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5 Water Heating Requirements

5.1 Overview

Chapter 5 describes the compliance requirements for domestic water heating for newly constructed residential dwellings, including single-family, and low-rise (three or fewer habitable floors) multifamily buildings. This chapter also describes common water heater types, best practices for water heater maintenance, hot water distribution system designs, and examples of commonly asked questions regarding compliance with Energy Standards requirements. For general information about compliance and enforcement please see Chapter 2 of this compliance manual. For information about water heating requirements for additions and alterations, please see Chapter 9.

5.1.1 What's New for 2019

This section summarizes changes to the requirements for residential water heating for the *2019 Energy Standards*. Please see Sections 5.3 and 5.4 for detailed information on the mandatory and prescriptive water heating requirements in the *2019 Energy Standards*.

5.1.1.1 **Mandatory Requirements**

1. Requirement for temperature controls in public lavatories has been removed to align with plumbing code.
2. The high efficiency water heater ready requirement for electrical receptacle has been updated to require the receptacles to be dedicated and connected to a 120/240 volt 3 conductor, 10 American Wire Gauge (AWG) branch circuit. This change allows easier and cheaper installation of heat pump water heater as a replacement.

5.1.1.2 **Prescriptive Requirements**

Significant changes to the 2019 prescriptive requirements for single-family buildings and multifamily buildings with a dedicated water heater in each dwelling unit include the following:

1. Heat pump water heaters were added as a possible prescriptive path option.
2. Drain water heat recovery was added as a possible prescriptive path option.
3. Hot water pipe insulation was removed since it is now required under the California plumbing code. (A Home Energy Rating System [HERS] verified pipe insulation remains as a compliance option)
4. The maximum input rating for gas storage water heaters over 55 gallons was reduced to 75,000 British thermal unit per hour (Btu/Hr) to better align with U.S. Department of Energy (DOE) classification.

Significant changes to the 2019 prescriptive requirements for multifamily buildings with a central water heating system include the following:

1. Drain water heat recovery can be used to reduce the required solar savings fraction of the solar thermal system.

5.1.1.3 Performance Compliance Method

When the performance compliance method is used, the water heating energy budget now has an independent gas or electric baseline based on the proposed water heater type. For gas type water heaters, the energy budget is based on the performance of a gas instantaneous water heater. For electric water heaters, the energy budget is based on the performance of a heat pump water heater with compact hot water distribution and a drain water heat recovery device. Both gas and electric water heaters used in the baseline meet the minimum requirements in California's *Title 20 Appliance Efficiency Regulations* Section 1605.1(f) for federally regulated appliances. For more information, see section 5.5.

5.1.2 At a Glance

Table 5-1 provides an overview of the location of the water heating requirements in the *2019 Energy Standards* by construction and building type.

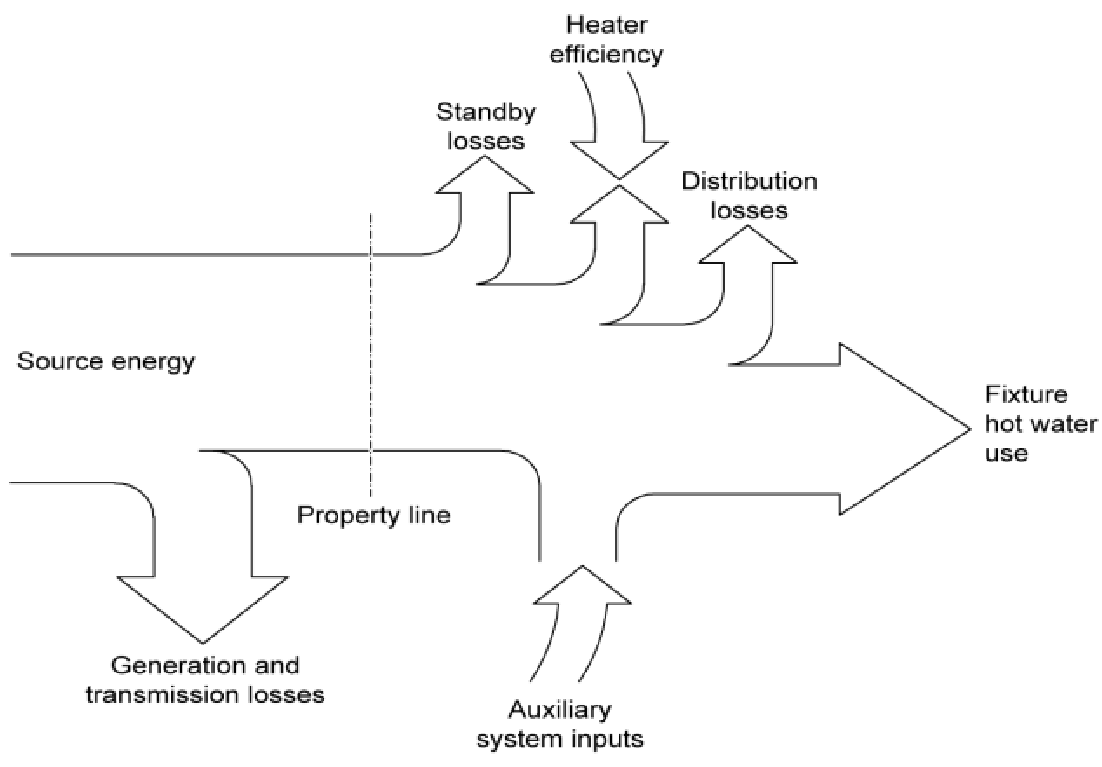
Table 5-1: Overview of Water Heating Requirements in the Energy Standards and This Chapter

Type	**Mandatory Requirements** Standards Section	**Mandatory Requirements** Manual Section	**Prescriptive Requirements** Standards Section	**Prescriptive Requirements** Manual Section	**Performance Requirements** Standards Section	**Performance Requirements** Manual Section
Single-family home – Newly built	§110.3; §150.0(j) §150.0(n)	5.3	§150.1(c)8A i, ii, iii, iv, v	5.4.1	§150.1(b)	5.5
Single-family home – Addition	§110.3; §150.0(j) §150.0(n)	5.3, 9	§150.2(a)1D	5.4.1	§150.2(a)2	5.5
Single-family home – Alteration	§110.3; §150.0(j) §150.0(n)	5.3, 9	§150.2(b)1H	5.4.1	§150.2(b)2	5.5
Multifamily – Newly built individual dwelling units	§110.3; §150.0(j) §150.0(n)	5.3	§150.1(c)8B	5.4.2	§150.1(b)	5.5

5.1.3 Water Heating Energy

Total energy use associated with water heating consists of the end use, heater inefficiencies, standby loss, and distribution system inