at the return grill(s) or other location where all the central fan airflow passes through the flow grid, or

   c. Fan flow meter device to perform the plenum pressure matching procedure.

   The flow grid and the fan flow meter both require access to static pressure measurements of the airflow exiting the cooling coil, which uses 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 Figure 4-5 below and Reference Residential Appendix RA3.3

Figure 4-5: Location of the Static Pressure Probe



Source: California Energy Commission

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

2. 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 watt draw. This method can be used for return systems with two returns. Each return shall be no longer than 30 feet from the return plenum to the filter grille. When bends are needed, metal elbows are desirable. Each return can have up to 180 degrees of bend, and no more 90 degrees of bend can be flex duct. To use this method, the designer and installer must provide return system sizing that meets the appropriate criteria in Table 4-10 or Table 4-11.

4.4.1.15 **Airflow and Fan Efficacy Testing Versus Return Duct Sizing**

Studies have shown that adequate airflow is critical to the efficient operation of air-conditioning systems. §150.0(m)13B establishes mandatory requirements that are intended to ensure adequate cooling airflow through properly sized ducts and efficient fan motors.

There are two options allowed to ensure adequate air flow; option one is to design and install the systems using standard design criteria and then have the systems airflow and fan efficacy (AF/FE) tested and third-party verified in the field. The second option is to size the return ducts according to Table 4-10 and Table 4-11 (as specified by EXCEPTION 1 to §150.0(m)13B). These tables are very simplified and very conservative. (The return ducts are much larger than would normally be used.) They should be used only in situations where there is a serious concern that the system will not pass the diagnostic tests for airflow and fan efficacy, such as in alterations where duct modification opportunities are limited. The first option, AF/FE testing, is always preferable, especially in new construction.

The California Green Code and the California Mechanical Code both require that residential duct systems be designed according to ACCA Manual D, or equivalent. If reasonable care and judgment is used in designing the duct system (both return and supply ducts), and the system is designed to reasonable parameters for airflow per ton, static pressure across the fan, and friction rate, these systems should have no problem passing the diagnostic tests. Return ducts should not be sized according to Table 4-10 or Table 4-11 purely as a way to avoid the diagnostic testing. While undersized return ducts are very often the cause of poor airflow in many systems, they are only part of the overall system.

The following design guidelines will increase the chances of the system passing the AF/FE testing without sizing the return ducts according to Table 4-10 or Table 4-11:

1. Right-size the HVAC system; if a 3-ton unit is enough to satisfy the cooling load, do not install a 4-ton unit "just to be safe." Oversizing equipment can cause comfort problems in addition to excessive energy use.
2. The HVAC designer must coordinate closely with the architect and structural engineer to make sure that the ducts will fit into the home as designed.
3. Prepare a detailed mechanical plan that can be followed in the field. If deviations must occur in the field, make sure that they are coordinated with the designer and that the design is adjusted as needed.
4. Follow Manual D for duct sizing:
   a. Make sure that the correct duct type is being used (vinyl flex, sheet metal, rigid fiberglass, or other).
   b. Make sure that all equivalent lengths and pressure drops are correctly accounted for (bends, plenum start collars, t-wyes, filters, grilles, registers, and so forth.
   c. Select a furnace that will provide at least 400 cfm/ton at the desired static pressure of 125 to 150 Pa (0.5 to 0.6 inches water column).
   d. Design the duct system to a static pressure across the fan of no more than 150 Pa (0.6 inches w.c.).
   e. Consider upsizing the evaporator coil relative to the condenser to reduce the static pressure drop. This results in better airflow and slightly better capacity and efficiency. Manufacturers commonly provide performance data for such condenser coil combinations.
   f. Consider specifying an air handler with a better quality fan motor.
5. Install a large grill area and use proper filter for the system; using a higher MERV filter than needed unnecessarily increases the static pressure.
6. Locate registers and equipment to make duct runs as short as possible.
7. Make all short-radius 90-degree bends out of rigid ducting.
8. Install flex duct properly by stretching all flex duct tight and cut off excess ducting, ensure the duct is not kinked or compressed, ensure flex duct is properly supported every four feet or less using one inch strapping having less than two inches of sag between supports.

Consider using better quality supply and filter grilles. "Bar-type" registers have considerably better airflow performance than standard "stamped-face" registers. Refer to manufacturer's specifications and select accordingly.

Energy Standards Tables 150.0-B and C (Table 4-10 and Table 4-11) allow for only one or two returns. There may be times where three returns are necessary on a single system. Furthermore, Table 150.0-C does not allow for deviation from the two sizes specified. For example, the table requires two 16” return ducts for a 3.5-ton system, but specific airflow requirements and architectural constraints may dictate something more like a 20” and a 14”. In this situation, the designers would have to rely on standard engineering principles and trust their design to pass the diagnostic tests.

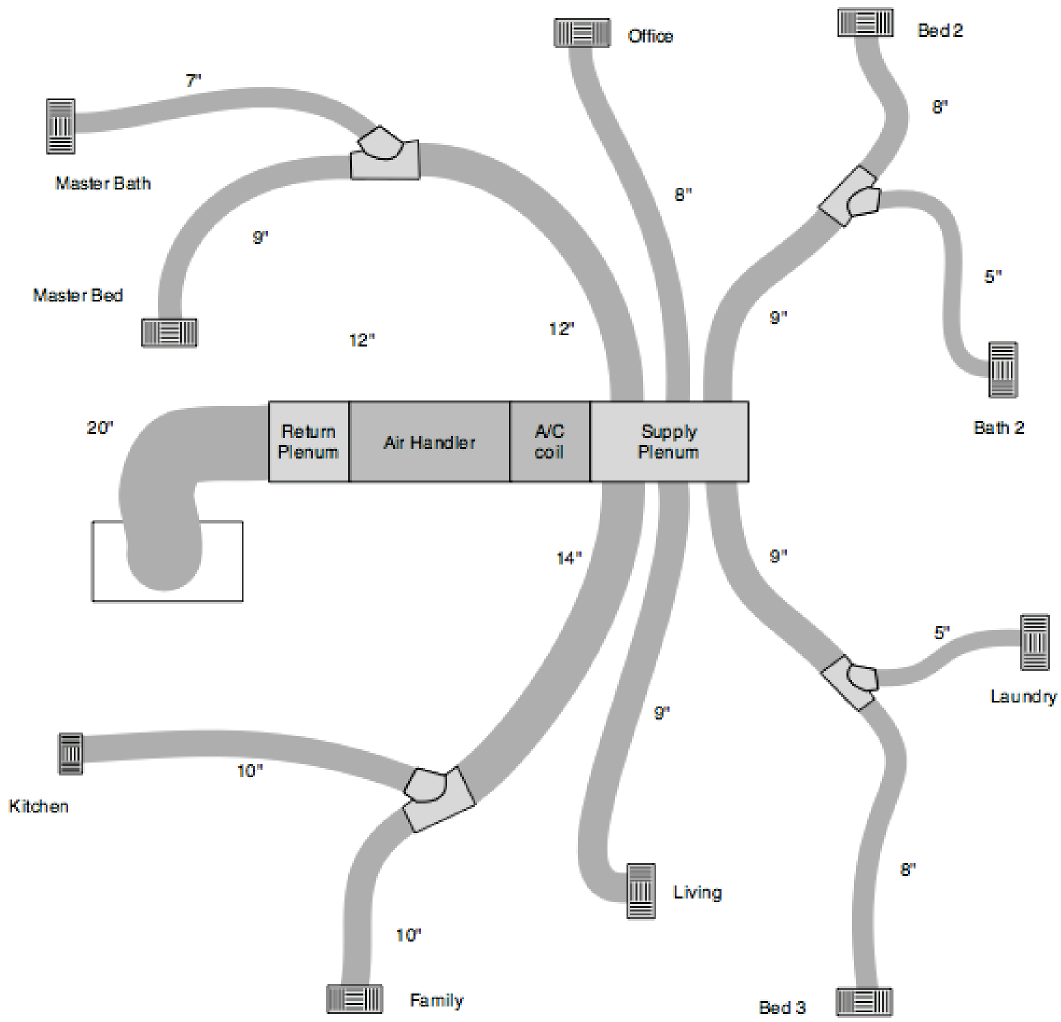
Having adequate room to run properly sized ducts has always been an issue. Historically, duct systems have been sized to fit into the home at the expense of proper airflow. The performance of these systems, in terms of efficiency and capacity, has suffered greatly because of this practice. It is the intent of these Standards to change these practices. The home should be designed to accommodate properly sized ducts. This requires improved coordination among the architect, structural engineer, and mechanical designer earlier in the process. This is not “best practice”; this is simply good design.

Tables 150.0-B and C require use of return grilles that are sized to achieve a reasonable face velocity and static pressure drop. Tables 150.0-B and C also require the return grille devices to be labeled in accordance with the requirements in §150.0(m)12A to disclose the design airflow rate of the grille determined taking into account a maximum allowable clean-filter pressure drop of 12 Pa (0.05 inches water) for the air filter media. The nominal size of the air filter grille or air filter media should be used to calculate the return filter grille gross area for determining compliance with Tables 150.0-B and C. The nominal size of the filter grille is expected to be the same as the nominal size of the air filter media that is used in the grille, and is most often the information used to identify these items for purchases. For example, a nominal 20 inch by 30 inch filter grille will use nominal 20 inch x 30 inch air filter media.

4.4.1.16 **Return Duct Sizing Example**

The mechanical contractor for a new home submitted the following mechanical design to the builder. It was designed using typical design specifications (400 cfm/ton at 125 Pa (0.5” w.c., friction rate = 0.1, etc.). The system is has 4-ton condenser, and the air handler is rated for 1,600 cfm.

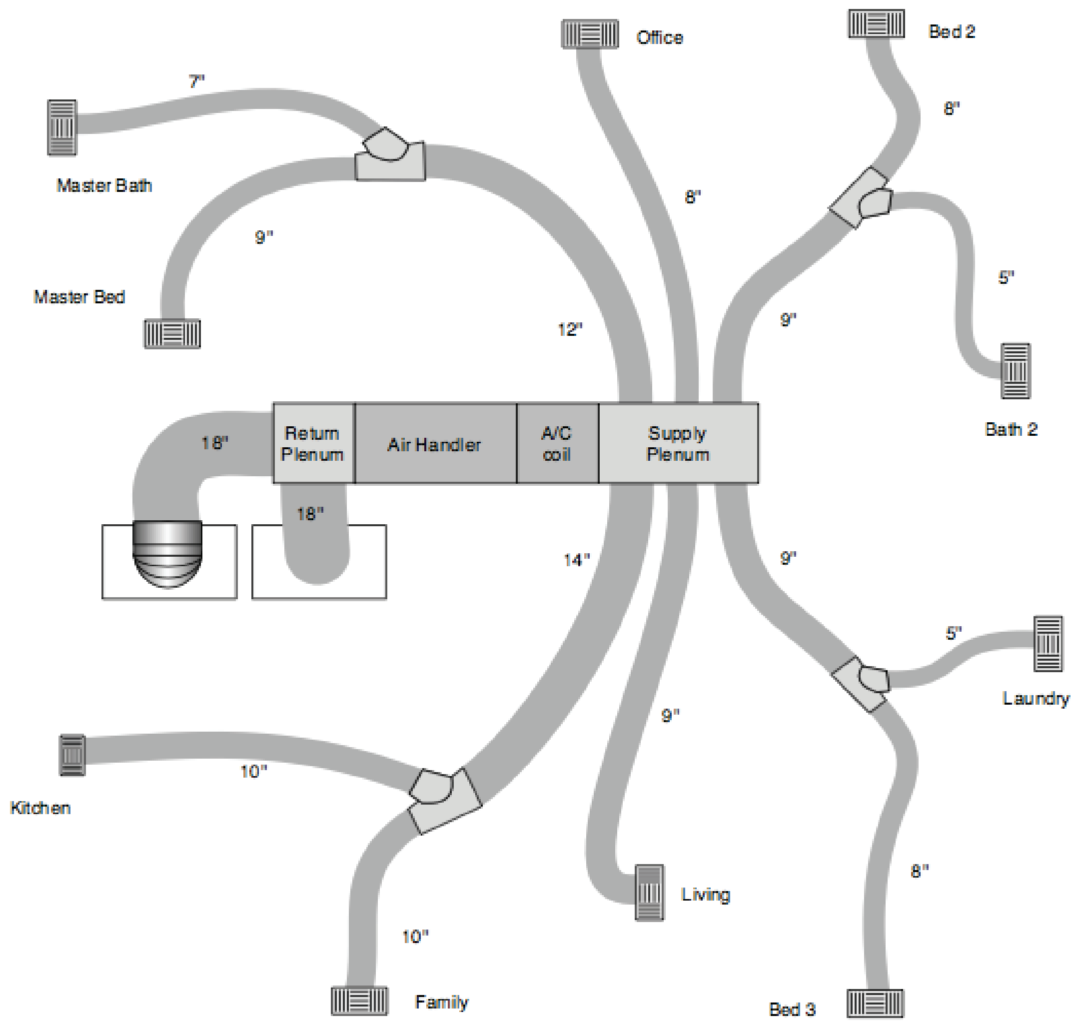
Figure 4-6: Return Duct Design Option 1



Source: California Energy Commission

Because the builder has specified a low-end air handler, he or she is concerned that the system may not pass the mandatory diagnostic testing requirement for airflow and fan efficacy. The builder requests that the system be redesigned with the return ducts sized according to Table 150.0-C. The following layout is the redesigned system (Figure 4-7). The only change is that the system now has two 18” return ducts and two filter grilles sized according to Table 150.0-C, rather than a single 20” return duct and a filter grille sized according to the manufacturer’s specifications for 1,600 cfm. Because one of the return ducts had more than one 90 degree bend, one of the bends is required to be a metal elbow (to be insulated). The two return filters are 20”x30” each and are rated by the manufacturer to show that they have a pressure drop of less than 125 Pa (0.5” w.c.) at 800 cfm each.

Figure 4-7: Return Duct Design Option 2



Source: California Energy Commission

Table 4-10: Return Duct Sizing for Single Return Duct Systems

System Nominal Cooling Capacity (Ton)	Minimum Return Duct Diameter (inch)	Minimum Total Return Filter Grille Gross Area (Inch^2)
1.5	16	500
2.0	18	600
2.5	20	800

From Table 150-B of the Energy Standards

Table 4-11: Return Duct Sizing for Multiple Return Duct Systems

Two Returns			
System Nominal Cooling Capacity (Ton)	**Return Duct 1 Minimum Diameter (inch)**	**Return Duct 2 Minimum Diameter (inch)**	**Minimum Total Return Filter Grille Gross Area ($inch^2$.)**
1.5	12	10	500
2.0	14	12	600
2.5	14	14	800
3.0	16	14	900
3.5	16	16	1000
4.0	18	18	1200
5.0	20	20	1500

From Table 150-C of the Energy Standards

4.4.1.17 **Zonally Controlled Central Forced Air Cooling Systems**

The primary purpose of zoning ducted air conditioners, heat pumps, and furnaces 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. For example, it is common for two-story homes to be too hot on the second floor in both 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 is comfortable, but it carries with it the distinct possibility of increased energy consumption. Since the most common home is single-zoned and has only one thermostat placed near the center of the house, temperatures in the rooms distant from that thermostat will vary, sometimes significantly. If zoning is added, the more distant rooms may be conditioned to a more comfortable temperature. This increased conditioning requires more energy. When designed correctly, zoning allows only the zones that need conditioning to be conditioned, thus potentially saving energy.

It is common for zonally controlled central forced air cooling systems to produce lower airflow through the returns thus lowering the sensible efficiency of the single-stage heating or cooling equipment. There are two primary methods by which the common multizoned dampered system lowers airflow: additional restriction of zoning dampers and recirculation through the air conditioner from a bypass duct. To avoid this efficiency problem, zonally controlled central forced air cooling systems using a single-speed air conditioner must simultaneously meet the following criteria:

1. In every zonal control mode, the system shall provide airflow through the return grilles that is equal to or greater than 350 CFM per ton of nominal cooling capacity.
2. In every zonal control mode, the fan watt draw must be less than or equal to 0.58 watts per CFM.

The airflow and fan watt draw must be HERS-verified. See Reference Residential Appendix RA3.3 for the HERS verification procedures.

Zonally controlled central forced air cooling systems with multispeed or variable speed compressors need to be verified only to meet the above 350 CFM per nominal ton and 0.58 watts per CFM criteria with the compressor on high speed and all zones calling for cooling.

4.4.1.18 **Zoned Systems and Airflow and Fan Efficacy Requirements**

Recent studies have shown that zoned systems (multiple zones served by a single air handler with motorized zone dampers), with or without bypass dampers, usually do not meet the AF/FE requirements when fewer than all zones are calling. The energy penalty that results from this is greater than the benefit of having zonal control; therefore zonal control is no longer simply assumed to be a “better than minimum” condition, and there are special compliance requirements for them. Zonal control accomplished by using multiple single-zone systems is not subject to these requirements.

There are two choices for modeling zoned systems. One is for air conditioning condensers that have single-speed compressors, and the other is for condensers that have “multispeed” compressors. Two-speed and variable-speed compressors are considered multi-peed. Multispeed compressors allow the system capacity to vary to more closely match reduced cooling loads when fewer than all zones are calling for cooling. Therefore, multispeed compressor systems are given special consideration when used in zoned systems and are not required to verify performance in all zonal control modes. Instead, the airflow and fan efficacy testing is required to be performed only at the highest speed with all zones calling. Zoned systems with single-speed compressors must be tested and pass in all operating modes.

Because zoned systems, with or without bypass dampers, are less likely to meet the AF/FE requirements when fewer than all zones are calling, a way is provided in the performance compliance option to take this penalty and still allow use of zone dampers. Other energy features must offset the penalty. In the performance compliance software, if the system is modeled as a zoned system with a single-speed compressor, the default airflow drops to 150 CFM/ton. The standard house is assumed to have an airflow of 350 CFM/ton, so there is definitely a penalty unless the designer specifies a value of 350 or higher. Entering a value between 150 and 350 can lessen the penalty.

It is extremely important that the energy consultant model airflow and fan efficacy values are reasonable and obtainable; otherwise they will fail in the field and will need to be remodeled at actual values. Energy consultants should coordinate with the HVAC designer before registering the certificate of compliance.

Note: Bypass dampers may be installed only if the certificate of compliance specifically states that the system was modeled as having a bypass damper.

Example:

1. A home is to be built with a zoned system (two zones) with a single-speed compressor 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.
2. The energy consultant models the system in the proposed house with 275 CFM/ton (better than default) and 0.58 W/CFM (default). Because the standard house assumes 350 CFM/ton, there is an energy penalty that must be made up with other better-than-standard features, but it is not nearly as bad as it would be at the default of 150 CFM/ton.
3. Because 275 CFM/ton is better than the default of 150, it must be tested in all individual control modes. Because the modeled fan efficacy is the default value, it needs to be tested only with all zones calling. If a better than default value was modeled for fan efficacy, it would need to be tested in all zonal control modes.
4. The home is built and the system is verified by a rater and passes at 287 CFM/ton with one zone calling, 298 CFM/ton with the other zone calling, and 372 CFM/ton with both

zones calling. It must still meet the mandatory requirements of 350 cfm/ton with all zones calling.

5. If this same home was to be built with a multispeed compressor, it would have to be tested only with both zones calling whether it has a bypass damper, but the target airflow would be no less than 350 CFM/ton. Compliance credit can be achieved by modeling airflows greater than 350 CFM/ton and/or fan efficacies less than 0.58 watts/CFM.

Table 4-12: Single-Zone Ducted Central Forced Air Cooling Systems

Single-Zone Ducted Cooling Systems (Single Zone Off of a Single Air Handler)			
Compressor Type	Mandatory Requirements for Airflow and Fan Efficacy	Performance Compliance Option	
		Proposed System Defaults	Modeled Improved Airflow and/or Fan Efficacy
Single Speed and Two Speed or Variable Speed (Testing Performed on Highest Speed only)	Airflow ≥ 350 CFM/ton, and Fan Efficacy ≤.58 W/CFM (Airflow and Fan Efficacy testing not required if Return System Sized to Tables 150.0-B or C, but verification of sizing is required)	350 CFM/ton and 0.58 W/CFM	Airflow ≥350 CFM/ton and/or Fan Efficacy ≤0.58 W/CFM

Source: California Energy Commission

Table 4-13: Zonally Controlled Central Forced Air Cooling Systems

Zoned Ducted Cooling Systems (Multiple Zones Off a Single Air Handler)			
Compressor Type	**Mandatory Requirements for Airflow and Fan Efficacy** [1]	**Performance Compliance** [2]	
		Proposed System Defaults [3]	**Modeled Improved Airflow and/or Fan Efficacy**
Single Speed	Airflow ≥ 350 CFM/ton and Fan Efficacy ≤ 0.58 W/ CFM (For Prescriptive Compliance Method, verification is mandatory in all zonal control modes. For Performance Compliance Method, verification is mandatory using highest capacity with all zones calling)	150 CFM/ton and 0.58 W/CFM	Airflow ≥ 150 CFM/ton and/or Fan Efficacy ≤ 0.58 W/CFM (Verification of better-than-default values required in all individual control modes. Mandatory requirement of 350 CFM/ton and 0.58 W/CFM still applies for all zones calling)
Two Speed or Variable Speed	Airflow ≥ 350 CFM/ton and Fan Efficacy ≤ 0.58 W/ CFM (Verification Required Only on Highest Capacity and with All Zones Calling)	350 CFM/ton and 0.58 W/CFM	Airflow ≥ 350 CFM/ton and/or Fan Efficacy ≤ 0.58 W/CFM (Verification of modeled improved values required only on Highest Capacity and with All Zones Calling)

[1] For the Prescriptive Compliance Method, all Mandatory Requirements for airflow and fan efficacy must be met, and use of a bypass duct is not allowed.

[2] For the Performance Compliance Method, all Mandatory Requirements for airflow and fan efficacy must be met, and use of a bypass duct may be specified in the compliance software input for the zoned system type.

[3] The Standard System Default for all cases is 350 CFM/ton and 0.58 W/CFM.

Source: California Energy Commission

4.4.1.19 Indoor Air Quality and Mechanical Ventilation

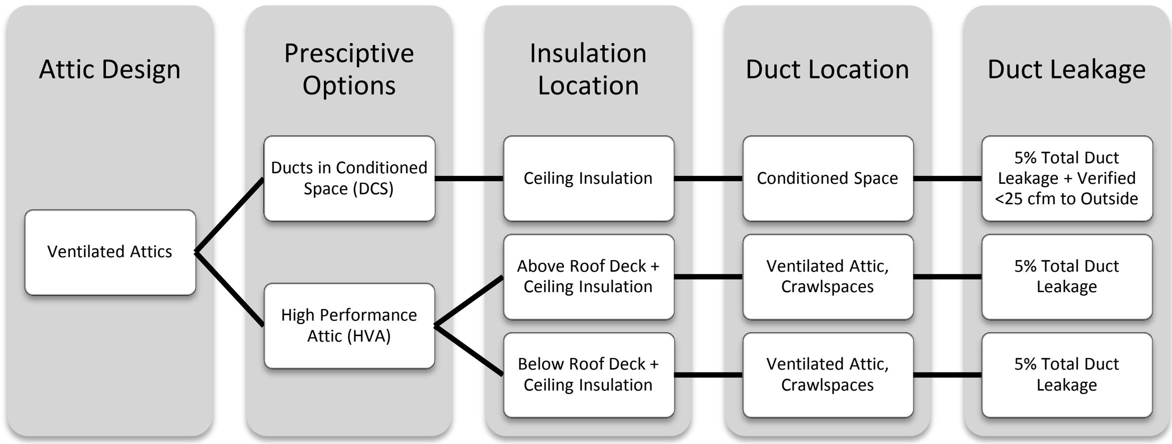
§150.0(o)

See Section 4.6 of this chapter for details.

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

The *2016 Energy Standards* are designed to offer flexibility to the builders and designers of residential new construction in terms of 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, 8-16 as shown in Figure 4-8.

Figure 4-8: Ventilated Attic Prescriptive Compliance Choices



Source: California Energy Commission

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 either below the roof deck or insulation above the roof deck in addition to insulation at the ceiling, R-8 ducts, and 5 percent total duct leakage of the nominal air handler airflow. These requirements and approaches to meet the requirements are explained in Section 3.6.2 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 in order to meet the prescriptive requirement. The following sections describe the duct related requirements for DCS.

4.4.2.1 Duct Location

§150.1(c)9

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

1. If meeting the prescriptive requirements of the high-performance attic (HPA) as explained above, the duct system and air handlers of HVAC systems are allowed to be located in the attic.
2. If meeting the prescriptive requirements of the ducts in conditioned space (DCS) as explained above, the duct system and air handlers of HVAC systems must be located in conditioned space, which includes a joist cavity between conditioned floors, or in sealed cavity below attic insulation.

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

1. 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.

2. Duct location needs to be verified through a visual inspection per Reference Residential Appendix RA 3.1.4.1.3.
3. Duct leakage to outside needs to be confirmed by field verification and diagnostic testing in accordance with Reference Residential Appendix RA3.1.4.3.8.
4. Ducts are insulated to a level required in Table 150.1-A.

Figure 4-9: Checklist for Prescriptive Requirement − Option C DCS (§ 150.1(c)1)

§150.1(c)1 **Option C (CZ 4, 8-16)**
☐ Vented attic ☐ R30 or R38 ceiling insulation (climate zone specific) ☐ R6 or R8 ducts (climate zone specific) ☐ Radiant Barrier ☐ Verified ducts in conditioned space

Source: California Energy Commission

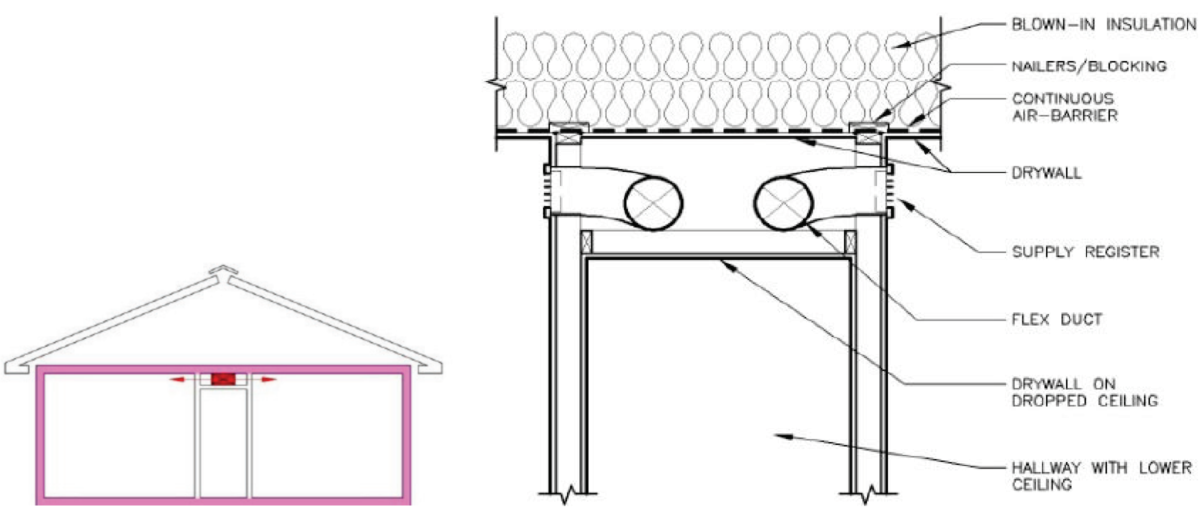
The checklist in Figure 4-9 lists all the prescriptive DCS requirements that must be met to meet prescriptive requirements using DCS strategy. It is not enough to only locate ducts in conditioned space, but insulation must also meet prescriptive values. If a building is not able to meet all of the requirements in this checklist, it must use the performance approach or Option A or B from the §150.1(c).1. Refer to Section 3.6 of the *Residential Compliance Manual* for more information on these options.

There are several methods of achieving the goal of DCS. The basic information of the strategies, their benefits, challenges, and potential solutions to those challenges are outlined below.

A. 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 the dropped ceiling.

Figure 4-10: Ducts in Conditioned Space using a Dropped Ceiling



Source: www.ductsinside.org/

Figure 4-11: Ducts Routed through a Dropped Ceiling

Source: BIRA Energy

Benefits of selecting this strategy include the following:

1. Attic ventilation remains the same as standard practice.
2. Does not affect attic assembly or insulation; no changes to truss design.
3. Works with simple and linear designs with rooms off main hallway but can work with more complex plans.
4. Can be integrated into architectural accents.

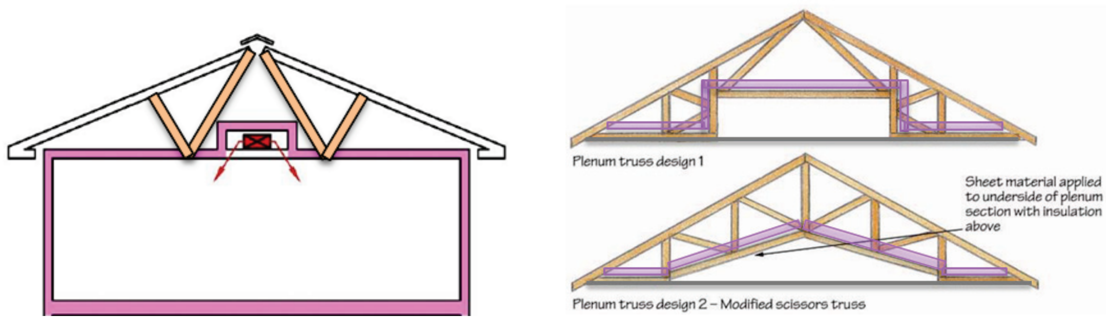
There are challenges associated with this strategy as outlined below, but they can be overcome with good design and installation practices.

1. Need to address 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.
2. Coordination needed between trades – moving the ducts and air handlers and the need to isolate and seal the dropped ceiling would necessitate coordination between different trades (HVAC installer, dry-wall, framing, and electrical contractors) to ensure thermal integrity of the dropped ceiling.

B. 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 to create the space by framing, sealing and insulating the plenum space above the ceiling plane.

Figure 4-12: Plenum Truss Design Example



Source: www.ductsinside.org

Similar to a dropped ceiling, this design is easier with a linear plan that allows for 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 for selecting the strategy:

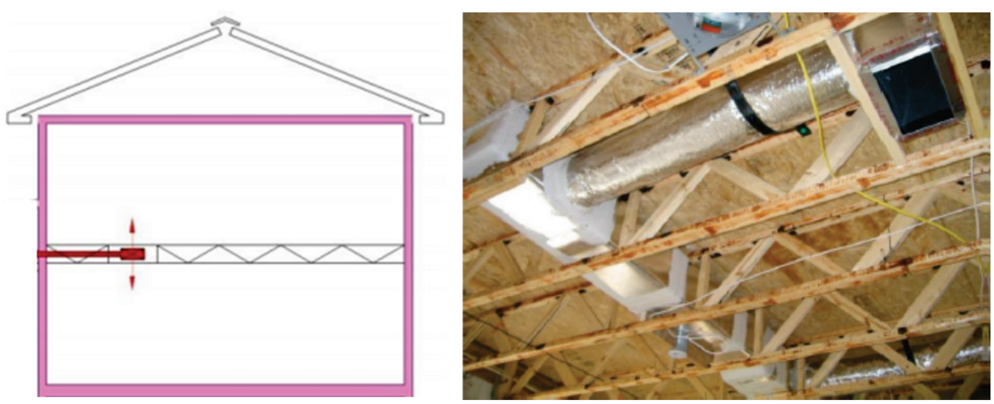
1. Vented attic space, same as standard construction
2. Aesthetically less disruptive than dropped ceiling
3. Works with simple and linear designs with rooms off main hallway

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

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

C. Vented Attic, Open Web Floor Truss

Figure 4-13: 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 not a common component 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” ducts into a 12” 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.

D. Mechanical Closet (and Placement of Sealed Combustion Furnace)

Figure 4-14: 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; therefore, a mechanical closet may not be needed.

One potential location for a mechanical closet is within the garage or other spaces normally not conditioned. 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.

4.4.2.2 **Duct Insulation**

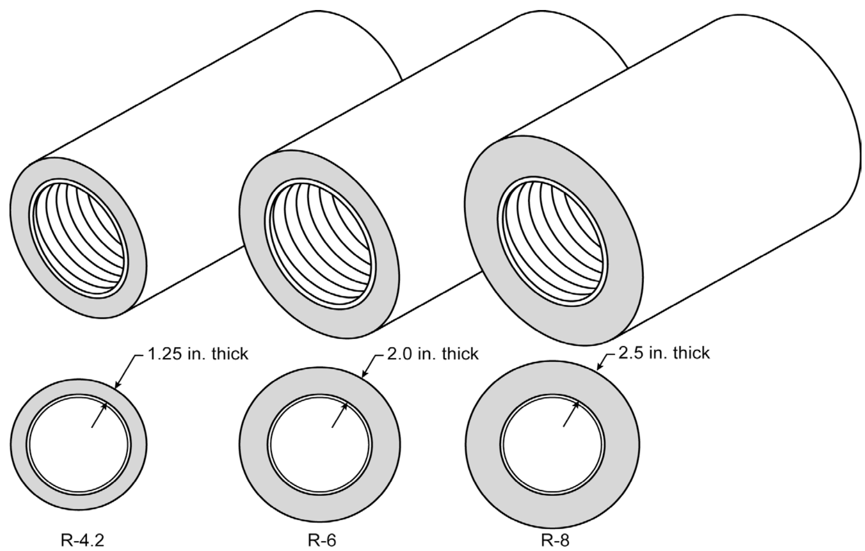
§150.1(c)9

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 A/B or Option C is chosen for Roof/Ceiling Insulation. Since R-6 is the mandatory minimum for ducts in unconditioned space and R-4.2 for ducts in conditioned space, the prescriptive duct insulation requirement can be opted out by using the performance approach and trading off the energy penalty against some other features.

4.4.2.3 **Central Fan Integrated (CFI) Ventilation**

There is a prescriptive requirement for ducted systems that have cooling and a CFI ventilation system to have the fan efficacy verified. This can be opted out using the performance approach.

Figure 4-15: R-4.2, R-6, and R-8 Ducts



Source: California Energy Commission

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

The Energy Standards provide credit for several compliance options related to duct design and construction.

4.4.3.1 **System Airflow and Fan Efficacy**

A performance compliance credit is available for demonstrating the installation of a high-efficiency fan and duct system with better performance than the mandatory requirement of 350 cfm/ton and 0.58 watts/cfm. This credit can be achieved by selecting a unit with a high-efficiency air handler fan and/or careful attention to efficient duct design. The performance compliance method allows the user’s proposed fan power to be entered into the program, and credit will be earned if it is lower than the default of 0.58 watts per CFM of system airflow. To obtain this credit, the system airflow must meet the prescriptive requirements of at least 350 CFM/ton of nominal cooling capacity. After installation, the contractor must test the actual fan power of each system using the procedure in *Reference Residential Appendix* RA3.3 and show that it is equal or less than what was proposed in the compliance software analysis.

The watt draw and airflow must also be verified by a HERS Rater.

4.4.3.2 **Duct Location**

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

1. Credit is available if no more than 12 LF (linear feet) of duct are outside the conditioned space and the user chooses the high-performance attic (HPA) as explained in Section 3.6.2. 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 a HERS Rater.

2. 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 Section 3.6.2. This credit results in eliminating the conduction losses associated with both 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 a HERS Rater.
3. Credit for a high-efficiency duct design is available through the diagnostic duct location, surface area, and R-value compliance option, which are described below. This option requires field verification of the duct design layout drawing(s) by a HERS Rater. Verified duct design, when required, will be included in the HERS Required Verification list on the certificate of compliance (CF-1R). 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 Section 3.6.2.

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.

4.4.3.3 **Duct Insulation**

Performance credit is also available if all of the ducts are insulated to a level higher than required by the prescriptive package. If ducts with multiple R-values are installed, the lowest duct R-value must be used for the entire duct system. However, the air handler, plenum, connectors, and boots can be insulated to the mandatory minimum R-value.

As an alternative when there is a mix of duct insulation R-values, credit is available through the method described in the next section.

4.4.3.4 **Diagnostic Duct Location, Surface Area, and R-value**

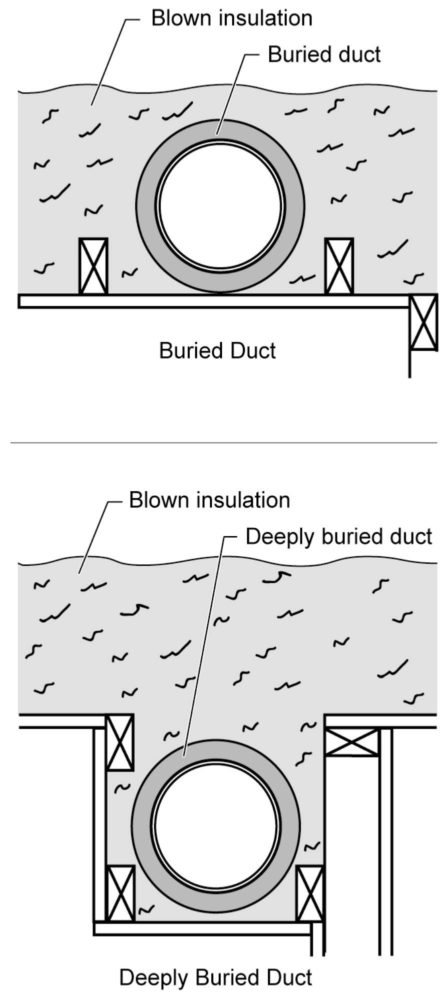
This compliance option allows the designer to take credit for a high-efficiency duct design that incorporates duct system features that may not meet the criteria for the duct location and/or insulation compliance options described above. This method requires that the designer must enter the design characteristics of all ducts that are not located within the conditioned space. The information required for the 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 is better than 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 HERS 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 a HERS Rater on the CF3R form. Details of this compliance option are described in the *Residential ACM*

Reference Manual, and verification procedures are described in RA3.1 of the Reference Residential Appendix.

4.4.3.5 **Buried and Deeply Buried Ducts**

Figure 4-16: Buried Ducts on Ceiling and Deeply Buried Ducts



Source: California Energy Commission

This compliance option also allows credit for the special case of ducts that are buried by blown attic insulation. For ducts that lie on the ceiling (or within 3.5 inch of the ceiling), the effective R-value is calculated based on the duct size and the depth of ceiling insulation as shown in Table R3-38 in the *Residential ACM Manual*. This case is referred to as “Buried Ducts on the Ceiling.” For the case of deeply buried ducts, which are ducts that are enclosed in a lowered portion of the ceiling and completely covered by attic insulation, then the effective R-value allowance in the compliance calculations is R-25 when the attic insulation is fiberglass and R-31 for cellulose attic insulation. To take credit for buried ducts, the system must meet the verified duct design criteria described above, be diagnostically tested for duct sealing compliance by a HERS Rater according to Reference Residential Appendix RA3.1, and meet the requirements for high insulation installation quality described in Reference Residential Appendix RA3.5. Verified minimum airflow (350 cfm/ton or higher if higher is specified on the CF1R) is required when a measure is selected for compliance that has a verified duct design as a prerequisite.

4.4.3.6 **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 HERS Rater verification.

4.4.4 Duct Installation Standards

The mandatory duct construction measures referenced in Section 4.4.1 above state that duct installations must comply with the California Mechanical Code Sections 601, 602, 603, 604, 605, and the applicable requirements of the Energy Standards. Some highlights of these requirements are listed in this section, along with some guidance for recommended quality construction practice.

4.4.4.1 **Tapes and Clamps**

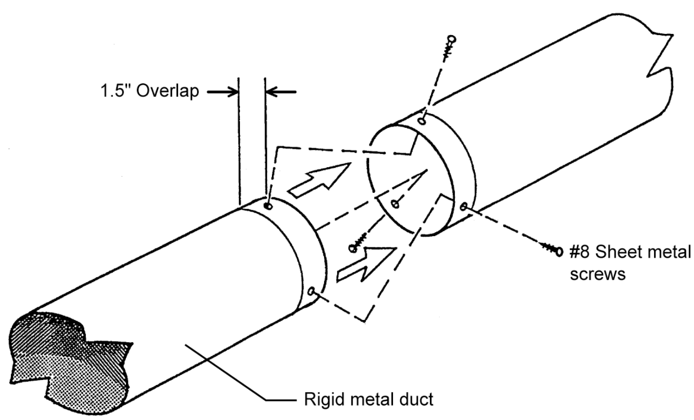
All tapes and clamps must meet the requirements of §150.0(m).

Cloth-backed, rubber-adhesive tapes must be used only in combination with mastic and draw bands, or have on its backing the phrase "CEC approved," a drawing of a fitting to plenum joint in a red circle with a slash through it (the international symbol of prohibition), and a statement that it cannot be used to seal fittings to plenums and junction box joints.

4.4.4.2 **All Joints Must Be Mechanically Fastened**

For residential round metal ducts, installers must overlap the joint by at least 1½ inch and use three sheet metal screws equally spaced around the joint. (See Figure 4-17.)

Figure 4-17: Connecting Round Metallic Ducts

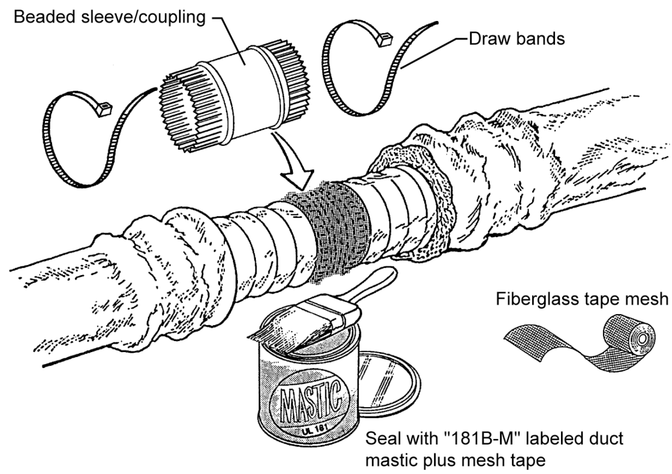


Source: Richard Heath & Associates/Pacific Gas & Electric

For round nonmetallic flex ducts, installers must insert the core over the metal collar or fitting by at least 1 in. This connection may be completed with either mesh, mastic and a clamp, or two wraps of tape and a clamp.

For a mesh and mastic connection, the installer must first tighten the clamp over the overlapping section of the core, apply a coat of mastic covering both the metal collar and the core by at least 1 in., and then firmly press the fiber mesh into the mastic and cover with a second coat of mastic over the fiber mesh. (See Figure 4-18.)

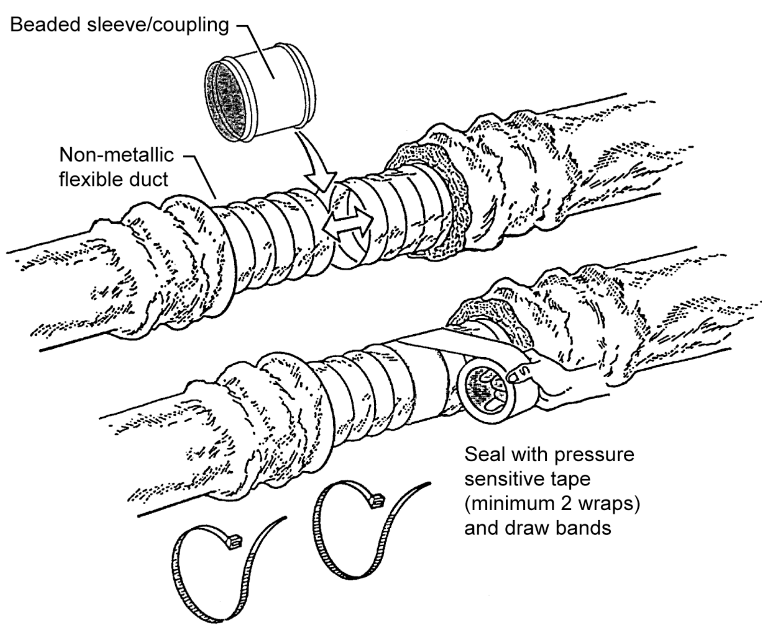
Figure 4-18: Connecting Flex Ducts Using Mastic and Mesh



Source: Richard Heath & Associates/Pacific Gas & Electric

For the tape connection first apply at least two wraps of approved tape covering both the core and the metal collar by at least 1 inch; then tighten the clamp over the overlapping section of the core. (See Figure 4-19.)

Figure 4-19: Connecting Flex Ducts Using Tape and Clamps



Source: Richard Heath & Associates/Pacific Gas & Electric

4.4.4.3 **All Joints Must Be Made Airtight**

§150(m)

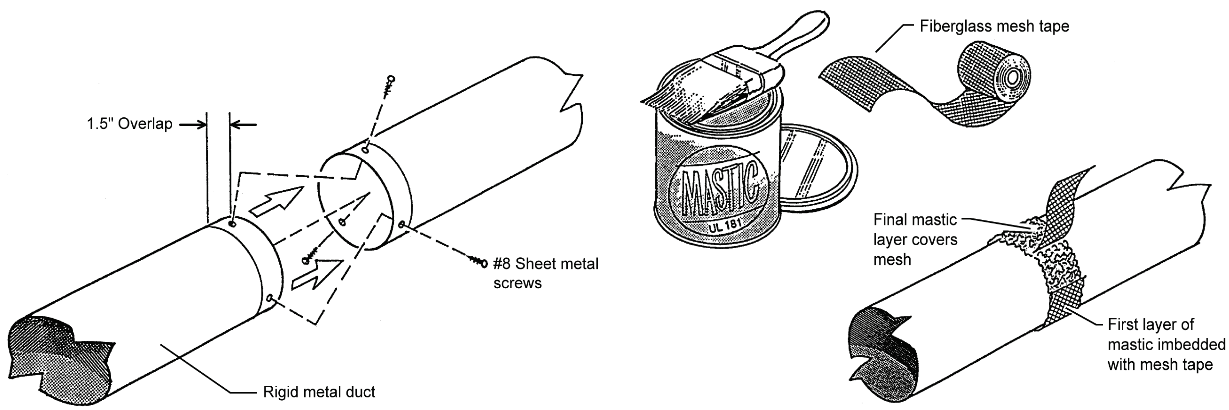
Seal all joints with either mastic, tape, aerosol sealant, or other duct-closure system that meets the applicable requirements of UL 181, UL 181A, UL 181B, or UL 723. Duct systems shall not use cloth-backed, rubber-adhesive duct tape regardless of UL designation, unless it is installed in combination with mastic and clamps. The Energy Commission has approved three cloth-backed duct tapes with special butyl synthetic adhesives rather than rubber adhesive to seal flex duct to fittings. These tapes are:

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

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

Mastic and mesh should be used where round or oval ducts join flat or round plenums. (See Figure 4-20.)

Figure 4-20: Sealing Metallic Ducts With Mastic and Mesh



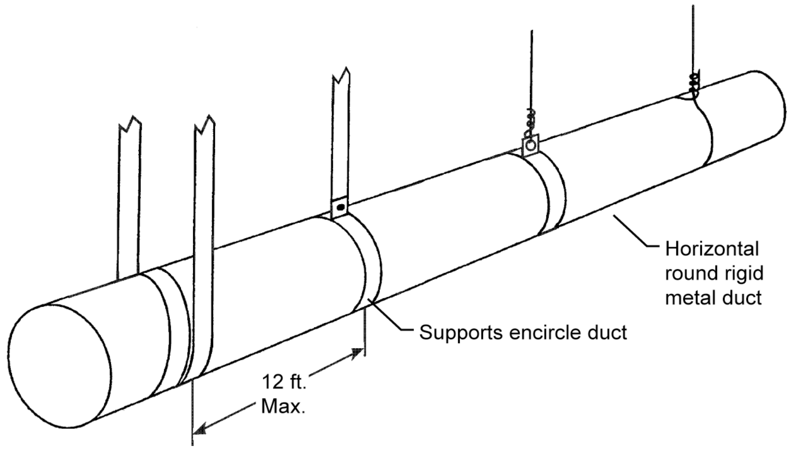
Source: Richard Heath & Associates/Pacific Gas & Electric

All ducts must be adequately supported.

Both rigid duct and flex duct may be supported on rigid building materials between ceiling joists or on ceiling joists.

For rigid round metal ducts that are suspended from above, hangers must occur 12 ft. apart or less. (See Figure 4-21)

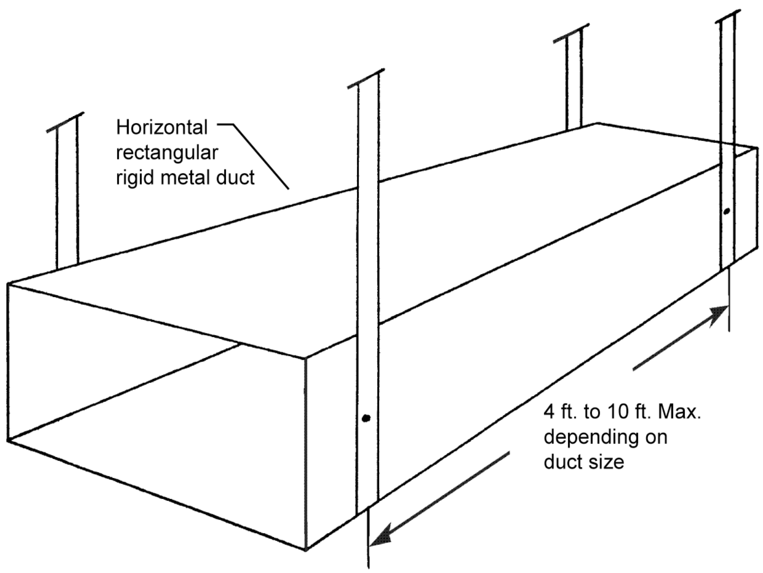
Figure 4-21: Options for Suspending Rigid Round Metal Ducts



Source: Richard Heath & Associates/Pacific Gas & Electric

For rectangular metal ducts that are suspended from above, hangers must occur at a minimum of 4 ft. to 10 ft., depending on the size of the ducts. (See Table 6-2A in Appendix A of the California Mechanical Code and refer to Figure 4-22.)

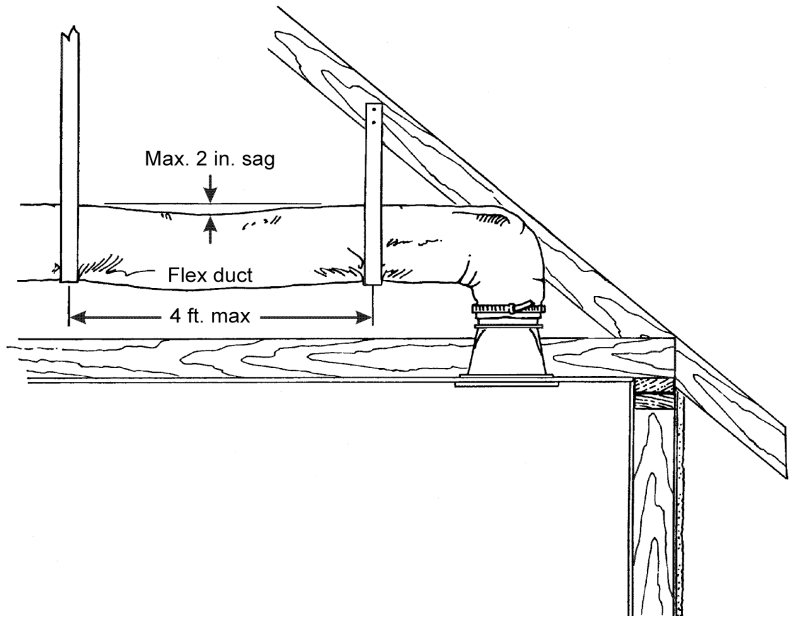
Figure 4-22: Options for Suspending Rectangular Metal Ducts



Source: Richard Heath & Associates/Pacific Gas & Electric

For flex ducts that are suspended from above, hangers must occur at 4 ft. apart or less and all fittings and accessories must be supported separately by hangers. (See Figure 4-23.)

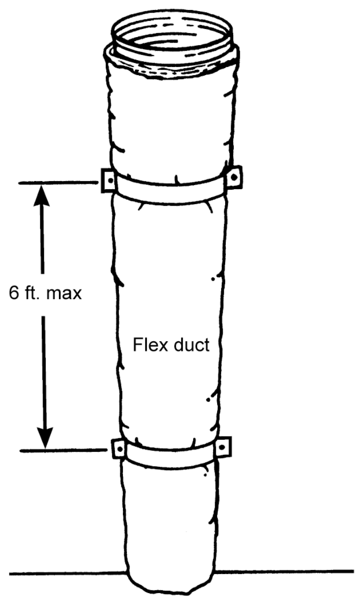
Figure 4-23: Minimum Spacing for Suspended Flex Ducts



Source: Richard Heath & Associates/Pacific Gas & Electric

For vertical runs of flex duct, support must occur at 6 ft. intervals or less. (See Figure 4-24)

Figure 4-24: Minimum Spacing for Supporting Vertical Flex Ducts

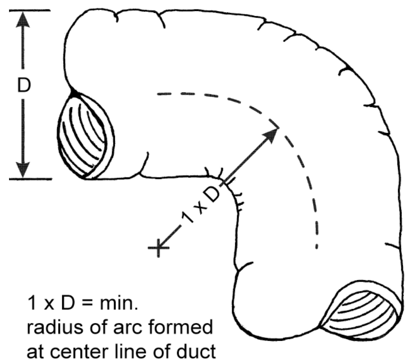


Source: Richard Heath & Associates/Pacific Gas & Electric

The routing and length of all duct systems can have significant effects on system performance due to possible increased airflow resistance. The Energy Commission recommends using the minimum length of duct to make connections and the minimum possible number of turns.

For flexible ducts, the Energy Commission recommends fully extending the duct by pulling the duct tightly, cutting off any excess duct, and avoiding bending ducts across sharp corners or compressing them to fit between framing members. (See Figure 4-25) Also avoid incidental contact with metal fixtures, pipes, or conduits or installation of the duct near hot equipment such as furnaces, boilers, or steam pipes that are above the recommended flexible duct use temperature.

Figure 4-25: Minimizing Radius for Flex Duct Bends



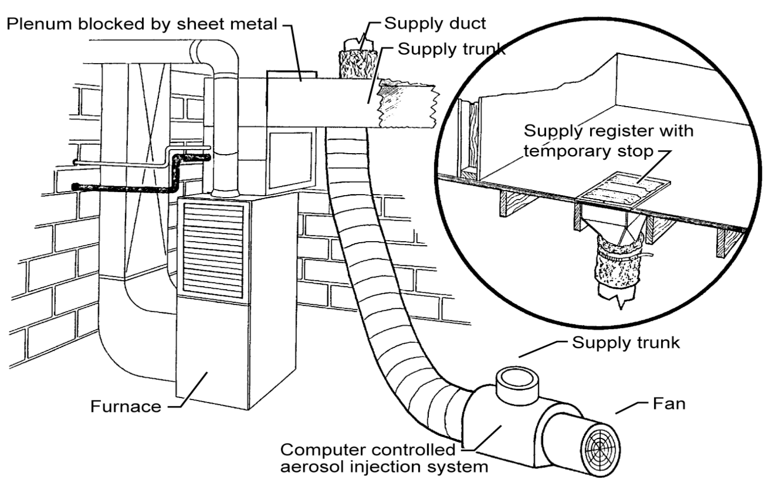
Source: Richard Heath & Associates/Pacific Gas & Electric

All joints between two sections of duct must be mechanically fastened and substantially airtight. For a flex duct, this must consist of a metal sleeve no less than 4 inches between the two sections of flex duct.

All joints must be properly insulated. For flex ducts, this must consist of pulling the insulation and jacket back over the joint and using a clamp or two wraps of tape. Aerosol sealant injection systems are an alternative that typically combines duct testing and duct sealing in one process.

Figure 4-26 shows the computer-controlled injection fan temporarily connected to the supply duct. The plenum is blocked off by sheet metal to prevent sealant from entering the furnace. Supply air registers are also blocked temporarily to keep the sealant out of the house. Ducts must still be mechanically fastened even if an aerosol sealant system is used.

Figure 4-26: Computer-Controlled Aerosol Injection System



Source: Richard Heath & Associates/Pacific Gas & Electric

4.5 Controls

4.5.1 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.

§110.2 (b) & (c), §150.0(i)

A thermostat is always required for central systems whether the prescriptive or performance compliance method is used. An exception is allowed only if:

1. The building complies using a computer performance approach with a non-setback thermostat.
2. The system is one of the following noncentral types:
   a. Noncentral electric heaters.
   b. Room air conditioners.
   c. Room air conditioner heat pumps.
   d. Gravity gas wall heaters.
   e. Gravity floor heaters.
   f. Gravity room heaters.
   g. Wood stoves.
   h. Fireplace or decorative gas appliances.

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

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

Thermostats for heat pumps must be “smart thermostats” that minimize the use of supplementary electric resistance heating during startup and recovery from setback, as discussed earlier in the heating equipment section.

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)?

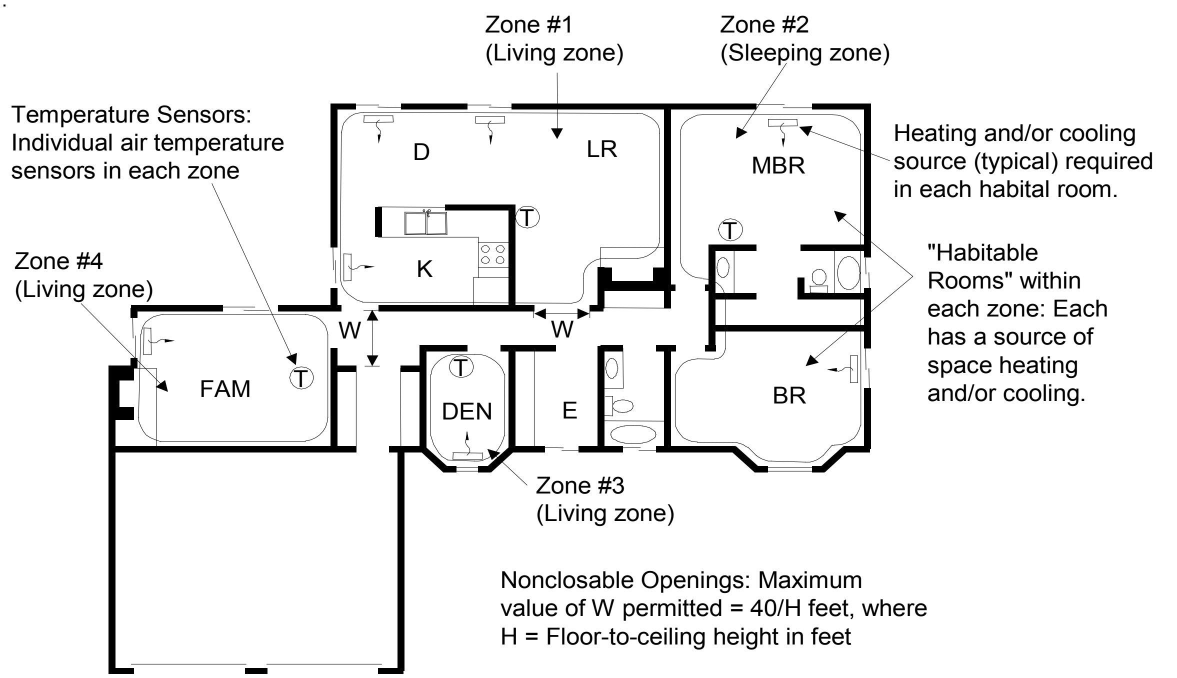
Answer:

The answer depends on the compliance approach. Under the prescriptive approach, the exception to §110.2(c) exempts gravity wall, floor and room heaters from the thermostat requirements. However, under the performance approach, the exception requires that “the resulting increase in energy use due to the elimination of the thermostat shall be factored into the compliance analysis.” This means that under the performance scenario, if the building is modeled with a nonsetback thermostat, any energy lost because of this will have to be made up using other efficiency features.

4.5.2 Zonal Control

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 areas in the daytime and the living area unit at night. (See Figure 4-27)

Figure 4-27: Zonal Control Example



Source: Richard Heath & Associates/Pacific Gas & Electric

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

1. **Temperature Sensors**. Each thermal zone, including a living zone and a sleeping zone, must have individual air temperature sensors that provide accurate temperature readings of the typical condition in that zone.
2. **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 individual 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.
3. **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 ft². 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.

4. **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:

1. Each zone must be served by a return air register located entirely within the zone. Return air dampers are not required.
2. Supply air dampers must be manufactured and installed so that when they are closed, there is no measurable airflow at the registers.
3. The system must be designed to operate within the equipment manufacturer's specifications.
4. 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 dwelling, 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.

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 purposes, include the square footage of any nonhabitable 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 ft² 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:

How do I model the energy efficiency of a gas-vented fireplace for zonal control heating?

Answer:

The efficiency of gas vented fireplaces places is described as annual fuel utilization efficiency (AFUE) and is calculated by the manufacturer per the ANSI Z21.88-2009 Standard. Gas-vented fireplaces must meet all the other relevant requirements of zonal control.

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.

4.6 Indoor Air Quality and Mechanical Ventilation

§150.0(o), §150.2(a)1C, and §150.2(a)2C

As houses have been tightened up over the last several years due to rising energy cost and the availability of higher performing building materials, normal infiltration and exfiltration have significantly reduced. This condition has increased the effect of contaminants and pollutants introduced through common building materials, cleaners, finishes, packaging, furniture, carpets, clothing, and other products. The Energy Standards have always assumed adequate indoor air quality would be provided by a combination of infiltration and natural ventilation and that home occupants would open windows as necessary to make up any shortfall in infiltration. However, Energy Commission-sponsored research on houses built under the *2001 Standards* revealed that overall ventilation rates are lower than expected, indoor concentration of chemicals such as formaldehyde are higher than expected, and many occupants do not open windows regularly for ventilation. The 2013 Standards included mandatory mechanical ventilation intended to improve indoor air quality (IAQ) in homes. The *2016 Energy Standards* continue this effort.

As specified by §150.0(o), all low-rise residential buildings must meet the requirements of ASHRAE Standard 62.2-2010, including Addenda b, c, e, g, h, i, j, l, and n to ASHRAE 62.2-2010. The exception is that opening and closing windows and continuous operation of central fan-integrated ventilation systems are not allowable options for meeting whole-building ventilation requirements.

The requirements of ASHRAE Standard 62.2 focus on whole-building mechanical ventilation and local ventilation exhaust at known sources of pollutants or moisture, such as kitchens, baths, and laundries. While not required by the Energy Standards, builders and homeowners should select materials, finishes, and furnishings that have no or low emissions of air pollutants, such as formaldehyde and volatile organic compounds (VOCs), because keeping air pollutants out of the building in the first place is more effective than flushing them out later through ventilation.

Most building materials emit some level of VOCs, formaldehyde, or other pollutants, and the resultant indoor pollutants can pose a substantial risk to occupant health. Pollutant emissions are highest immediately after a new product is installed, but emissions may continue for days, weeks, months, or years. Buildup of these air pollutants in the home is affected by ventilation, infiltration, and filtration rates; thus, these rates are addressed by the requirements in ASHRAE Standard 62.2.

The California Air Resources Board (ARB) provides guidance for reducing indoor air pollution in homes. For more information, see the ARB Indoor Air Quality Guidelines:

http://www.arb.ca.gov/research/indoor/guidelines.htm

This Section will cover compliance and enforcement, typical design solutions, energy consumption issues, and other requirements specified by ASHRAE 62.2.

Compliance with the whole-building ventilation airflow specified in ASHRAE 62.2 is required in new buildings and in buildings with additions greater than 1,000 ft^2. All other mechanical ventilation requirements, including local exhaust, must be met (as applicable) in all additions and alterations. 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). Individual dwelling units in multifamily buildings are required to each meet the same requirements as single-family dwelling units, except as otherwise described in Section 4.6.8.

The following summarizes the key requirements for most newly constructed buildings:

1. A whole-building mechanical ventilation system shall be provided. The typical solutions are described in the Section 4.6.2 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 Reference Residential Appendix RA3.7.
2. Kitchens and bathrooms shall have local exhaust systems vented to the outdoors.
3. Clothes dryers shall be vented to the outdoors.

Miscellaneous indoor air quality design requirements apply, including the following:

1. Ventilation air shall come from outdoors and shall not be transferred from adjacent dwelling units, garages, or crawl spaces.
2. Ventilation system controls shall be labeled, and the homeowner shall be provided with instructions on how to operate the system.
3. Combustion appliances shall be properly vented, and exhaust systems shall be designed to prevent back drafting.
4. The walls and openings between the house and the garage shall be sealed.
5. Habitable rooms shall have windows with a ventilation area of at least 4 percent of the floor area.
6. Mechanical systems including heating and air-conditioning systems that supply air to habitable spaces shall have MERV 6 filters or better and be designed to accommodate the system's air filter media rated pressure drop for the system design airflow rate.
7. Dedicated air inlets (not exhaust) that are part of the ventilation system design shall be located away from known contaminants.
8. A carbon monoxide alarm shall be installed in each dwelling unit in accordance with NFPA Standard 720.
9. Air-moving equipment used to meet the whole-building ventilation requirement and the local ventilation exhaust requirement shall be rated in terms of airflow and sound:
   a. All continuously operating fans shall be rated at a maximum of 1.0 sone.

b. Intermittently operated whole-building ventilation fans shall be rated at a maximum of 1.0 sone.

c. Intermittently operated local exhaust fans shall be rated at a maximum of 3.0 sone.

d. Remotely located air-moving equipment (mounted outside habitable spaces) need not meet sound requirements if there is at least 4 feet of ductwork between the fan and the intake grille.

4.6.1 Compliance and Enforcement

Compliance with ASHRAE 62.2 requirements must be verified by the enforcement agency, and the whole-building ventilation airflow rate must be verified by a HERS Rater in accordance with the procedures in Residential Appendix RA3.7. The applicable certificates of compliance, installation, and verification must be registered with an approved HERS Provider.

If a central heating/cooling system air-handler fan is used to ventilate the dwelling (central fan integrated ventilation), the air handler must meet or exceed the mandatory fan efficacy criteria. This requires the installer to perform the test given in Reference Appendix RA3.3, and a HERS Rater to verify the performance of the air handler.

4.6.1.1 **Certificate of Compliance Reporting Requirements**

When the performance compliance approach is used, the required whole-building ventilation airflow is calculated based on the total conditioned floor area (CFA) and the number of bedrooms. (See Section 4.6.3.1A.) Therefore, it is important that these values are input into the compliance software correctly and checked by the plans examiner. The performance certificate of compliance (CF1R) will report:

1. Required ventilation airflow rate (calculated value) that must be delivered by the system.
2. System type selected (that is, exhaust, supply, balanced, CFI).
3. Fan power ratio (watts/CFM) for the selected system.
4. The requirement of HERS verification of fan watt draw for the air handler when a CFI ventilation system is being used.

The installed whole-building ventilation system must conform to the performance requirements on the CF1R. For more information about the performance calculations for whole-building ventilation systems, see Section 4.6.4. There are no requirements to describe fans installed for other purposes, such as local exhaust, on the performance CF1R.

When using the prescriptive compliance approach, information that describes the whole-building ventilation system is not required on the CF1R. Unless otherwise required by the enforcement agency, calculation of the required ventilation airflow rate and selection of the system type can be done at installation. There are no requirements to describe fans installed for other purposes, such as local exhaust, on the prescriptive CF1R.

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

4.6.1.2 Certificate of Installation and Certificate of Verification Reporting Requirements

The builder/installer must complete a certificate of installation (CF2R-MCH-27) for the dwelling. The HERS Rater must complete a certificate of verification (CF3R-MCH-27) for the dwelling.

The following information must be provided on the CF2R-MCH-27 and CF3R-MCH-27 to document compliance with §150.0(o):

1. Required whole-building ventilation airflow rate for continuous or intermittent operation as specified by ASHRAE 62.2 equations. (See Section 4.6.3.)
2. Installed system type (that is, exhaust, supply, balanced, CFI).
3. Measured airflow rate of the installed whole-building ventilation system.
4. Confirmation from the builder/installer that the other applicable requirements given in ASHRAE 62.2 have been met. (See Sections 4.6.5 and 4.6.6.)

4.6.2 Typical Solutions for Whole-Building Ventilation

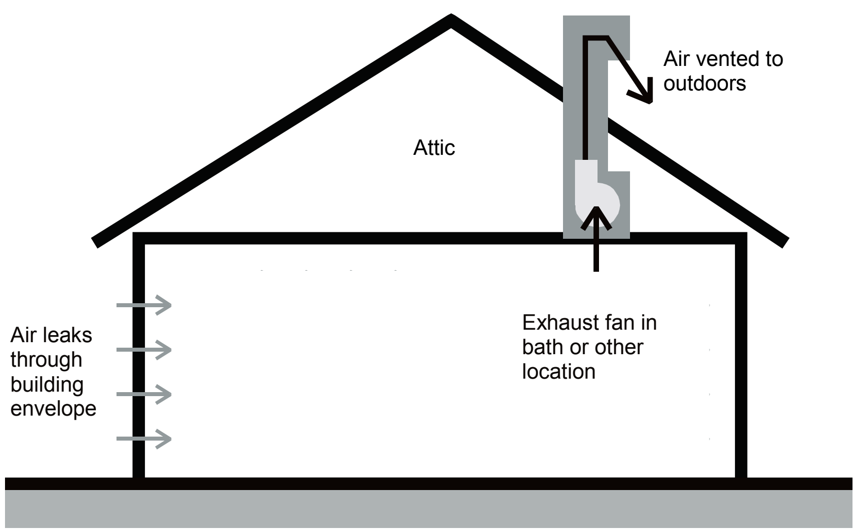
There are three typical solutions for meeting the outside air ventilation requirement:

1. Exhaust ventilation.
2. Supply ventilation.
3. Combination of supply and exhaust ventilation. (If the supply and exhaust flows are within 10 percent of each other, this is called a “balanced ventilation system.”)

Whole-building ventilation may be achieved through a single fan or a system of fans that are dedicated to whole-building ventilation only or by fans that also provide local exhaust or distribute heating and cooling.

4.6.2.1 Exhaust Ventilation

Figure 4-28: Exhaust Ventilation Example



Source: California Energy Commission

Exhaust ventilation is usually achieved by a quiet ceiling-mounted bath fan or remote-mounted inline or exterior-mounted fan. Air is drawn from the house by the exhaust fan, and outdoor air enters the house through infiltration.

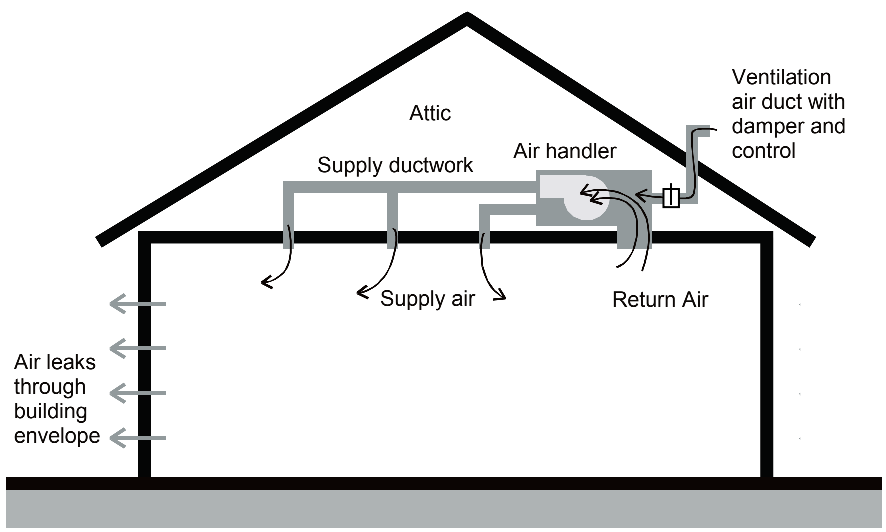
Many high-quality bath fans are available in the 30- to 150-cfm size range that are quiet enough to be used continuously. One or more fans of this size will meet the requirements of most homes. The exhaust fan can be a dedicated IAQ fan or a typical bath fan that is used for both whole-building ventilation and local ventilation.

Inline fans (either single pickup or multipoint pickup) can be a very effective method of providing quiet exhaust ventilation from one or several bathrooms. Inline fans can be located in the garage, attic, basement, or mechanical room.

Exterior-mounted fans can be mounted on the exterior wall or on the roof. A sound rating is not required for remote or exterior fans with at least 4 ft. of duct between the closest pickup grille and the fan.

4.6.2.2 **Supply Ventilation**

Figure 4-29: Supply Ventilation Example



Source: California Energy Commission

Supply ventilation works by bringing outside air into the house through a dedicated supply fan or the central forced-air system air handler and escapes through exfiltration.

The air handler or supply fans can be located on the exterior of the house or in the garage, attic, basement, or mechanical room, but the placement of the outdoor air inlet should avoid areas with contaminants, such as garages, barbeque areas, and chimneys. If a dedicated fan is used, care must be taken to avoid introducing too much outdoor air into one location and creating uncomfortable conditions. The ventilation air can be distributed by a dedicated duct system separate from the central forced air distribution duct system.

Alternatively, the central forced-air system air handler can be configured to function as a ventilation supply system by installing a dedicated ventilation air duct that connects to the return plenum of the air handler and to the dwelling exterior. This strategy, called *central fan integrated* (CFI) *ventilation*, uses negative pressure in the return plenum to pull outdoor air in through the ventilation air duct and into the return plenum, then the central system air handler distributes the ventilation air through the house. A damper and controls must be installed that ensure the air handler delivers the required ventilation airflow regardless of the size of the heating or cooling load.

When considering design and compliance for CFI ventilation systems, it is important to distinguish between the central forced-air system fan total airflow and the much smaller ventilation airflow (the airflow that is induced to flow into the return plenum from outdoors). Refer to Figure 4-29 and note that the total airflow through the air handler is the sum of the return airflow and the ventilation airflow.

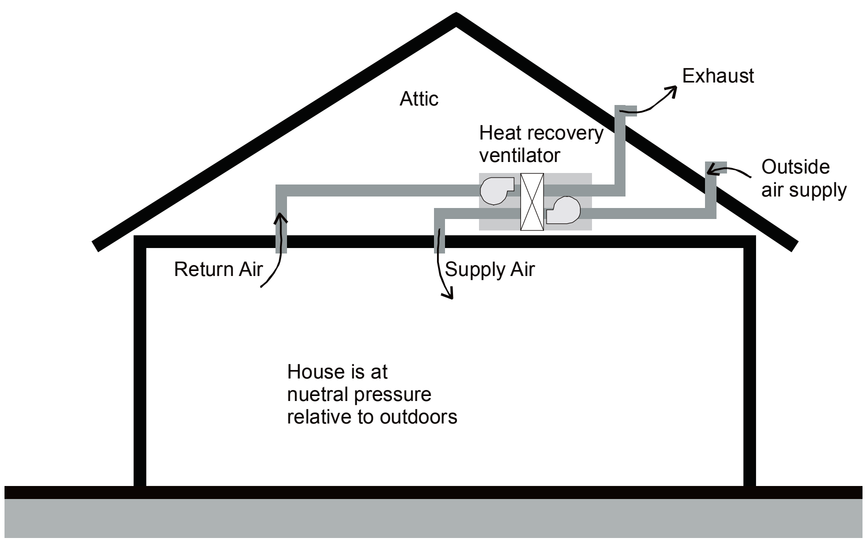
ASHRAE Standard 62.2, Section 4.3 requires the installer to measure the ventilation airflow rate in a CFI system in all operation modes to ensure that it will meet the ventilation rate requirements, regardless of whether the system operates to provide heating or cooling. Because §150.0(o) specifically prohibits continuously operating the central forced air system with CFI ventilation systems, CFI systems must be intermittent. The results of the airflow measurement of the installed CFI system and the intermittent ventilation control schedule used for the CFI system must be given on the Certificate of Installation. The whole-house ventilation rate must also be verified by a HERS Rater.

The outside air (OA) ducts for CFI ventilation systems cannot be sealed/taped off during duct leakage testing. However, CFI OA ducts that use controlled motorized dampers that open only when OA ventilation is required and close when OA ventilation is not required may be closed during duct leakage testing.

CFI ventilation systems can use a very significant amount of electricity annually. Air handlers used in CFI ventilation systems are required to meet the prescriptive fan watt draw requirements in all climate zones.

4.6.2.3 **Combination Ventilation**

Figure 4-30: Combination Ventilation Example



Source: California Energy Commission

Combination systems use both exhaust fans and supply fans. If both fans supply the same airflow, the system is balanced, and the house has a neutral pressure.

Combination systems are often integrated devices, sometimes with a heat exchanger or heat recovery wheel. The supply and exhaust airstreams are typically of equal flow.

Combination systems can also be a mixture of supply fans and exhaust fans, such as a quiet continuous bathroom exhaust fan matched to an outdoor air connection that introduces air into the return air plenum of a continuously operating central heating/cooling system air handler.

Note: Ventilation systems that constantly operation the central heating/cooling system air handler can use a very significant amount of electricity annually and are not permitted by the Energy Standards.

4.6.3 Whole-Building Ventilation Flow Rate (Section 4 of ASHRAE 62.2)

The whole-building ventilation system may operate continuously or intermittently. The whole-building ventilation rate is determined for continuous ventilation; if the system is operated intermittently, an adjustment is made.

4.6.3.1 **Continuous Whole-Building Ventilation**

There are two strategies for determining the continuous whole-building ventilation rate: the fan ventilation rate method, which assumes that all required ventilation will be provided mechanically, and the total ventilation rate method, which assumes that ventilation will be achieved by a combination of natural infiltration and mechanical ventilation.

Both methods are allowed for newly constructed homes and alterations. The fan ventilation rate method may be advantageous from a design perspective because the infiltration rate of the house does not need to be determined before construction. In either case, a fan system must be designed and installed that meets the whole-building ventilation airflow requirements, however it is determined.

A. Fan Ventilation Rate Method

The continuous whole-building ventilation rate is 1 cfm for each 100 ft² of conditioned floor area plus 7.5 cfm for each occupant. The number of occupants is calculated as the number of bedrooms plus one. For example, a three bedroom house is assumed to have four occupants. The required ventilation rate is given by the following Equation 4-1.

Equation 4-1

$$Q_{fan} = 0.01A_{floor} + 7.5(N_{br} + 1)$$

Where:

Q_{fan} = fan flow rate (cfm)

A_{floor} = floor area of residence (ft^2)

N_{br} = number of bedrooms (not less than one)

Instead of using one of the equations given above, Table 4-14 may be used to determine the required ventilation. This table allows the user to find the required ventilation rate directly if he or she knows the floor area and number of bedrooms. To comply with ASHRAE 62.2, the delivered airflow of the whole house ventilation fan must be greater than or equal to the required ventilation rate (cfm) from either Table 4-14 or Equation 4-1.

Table 4-14: Continuous Whole-Building Ventilation Rate (cfm) (from ASHRAE 62.2, Table 4.1a (I-P))

Conditioned Floor Area (ft²)	Bedrooms				
	0-1	**2-3**	**4-5**	**6-7**	**>7**
≤1500	30	45	60	75	90
1501-3000	45	60	75	90	105
3001-4500	60	75	90	105	120
4501-6000	75	90	105	120	135
6001-7500	90	105	120	135	150
>7500	105	120	135	150	165

Source: ASHRAE 62.2

Example 4-6 – Required Ventilation

Question:

What is the required continuous ventilation rate for a three-bedroom, 1,800 ft² townhouse?

Answer:

$$A_{floor} = 1800$$

$$N_{br} = 3$$

Equation 4-1 gives a required ventilation rate of 48 cfm:

$$Q_{fan} = 0.01A_{floor} + 7.5(N_{br} + 1) = 0.01(1800) + 7.5(3 + 1) = 48$$

Table 4-14 gives a required ventilation rate of 60 cfm.

Example 4-7

Question:

The house has a floor area of 2,240 ft² and three bedrooms. My calculations come out to 52.4 cfm. Can I use a 50 cfm fan?

Answer:

No. A 50 cfm fan does not meet the standard.

Also, note that the nominal rating of a fan can be very different than what a fan actually delivers when installed. Actual airflow depends greatly on the length and size of the duct needed to get the air outside. Proper fan sizing requires more detailed manufacturer's data, such as airflow vs. static pressure. This is why whole-building ventilation rates must be verified by a HERS Rater.

B. Total Ventilation Rate Method

This method for determining a continuous whole-building ventilation rate starts with calculating the total ventilation rate, which consists of both the natural and mechanical ventilation rates.

The total ventilation rate is calculated using an equation similar to that used in the fan ventilation rate method. Next, the natural ventilation (infiltration) rate is calculated from diagnostically tested values.

The infiltration rate is subtracted from the total ventilation rate, leaving the ventilation rate that must be provided mechanically.

The equation for calculating the total ventilation rate is:

Equation 4-2

$$Q_{total} = 0.03A_{floor} + 7.5(N_{br} + 1)$$

Where:

Q_{total} = total required ventilation rate (cfm)

A_{floor} = floor area of residence (ft^2)

N_{br} = number of bedrooms (not less than one)

The number multiplied times the floor area is three times greater than that used in Equation 4-1.

The ventilation rate associated with infiltration is calculated using an effective leakage area (ELA) value that must be diagnostically verified in the field.

The ELA value used for these equations is in square feet, not square inches as may be the case in other equations.

RA3.8 covers the protocols for blower door testing for verifying infiltration for reduced infiltration compliance credit. Unless specifically directed otherwise in this section, RA3.8 shall be met.

Because infiltration can occur by air coming into the home as well as air going out of the home, it is more accurate to measure ELA under depressurization and pressurization (using a 4 Pa reference pressure), then average the two values using Equation 4-3.

Equation 4-3

$$ELA = \frac{(L_{press} + L_{depress})}{2}$$

Where:

ELA = effective leakage area (ft^2)

L_{press} = leakage area from pressurization (ft^2)

$L_{depress}$ = leakage area from depressurization (ft^2)

When designing for a house that is not built yet, the ELA values will be estimated numbers. If the actual (measured) number is different, the ventilation system design may need to be modified to comply.

The leakage is normalized based on the area of the house and the potential for stack effect using Equation 4-4.

Equation 4-4

$$NL = 1000\left(\frac{ELA}{A_{floor}}\right)\left(\frac{H}{H_r}\right)^Z$$

Where:

NL = normalized leakage

ELA = effective leakage area (ft^2)

A_{floor} = floor area of residence (ft^2)

H_r = reference height, 8.2 ft

H = vertical distance from lowest above grade floor to highest ceiling (ft)

Z = 0.4 for the purpose of calculating the effective annual infiltration rate

The effective annual infiltration rate is then calculated using Equation 4-5. This is the amount of infiltration that is considered to offset the need for fan-powered ventilation.

Equation 4-5

$$Q_{inf} = \frac{(NL)(wsf)(A_{floor})}{7.3}$$

Where:

Q_{inf} = effective annual average infiltration rate (cfm)

NL = normalized leakage

wsf = weather and shielding factor from ANSI/ASHRAE Standard 62.2-2010, Normative Appendix X, Table X1- US Climates

A_{floor} = floor area of residence (ft^2)

The ventilation rate required by the fan is then calculated by subtracting the infiltration ventilation rate from the total ventilation rate.

Equation 4-6

$$Q_{fan} = Q_{total} - Q_{inf}$$

Where:

Q_{fan} = required mechanical ventilation rate (cfm)

Q_{total} = total required ventilation rate (cfm)

Q_{inf} = effective annual average infiltration rate (cfm)

For well-sealed houses, the fan ventilation rate calculated using the total ventilation rate method may be higher than that calculated by the fan ventilation rate method, so it is worth checking both.

No whole-building ventilation is required if Q_{fan} is less than or equal to zero.

C. Ventilation Rate for Combination Systems

When a combination ventilation system is used, meaning that both supply and exhaust fans are installed, the provided ventilation rate is the larger of the total supply airflow or the total exhaust airflow. The airflow rates of the supply and exhaust fans cannot be added together to determine the provided ventilation rate.

Example 4-8

Question:

A 2,400 ft² house has exhaust fans running continuously in two bathrooms providing a total exhaust flow rate of 40 cfm, but the requirement is 60 cfm. What are the options for providing the required 60 cfm?

Answer:

The required 60 cfm could be provided either by increasing the exhaust flow by 20 cfm or by adding a ventilation system that blows 60 cfm of outdoor air into the building. It cannot be achieved by using a make-up air fan blowing 20 cfm into the house.

4.6.3.2 **Intermittent Whole-Building Ventilation**

In some cases, it may be desirable to design a whole-building ventilation system that operates intermittently. One common example of intermittent ventilation is when outside air is ducted to the return plenum of the central heating/cooling system, and thus the central heating/cooling system fan is used to distribute the ventilation air to the rooms in the building. (See CFI system described above in the supply ventilation section.)

Intermittent mechanical ventilation systems, devices, or controls may be approved for use for compliance with the HERS field verification requirements for whole-building mechanical ventilation airflow. A listing of certified intermittent mechanical ventilation systems is posted here: http://www.energy.ca.gov/title24/equipment_cert/imv/

Intermittent ventilation is permitted as long as the ventilation airflow is increased to respond to the fewer hours of fan operation and the tendency of pollutant concentrations to build up during off cycles.

Equation 4-7

$$Q_{on} = \frac{Q_{fan}}{(\varepsilon)(f)}$$

Where:

Q_{on} = intermittent fan flow rate during the on-cycle (cfm)

Q_{fan} = continuous mechanical ventilation air requirement from Table 4-14 or Equation 4-1 (cfm)

ε = mechanical ventilation effectiveness (from Table 4–15)

f = fractional on-time

To obtain ε from Table 4–15, the required turnover, N, and fractional on-time, f, must be known. f is calculated by dividing the on-time for one cycle by the cycle time. N is calculated using Equation 4-8.

Equation 4-8

$$N = \frac{12.8(Q_{fan})(T_{cyc})}{A_{floor}}$$

Where

N = the required turnover

Q_{fan} = continuous mechanical ventilation air requirement from Table 4-14 or Equation 4-1 (cfm)

T_{cyc} = fan cycle time, defined as the total time for one off-cycle and one on-cycle (hours)

A_{floor} = floor area of residence (ft^2)

The maximum allowable T_{cyc} is 24 hours.

To obtain ε, find the column in Table 4–15 with the calculated value for N at the top and the row in Table 4–15 with the calculated value for f on the left side. The number in the cell where that column and row intersect is the value of ε needed for Equation 4-7. If the calculated values for N and f are not listed on Table 4–15, use the next higher value for N, the next lower value for f, or linear interpolation.

Table 4–15: Mechanical Ventilation Effectiveness for Intermittent Fans

Mechanical Ventilation Effectiveness for Intermittent Fans

Fractional On-Time, *f*	Turnover, *N*														
	0.0	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0	6.0	8.0	12	20	40	100+
0.00	1.00	0.95	0.88	0.78	0.60	0.00									
0.05	1.00	0.96	0.90	0.81	0.67	0.41	0.00								
0.10	1.00	0.96	0.91	0.83	0.72	0.55	0.21	0.00							
0.15	1.00	0.96	0.92	0.85	0.76	0.63	0.44	0.18	0.00						
0.20	1.00	0.97	0.93	0.87	0.79	0.69	0.56	0.40	0.03	0.00					
0.25	1.00	0.97	0.94	0.89	0.82	0.74	0.64	0.53	0.26	0.02	0.00				
0.30	1.00	0.98	0.95	0.90	0.85	0.78	0.71	0.62	0.42	0.24	0.00				
0.35	1.00	0.98	0.95	0.92	0.87	0.82	0.76	0.69	0.54	0.39	0.14	0.00			
0.40	1.00	0.98	0.96	0.93	0.89	0.85	0.80	0.75	0.63	0.52	0.32	0.02	0.00		
0.45	1.00	0.99	0.97	0.94	0.91	0.88	0.84	0.79	0.70	0.61	0.45	0.21	0.00		
0.50	1.00	0.99	0.97	0.95	0.93	0.90	0.87	0.83	0.76	0.69	0.57	0.37	0.13	0.00	0.00
0.60	1.00	0.99	0.98	0.97	0.96	0.94	0.92	0.90	0.86	0.81	0.74	0.61	0.45	0.27	0.14
0.70	1.00	1.00	0.99	0.98	0.98	0.97	0.96	0.94	0.92	0.90	0.85	0.78	0.68	0.55	0.46
0.80	1.00	1.00	1.00	0.99	0.99	0.99	0.98	0.98	0.97	0.96	0.94	0.90	0.85	0.77	0.70
0.90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99	0.98	0.97	0.96	0.93	0.88
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Source: ASHRAE 62.2

Intermittent ventilation systems must be automatically controlled by a timer or other device that assures they will operate the minimum amount of time needed to meet the ventilation requirement. The scheduling of the automatic controls must be such that the fan operates at least 10 percent of the time and that a single on/off cycle occurs at least once per day.

Example 4-9 – Flowrate for Intermittent Fan

Question:

The required ventilation rate is 56 cfm. If the ventilation fan runs for 80 percent of the day, what must the airflow rate be for a 2600 ft² townhouse?

Answer:

f is 0.8 (80 percent). The required turnover is calculated to be 7 using Equation 4-8:

$$N = \frac{12.8(Q_{fan})(T_{cyc})}{A_{floor}} = \frac{12.8(56)(24)}{2600} = 6.62 \approx 7$$

From Table 4–15, ε is 0.95. The fan flow rate is calculated to be 74 cfm using Equation 4-7:

$$Q_{on} = \frac{Q_{fan}}{(\varepsilon)(f)} = \frac{56}{(0.95)(0.8)} = 73.7 \approx 74$$

Example 4-10

Question:

For the same house, if the fan runs half the day (12 hours per day), what is the required airflow?

Answer:

The fractional on-time, f is 0.5 (50 percent). T_{cyc} is still 24 hours, so N is still 7.

From Table 4–15, ε is now 0.63. The fan flow rate is calculated to be 178 cfm using Equation 4-7:

$$Q_{on} = \frac{Q_{fan}}{(\varepsilon)(f)} = \frac{56}{(0.63)(0.5)} = 177.78 \approx 178$$

This is a much larger increase in fan size. More than double the fan size over Example 4-10 is required to move the same amount of air, even though the on-cycle was only decreased by less than half. In many designs, it may be better to consider a lower power, quieter fan that will run for longer over a high power fan that will run for a shorter period.

Example 4-11

Question:

A three-bedroom, 2250 ft² apartment, the flow required is 52.5 cfm. If the ventilation fan runs 20 minutes on and 10 minutes off, what is the required fan size?

Answer

Fractional on-time is 0.67:

$$f = \frac{20}{20 + 10} = 0.67$$

The required turnover is calculated to be 0.149 using Equation 4-8:

$$N = \frac{12.8(Q_{fan})(T_{cyc})}{A_{floor}} = \frac{12.8(52.5)(0.5)}{2250} = 0.149$$

From Table 4–15, ε is 1.0. The fan flow rate is calculated to be 78 cfm using Equation 4-7:

$$Q_{on} = \frac{Q_{fan}}{(\varepsilon)(f)} = \frac{52.5}{(1.0)(0.67)} = 78.36 \approx 78$$

Example 4-12

Question:

For the same apartment, if the fan runs 8 hours on and 4 hours off, what flow rate is required?

Answer:

Fractional on-time is again 0.67, but T_{cyc} has changed, which changes N. N is now calculated to be 3.6 (round up from 3.584) using Equation 4-8:

$$N = \frac{12.8(Q_{fan})(T_{cyc})}{A_{floor}} = \frac{12.8(52.5)(12)}{2250} = 3.584$$

From Table 4–15, ε is now approximately 0.95. The fan flow rate is calculated to be 83 cfm using Equation 4-7:

$$Q_{on} = \frac{Q_{fan}}{(\varepsilon)(f)} = \frac{52.5}{(0.95)(0.67)} = 82.5 \approx 83$$

Example 4-13

Question:

An electronic timer system on a 9001 ft² estate with 6 bedrooms can be set to operate a fan for 1 minute every hour. The timer runs the fan 2 hours in the morning and 8 hours in the evening. What is the required intermittent flow rate?

Answer:

The scheduling of the automatic controls must be such that the fan operates at least 10 percent of the time and that a single on/off cycle occurs at least once per day. An on/off cycle of 1 minute every hour is only 1.67 percent and does not meet this requirement.

Equation 4-1 gives a required ventilation rate of 142.5 cfm ($Q_{fan}$from Table 4-14 would be 150 cfm):

$$Q_{fan} = 0.01A_{floor} + 7.5(N_{br} + 1) = 0.01(9001) + 7.5(6 + 1) = 142.5$$

The fractional on-time for a fan running 2 hours in the morning and 8 hours in the evening is equivalent to 0.42:

$$f = \frac{2 + 8}{24} = 0.42$$

The required turnover is calculated to be 4.86 using Equation 4-8:

$$N = \frac{12.8(Q_{fan})(T_{cyc})}{A_{floor}} = \frac{12.8(142.5)(24)}{9001} = 4.86$$

From Table 4–15, ε is 0.68. The fan flow rate is calculated to be 500 cfm (rounded up from 498.95 cfm) using Equation 4-7:

$$Q_{on} = \frac{Q_{fan}}{(\varepsilon)(f)} = \frac{142.5}{(0.68)(0.42)} = 498.95 \approx 500$$

4.6.3.3 Control and Operation

From ASHRAE 62.2, Section 4.4, Control and Operation.

The “fan on” switch on a heating or air-conditioning system shall be permitted as an operational control for systems introducing ventilation air through a duct to the return side of an HVAC system. Readily accessible override control must be provided to the occupant. Local exhaust fan switches and “fan on” switches shall be permitted as override controls. Controls, including the “fan-on” switch of a conditioning system, must be appropriately labeled.

Exception: An intermittently operating, whole-house mechanical ventilation system may be used if the ventilation rate is adjusted, according to Section 4.5.1. The system must be designed so that it can operate automatically based on a timer. The intermittent mechanical ventilation system must operate at least once per day and must operate at least 10% of the time.

ASHRAE 62.2 requires that the ventilation system have an override control that is readily accessible to the occupants. The control must be capable of being accessed quickly and easily by the occupants without having to remove panels or doors. It can be a labeled wall switch by the electrical panel or it may be integrated into a labeled wall-mounted control. It cannot be buried in the insulation in the attic or the inside the fan. The occupant must be able to modify the settings or override the system.

If intermittent fans are used, they must be controlled by a timer, and they must have an increased airflow rate to compensate for the off time.

Time-of-day timers or duty cycle timers can be used to control intermittent whole-building ventilation. Manual crank timers cannot be used, since the system must operate automatically without intervention by the occupant. Some controls “look back” over a set time interval to see if the air handler has already operated for heating or cooling before it turns on the air handler for ventilation only operation.

Example 4-14 – Control Options

Question:

A bathroom exhaust fan is used to provide whole-building ventilation for a house. The fan is designed to be operated by a typical wall switch. Is a label on the wall plate necessary to comply with the requirement that controls be “appropriately labeled”?

Answer:

Yes. Since the fan is providing the required whole-building ventilation, a label is needed to inform the occupant that the fan should be operating whenever the home is occupied. If the exhaust fan were serving only the local exhaust requirement for the bathroom, then a label would not be required.

Example 4-15 – Thermostatic Control

Question:

Ventilation air is provided whenever the air handler operates via a duct run connecting the return side of the central air handler to the outdoors. The system is estimated to run on calls for heating and cooling about 40 percent of the time, averaged over the year. If it is assumed that the air handler only runs 25 percent of the time, and the airflow is sized accordingly, can the system be allowed to run under thermostatic control?

Answer:

No. A system under thermostatic control will go through periods with little or no operation when the outdoor temperature is near the indoor setpoint, or if the system is in setback mode. An intermittently operating ventilation system must be controlled by a timer that will cycle at least once within 24 hours to assure that adequate ventilation is provided regardless of outdoor conditions.

Cycle timer controls are available that function to keep track of when (and for how long) the system operates to satisfy heating/cooling requirements in the home. These controls turn on the central fan to provide additional ventilation air when heating/cooling operation of the central fan has not already operated enough to provide the required ventilation.

4.6.4 Whole-Building Mechanical Ventilation Energy Consumption

For builders using the performance compliance approach, the energy use of fans (other than CFI fans) installed to meet the whole-building ventilation requirement is usually not an issue. The reason is the standard design W/CFM is set equal to the proposed design W/CFM up to an energy use level sufficient to accommodate most well-designed ventilation systems. Also, the standard design whole-building ventilation system airflow rate is set equal to the proposed design whole-building ventilation system airflow rate, so there is no energy penalty or credit for most systems. Systems that use heat recovery or energy recovery ventilators (HR/ERV) may need to account for the heat recovery benefit in the performance calculation to make up for the high energy use.

The energy use of the central air handler fan 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. CFI systems are the only type of ventilation system that must meet a prescriptive fan watt draw requirement that must be tested by the builder/installer and verified by a HERS Rater in accordance with the diagnostic test protocols given in RA3.3.

Energy use of fans installed for other purposes, such as local exhaust, is not regulated in the Energy Standards.

4.6.4.1 **Central Fan Integrated Ventilation Systems − Watt Draw**

§150.1(f)10

CFI system automatic controls must operate the central system air handler fan (generally part of every hour of the year) to draw in and/or distribute ventilation air around the home even when there is no heating or cooling required. CFI systems generally do not operate continuously, thus do not meet the whole-building ventilation requirement as a “continuous" system. Because the CFI ventilation control increases the central system air handler fan run time significantly, and because typical central system air handler fan and duct systems require a large amount of power, a CFI ventilation system can use a very significant amount of electricity annually.

The Energy Standards include mandatory requirements for ducted central cooling system air handlers to comply with maximum fan watt draw targets. The watt draw requirement also applies to any ducted central system air handler used for a CFI system. Compliance with this requirement involves a postconstruction measurement by the installing contractor of the airflow through the air handler, and the simultaneous measurement of the watt draw of the air handler fan motor. This fan watt draw measurement must be measured by the installer and verified by a HERS Rater. (See Reference Residential Appendix RA3.3.) The central system air handler must be operating in ventilation mode (outdoor air damper is open and ventilation air is flowing into the return plenum from outside the building). Furthermore, the airflow that must be measured is the total airflow through the air handler (system airflow), which is the sum of the return airflow, and the outside air ducted to the return plenum (ventilation airflow). To pass the test, the watt draw must be less than 0.58 W/CFM.

Builders who use CFI systems and comply using the performance approach have the option of accepting the default value for the central system fan watt draw of 0.8 W/CFM, which does not require a postconstruction measurement and HERS verification. Alternatively, the builder can specify a lower W/CFM value for compliance, which must be tested and verified by a HERS Rater. In either case the compliance software will check the furnace fan heating and cooling operation every hour, and if the air handler has not been operating for at least 20 minutes during that hour, the software will calculate energy use for operation in CFI mode until 20 minutes of fan operating occurs. The standard design ventilation energy consumption for that hour will be calculated as the extra fan run time at a watt draw of 0.58 W/CFM. The proposed design ventilation energy for that hour will be calculated as the extra fan run time at the watt draw that was specified for compliance, otherwise at the default Watt draw of 0.8 W/CFM.

4.6.4.2 **Other Whole-Building Ventilation Systems – Watt Draw**

There are no prescriptive or mandatory requirements for maximum fan energy (watt draw) for whole-building ventilation systems other than CFI systems.

Builders who specify other whole-building ventilation systems and comply using the performance approach have the option of accepting the default minimum whole-building ventilation airflow rate and a watt draw value of 0.25 W/CFM, which is typical of simple exhaust fans that meet the 1 sone requirement. Otherwise, the airflow rate and fan watt draw of the fan may be input. If the builder installs a whole-building ventilation system that has a fan watt draw specification greater than 1.2 W/CFM of ventilation airflow, then he or she must input the ventilation airflow (CFM) and watt draw (W/CFM) corresponding to the system that he or she proposes to install. The compliance software will simulate whole-building ventilation using the builder’s specified ventilation CFM and W/CFM for the proposed design. For the standard design, the builder’s proposed CFM and 1.2 W/CFM will be used. If the builder specifies a system with heat recovery, he or she inputs the recovery efficiency of the proposed system and the compliance software uses it in the proposed design to calculate the heating and cooling effect of the whole-building ventilation. Ventilation heat recovery is never used in the standard design.

4.6.5 Local Exhaust (Section 5 of ASHRAE 62.2)

Local exhaust (sometimes called *spot ventilation*) has long been required for bathrooms and kitchens to deal with moisture and odors at the source. Building codes have required an operable window or an exhaust fan in baths for many years and have generally required kitchen exhaust either directly through a fan or indirectly through a ventless range hood and an operable window. The Energy Standards recognize the limitations of these indirect methods of providing ventilation to reduce moisture and odors and requires that these spaces be mechanically exhausted directly to outdoors, even if windows are present. As tighter homes with more insulation are built, the relative humidity in the home has increased, and the potential for condensation on cool or cold surfaces has increased as well. The presence of moisture condensation has been a leading cause of mold and mildew in both new and existing construction. The occurrence of asthma has also increased as the interior relative humidity has gotten higher. Therefore, it has become more important to remove the moisture from bathing and cooking right at the source.

The Energy Standards require that each kitchen and bathroom have a local exhaust system installed. Generally, this will be accomplished by installing a dedicated exhaust fan in each room that requires local exhaust, although ventilation systems that exhaust air from multiple rooms using a duct system connected to a single ventilation fan are allowed as long as the minimum local ventilation airflow rate requirement is met in all rooms served by the system. The standards define kitchens as any room containing cooking appliances, and bathrooms are rooms containing a bathtub, shower, spa, or other similar source of moisture. A room containing only a toilet is not required by the Energy Standards to have mechanical exhaust; it assumes that there will be an adjacent bathroom that will have local exhaust.

The Energy Standards allow the designer to choose between intermittent operation or continuous operation for the local exhaust ventilation system. The ventilation rates are different because the ventilation effectiveness of an intermittent operation fan is different than the ventilation effectiveness of a continuous operation fan.

Building codes may require that fans used for kitchen range hood ventilation be safety-rated by UL or some other testing agency for the particular location and/or application. Typically, these requirements address the fire safety issues of fans placed within an area defined by a set of lines at 45° outward and upward from the cooktop. Few “bath” fans will have this rating and cannot be used in this area of the kitchen ceiling.

Example 4-16 – Local Exhaust Required for Toilet

Question:

I am building a house with 2½ baths. The half-bath consists of a room with a toilet and sink. Is local exhaust required for the half bath?

Answer:

No. Local exhaust is required only for bathrooms, which are defined by the Energy Standards as rooms with a bathtub, shower, spa or some other similar source of moisture. This does not include a simple sink for occasional hand washing.

Example 4-17

Question:

The master bath suite in a house has a bathroom with a shower, spa and sinks. The toilet is in a separate, adjacent room with a full door. Where do I need to install local exhaust fans?

Answer

The standards require local exhaust only in the bathroom, not the separate toilet room.

4.6.5.1 Intermittent Local Exhaust

The Energy Standards require that intermittent local exhaust fans be designed to be operated by the occupant. This usually means that a wall switch or some other type of control is accessible and obvious. There is no requirement to specify where the control or switch needs to be located, but bath fan controls are generally located next to the light switch, and range hood or downdraft 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 typical ceiling bath fans or may use one or two pickups for remote inline or exterior-mounted fans or heat recovery products. Intermittent local exhaust can be integrated with the whole-building ventilation system to provide both functions. Kitchens can have range hoods, down-draft exhausts, ceiling fans, wall fans, or pickups for remote inline or exterior-mounted fans. Generally, HVR/ERV manufacturers will not allow kitchen pickups to avoid the issue of grease buildup in the heat exchange core. Building codes typically require that the kitchen exhaust must be exhausted through metal ductwork for fire safety.

Example 4-18 – 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 outdoors. How do I do it?

Answer:

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 4-19

Question:

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

Answer:

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

A. Control and Operation for Intermittent Local Exhaust

The choice of control is left to the designer. It can be an automatic control like an occupancy sensor or a manual switch. Some products have multiple speeds, and some switches have a delay-off function that continues the exhaust fan flow 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.

B. Ventilation Rate for Intermittent Local Exhaust

A minimum intermittent ventilation airflow of 100 cfm is required for the kitchen range hood, and a minimum intermittent ventilation airflow of 50 cfm is required for the bath fan.

The 100 cfm requirement for the range hood or microwave/hood combination is the minimum to adequately capture the moisture and other products of cooking and/or combustion. The kitchen 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 the ASHRAE Standard 62.2 unless paired with an exhaust system that can provide at least five air changes of the kitchen volume per hour.

Most range hoods provide more than one speed, with the high speed at 150 cfm or more – sometimes much more. Range hoods are available that are rated for 1,000 or 1,500 cfm on high speed and are often specified when large commercial-style stoves are installed. Care must be taken to avoid backdrafting combustion appliances when large range hoods are used. Refer to Table 5.1 in ASHRAE 62.2 for intermittent local ventilation exhaust airflow rates and to Section 6.4 in ASHRAE 62.2 for makeup air requirements associated with large exhaust appliances.

Example 4-20 – Is an Intermittent Range Hood Required?

Question:

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

Answer:

The kitchen volume is 12 ft x 14 ft x 10 ft = 1680 ft^3. Five air changes are a flow rate of 1680 ft^3 x 5/ hr ÷ 60 min/hr = 140 cfm. So this kitchen must have a ceiling or wall exhaust fan of 140 cfm or a 100 cfm vented range hood.

4.6.5.2 Continuous Local Exhaust

The Energy Standards allow the designer to install a local exhaust system that operates without occupant intervention continuously and automatically during all occupiable hours. Continuous local exhaust is generally specified when the local exhaust ventilation system is combined with a continuous whole-building ventilation system. For example, if the whole-building exhaust is provided by a continuously operating exhaust fan located in the bathroom, this fan satisfies the local exhaust requirement for the bathroom. The continuous local exhaust may also be part of the continuous whole-building ventilation system, such as a pickup for a remote fan or HRV/ERV system.

Continuously operating bathroom fans must operate at a minimum of 20 cfm and continuously operating kitchen fans must operate at five air changes per hour. These continuous ventilation airflow rates are different than the ventilation airflow rates required for intermittent local exhaust. Refer to Table 5.2 in ASHRAE 62.2 for continuous local ventilation exhaust airflow rates.

The requirement that continuous kitchen exhaust fans must provide five air changes per hour is due to the difficulty of a central exhaust to adequately remove contaminants released during cooking from large kitchens, have an open-plan design, or have high ceilings. The only way to avoid a vented kitchen hood is to provide more than five air changes per hour of constant local exhaust ventilation.

Example 4-21 – Continuous Kitchen Exhaust

Question:

The kitchen in an apartment is 5 ft by 10 ft, with an 8 ft ceiling. If a continuous ceiling-mounted exhaust fan is used, what must the airflow be?

Answer:

The kitchen volume is 5 ft x 10 ft x 8 ft = 400 ft^3. 5 air changes equates to 400 ft^3 x 5/hr ÷ 60 min/hr = 34 cfm.

Example 4-22

Question:

A new house has an open-design, 12 ftx18 ft ranch kitchen with 12 ft cathedral ceilings. What airflow rate will be required for a continuous exhaust fan?

Answer:

The kitchen volume is 12 ft x 18 ft x 12 ft = 2592 ft^3. The airflow required is 2592 ft^3 x 5/hr ÷ 60 min/hr = 216 cfm.

4.6.6 Other Requirements (Section 6 of ASHRAE 62.2)

4.6.6.1 Transfer Air

From ASHRAE 62.2,

6.1 Adjacent Spaces. Measures shall be taken to minimize air movement across envelope components to occupiable spaces from garages, unconditioned crawl spaces, and unconditioned attics. Supply and balanced ventilation systems shall be designed and constructed to provide ventilation air directly from the outdoors.

8.4.1 Transfer Air. Measures shall be taken to minimize air movement across envelope components separating dwelling units, including sealing penetrations in the common walls, ceilings, and floors of each unit and by sealing vertical chases adjacent to the units. All doors between dwelling units and common hallways shall be gasketed or made substantially airtight

ASHRAE Standard 62.2 requires that the air used for ventilation come from the outdoors. Air may not be drawn in as transfer air from other spaces that are outside the occupiable space of the dwelling unit, or from between dwelling units and corridors. This is to prevent airborne pollutants originating in those other spaces from contaminating the dwelling unit. For example, drawing ventilation air from the garage could introduce VOCs or pesticides into the indoor air. Drawing ventilation air from an unconditioned crawlspace could cause elevated allergen concentrations in the dwelling such as mold spores, insects or rodent allergens. Likewise, drawing air from an adjacent dwelling could introduce unwanted contaminants such as cooking products or cigarette smoke.

In addition to designing the ventilation system to draw air from the outdoors, the standard also requires that measures be taken to prevent air movement between adjacent dwelling units and between the dwelling unit and other nearby spaces, such as garages. The measures can include air sealing of envelope components, pressure management, and use of airtight recessed light fixtures. The measures must apply to adjacent units both above and below, as well as side by side.

Air sealing must include pathways in vertical components such as demising walls and walls common to the unit and an attached garage, and in horizontal components such as floors and ceilings. Pipe and electrical penetrations are examples of pathways that require sealing.

Section 6.1 of ASHRAE 62.2 does not prohibit whole-building exhaust or local exhaust ventilation systems and does not require mechanical systems to maintain pressure relationships with adjacent spaces except as required by Section 6.4 of ASHRAE 62.2.

4.6.6.2 **Instructions and Labeling**

> From ASHRAE 62.2*, Section 6.2, Instructions and Labeling.*
>
> *Information on the ventilation design and/or ventilation systems installed, instructions on their proper operation to meet the requirements of this standard, and instructions detailing any required maintenance (similar to that provided for HVAC systems) shall be provided to the owner and the occupant of the dwelling unit. Controls shall be labeled as to their function (unless that function is obvious, such as toilet exhaust fan switches). See Chapter 13 of Guideline 24 for information on instructions and labeling.*

There has been a history of ventilation systems that worked initially but failed due to lack of information for the occupant or lack of maintenance. ASHRAE Standard 62.2 requires that the installer or builder provide written information on the basic ventilation concept being used and the expected performance of the system. These instructions must include how to operate the system and what maintenance is required.

Because the concept of a designed whole-building ventilation system may be new to many occupants, the standard requires that ventilation system controls be labeled as to the function. No specific wording is mandated, but the wording must make clear what the control is for and the importance of operating the system. This may be as simple as “Ventilation Control” or might include wording such as “Operate whenever the house is in use” or “Keep on except when gone over 7 days.” If the system is designed to operate with a timer as an intermittent system, the labeling may need to be more detailed. One acceptable option is to affix a label to the electrical panel that provides some basic system operation information.

4.6.6.3 **Clothes Dryers**

> *From ASHRAE 62.2, Section 6.3, Clothes Dryers.*
>
> *Clothes dryers shall be exhausted directly to the outdoors. Exception: Condensing dryers plumbed to a drain.*

All laundry rooms must be built with a duct to the outdoors, designed to be connected to the dryer. Devices which allow the exhaust air to be diverted into the indoor space to provide extra heating are not permitted. This requirement is consistent with existing clothes dryer installation and design standards.

In multifamily buildings, multiple dryer exhaust ducts can be connected to a common exhaust only when dampers are provided to prevent recirculation of exhaust air from one apartment to another.

Example 4-23 – Clothes Dryer Exhaust Diverter

Question:

I am building a home that has been purchased prior to completion. The buyer has asked for an exhaust air diverter to be installed in the dryer exhaust duct. He says that it is wasteful of heating energy to exhaust the warm humid air to the outdoors during the winter when the furnace and humidifier are working. He says that the screen on the diverter will prevent excess dust being released into the space. Can I install the device for him?

Answer:

If you do, you will not comply with the Energy Standards. The device is specifically prohibited. Significant amounts of dust are released from such devices, and the moisture in the dryer exhaust can lead to humidity problems as well, particularly in warmer climates.

4.6.6.4 **Combustion and Solid-Fuel Burning Appliances**

> *From ASHRAE 62.2, Section 6.4, Combustion and Solid-Fuel Burning Appliances*
>
> *Combustion and solid-fuel burning appliances must be provided with adequate combustion and ventilation air and vented in accordance with manufacturers' installation instructions, NFPA 54/ANSI Z223.1, National Fuel Gas Code, NFPA 31, Standard for the Installation of Oil- Burning Equipment, or NFPA 211, Standard for Chimneys, Fireplaces, Vents, and Solid-Fuel Burning Appliances, or other equivalent code acceptable to the building official. Where atmospherically vented combustion appliances or solid-fuel burning appliances are located inside the pressure boundary, the total net exhaust flow of the two largest exhaust fans (not including a summer cooling fan intended to be operated only when windows or other air inlets are open) shall not exceed 15 cfm/100 ft^2 (75 Lps/100 m^2) of occupiable space when in operation at full capacity. If the designed total net flow exceeds this limit, the net exhaust flow must be reduced by reducing the exhaust flow or providing compensating outdoor airflow. Atmospherically vented combustion appliances do not include direct-vent appliances.*

ASHRAE Standard 62.2 requires that the vent system for combustion appliances be properly installed, as specified by the instructions from the appliance manufacturer and by the California Building Code. Compliance with the venting requirements will involve determining the type of vent material to be used, the sizing of the vent system, and vent routing requirements.

ASHRAE Standard 62.2 includes a provision intended to prevent backdrafting where one or more large exhaust fans are installed in a home with atmospherically vented or solid fuel appliances. If the two largest exhaust fans have a combined capacity that exceeds 15 cfm/100 ft² of floor area, then makeup air must be provided. This provision applies only when the atmospherically vented appliance is inside the pressure boundary of the house and does not include a summer cooling fan that is designed to be operated with the windows open. Direct-vent appliances are not considered “atmospherically vented.”

The two largest exhaust fans are normally the kitchen range hood and the clothes dryer (if located inside the dwelling unit pressure boundary). Large-range hoods, particularly downdraft range hoods, can have capacities of 1,000 cfm or more.

A problem with this requirement can be solved in one of three ways. First, all atmospherically vented combustion appliances can be moved outside the pressure boundary of the house (to the garage or other similar space). Second, the flow rate of one or more of the fans can be reduced so that the combined flow is less than 15 cfm/100 ft². Finally, makeup air can be provided to offset the net exhaust rate.

Example 4-24 – Large Exhaust Fan

Question:

I am building a 3,600 ft^2 custom home that has four bedrooms. The kitchen will have a high-end range hood that has three speeds, nominally 1000 cfm, 1400 cfm and 1600 cfm. The house will be heated with an atmospherically vented gas furnace located in the basement. If I am using a central exhaust fan for the whole-building ventilation of 75 cfm, and there is a clothes dryer installed, how much compensating outdoor airflow (makeup air) is needed?

Answer:

You must use the high speed value for the range hood of 1600 cfm. The clothes dryer will have a flow that is assumed to be 150 cfm for sizing purposes. These two flows must be added together for a total exhaust capacity of 1750 cfm. Since the whole-building ventilation fan is not one of the two largest exhaust fans, it does not figure into the makeup air calculation. Using the equation above, there must be at least 1750 cfm – (15 cfm x 3600 ft² / 100 ft²) = 1210 cfm of makeup airflow.

Example 4-25

Question:

The same custom house will have the furnace located in the garage instead of the basement. Does that change anything?

Answer:

The garage and the attic would both normally be considered outside the pressure boundary, so no makeup airflow would be required. An exception to this would be if the attic is specially designed to be inside the pressure boundary, then the answer would be the same as for Example 4-24.

Example 4-26

Question:

For this house, I need to keep the furnace in the basement. What are my options that would avoid the requirement to provide makeup air?

Answer:

There are several things you could do. First, you could use a direct vent furnace that would also provide higher fuel efficiency. You could use a lower capacity range hood, one that is less than 390 cfm (15 cfm x 3600 ft² / 100 ft² – 150 cfm). Use of supply-only whole-building ventilation would allow the hood capacity to increase to 465 cfm (15 cfm x 3600 ft² / 100 ft² – 150 cfm + 75 cfm). There are also range hoods available in the commercial market that provides makeup air.

4.6.6.5 Garages

From ASHRAE 62.2, Section 6.5.1, Garages.

When an occupiable space adjoins a garage, the design must prevent migration of contaminants to the adjoining occupiable space. Air seal the walls, ceilings, and floors that separate garages from occupiable space. To be considered air sealed, all joints, seams, penetrations, openings between door assemblies and their respective jambs and framing, and other sources of air leakage through wall and ceiling assemblies separating the garage from the residence and its attic area shall be caulked, gasketed, weather stripped, wrapped, or otherwise sealed to limit air movement. Doors between garages and occupiable spaces shall be gasketed or made substantially airtight with weather stripping.

Garages often contain numerous sources of contaminants. These include gasoline and exhaust from vehicles, pesticides, paints and solvents, and others. The Energy Standards require that when garages are attached to the house, these contaminants be prevented from entering the house. The wall between the unit and garage (or garage ceiling in designs with living space above garages) shall be designed and constructed so that no air migrates through the wall or ceiling. The common doors and any air handlers or ducts located in the garage shall also be sealed, weather-stripped, or gasketed. Use of an exterior door system would address this requirement.

ASHRAE 62.2 Section 6.5.2 requires a system with an air handling unit (furnace) located in the garage, or return ducts located in the garage (regardless of the air handler location) to meet a sealed and tested ducts criteria of 6 percent of system airflow.

Leakage testing is mandatory for all forced-air duct systems in newly constructed buildings as specified by §150.0(m)11. For additions and alterations to existing buildings, any length of new or altered duct in the garage, or any new or altered air-handling unit in the garage triggers duct leakage testing requirements for the entire system since §150.2(a) and §150.2(b) require new or altered components to meet all applicable requirements in §150.0(o).

Example 4-27 – Garages

Question:

In a newly constructed building, the building designer located the air handler in the garage. The main return trunk from the dwelling is connected to the air handler. Is this acceptable?

Answer:

Yes. The duct system must be leak-tested at 25 Pa. and sealed, if necessary, to have leakage no greater than 5 percent of the total fan flow.

Example 4-28

Question:

For an alteration to an existing building, the air handler is located in the dwelling unit, and a portion of the return duct is run through the garage to a bedroom above the garage. The return duct has 4 ft of length located in the garage, and this 4 ft section is being replaced. How do I test that length of the duct for leakage?

Answer:

The entire duct system must be leak-tested at 25 Pa. and sealed, if necessary, to have leakage no greater than 6 percent of the total fan flow as required by ASHRAE 62.2. There is no test available to leak test only the garage portion of the duct system.

4.6.6.6 Ventilation Opening Area

From ASHRAE 62.2, Section 6.6, Ventilation Opening Area.

Spaces shall have ventilation openings as listed below. Such openings shall meet the requirements of Section 6.8.

Exception: Spaces that meet the local ventilation requirements set for bathrooms in Section 5.

6.6.1 Habitable Spaces. Each habitable space shall be provided with ventilation openings with an openable area not less than 4% of the floor area nor less than 5 ft^2 (0.5 m^2).

6.6.2 Toilets and Utility Rooms. Toilets and utility rooms shall be provided with ventilation openings with an openable area not less than 4% of the room floor area nor less than 1.5 ft^2 (0.15 m^2).

Exceptions: (1) Utility rooms with a dryer exhaust duct; (2) toilet compartments in bathrooms.

The whole-building mechanical ventilation is intended to provide adequate ventilation to typical new homes under normal circumstances. On occasion, however, houses experience unusual circumstances where high levels of contaminants are released into the space. When this occurs, a means of providing the significantly higher levels of ventilation required to remove the contaminants is needed. Operable windows are the most likely means of providing the additional ventilation.

This section of ASHRAE Standard 62.2 requires ventilation openings in habitable spaces, toilets, and utility rooms. Ventilation openings usually mean operable windows, although a dedicated nonwindow opening for ventilation is acceptable. Spaces that meet the local exhaust requirements are exempted from this requirement.

4.6.6.7 Habitable Spaces

Habitable spaces are required to have ventilation openings with openable area equal to at least 4 percent of the space floor area (but not less than 5 ft^2). Rooms people occupy are considered habitable space. Dining rooms, living rooms, family rooms, bedrooms and kitchens are considered habitable space. Closets, crawl spaces, garages and utility rooms are generally not. If the washer and dryer are located in an open basement that is also the family room, it would be considered habitable space.

The openings do not have to be provided by windows. They can also be provided by operable, insulated, weather-stripped panels.

Ventilation openings, which include windows, skylights, through-the-wall inlets, window air inlets, or similar devices, shall be readily accessible to the occupant. This means that the occupant must be able to operate the opening without having to climb on anything. An operable skylight must have some means of being operated while standing on the floor: a push rod, a long crank handle, or an electric motor.

If a ventilation opening is covered with louvers or otherwise obstructed, the openable area is the unobstructed free area through the opening.

Example 4-29 – Ventilation Openings

Question:

I am building a house with a 14 ft. by 12 ft. bedroom. What size window do I need to install?

Answer:

It depends on the type of window. The standard requires that the openable area of the window, not the window unit, be 4 percent of the floor area, or 14 ft x 12 ft' x 0.04 = 6.7 ft². The fully opened area of the window or windows must be greater than 6.7 ft^2. The requirement for this example can be met using two double-hung windows each with a fully opened area of 3.35 ft^2. Any combination of windows whose opened areas add up to at least 6.7 ft^2 will meet the requirement.

Example 4-30 – Ventilation Opening Louvers

Question:

There are fixed wooden louvers over a window in a bedroom. The louvers have slats that are 1/8-in thick, and they are spaced 1 inch apart. What is the reduction in openable area?

Answer:

Assuming that the 1-inch spacing was measured perpendicular to the slats (the correct way), then the reduction is the slat thickness divided by the spacing, or 1/8 inch. So the credited opening area is the original opening area x (1 inch – 1/8 inch)/1 inch = 7/8 inch of the original opening area.

4.6.6.8 **Minimum Filtration**

From ASHRAE 62.2, Section 6.7 Minimum Filtration.

Mechanical systems that supply air to an occupiable space through ductwork exceeding 10 ft (3 m) in length and through a thermal conditioning component, except evaporative coolers, shall be provided with a filter having a designated minimum efficiency of MERV 6 or better when tested in accordance with ANSI/ASHRAE Standard 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size or a minimum Particle Size Efficiency of 50% in the 3.0–10 µm range in accordance with AHRI Standard 680, Performance Rating of Residential Air Filter Equipment. The system shall be designed such that all recirculated and mechanically supplied outdoor air is filtered before passing through the thermal conditioning components. The filter shall be located and installed in such a manner as to facilitate access and regular service by the owner.

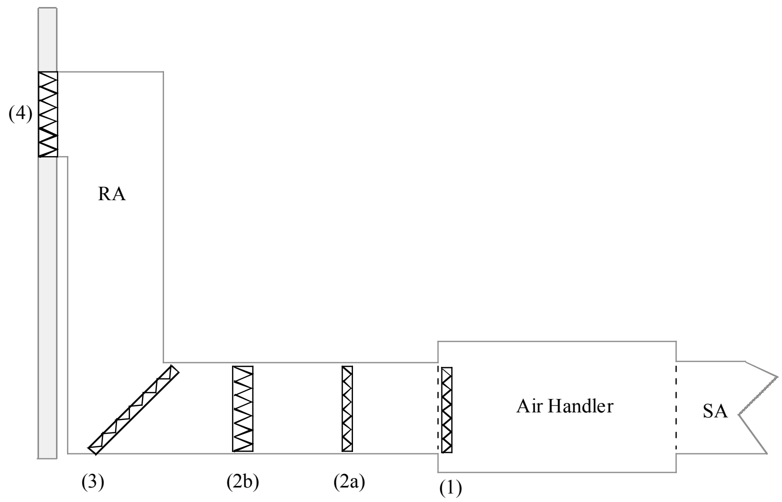
6.7.1 Filter Pressure Drop. New mechanical and distribution systems covered by Section 6.7, installed after January 1, 2014, shall be designed to accommodate the clean-filter pressure drop as rated using AHRI Standard 680, Performance Rating of Residential Air Filter Equipment13, for the system design flow. The filter locations shall be labeled with the design airflow and maximum allowable clean-filter pressure drop. The label shall be visible to a person replacing the filter.

ASHRAE Standard 62.2 requires that particulate air filtration of no less than MERV 6 efficiency is installed in any HVAC system having more than 10 ft of ductwork. The particulate filter must be installed such that all the air circulated through the furnace or air handler is filtered before passing through the thermal conditioning portion of the system. In addition, the standard requires that the filter be located and installed for easy access and service by the homeowner. The filter must be of a type and size that allows the system to operate at the design airflow rate and at less than the design pressure drop across the filter. Refer to Section 4.4.1.13 for additional information on air filtration requirements.

The filter retainer section must be easily accessible by the homeowner to assure continued monitoring and replacement. The filter bank may be located in the following locations:

1. The air handler/furnace
2. The return air plenum near the air handler
3. In the return air plenum with a deep pleat cartridge
4. Angled across the return air plenum to increase cross-sectional area
5. Situated in a wall return grille

Figure 4-31: Filter Location Options



Source: California Energy Commission

The MERV 6 pleated filter provides enhanced particulate arrestance but also provides longer service life than the conventional low efficiency panel filter. Typically, the pleated type filter will last three months or longer, depending upon operating conditions, as compared to the typical one-month life cycle of disposable fiberglass filters. The deeper pleated versions will typically provide even longer life cycles, up to a year or more.

Example 4-31– Filter Sizing

Question:

I am installing a 1200 cfm furnace in a new house. It has a 20 inches x 20 inches filter furnished and installed in the unit. Is this in compliance?

Answer:

Yes, you may assume that the equipment manufacturer has selected a compliant filter efficiency and pressure drop to match the features of the air handler.

Example 4-32

Question:

What if the above unit has no filter installed but recommends a 20 inches x 20 inches filter size? Which filter do I select?

Answer:

Several manufacturers produce a 1-inch deep MERV 6 for use in slide-in tracks and return air grills. If the pressure drop information is not furnished with the filter to assist with the selection, oversize the filter by at least one size multiple beyond the normal manufacturer recommendation. In this case, a filter selection of 20 inches x 25 inches to oversize the filter would reduce the face velocity by 25 percent, which in turn reduces the initial pressure drop by almost 50 percent.

Example 4-33

Question:

For the same 1200 cfm furnace, what other options do I have?

Answer:

For any filter, the pressure drop, efficiency, and life cycle can all be affected by velocity control. By enlarging the filter cartridge size, the approach velocity is decreased along with the pressure drop. If the depth of the filter is increased, likewise the air velocity through the media is decreased, and that, in turn, substantially reduces the actual pressure drop. Doubling the pleat depth will halve the velocity through the media and decrease pressure drop by up to 75 percent.

Example 4-34

Question:

I am installing an HVAC system with the filter to be installed at the return air grille. What should I do to accommodate a 1-inch pleated MERV 6 filter?

Answer:

You can reduce the face velocity and related pressure drop by employing multiple return air grilles. By doubling or tripling the return air filter surface area, the pressure drop is reduced by 75 percent or greater. Alternatively, you can increase the size of the return air grille similar to what was discussed in Example 4-32, above, or increase the depth of the filter as discussed in Example 4-33.

Example 4-35

Question:

I am installing a ductless split system in a space that is being added on to the house. Must I use the designated MERV 6 filter?

Answer:

No, the requirement does not apply since there is no ductwork attached to the unit.

Example 4-36

Question:

My builder supply house has only MERV 8 or greater efficiency filters. Is this in compliance?

Answer:

Yes, this is a better efficiency. However, higher MERV filters usually have higher pressure drop. Make sure that the pressure drop does not exceed the maximum design pressure drop at the design airflow rate for the system.

4.6.6.9 **Air Inlets**

From ASHRAE 62.2, Section 6.8, Air Inlets.

Air inlets that are part of the ventilation design shall be located a minimum of 10 ft (3 m) from known sources of contamination such as a stack, vent, exhaust hood, or vehicle exhaust. The intake shall be placed so that entering air is not obstructed by snow, plantings, or other material. Forced air inlets shall be provided with rodent/insect screens (mesh not larger than 1/2 in. [13 mm]).

Exceptions:

a. Ventilation openings in the wall may be as close as a stretched-string distance of 3 ft (1 m) from sources of contamination exiting through the roof or dryer exhausts.

b. No minimum separation distance shall be required between windows and local exhaust outlets in kitchens and bathrooms.

c. Vent terminations covered by and meeting the requirements of the National Fuel Gas Code (NFPA 54/ANSI Z223.1, National Fuel Gas Code) or equivalent.

When the ventilation system is designed with air inlets, the inlets must be located away from locations that can be expected to be sources of contamination. The minimum separation is 10 ft. Inlets include not only inlets to ducts, but windows that are needed to the opening area.

The Energy Standards list some likely sources of contaminants. For typical residential applications, the sources will include:

1. Vents from combustion appliances
2. Chimneys
3. Exhaust fan outlets
4. Barbeque grills
5. Locations where vehicles may be idling for any significant length of time
6. Any other locations where contaminants will be generated

The Energy Standards also require that air intakes be placed so that they will not become obstructed by snow, plants, or other material. Forced air inlets must also be equipped with insect/rodent screens, where the mesh is no larger than 1/2 inch.

There are three exceptions to the separation requirements.

1. Windows or ventilation openings in the wall can be as close as 3 feet to sources of contamination that exit through the roof or to dryer exhausts.
2. There is no minimum distance between windows and the outlet of a local exhaust outlet from kitchens or bathrooms.
3. Vent terminations that meet the requirements of the National Fuel Gas Code, which has separation and location requirements, do not need to meet the requirements.

4.6.7 Air-Moving Equipment (Section 7 of ASHRAE 62.2)

> *From ASHRAE 62.2, Section 7.1, Selection and Installation.*
>
> *Ventilation devices and equipment shall be tested in accordance with ANSI/ASHRAE Standard 51/AMCA 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating and ANSI/AMCA Standard 300, Reverberant Room Method for Sound Testing of Fans, and rated in accordance with the airflow and sound rating procedures of the Home Ventilating Institute (HVI 915, Procedure for Loudness Rating of Residential Fan Products, HVI 916, Air Flow Test Procedure, and HVI 920, Product Performance Certification Procedure Including Verification and Challenge). Installations of systems or equipment shall be carried out in accordance with manufacturers' design requirements and installation instructions.*

Equipment used to meet the whole-building ventilation requirements or the local ventilation exhaust requirements shall be rated to deliver the required airflow and shall have sound ratings that meet the requirements of this section.

4.6.7.1 **Selection and Installation**

ASHRAE Standard 62.2 requires that equipment used to comply with the standard be selected based on tested and certified ratings of performance for airflow and sound. When selecting fans for use in meeting the requirements of the standard, you must check the Home Ventilating Institute-certified (HVI) products directory to confirm that the equipment you select has been tested, and the rated performance meets the requirements. The *HVI-Certified Products Directory* can be viewed here: http://www.hvi.org/proddirectory/index.cfm.

In addition, the Energy Standards require that the fans be installed in accordance with the manufacturer's instructions. You must review the installation instructions and other literature shipped with the fan and make sure that the installation complies with those instructions.

4.6.7.2 **Sound Ratings for Fans**

> *From ASHRAE 62.2, Section 7.2, Sound Ratings for Fans.*
>
> *Ventilation fans shall be rated for sound at no less than the minimum airflow rate required by this standard, as noted below. These sound ratings shall be at a minimum of 0.1 in. w.c. (25 Pa) static pressure in accordance with the HVI procedures referenced in Section 7.1.*
>
> *7.2.1 Whole-Building or Continuous Ventilation Fans.*
>
> *These fans shall be rated for sound at a maximum of 1.0 sone.*
>
> *7.2.2 Intermittent Local Exhaust Fans.*
>
> *Fans used to comply with Section 5.2 shall be rated for sound at a maximum of 3 sone, unless their maximum rated airflow exceeds 400 cfm (200 L/s).*
>
> *Exception: HVAC air handlers and remote-mounted fans need not meet sound requirements. To be considered for this exception, a remote-mounted fan must be mounted outside the habitable spaces, bathrooms, toilets, and hallways, and there must be at least 4 ft (1 m) of ductwork between the fan and the intake grille.*

One common reason for not using ventilation equipment, particularly local exhaust fans, is the noise they create. To address this, ASHRAE Standard 62.2 requires that certain fans be rated for sound, and that installed fans shall have ratings below specified limits. The sound rating must be done at an airflow that is no less than the airflow that the fan must provide to meet the ventilation airflow requirement.

Because of the variables in length and type of duct and grille, there is no clearly repeatable way to specify a sound level for ventilation devices that are not mounted in the ceiling or wall surface. Consequently, air handlers, HRV/ERVs, inline fans, and remote fans are exempted from the sound rating requirements that apply to surface-mounted fans. However, to reduce the amount of fan and/or motor noise that could come down the duct to the grille, the Energy Standards sets a minimum of 4 ft of ductwork between the grille and the ventilation device. This may still produce an undesirable amount of noise for the occupant, especially if hard metal duct is used. Flexible insulated duct or a sound attenuator will reduce the transmitted sound into the space.

A. Continuous Ventilation Fans (surface mounted fans)

Continuously operated fans shall be rated at 1.0 sone or less. This 1.0 sone requirement applies to continuous whole-building ventilation fans, and also to continuous local ventilation exhaust fans.

B. Intermittent Fans (Surface-Mounted Fans)

Intermittently operated whole-building ventilation fans shall be rated at a maximum of 1.0 sone. Intermittently operated local exhaust fans shall be rated at a maximum of 3.0 sone, unless the maximum rated airflow is greater than 400 cfm.

Thus, ASHRAE Standard 62.2 extends the requirement for quiet fans to include range hoods and regular bath fans, not just whole-building ventilation system fans. The whole-building fan or other combined systems that operate continuously to provide whole-building ventilation must be rated at 1.0 sone or less, but intermittent local ventilation exhaust fans, including intermittently operated bath fans, must be rated at a maximum of 3.0 sones. Range hoods must also be rated at 3.0 sones or less, but this is at their required “working speed” of 100 cfm. Most range hoods have maximum speeds of much more than 100 cfm, but 100 cfm is the minimum airflow that is required by the Standards.

4.6.7.3 Airflow Rating

From ASHRAE 62.2.

4.3 Airflow Measurement (Whole-Building Ventilation). The airflow required by this section is the quantity of outdoor ventilation air supplied and/ or indoor air exhausted by the mechanical ventilation system as installed and shall be measured using a flow hood, flow grid, or other airflow measuring device. Ventilation airflow of systems with multiple operating modes shall be tested in all modes designed to meet this section.

5.4 Airflow Measurement. (Local Exhaust). The airflow required by this section is the quantity of indoor air exhausted by the ventilation system as installed and shall be measured using a flow hood, flow grid, or other airflow measuring device.

Exception: The airflow rating, according to Section 7.1, at a pressure of 0.25 in. w.c. (62.5 Pa) may be used, provided the duct sizing meets the prescriptive requirements of Table 5.3 or manufacturer’s design criteria.5.4

All ventilation systems used to meet the whole-building airflow requirement must demonstrate compliance by direct measurement using a flow hood, flow grid, or other measuring device. HERS verification of whole-building airflow is required for newly constructed buildings and additions greater than 1,000 square feet to existing buildings.

Compliance with the ventilation airflow requirements for local exhaust ventilation systems can be demonstrated in one of two ways:

1. The ventilation system can be tested using an airflow measuring device after completion of the installation to confirm that the delivered ventilation airflow meets the requirement.
2. Simple exhaust systems can comply by conformance to a prescriptive requirement that the fan has a certified airflow rating that meets or exceeds the required ventilation airflow, and the ducts for the ventilation system meet either the fan manufacturer’s published duct design specifications or the prescriptive duct design requirements given in Table 4-16 (Table 5.3 of ASHRAE 62.2).

When using the prescriptive duct sizing table or manufacturer's design criteria for compliance, the certified airflow rating of the fan must be based on tested performance at the 0.25 inch w.c. operating point. The certified airflow rating of a ventilation device is generally available from the manufacturer and is available for hundreds of products in the Home Ventilating Institute (HVI) Certified Products Directory at the HVI website (www.hvi.org). Manufacturers can choose whether to provide the certified data for posting at the HVI website, but all of them should have available the rated data at 0.25 inches of water column static pressure.

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

The prescriptive duct design criteria given in Table 4-16 provides maximum duct lengths based on various duct diameters and duct type. As can be seen, the higher the flow, the larger in diameter or shorter in length the duct has to be. Moreover, smooth duct can be used to manage longer duct runs. Interpolation and extrapolation of Table 4-16 are not allowed. For airflow values not listed, use the next higher value. The table is not applicable for systems with airflow greater than 125 cfm at 62 Pa (0.25 inches of water column) static pressure.

Table 4-16: Prescriptive Duct Sizing for Single-Fan Exhaust Systems

Duct Type	Flex Duct				Smooth Duct			
Fan Rating 62 Pa (cfm@ 0.25 in. w.c.)	50	80	100	125	50	80	100	125
Diameter inch	Maximum Length ft.							
3	X	X	X	X	5	X	X	X
4	70	3	X	X	105	35	5	X
5	NL	70	35	20	NL	135	85	55
6	NL	NL	125	95	NL	NL	NL	145
7 and above	NL	NL	NL	NL	NL	NL	NL	NL
This table assumes no elbows. Deduct 15 feet of allowable duct length for each elbow. NL = no limit on duct length of this size. X = not allowed, any length of duct of this size with assumed turns and fitting will exceed the rated pressure drop.								

ASHRAE 62.2, Table 5.3

Example 4-37 – Prescriptive Duct Sizing

Question:

I need to provide 75 cfm of continuous ventilation, which I plan to do using a central exhaust fan. I plan to connect the fan to a roof vent termination using flex duct. The duct will be about 8 ft long, with no real elbows, but some slight bends in the duct. What size duct do I need to use?

Answer:

From Table 4-16, using the 80 cfm, flex duct column, the maximum length with a 4-inch duct is 3 ft, so you cannot use 4 inches of duct. With a 5-inch duct, the maximum length is 70 ft, so that will clearly be adequate. Even if the bend in the duct is treated as an elbow, the allowable length only drops to 55 ft, more than adequate for the 8 ft required.

Example 4-38

Question:

For the situation in Example 4-37, again providing 75 cfm, what size duct would I need if smooth metal duct were used? In this case the total length would increase to about 10 ft, and there would be two elbows.

Answer:

Using the 80 cfm, smooth duct column of Table 4-16, the maximum length of 4 inches duct is 35 ft. Subtracting 15 ft for each of the two elbows leaves 5 ft, which is not long enough. With a 5-inch duct the maximum length is 135 ft. Subtracting 15 ft for each of the 2 elbows leaves 105 ft, so that will clearly be adequate.

Example 4-39

Question:

I will need a 100 cfm range hood. I have two possible duct routings. One is 15 ft long and will require three elbows. The other is 35 ft long but requires only one elbow. What size flex duct do I need to use?

Answer:

First, take the two routings and add in the correction for the elbows. Elbow corrections can be either added to the desired length or subtracted from the allowable length. In this case, we know the desired length, so we'll add the elbows. We get 15 ft plus 3 times 15 ft for a total of 60 ft, or 35 ft plus 15 ft equals 50 ft.

Looking at Table 4-16, in the 100 cfm, flex duct column, the maximum length with 5 inches duct is 35 ft, which is less than the adjusted length for either routing. With a 6-inch duct, the maximum length is 125 ft, longer than either adjusted length. A 6-inch duct would need to be used for either routing.

Note: The building code may not allow flex duct to be used for the range hood, in which case a smooth duct would be required. For a smooth duct, 5 inches would be acceptable.

4.6.7.4 Multibranch Exhaust Ducting

From ASHRAE 62.2, Section 7.3, Multibranch Exhaust Ducting.

If more than one of the exhaust fans in a dwelling unit shares a common exhaust duct, each fan shall be equipped with a back-draft damper to prevent the recirculation of exhaust air from one room to another through the exhaust ducting system.

ASHRAE Standard 62.2 contains restrictions on several situations where multiple exhausts are connected through a combined duct system. These restrictions are intended to prevent air from moving between spaces through the exhaust ducts.

The first restriction is that if more than one exhaust fan in a dwelling shares a common duct, then each fan must be equipped with a backdraft damper so that air exhausted from one bathroom or unit is not allowed to go into another space. Exhaust fans in multiple dwelling units may not share a common duct.

The other restriction applies to remote fans serving more than one dwelling unit. Sometimes a single remote fan or HRV/ERV will exhaust from several units in a multifamily building. This section does not preclude the use of that type of system, but it does require that either the shared exhaust fan operate continuously or that each unit be equipped with a backdraft damper so that air cannot flow from unit to unit when the fan is off.

In multifamily buildings, fire codes may impose additional restrictions.

4.6.8 Multifamily Buildings (Section 8 of ASHRAE 62.2)

Individual dwelling units in multifamily buildings are each required to meet all the IAQ and whole-building ventilation requirements for ASHRAE 62.2 discussed in the preceding section, as modified by this section. This means that the terms "building" and "dwelling" in the preceding sections are referring to single dwelling units for multifamily buildings.

4.6.8.1 Whole-Building Mechanical Ventilation

From ASHRAE 62.2, Section 8.2, Whole-Building Mechanical Ventilation.

8.2.1 Ventilation Rate. The required dwelling unit mechanical ventilation rate, Q_{fan}, shall be the rate in Section 4.1.1 plus 0.02 cfm per ft^2 (10 L/s per 100 m^2) of floor area or, equivalently, the rate from Tables 8.2.1a and 8.2.1b. The required mechanical ventilation rate shall not be reduced as described in Section 4.1.2.

The methods for determining the required whole-building ventilation rate for multifamily buildings are almost the same as those used for single-family buildings.

As this section will discuss only the differences, it would be beneficial for the reader to review Section 4.6.3 before continuing.

Multifamily buildings must use the fan ventilation rate method to determine the required ventilation rate, specified in this section. The total ventilation rate method cannot be used for multifamily buildings.

The fan system may use an intermittent ventilation option using the same method as Section 4.6.3.2 to determine the required minimum intermittent ventilation flow rate, replacing the use of Equation 4-1 and Table 4-14 in Section 4.6.3.2 with Equation 4-9 and Table 4–17.

The continuous whole-building ventilation rate is larger for multifamily buildings, but is given by an equation similar to Equation 4-1 and is calculated in the same manner:

Equation 4-9

$$Q_{fan} = 0.03A_{floor} + 7.5(N_{br} + 1)$$

Where:

Q_{fan} = fan flow rate (cfm)

A_{floor} = floor area of residence (ft^2)

N_{br} = number of bedrooms (no fewer than one)

The required ventilation rate may also be found using Table 4–17. This table allows users to find the required ventilation rate directly if they know the floor area and number of bedrooms.

Table 4–17: Dwelling Unit Ventilation Air Requirements, cfm

Floor Area (ft^2)	Number of Bedrooms				
	1	2	3	4	≥5
<500	30	40	45	55	60
500-1000	45	55	60	70	75
1001-1500	60	70	75	85	90
1501-2000	75	85	90	100	105
2001-2500	90	100	105	115	120
2501-3000	105	115	120	130	135
3001-3500	120	130	135	145	150
>3501	135	145	150	160	165

From ASHRAE 62.2, Table 8.2.1a

Corridors and other common areas within conditioned space must be provided a ventilation rate of 0.06 cfm per ft^2 of floor area. This required ventilation rate for common areas can be calculated using Equation 4-10:

Equation 4-10

$$Q_{fan} = 0.06A_{common}$$

Where:

Q_{fan} = fan flow rate (cfm)

A_{common} = floor area of common area (ft^2)

Nonresidential spaces in mixed-use buildings must meet the requirements of ASHRAE 62.1, Ventilation for Acceptable Indoor Air Quality.

Common parking garages adjoining occupiable spaces, except parking garages with at least two walls that are at least 5 percent open to the outside, must be provided with exhaust ventilation at a rate given by Equation 4-11:

Equation 4-11

$$Q_{fan} = 0.4A_{garage}$$

Where:

Q_{fan} = fan flow rate (cfm)

A_{garage} = floor area of Parking Garage (ft^2)

This ventilation rate is much higher per ft^2 of floor area than most ventilation requirements due to vehicle emission concerns.

4.6.8.2 Other Requirements

> *From ASHRAE 62.2, Section 8.4, Other Requirements*
>
> *8.4.1 Transfer Air. Measures shall be taken to minimize air movement across envelope components separating dwelling units, including sealing penetrations in the common walls, ceilings, and floors of each unit and by sealing vertical chases adjacent to the units. All doors between dwelling units and common hallways shall be gasketed or made substantially airtight.*
>
> *8.4.1.1 Compliance. One method of demonstrating compliance with Section 8.4.1 shall be to verify a leakage rate below a maximum of 0.2 cfm per ft^2 (100 L/s per 100 m^2) of the dwelling unit envelope area (i.e., the sum of the area of the walls between dwelling units, exterior walls, ceiling and floor) at a test pressure of 50 Pa by a blower door test conducted in accordance with either ANSI/ASTM-E779-10, Standard Test Method for Determining Air Leakage Rate by Fan Pressurization, or ANSI/ASTM E1827, Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door. The test shall be conducted with the dwelling unit as if it were exposed to outdoor air on all sides, top, and bottom by opening doors and windows of adjacent dwelling units.*

ASHRAE Standard 62.2 requires that measures be taken to minimize air movement across envelope components separating dwelling units from adjacent dwelling units and nearby spaces outside the occupiable space of the dwelling unit. This should include sealing all penetrations in envelope components (for example, light fixtures in roofs, outlets in walls, and base boards around the edge of floors) and sealing vertical chases adjacent to units. Pipe and electrical penetrations are also examples of envelope component penetrations that require sealing. The measures must apply to adjacent units both above and below, as well as side by side.

All doors between dwelling units and common areas must be gasketed or made substantially airtight.

The Energy Standards do not require HERS verification of multifamily envelope leakage rates. The builder or installer must implement measures that meet the ASHRAE 62.2 Section 8.4.1 transfer air requirements. The enforcement agency is responsible for determining compliance, thus may specify inspection criteria or other methods such as the diagnostic method detailed in ASHRAE 62.2 Section 8.4.1.1.

4.6.8.3 **Air-Moving Equipment**

> *From ASHRAE 62.2, Section 8.5, Air-Moving Equipment.*
>
> *8.5.1 Exhaust Ducts. Exhaust fans in separate dwelling units shall not share a common exhaust duct. Exhaust inlets from more than one dwelling unit may be served by a single exhaust fan downstream of all the exhaust inlets if the fan is designated and intended to run continuously or if each inlet is equipped with a back-draft damper to prevent cross-contamination when the fan is not running.*
>
> *8.5.2 Supply Ducts. Supply outlets to more than one dwelling unit may be served by a single fan upstream of all the supply outlets if the fan is designed and intended to run continuously or if each supply outlet is equipped with a back-draft damper to prevent cross-contamination when the fan is not running.*

Exhaust fans in separate dwelling units cannot share a common exhaust duct. Exhaust inlets from more than one dwelling unit may be served by a single exhaust fan downstream of all the exhaust inlets if the fan is designed and intended to run continuously or if each inlet is equipped with a backdraft damper to prevent cross-contamination when the fan is not running.

Supply outlets to more than one dwelling unit may be served by a single fan upstream of all the supply outlets if the fan is designed and intended to run continuously or if each supply outlet is equipped with a backdraft damper to prevent cross-contamination when the fan is not running.

4.7 Alternative Systems

4.7.1 Hydronic Heating Systems

Hydronic heating is the use of hot water to distribute heat. Hydronic heating is discussed in this compliance manual as an “alternative system” because it is much less common in California than in other parts of the United States.

A hydronic heating system consists of a heat source, which is either a boiler or water heater, and a distribution system. There are three main types of hydronic distribution systems, and they may be used individually or in combination: baseboard convectors or radiators, hot water air handlers, and radiant panel heating systems. These three options are illustrated in Figure 4-32.

Baseboard convectors or radiators are most effective when mounted near the floor. Cool air drawn by gravity over heated panels or finned tubes is heated and pushed upward to warm the room. These devices also increase the mean radiant temperature of the space, improving comfort. Baseboard convectors or radiators do not require ducting.

Air handlers consist of a blower and finned tube coil enclosed in a sheet metal box (similar to a typical residential furnace) and may be ducted or nonducted. Air handlers may also include refrigerant coils for air conditioning. Some air handlers are compact and can fit under cabinets.

Radiant panels may be mounted on or integrated with floors, walls, and ceilings. Radiant floor panels are most typical. See the separate section below for additional requirements specific to radiant floor designs.

4.7.1.1 **Mandatory Requirements**

For hydronic heating systems without ducts, the mandatory measures cover only pipe insulation, tank insulation, and boiler efficiency. Otherwise, for fan coils with ducted air distribution, the mandatory air distribution measures also apply. For combined hydronic systems, as described below, mandatory water heating requirements also apply to the water heating portion of the system.

A. Pipe and Tank Insulation

§150.0(j) Water System Pipe and Tank Insulation and Cooling Systems Line Insulation, §123.0 Requirements for Pipe Insulation

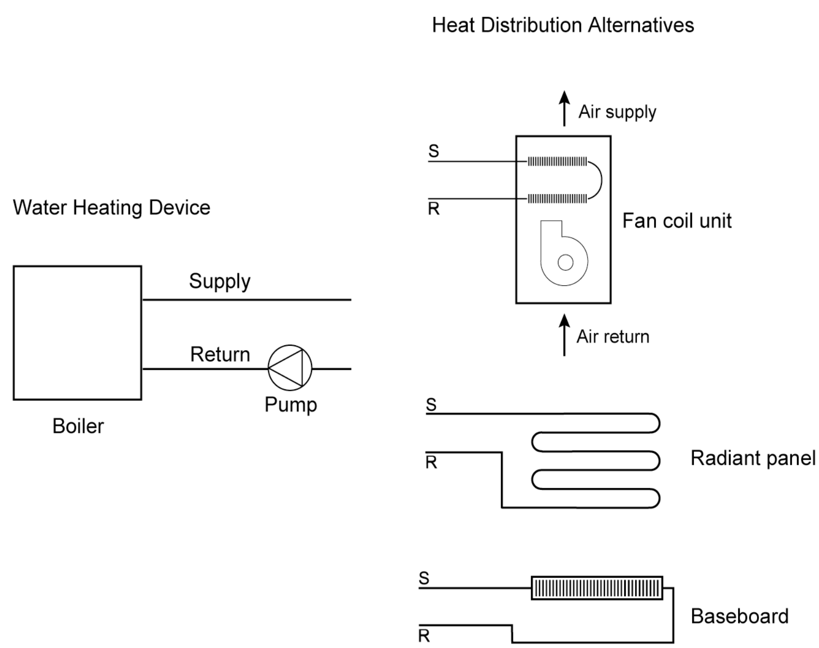
The typical residential hydronic heating system operating between 105° and 140° F must have at least 1 inch (25 mm) of insulation on pipes less than 1 inch in diameter and 1.5 inch (38 mm) of insulation on pipes between 1 inch and less than 1.5 inches in diameter. Systems operating between 141° and 200° F must have at least 1.5 inches of insulation on pipes less than 1.5 inches in diameter. For other temperatures and pipe insulation characteristics, see Table 4-5.

There are a few exceptions where insulation is not required:

1. Sections of pipes where they penetrate framing members.
2. Pipes that provide the heat exchange surface for radiant floor heating.
3. Piping in the attic that is covered by at least 4 inches (100 mm) of blown insulation on top.
4. Piping installed within walls if all the requirements for Insulation Installation Quality are met (see Chapter 3 Building Envelope Requirements).

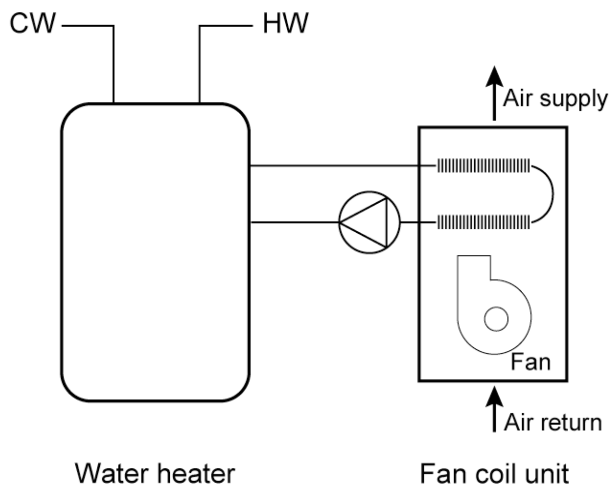
If the system includes an unfired hot water storage tank, then the tank must be either wrapped with R-12 insulation or insulated internally to at least R-16.

Figure 4-32: Hydronic Heating System Components



Source: Richard Heath & Associates/Pacific Gas & Electric

Figure 4-33: Combined Hydronic System With Water Heater as Heat Source



Source: Richard Heath & Associates/Pacific Gas & Electric

For pipes in hydronic heating systems that operate at pressure greater than 15 psi, the requirements of §120.3 apply. These are the same requirements that apply to nonresidential piping systems.

B. Boiler Efficiency

Gas or oil boilers of the size typically used for residential space heating (less than 300,000 Btu/h capacity) must be rated with an AFUE of 80 percent or greater. (See *Appliance Efficiency Regulations, Title 20 for minimum efficiencies of other heating equipment.)* A gas or oil water heater may also be used as a dedicated source for space heating. Other hot water sources, including heat pumps or electric resistance water heaters, are not allowed for use in dedicated space-heating systems. Therefore, some water heaters may be used for space heating only if used as part of a combined hydronic system as described below. In that case, the mandatory water heater requirements apply.

Thermostat requirements also apply to hydronic systems as described in Section 4.5.1.

4.7.1.2 **Prescriptive Requirements**

There are no specific prescriptive requirements that apply to hydronic systems. However, if the system has a fan coil with ducted air distribution, the relevant prescriptive requirements apply, including duct insulation and duct sealing.

4.7.1.3 **Performance Compliance Options**

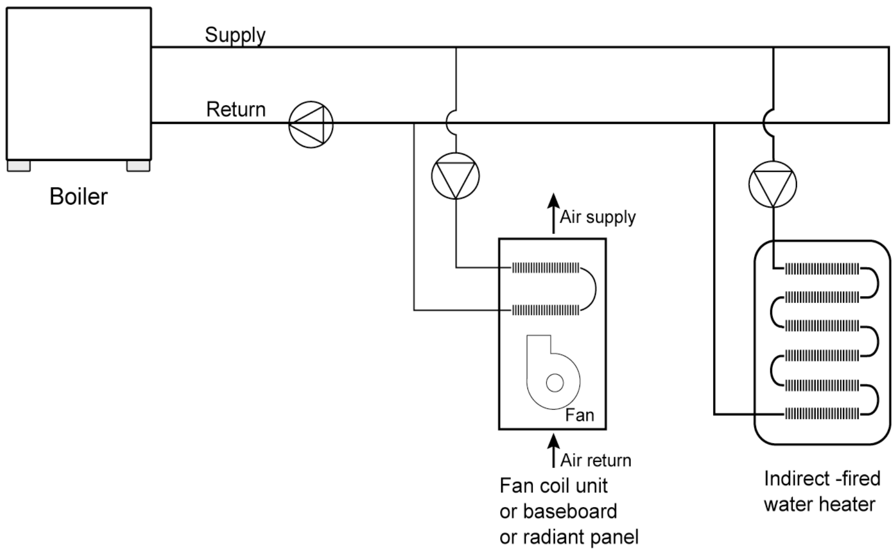
Credit for choosing a hydronic heating system is possible using the performance compliance method. The standard design is assumed to have a furnace and ducted air distribution system. Therefore, hydronic systems without ducts can take credit for avoiding duct leakage penalties. In addition, minimizing the amount of pipe outside conditioned space will provide some savings. Hydronic heating 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 adequate 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 method. *Combined hydronic heating* refers to the use of a single water heating device as the heat source for both space and domestic hot water heating.

There are two types of combined hydronic systems. One uses a boiler as a heat source for the hydronic space heating system. The boiler also heats domestic water by circulating hot water through a heat exchanger in an indirect-fired water heater.

Figure 4-34: Combined Hydronic System With Boiler and Indirect Fired Water Heater



Source: Richard Heath & Associates/Pacific Gas & Electric

The other type of hydronic heating uses a water heater as a heat source. The water heater provides domestic hot water as usual. Space heating is accomplished by circulating water from the water heater 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 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 HSPF rating is calculated. These calculations are performed automatically by the compliance software.

4.7.2 Radiant Floor System

§110.8(g) and Table 118.0-A

One type of distribution system is the radiant floor system, either hydronic or electric, which must meet mandatory insulation measures. (See below.) Radiant floors may take one of several forms. Tubing or electric elements for radiant floor systems may be:

1. Embedded in a concrete floor slab.
2. Installed over the top of a wood subfloor and covered with a concrete topping.
3. Installed over the top of wood subfloor in between wood furring strips.
4. Installed on the underside surface of wood subfloor

In the latter two types of installations, aluminum fins are typically installed to spread the heat evenly over the floor surface and to reduce the temperature of the water as required. All hydronic systems use one or more pumps to circulate hot water. Pumps are controlled directly or indirectly by thermostats, or by special outdoor reset controls.

Table 4–18: Slab Insulation Requirements for Heated Slabs

Location of Insulation	Orientation of Insulation	Installation Criteria	Climate Zone	Insulation R-value
Outside edge of heated slab, either inside or outside the foundation wall	Vertical	From the level of the top of the slab, down 16 inches or to the frost line, whichever is greater? Insulation may stop at the top of the footing where this is less than the required depth.	1-15	5
			16	10
		For below-grade slabs, vertical insulation shall be extended from the top of the foundation wall to the bottom of the foundation (or the top of the footing) or frost line, whichever is greater.	1-15	5
Between heated slab and outside foundation wall	Vertical and Horizontal	Vertical insulation from the top of the slab at the inside edge of the outside wall down to the top of the horizontal insulation. Horizontal insulation from the outside edge of the vertical insulation extending 4 feet toward the center of the slab in a direction normal to the outside of the building in the plan view.	16	10 vertical and 7 horizontal

Source: 2016 Energy Standards Table 110.8-A

Radiant floor systems in concrete slabs must have insulation between the heated portion of the slab and the outdoors.

When space heating hot water pipes or heating elements are set into a concrete slab-on-grade floor, slab-edge insulation from the level of the top of the slab, down 16 inches (200 mm) or to the frost line, whichever is greater (insulation may stop at the top of the footing, where this is less than the required depth) is required. Alternatively, insulation may be installed down from the top of the slab and wrapped under the slab for a minimum of 4 ft toward the middle of the slab. The required insulation value for each of these insulating methods is either R-5 or R-10 depending on climate zone as shown in Table 4–18. Any part of the slab extending outward horizontally must be insulated to the level specified in Table 4–18.

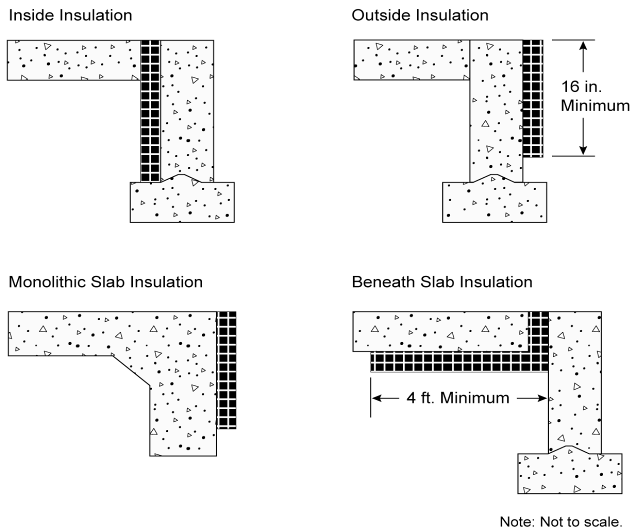
When using the performance compliance method with slab-on-grade construction, the standard design includes slab edge insulation as described above using the F-factors in Reference Joint Appendix JA4, Table 4.4.8.

When space-heating hot water pipes or heating elements are set into a lightweight concrete topping slab laid over a raised floor, insulation must be applied to the exterior of any slab surface from the top of the slab where it meets the exterior wall, to the distance below ground level as described in Table 4–18. If the slab does not meet the ground on the bottom surface, the specified insulation level must be installed on the entire bottom surface of the raised slab. Any part of the slab extending outward horizontally must be insulated to the level specified in Table 4–18. For lightweight slabs installed on raised floors and inside exterior walls, the overall wall R-value and overall floor R-value (determined as 1/(U-factor)) may be counted toward meeting the minimum R-value requirements specified in Table 4–18.

Raised floor insulation that meets the mandatory minimum R-value for wood floor assemblies also meets the requirement for insulation wrapping under the lightweight topping slab.

Slab edge insulation applied to basement or retaining walls (with heated slab below grade) must be installed so that insulation starts at or above ground level and extends down to the bottom of the foundation or to the frost line, whichever is greater.

Figure 4-35: Heated Slab-On-Grade Floor Insulation Options



Source: California Energy Commission

Local conditions (such as a high water table) may require special insulation treatment to achieve satisfactory system performance and efficiency. To determine the need for additional insulation, follow the recommendations of the manufacturer of the hydronic tubing or heating element being installed. Where there is a danger of termite infestation, install termite barriers, as required, to prevent hidden access for insects from the ground to the building framing.

In addition to the insulation R-value requirements, §110.8(g)1 also sets mandatory measures related to moisture absorption properties of the insulation and protection of the insulation from physical damage or pest intrusion.

Example 4-40

Question:

My client wants a dedicated hydronic-heating system (space heating only), but a few things are unclear: (1) What piping insulation is required? (2) Can I use any compliance approach? (3) Do I have to insulate the slab with slab edge insulation? (4) What special documentation must be submitted for this system type?

Answer:

(1) The supply lines not installed within a concrete radiant floor must be insulated in accordance with §150.0(j)2— Systems operating between 105° and 140° F must have at least 1 inch of insulation on pipes less than 1 inch in diameter, and 1.5 inches of insulation on pipes between 1 inch and less than 1.5 inches in diameter. Systems operating between 141° and 200° F must have at least 1.5 inches of insulation on pipes less than 1.5 inches in diameter.

(2) You can use any compliance approach, but the boiler must meet the mandatory efficiency 80 percent AFUE.

(3) The slab edge insulation shown in Table 4–18 is required only when the distribution system is a radiant floor system (pipes in the slab). When this is the case, the insulation values shown are mandatory measures (no modeling or credit).

(4) No special documentation is required.

Example 4-41

Question:

What are the slab edge insulation requirements for a hydronic-heating system with the hot water pipes in the slab?

Answer:

The requirements for slab edge insulation can be found in §110.8 and §150.0(l).

Material and installation specifications are as follows:

Insulation values as shown in

1. Table 4–18
2. Protected from physical damage and ultra-violet light deterioration
3. Water absorption rate no greater than 0.3 percent (ASTM-C272)
4. Water vapor permeance no greater than 2.0 per inch (ASTM-E96-14).

4.7.3 Evaporative Cooling

Evaporative coolers cool a building by either 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 combination indirect-direct system that combines an indirect heat exchanger with a downstream direct evaporative process. Although direct coolers are the most common systems available, the more advanced indirect and indirect-direct systems offer generally lower supply air temperatures with less moisture introduced to the indoor space. For the Energy Standards, performance credit is allowed only for indirect and indirect-direct evaporative cooling systems. All coolers receiving credits within the *ACM Manual* must be listed in the Energy Commission's Title 20 Evaporative Cooler appliance database (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 13.0 SEER air conditioner.

In the performance 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. Direct coolers, as well as indirect and indirect-direct coolers not meeting these criteria, shall be modeled as a minimum efficiency (13.0 SEER) central air conditioner.

1. 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.

2. Equipment shall be permanently installed (no window or portable units).
3. Installation shall provide for automatic relief of supply air from the house with maximum air velocity through the relief dampers not exceeding 800 fpm (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.
4. To minimize water consumption, bleed systems are not allowed.
5. 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.
6. Automatic thermostats are required. Manual on/off controls are not allowed.
7. 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.
8. The installing contractor must provide a winter closure device that substantially blocks outdoor air from entering the indoor space.
9. The size of the water inlet connection at the evaporative cooler shall not exceed 3/8 inch.
10. 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 4-42

Question:

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

Answer:

In situations where both 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 4-43

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.

4.7.4 Ground-Source Heat Pumps

Table 4–19 – Standards for Ground Water-Source and Ground-Source Heat Pumps Manufactured on or After October 29, 2003

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

Source: Section 1605.3 Table C-8 of the *2012 California Appliance Efficiency Regulations*

A geothermal or ground-source heat pump uses the earth as a source of energy for heating 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 efficiencies for ground water source heat pumps are specified in the *California Appliance Efficiency Regulations* and repeated in Table 4–19. These efficiency values 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.

For the performance compliance approach, the COP must be converted to HSPF. To take appropriate credit, the EER should be entered as a HERS-verified EER, which requires that a HERS Rater verify the equipment efficiency. When this approach is used, a significant portion of the ground-source heat pumps efficiency will not be accounted for. If credit is not taken, the EER may be used in place of the SEER. When heat pump equipment is not tested for HSPF, calculate the HSPF as follows:

Equation 4-12

$$HSPF = (3.2 \times COP) - 2.4$$

The efficiency of geothermal heat pump systems depends on how well the portion of the system in the ground works. Manufacturers' recommendations must be followed carefully to ensure that the system is appropriately matched to the soil types and weather conditions. Local codes may require special installation practices for the ground-installed portions of the system. Verify that the system will meet local code conditions before choosing this type of system to meet the Standards.

4.7.5 Solar Space Heating

Solar space-heating systems are not recognized within either the prescriptive packages or the performance compliance method.

4.7.6 Wood Space Heating

The Energy Commission's exceptional method for wood heaters with any type of backup heating is available in areas where natural gas is not available. If the required eligibility criteria are met, a building with one or more wood heaters may be shown to comply with the Energy Standards using either the prescriptive or performance approaches as described below.

4.7.6.1 **Prescriptive Approach**

The building envelope conservation measures of the component package must be installed. The overall heating system efficiency (wood stove plus backup system) must comply with the prescriptive requirements.

4.7.6.2 **Performance Approach**

A computer method may be used for compliance when a home has wood space heat. There is no credit, however. Both the proposed design and the standard building are modeled with the same system, for example, with the overall heating system efficiency equivalent to a 80 percent AFUE central furnace with ducts in the attic insulated to Package A and with diagnostic duct testing.

4.7.6.3 **Wood Heater Qualification Criteria**

The Energy Standards establish exceptional method guidelines for the use of wood heaters. If all the criteria for the wood heat exceptional method are not met, a backup heating system must be included in the compliance calculations as the primary heat source.

The building department having jurisdiction must determine that natural gas is not available.

Note: Liquefied petroleum gas, or propane, is not considered natural gas.

The following eligibility criteria apply:

1. The local or regional air quality authority must determine that its authorization of this exceptional method is consistent with state and regional ambient air quality requirements according to Sections 39000 to 42708 of the California Health and Safety Code.
2. The wood heater must be installed in a manner that meets the requirements of all applicable health and safety codes, including, but not limited to, the requirements for maintaining indoor air quality in the CMC, in particular those homes where vapor barriers are.
3. The wood heater must meet the EPA definition of a wood heater as defined in Title 40, Part 60, Subpart AAA of the Code of Federal Regulations (40CFR60 Subpart AAA) (See below.)
4. The performance of the wood heater must be certified by a nationally recognized agency and approved by the building department having jurisdiction to meet the performance standards of the EPA.
5. The rated output of the wood heater must be at least 60 percent of the design heating load, using calculation methods and design conditions as specified in §150(h).
6. At the discretion of the local enforcement agency, a backup heating system may be required and be designed to provide all or part of the design heating load, using calculation methods and design conditions as specified in §150(h).
7. The wood heater must be located such that transfer of heat from the wood heater is effectively distributed throughout the entire residential dwelling unit, or it must be used in conjunction with a mechanical means of providing heat distribution throughout the dwelling.
8. Habitable rooms separated from the wood heater by one free opening of less than 15 ft^2 or two or more doors must be provided with a positive heat distribution system, such as a thermostatically controlled fan system. Habitable rooms do not include closets or bathrooms.

9. Wood heaters on a lower level are considered to heat rooms on the next level up, provided they are not separated by two or more doors.
10. The wood heater must be installed according to manufacturer and local enforcement agency specifications and must include instructions for homeowners that describe safe operation.
11. The local enforcement agency may require documentation that demonstrates that a particular wood heater meets all these requirements.

Federal regulation in 40CFR60 Subpart AAA includes minimum criteria for wood heaters established by the U.S. EPA. These criteria define a wood heater as an enclosed, wood-burning appliance capable of and intended for space heating or domestic water heating that meets all the following criteria:

1. An air-to-fuel ratio averaging less than 35 to 1
2. A firebox volume less than 20 ft^3.
3. A minimum burn rate less than 5 kilogram/hour (11.0 lbs/hr)
4. A maximum weight of less than 800 kilograms (1760 lbs)
5. The federal rules explicitly exclude furnaces, boilers, cook stoves, and open masonry fireplaces constructed on site, but include wood-heater inserts.

Example 4-44

Question:

Are pellet stoves treated the same as wood stoves for compliance with the Standards?

Answer:

Yes.

Example 4-45

Question: If a wood stove is installed in a wall, does it have to meet the fireplace requirements of §150(e)?

Answer:

No. A wood stove that meets EPA certification requirements does not have to meet any requirements applicable to fireplaces.

4.7.7 Gas Appliances

§110.5 Pilot Lights

As noted in an earlier section, pilot lights are prohibited in fan-type central furnaces. The Energy Standards also prohibit pilot lights in cooking appliances, pool heaters, and spa heaters. However, one exception is provided for household cooking appliances without an electrical supply voltage connection and in which each pilot consumes less than 150 Btu/h.

For requirements related to installation of fireplaces, decorative gas appliances, and gas logs, see Chapter 3 of this manual.

4.7.8 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 such as the Central Valley, the interior South Coast, and the deserts of California. The equipment minimal efficiencies are determined according to federal test procedures. Their efficiencies are reported in terms of energy efficiency rating (EER).

The EER is the full load efficiency at specific operating conditions. In cooling climate zones of California, high EER units are more effective in saving energy than high SEER units. Using the performance compliance method, credit is available for specifying an evaporatively cooled air conditioner. When credit is taken for a high EER, field verification by a HERS Rater is required.

If an evaporatively cooled air conditioner is installed, HERS-verified measures must be installed, including duct sealing, airflow, and refrigerant charge or fault indicator display. Besides the HERS 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.

4.7.9 Nonducted Systems

Several manufacturers offer equipment that does not use air distribution ducts to heat or cool spaces. These systems use either refrigerant or water that has been heated and/or cooled to condition the space. Besides not using duct work, these systems have advanced controls and full range multispeed compressors that will allow for optimal performance through a wide range of conditioning loads without losing efficiency.

These systems must be modeled as though they were minimally efficient units. The Energy Commission expects that the manufacturers will apply for a compliance option in the near future that will allow for the development of appropriate modeling rules to be included in the performance calculation approach.

As with all other high-performance systems, the Energy Commission recommends that all associated HERS verified measure be conducted to assure that all the efficiency of this equipment is captured.

4.7.10 Ventilation Cooling

Ventilation cooling is differentiated from fresh air ventilation in that the primary focus is not to provide a minimum amount of air to meet ventilation requirements, but to use higher volumes of outdoor air to cool the indoor space in lieu of air conditioning.

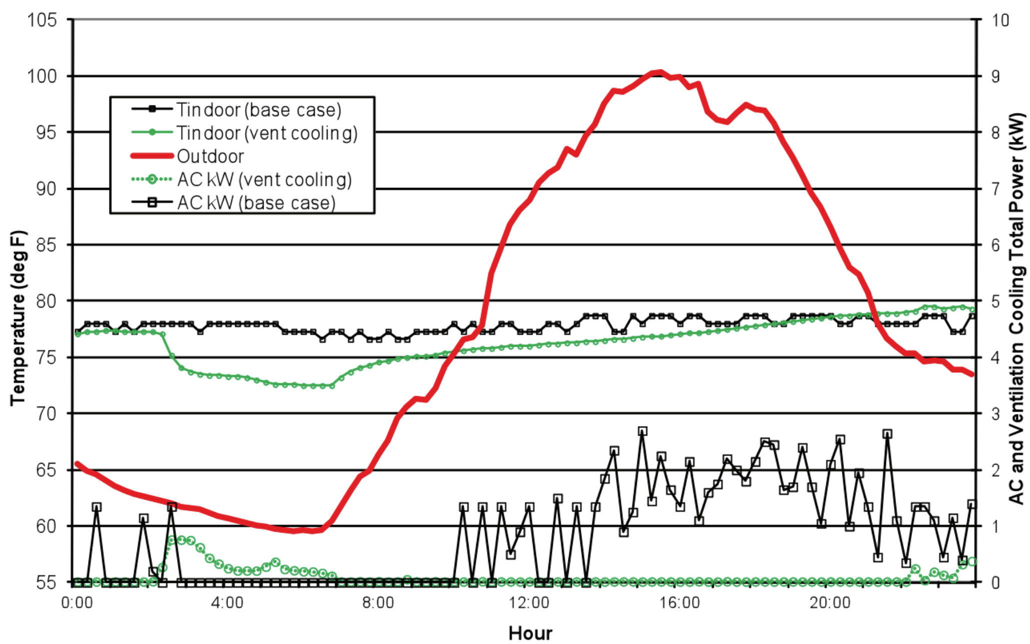
The simplest form of ventilation cooling uses windows to promote the flow of cooler air from outside to inside.

Whole house fans incorporate a fan (typically located in the attic) to pull cooler outdoor air through open windows and up into the attic, exhausting the air to the outside through attic vents. By pulling cooler outdoor air throughout the house, indoor air temperatures and the temperature of building mass are reduced, offsetting next day cooling loads. The effectiveness of night ventilation cooling depends upon the climate conditions and how much indoor temperature variation the occupant will tolerate.

Another type of ventilation cooling system is characterized as a central fan system, whereby the HVAC air handler is integrated with a damper, outdoor air duct, and controls to provide automated outdoor air delivery when conditions are favorable.

Although any of these ventilation cooling approaches can be used whenever outdoor temperatures are lower than indoor temperatures, the primary benefit occurs during summer nights when cooler outdoor air can be used to efficiently reduce indoor air temperatures below the daytime air conditioner thermostat set point, offsetting or eliminating next-day cooling loads. The key distinction between ventilation cooling and night ventilation cooling is that the latter approach involves cooling beyond the air conditioner set point and using building mass as a thermal storage system. The effectiveness of night ventilation cooling depends upon the climate conditions, thermal envelope, and how much indoor temperature variation the occupant will tolerate.

Figure 4-36: Diurnal Temperature Variation and Ventilation Cooling



Source: California Energy Commission

Figure 4-36 above illustrates how ventilation cooling can offset air-conditioning energy use with a relatively small amount of off-peak fan energy.

4.7.10.1 **Whole-House Fans**

Traditional whole-house fans have a simple barometric damper (Figure 4-37) and either a belt driven or direct-drive motor driving a prop fan. Figure 4-38 shows the damper open with the fan immediately above.

Figure 4-39 shows a similar product that moves less air but provides an insulated damper with a better leakage seal between the attic and conditioned space. These units are generally designed to fit between standard rafter spacing, simplifying retrofit installations.

Finally, Figure 4-40 shows remote whole-house fan design that removes the fan farther from indoor space, reducing the noise during operation.

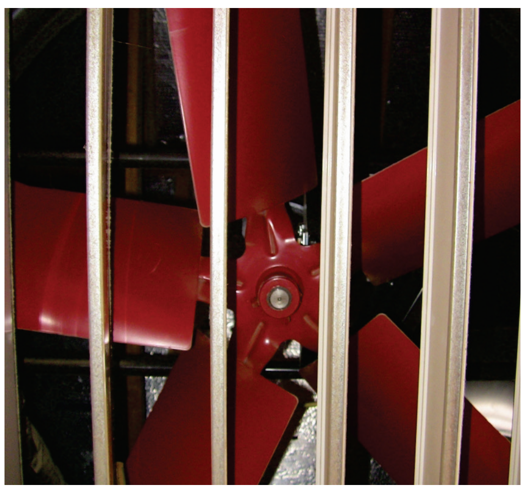
Whole-house fans operate most effectively at cooling a space when windows throughout the house are opened to a limited extent to ensure fairly uniform airflow throughout the dwelling. This results in the greatest interaction of the cool air with the interior mass throughout the dwelling, providing the greatest amount of stored cooling. Running the fan all night long is most effective at fully “charging” the thermal mass. Noise can be reduced somewhat through either use of a variable-speed control or installation of a multispeed fan, allowing low-speed nighttime operation. Security concerns and added dust and allergens are other factors to consider with the installation of a whole-house fan.

The WHFs used to comply with the Energy Standards must be listed in the Energy Commission's Appliance Database which can be accessed at: https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx.

Figure 4-37: Whole-House Fan Damper

Source: California Energy Commission

Figure 4-38: Open Barometric Damper With Fan Above



Source: California Energy Commission

Figure 4-39: Insulated Whole-House Fan With Damper Actuation

Source: California Energy Commission

Figure 4-40: Ducted Remote Whole House Fan

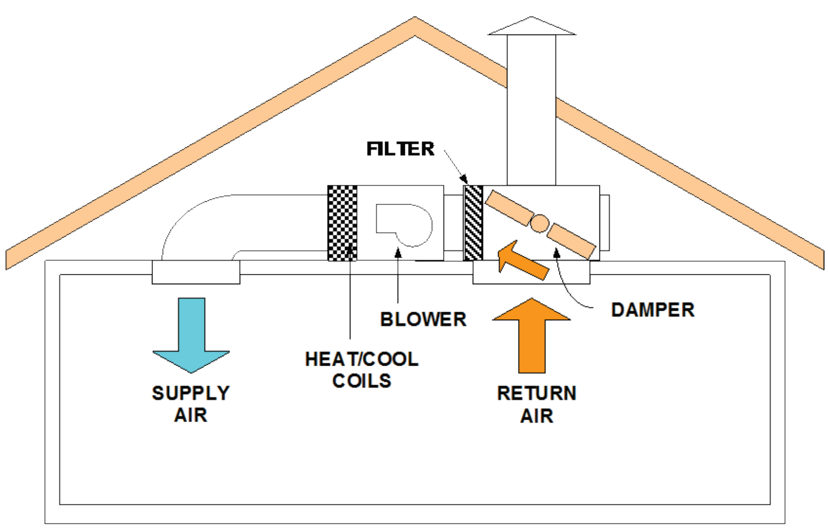
Source: California Energy Commission

4.7.10.2 Central Fan Systems

Central fan ventilation cooling systems use the furnace or air handler fan to deliver outdoor air to conditioned space. By adding an automated damper, outside air duct, and temperature sensors and controls, these systems can automatically deliver filtered outdoor air to occupant-specified comfort levels when outdoor conditions warrant the use of ventilation. This automated operation represents an improvement over WHFs, which rely entirely on the occupant being available to initiate operation and open windows throughout the house. A disadvantage of the central fan systems is that they typically move less air and consume more energy per cfm due to the more restrictive duct systems.

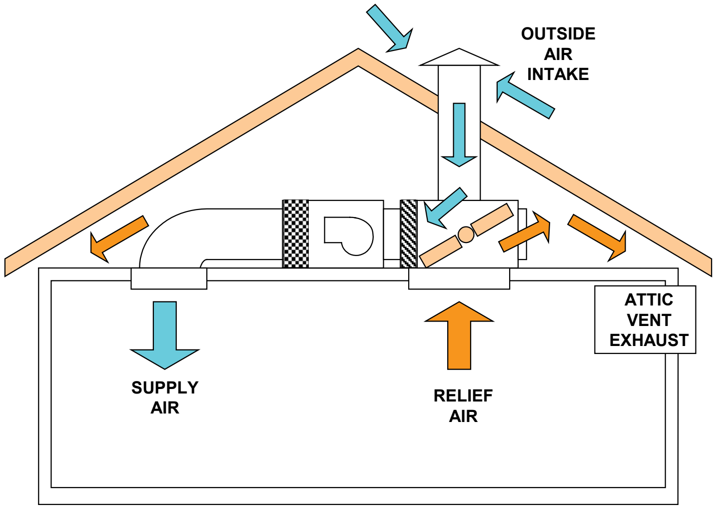
Figure 4-41 and Figure 4-42 show the airflow paths when the systems operate in conventional return air mode or outdoor air mode. In Figure 4-41, the damper is positioned to direct return air to the air handler for normal heating and cooling operation. In Figure 4-42 (ventilation cooling mode), the damper position is reversed so that air entering the air handler is now pulled from the outside air duct and then delivered to the house, with relief air exhausted through the damper to the attic. The air intake shown in these figures can be either a roof penetration inlet as shown in Figure 4-43 or a gable end screen vent as shown in Figure 4-44. A larger diameter duct sized to handle the full ventilation airflow runs from the air inlet to the damper box.

Figure 4-41: Central Fan System (Return Air Mode)



Source: California Energy Commission

Figure 4-42: Central Fan System (Outdoor Air Mode)

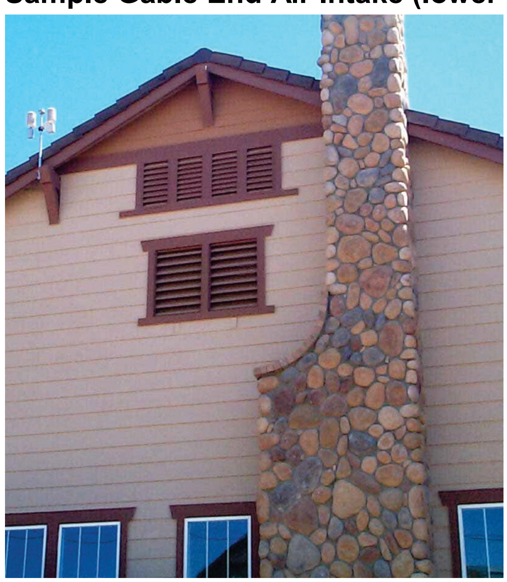


Source: California Energy Commission

Figure 4-43: Sample Rooftop Air Intake

Source: California Energy Commission

Figure 4-44: Sample Gable End Air Intake (lower set of vents)



Several advantages for central fan systems include control integration with the central system thermostat, precise control of ventilation initiation and termination, filtered outdoor air, and increased home security (windows can remain shut). One of the systems currently available also uses a variable-speed motor, promoting fan speed control in response to outdoor conditions and indoor comfort settings. This has been shown to provide energy savings relative to a fixed speed central fan ventilation system.

4.7.10.3 **Prescriptive Requirements**

Component Package A specifies a whole-house fan as a prescriptive requirement for single-family newly constructed buildings in Climate Zones 8 through 14. The whole-house fan, or central fan system, must meet the eligibility criteria specified below to meet the prescriptive requirement.

Additions of 1,000 ft^2 or less are exempt from the whole-house fan prescriptive requirements.

A. Eligibility Criteria for Whole-House Fans

§150.1(c)12

1. Whole-house fans must meet combustion air safety requirements related to indoor gas-fired appliances.
2. Whole House Fans modeled for Title 24 credits must be listed in the Energy Commission Appliance Database.
3. To meet the prescriptive requirement, the installed whole-house fan(s) must have a listed airflow of at least 1.5 cfm/ft^2 of house conditioned floor area. The house must have a minimum attic net free vent area to outdoors of one square foot per 750 cfm of installed whole-house fan(s) rated airflow. See Table 4-20 and Table 4–21 for net free ventilation area based on the square footage of the house.
4. Homeowners who have WHFs installed must be provided with a one page “How to operate your whole house fan” informational sheet.

B. Eligibility Criteria for Central Fan Systems

1. Central fan night ventilation systems will be required to meet Title 24 duct leakage requirements (with system operating in return air mode).
2. Central fan night ventilation systems will be required to meet the fan watt draw requirement that involve HERS verification of airflow and fan power, demonstrating an efficacy of no more than 0.58 watts/cfm.
3. In addition to sensing temperature at the thermostat, the central fan system must have an outdoor temperature sensor (used to initiate and terminate night ventilation operation) and a temperature sensor sensing the air temperature entering the air handling unit (used for damper position verification).
4. Central fan systems will be treated as “fixed-speed” systems, unless the manufacturer can provide documentation to the California Energy Commission that the product demonstrates the criteria listed below. The Commission will review the submittal and determine that the system adequately meets the qualifying criteria:
   a. The installed fan motor is a variable-speed motor.

b. The motor is controlled in night ventilation mode to vary in a continuous range between full air flow (100 percent) and a minimum airflow of no more than 25 percent of full airflow.

c. The manufacturer will provide written documentation on how its control strategy is implemented, how night ventilation fan speed is controlled, and how ventilation cooling rates are determined. The ventilation cooling rate calculation will occur within a 24-hour interval or less to ensure that the system responds in a timely manner to changes in weather patterns.

Table 4–20 shows example conversions for the calculated net free vent area (NFVA) for a range of Energy Commission- listed whole-house fan airflow levels. Instead of using the table, one can calculate the NFVA by dividing the listed cfm by 750.

Table 4–20: Sample NFVA Calculation

CEC Listed Airflow (cfm)	Minimum Attic NFVA (ft2)
2000	2.7
3000	4
4000	5.3
5000	6.7
6000	8
7000	9.3

Source: California Energy Commission

Since attic vents present some level of airflow restriction, use the appropriate screen and louver reduction factor from Table 4–21.

Table 4–21: Attic Vent Airflow Reduction Factors

Vent Type	Reduction Factor
¼" screen (hardware cloth)	0.90
¼" screen with metal louvers	0.75
¼" screen with wood louvers	0.25
Insect screen (mesh under ¼")	0.50
Insect screen with metal louvers	0.50
¼" screen with wood louvers	0.25

Source: California Energy Commission

Example 4-46

Required vent area = Minimum Attic NFVA (Table 4–20) ÷ Reduction Factor

A 3,000 cfm fan is selected from the Energy Commission Appliance Database. The builder plans to use vents with "¼" screen with metal louvers".

Answer

The minimum required vent area is = 4.0 ÷ 0.90 = 4.4 ft^2

Example 4-47 – Ventilation Cooling

Question:

I am building a 2,350 ft^2 house in Climate Zone 8. Do I need to install a whole-house fan or central fan ventilation system?

Answer:

Yes, if you are complying prescriptively.

No, if you are complying using the performance method.

Whole-house fans (or eligible central fan systems) are a prescriptive requirement in Climate Zones 8-14, meaning that they are not mandatory, although they define the prescriptive compliance level. If you decide to install a whole-house fan to meet the prescriptive requirement, you should select a fan from the Energy Commission Appliance Database. The prescriptive requirement specifies a minimum airflow of 1.5 cfm/ft2 (3,525 cfm for the proposed house) and 1 ft^2 of attic net free ventilation area per 750 cfm of airflow (4.7 ft2 for a 3525 cfm fan).

Example 4-48

Question:

Why do I need to provide attic ventilation area for a whole-house fan?

Answer

Whole-house fans move a lot of air, all of which is exhausted to the attic. Without sufficient attic relief to the outdoors, the air velocity will increase (potentially disturbing blown insulation), and the fan will move less air.

Example 4-49

Question:

What are the advantages and disadvantages of whole-house fans relative to central fan ventilation cooling systems?

Answer:

Whole-house fans are relatively inexpensive; both in first cost and operating cost, and are highly effective if used properly in the right climate. They move much more air than central fan systems, which must deliver air through the existing duct system. Whole-house fans can be noisy, require user operation to open windows, turn on and off, bring dust and allergens indoors from outside, and potentially reduce home security if operated throughout the night. Central fan systems are more expensive and generally move less air, but provide totally automated operation, independent of whether the occupant is home. Windows can remain shut, and all outdoor air is filtered. Some central fan systems may also be configured to provide fresh air ventilation consistent with the mechanical ventilation requirements. Review product literature to determine if available products meet the Energy Commission's fresh air ventilation requirements.

Example 4-50

Question:

A two-story home with a 2,500 sf of conditioned space and having an attic of 1,500 sf is located in Climate Zone 10. Are whole-house fans required? Does this affect the number of vents in the attic?

Answer:

Yes. §150.1(c) 12 requires whole-house fans (WHF) in single-family houses that are located in Climate Zones 8-14. These are climate zones that have summer cooling needs but where the home can be efficiently cooled on cool summer evenings by the use of a whole-house fan.

§150.1(c)12 also requires that these fans be sized so they provide at least 1.5 cubic feet per minute (cfm) of flow for each square foot of conditioned space in the house. The fans used must be listed in the Energy Commission’s Appliance Database (http://appliances.energy.ca.gov/QuickSearch.aspx) and the rated cfm listed on the CF2R-Mech 02 form. In addition, the attic must have at least 1 sf of attic vent free area for each 750 cfm of whole-house fan-rated flow.

Thus, for this house with 2,500 sf of conditioned floor area, the minimum total flow rate of whole house fans installed in the house must be at least:

Min WHF flow rate = Conditioned Floor Area x 1.5 CFM/sf = 2,500 sf x 1.5 cfm/sf = 3,750 cfm.

In this case, the builder has selected two 2,000 cfm whole house fans. The minimum amount of vent net free area in the attic is calculated as follows:

Net Free Area = Total WHF cfm / (750 cfm/sf NFA) = (2,000 + 2,000) / 750 = 5.3 sf

4.8 Compliance and Enforcement

This section describes compliance documentation and field verification requirements related to heating and cooling systems.

4.8.1 Design-Phase Documentation

The initial compliance documentation consists of the certificate of compliance (CF1R). It lists the features that the house needs for it to comply with the prescriptive or performance requirements, depending on the compliance path taken.

Mandatory features as required by §150.0 are not documented on any required compliance forms. They are, however, listed in a Mandatory Features Checklist provided in Appendix A that enforcement personnel can use as a compliance tool, if they choose.

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

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 Prescriptive Component Package A. The calculations for documenting this are done using the approved performance software, the algorithm of which is detailed in the *Alternative Calculation Method (ACM) Manual.*

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

The CF1R has a section where special modeling features are listed. These are features for which special compliance credit was taken using the performance approach. They required additional visual verification by the enforcement agency to ensure proper installation. Some require field verification and diagnostic testing by a HERS Rater. These will be listed in a separate section.

The following are heating and cooling system features that will be listed in this section if they exist in the proposed design:

Special Features Not Requiring HERS Rater Verification:

1. Ducts in a basement
2. Ducts in a crawlspace
3. Ducts in an attic with a radiant barrier
4. Hydronic heating and system design details
5. Gas-fired absorption cooling
6. Zonal control
7. Ductless wall heaters

Special Features Requiring HERS Rater Verification:

1. Duct sealing
2. Verified duct design – for reduced duct surface area and ducts in conditioned space
3. Low-leakage ducts in conditioned space
4. Low -leakage air handlers
5. Verification of return duct design
6. Verification of air filter device design
7. Verification of bypass duct prohibition
8. Refrigerant charge
9. Installation of a fault indicator display (FID)
10. Verified system airflow
11. Air handler fan watt draw
12. High energy efficiency ratio (EER)
13. Verified seasonal energy efficiency ratio (SEER)
14. Maximum-rated total cooling capacity
15. Evaporative cooled condensers
16. Ice storage air conditioners
17. Continuous whole-building mechanical ventilation airflow
18. Intermittent whole-building mechanical ventilation airflow
19. High-quality insulation installation (QII)

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

Registration of the CF1R with an approved HERS Provider is required. The building owner or the person responsible for the design must submit the CF1R to the HERS Provider Data Registry for retention by following the procedures described in Chapter 2 and in RA2 of the Reference Residential Appendix. Registration ensures that the project follows the appropriate verification process, provides tracking, and provides instant access to the most current documentation.

4.8.2 Construction-Phase Documentation

During construction, the general contractor or specialty subcontractors must complete all applicable sections of the certificate of installation (CF2R) for any building design special features specified on the certificate of compliance (CF1R). A list of CF2R sections that apply to the HVAC special feature requirements follows:

1. HVAC Systems
2. Duct Leakage Diagnostics
3. Refrigerant Charge Verification
4. Duct Design Verification for the Location and Area Reduction Compliance Measures. The duct design specifications and layout must be included on the building plans submitted to the enforcement agency, and a copy of the duct design layout must be posted or made available with the building permit(s) issued for the building and must be made available to the enforcement agency, installing contractor, and HERS Rater for use during installation and for all applicable inspections.
5. Fan Efficacy Verification
6. System Airflow Verification.
7. High SEER/EER Verification.
8. Whole-Building Ventilation for Indoor Air Quality (IAQ), Local Ventilation Exhaust, and Other IAQ Measures Given in ASHRAE Standard 62.2

Like 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 a HERS Provider Data registry using procedures described in Chapter 2 and in RA2 of the Reference Residential Appendix.

4.8.3 Field Verification and/or Diagnostic Testing

For buildings for which the certificate of compliance (CF1R) requires HERS field verification for compliance with the Energy Standards, a HERS Rater must visit the site to perform field verification and diagnostic testing to complete the applicable heating and cooling system certificates of field verification and diagnostic testing (CF3R). The following measures require field verification and diagnostic testing if they are used in the proposed design for compliance and are listed on the CF1R as special “Features Requiring HERS Rater Verification.”

1. Verified duct leakage. Outside air (OA) ducts for central fan integrated (CFI) ventilation systems shall not be sealed/taped off during duct leakage testing. CFI OA ducts that use controlled motorized dampers, open only when OA ventilation is required to meet ASHRAE Standard 62.2, and closed when OA ventilation is not required may be configured to the closed position during duct leakage testing.
2. Verified duct design − supply duct location, surface area, and R-value (including buried ducts).
3. Low-leakage ducts in conditioned space.
4. Low-leakage air handlers.

5. Refrigerant charge verification
6. Verification of installation of a fault indicator display (FID)
7. Forced air system airflow verification using the installer-provided hole for the placement of a hole for a static pressure probe (HSPP), or a permanently installed static pressure probe (PSPP).
8. Air handler fan watt draw.
9. High-efficiency air conditioner energy efficiency ratio (EER).
10. Evaporatively cooled condensers.
11. Photovoltaic (PV) field verification. To receive PV rebates for photovoltaic installations under the New Solar Home Partnership, the output of the installed system must be measured and shown to comply with the output specified on the rebate application (taking into account variables such as the solar insolation, the time, and the temperature)
12. Central fan-integrated systems for ventilation cooling for air handler fan watt draw.
13. Whole-building ventilation for indoor air quality (IAQ), local ventilation exhaust, and other IAQ measures given in ASHRAE Standard 62.2

Field verification for nonmandatory features is necessary only when performance credit is taken for the measure. For example, maximum cooling capacity need only be HERS-verified if maximum cooling capacity was used to achieve credit in the proposed design. Some field verification is for mandatory measures and will occur in all homes, unless they are exempt from the measure.

Like the CF1R and CF2R, registration of the CF3R is required. The HERS Rater must submit the field verification and diagnostic testing information to the HERS Provider data registry as described in Chapter 2. For additional details describing HERS verification and the registration procedure, refer to RA2 of the Reference Residential Appendix.

4.9 Refrigerant Charge

4.9.1 Refrigerant Charge Verification

This section summarizes the procedures for verifying refrigerant charge for air-conditioning systems as described in Section RA3.2 of the Reference Residential Appendix. Refrigeration technicians and HERS Raters who perform the testing should refer to these and other technical documents. This section is intended to provide an overview and explanation of these procedures.

4.9.1.1 **Overview**

A split-system air conditioner undergoes the final assembly at installation. The installation 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. Air conditioner energy efficiency suffers if the refrigerant charge is either too low or too high and if the metering device (TXV or 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 systems be correctly installed. The prescriptive standards also require that they be field-verified in Climate Zones

2, and 8 through 15. Refrigerant charge verification is also required in any climate zone when chosen as a compliance feature using the performance 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; however, airflow and other requirements must still be verified. The prescriptive standards regarding verification of refrigerant charge do apply to altered package systems in Climate Zones 2 and 8 through 15.

Verification of proper refrigerant charge must occur after the HVAC contractor has installed and charged the system in accordance with the manufacturer's specifications. The procedure requires properly calibrated digital refrigerant gauges, thermocouples, and digital thermometers. When multiple systems in the same home require testing, test each system.

In a typical home cooling system, there are two important performance criteria that are relatively easy to verify that there is neither too much nor too little refrigerant in the system. In systems with a fixed orifice device in the evaporator coil, the number to check is called the *superheat*. In a system with a variable metering device, the number to check is called the *subcooling*.

Superheat refers to the number of degrees the refrigerant is raised after it evaporates into a gas. This occurs inside the evaporator coil (or *indoor coil*). The correct superheat for a system will vary depending on certain operating conditions. The target superheat for a system must be obtained from a table provided in the RA3.2 protocols or the manufacturer's superheat table. There is an allowed range of several degrees between the measured superheat and the target superheat for a system to pass.

Subcooling refers to the number of degrees the refrigerant is lowered after it condenses into a liquid. This occurs inside the condenser coil (or *outdoor coil*). The manufacturer specifies the correct subcooling for a system. It may vary depending on operating conditions. Like superheat, there is an allowed range of several degrees between the measured subcooling and the target subcooling for a system to pass.

The temperature at which a refrigerant condenses or evaporates is called the *saturation temperature*. Above the saturation temperature, a refrigerant is always a gas. Below the saturation temperature, a refrigerant is always a liquid.

Saturation is when a refrigerant exists as both a liquid and a gas. It always occurs at the same temperature, depending on what the pressure of the refrigerant happens to be. At higher pressures, the saturation temperature goes up and vice versa. This convenient property is what makes refrigeration work.

The saturation temperature can be determined by simply measuring the pressure of a refrigerant and referring to a table, known as a *pressure-temperature* (PT) *table*, for that specific refrigerant. Saturation temperatures are well-documented for all common refrigerants.

Because variable refrigerant metering devices are prone to failure and even more so to improper installation, it is important that the operation of these devices be checked. A metering device maintains a relatively constant superheat over a wide range of operating conditions; therefore, checking the superheat, in addition to the other tests performed, will indicate if the metering device is operating correctly.

Unfortunately, checking superheat and subcooling can be done only under certain indoor and outdoor conditions. This verification procedure, called the Standard Charge Verification Method, is very weather-dependent.

There is another way to verify proper refrigerant charge that is not weather–dependent, and that is by weighing the refrigerant. Called the Weigh-in Charge Verification Method, this approach can be performed only by the installer. It can be verified by the HERS Rater either by simultaneous observation or by using the standard method when conditions permit.

4.9.1.2 **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.

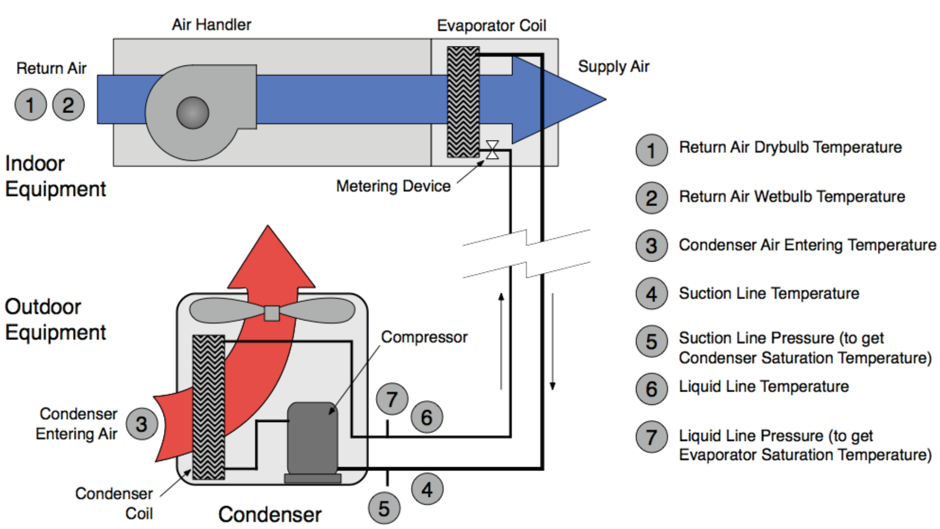
If an altered system does not meet the minimum airflow requirements, remedial steps are required to increase the system airflow. More airflow is generally better for systems with air conditioning. Not only does this allow proper refrigerant charge to be verified, but it improves the overall performance of the system. When able to be performed on a system, regardless of the refrigerant charge verification procedure, minimum system airflow must always be verified.

In some alterations, improving airflow may be cost-prohibitive and there is a process for documenting this (RA3.2.2.7.3). When this option is used, verification by sample groups is not allowed. Minimum airflow is critical to proper air-conditioner operation. Reducing airflow reduces cooling capacity and efficiency. Many systems in California have oversized equipment and undersized ducts. In newly installed duct systems, the minimum airflow requirement is higher because the opportunity exists to design and install a better system. In altered systems, the installer may be required to modify the ducts system to meet the minimum airflow. The minimums of 300 and 350 cfm/ton are far lower than the desired airflow for most systems, which is usually 400 cfm/ton and higher.

4.9.1.3 **Standard Charge Verification Procedure (RA3.2.2)**

The first step is to turn on the air-conditioning system and let it run for at least 15 minutes to stabilize temperatures and pressures. While the system is stabilizing, the HERS Rater or the installer may attach the instruments needed to take the measurements.

Figure 4-45: Measurements for Refrigerant Charge and Airflow Tests



Source: California Energy Commission

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

1. The return air wet bulb and dry bulb temperatures are measured in the return plenum before the blower at the location labeled "Title 24 – Return Plenum Measurement Access Hole." This hole must be provided by the installer, not the rater (See Point 2 in Figure 4-45). See Figure RA 3.2-1 for more information on the placement of the measurement access hole (MAH).
2. Moreover, the outdoor air dry bulb temperature is measured at the point where the air enters the outdoor condensing coil. (See Point 4 in Figure 4-45). It is important that this outdoor temperature sensor be shaded from direct sun during the verification procedure.

In addition to the air temperature measurements, four refrigerant properties need to be measured. Two of these measurements are taken near the suction line service valve before the line enters the outdoor unit and are used to check the superheat.

1. The first measurement is the temperature of the refrigerant in the suction line, which is taken by a clamp-on thermocouple or other suitable device insulated from the outdoor air. (See Point 5 in Figure 4-45.)
2. The second measurement determines the saturation temperature of the refrigerant in the evaporator coil. (See Point 6 in Figure 4-45.)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. (See Points 7 in Figure 4-45):

1. The liquid refrigerant temperature in the liquid line is measured by a clamp-on thermocouple insulated from the outdoor air.
2. The condenser saturation temperature can be determined from the liquid line pressure and a saturation temperature table for the applicable refrigerant.

Note: 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.

4.9.1.4 Superheat Charge Verification Method (RA3.2.2.6.1)

The *Superheat Charge Verification Method* is used on units with a fixed refrigerant metering device (not a TXV or EXV).

Airflow verification must be confirmed prior to starting the Superheat Verification Method.

Table 4–22: Structure of Target Superheat

		Return Air Wet-Bulb Temperature (°F) (T Return, wb)									
		50	**51**	**52**	**53**	**54**	**55**	**--**	**--**	**75**	**76**
Condenser Air Dry-Bulb Temperature (°F) (T condenser, db)	**55**	Target Superheat = Suction Line Temperature minus Evaporator Saturation Temperature. See Reference Residential Appendix Table RA3.2-2									
	56										
	57										
	--										
	--										
	93										
	94										
	95										

Source: California Energy Commission

The *Superheat Verification Method* compares the actual (measured) superheat temperature to a target value from a table. The actual superheat temperature is the measured suction line temperature ($T_{Suction,\ db}$) minus the evaporator saturation temperature ($T_{Evaporator,\ Saturation}$). The target superheat value is read from a table (Table RA3.2-2 of the Reference Residential Appendix or the manufacturer's superheat table).

For illustration, the structure of Table RA3.2-2 is shown above as Table 4–22.

Only an EPA-certified technician may add or remove refrigerant. Under no circumstances may HERS Raters add or remove refrigerant on systems that they are verifying.

4.9.1.5 **Subcooling Verification Method (RA3.2.2.6.2)**

The *Subcooling Verification Method* is used on units with a variable refrigerant metering device (a TXV or EXV).

Airflow verification must be confirmed prior to starting the Subcooling Verification Method.

The Subcooling Verification Method compares the actual subcooling temperature to the target value supplied by the manufacturer. The actual subcooling is the condenser saturation temperature ($T_{Condenser,\ Saturation}$) minus the liquid line temperature (T_{Liquid}).

4.9.1.6 **Weigh-In Charging Procedure**

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 actual performance of the system. Systems using the weigh-in procedure by the installer for any reason may not be third-party-verified by using sample groups.

The weigh-in procedure does not relieve the installer from having to ensure proper airflow.

There are two installer options for the weigh-in procedure. One involves adjusting the amount of refrigerant in a system by adding or removing a fraction of the refrigerant 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 only be used when a new factory-charged outdoor unit is being installed and the manufacturer provides adjustment specifications based on evaporator coil size and refrigerant line size and length.

The weigh-in total charge may be used for any weigh-in procedure but still requires manufacturer's adjustment specifications. Only the installer/technician may perform any kind of weigh-in procedure.

4.9.1.7 **Equipment Limitations**

The Energy Standards specifically require 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 verify with the manufacturer and confirm with the Energy Commission. The installer must adhere strictly to the manufacturer's specifications.

Variable refrigerant flow systems and systems such as minisplits that cannot be verified using the standard approach must demonstrate compliance using the weigh-in method. Verification by the HERS Rater can only be accomplished by simultaneous observation of the installer's weigh-in.

4.9.1.8 **HERS Rater Verification Procedures**

When required by the certificate of compliance, HERS Raters will perform third-party field verification and diagnostic testing of refrigerant charge. These may include the standard method, simultaneous observation of the weigh-in method, verification of minimum system airflow, and verification of installation of the measurement access hole.

The verification procedures are essentially identical for the Rater and the installer except that the tolerances for passing the superheat and subcooling tests are less stringent for the 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:

1. When the weigh-in method is used
2. When the minimum airflow cannot be met despite reasonable remediation attempts. (See RA3.2.2.7.3).

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

4.9.1.9 **Winter Setup Procedures**

Reference Appendix RA1 provides for the approval of special case refrigerant charge verification procedures when the equipment is specifically approved by the manufacturer for such procedures. One such procedure is found in RA1.2. It provides for a modification to the standard charge procedure when conditions make the standard charge method difficult.

The Standard Charge Verification Procedure (Section RA3.2.2 of the Reference Residential Appendices) calls for the outdoor temperature to be within the manufacturer's specified range. When outdoor temperatures are below 70°F, the setup for the Standard Charge Verification Procedure must be modified to achieve the proper system pressure differential needed for the procedure. (The Standard Charge Verification procedure is generally allowed to be used down to 55°F without the winter setup; however, the 70°F requirement mentioned here is typical of most manufacturers' requirements for the winter setup). The winter setup for the Standard Charge Verification Procedure (winter charge setup) allows both installers and HERS Raters to use the Standard Charge Verification Procedure of RA3.2.2 in the winter. The Weigh-in Charging Procedure specified in Section RA3.2.3 may also be used, only by the installer, as long as the manufacturer did not certify an alternative refrigerant charge verification protocol that can be used for the system. In the case where the manufacturer has certified to the Energy Commission an "Alternative Refrigerant Charge Verification Protocol" meeting the requirements of RA1.1.1, HERS Rater refrigerant charge verification procedures may adhere to an approved alternative protocol.

The winter charge setup creates the right conditions at the unit being tested for outdoor temperatures above 37°F and below 71°F that allow 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. The winter charge setup is used only for units equipped with variable metering devices, which include thermostatic expansion valves (TXV) and electronic expansion valves (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. The winter charge setup achieves an appropriate high side-low side pressure differential to conduct the Standard Charge Verification Procedure, by restricting the airflow at the condenser fan outlet by using a condenser outlet air restrictor. 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 Reference Residential Appendix RA 3.2.2.6.2. All other applicable requirements of Section RA3.2.2 remain the same and must be completed when using the winter charge setup.

Though not specifically mentioned in the FID protocols of Residential Appendix RA3.4.2, the winter setup method detailed in RA 1.2 may be used when normally allowed. For FID verification the winter setup method will be treated the same as the subcooling method.

4.9.1.10 **Using Weigh-In Charging Procedure at Low Outdoor Temperatures**

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

Typically, when the weigh-in method is used by the installing contractor to ensure proper refrigerant charge, a HERS Rater must perform a charge verification in accordance to the procedures outlined in the Reference Residential Appendix RA3.2, which is the standard charge procedure described above in this chapter. However, since the standards charge verification procedures (RA3.2) cannot be performed when the outdoor temperatures are less than 55 degrees, the Energy Standards provide the installer with two choices:

1. Use the "HERS Rater - Observation of Weigh-In Charging Procedure" as prescribed in Reference Residential Appendix RA3.2.3.2, to demonstrate compliance, and install an Occupant Controlled Smart Thermostat (OCST).
2. Wait for warmer temperatures and perform the standard charge verification procedure, which can delay the project. In this case, the installer must include the signatures of the homeowner and HERS Rater on the CF2R - MCH25c form for the local enforcement agency, as part of an agreement that he or she will return to correct refrigerant charge if a HERS Rater determines it is needed later, as per Residential Appendix RA 2.4.4. The installer must also provide written notice to the homeowner that the charge has not yet been verified (RA2.4.4). An example form is provided in Figure 4-46.

As noted above, when the HVAC installer elects this procedure for verification (RA3.2.3.2), the system thermostat must be an occupant controlled smart thermostat (OCST), which conforms to the requirements of Reference Joint Appendix JA5.

Figure 4-46: Example of Notification to Homeowners of Delayed Charged Verification

Note to Homeowner: We're not done yet!

Congratulations on your new Air-Conditioning system! Your new system is much more efficient than older systems, and it has been installed to industry guidelines, ensuring many years of comfort and efficient service.

One thing you need to know, however, is that the installation process is not complete! Because your unit was installed when the outside air temperature was too low to fine tune the air conditioner, the unit must be serviced and verified when the weather is warmer.

This requires your cooperation. You need to allow access to the unit for your Installer and/or HERS Rater (verifier) to verify that the refrigerant charge and airflow are set correctly. Your project is not considered finished until this verification takes place. If it is not done, **your unit may cost more to operate, may not heat and cool as effectively, and may not last as long**.

You will be contacted within the next few months to schedule this service. If you do not hear something after a few months of warmer weather, please contact your Installer. Enjoy your new system!

Source: California Energy Commission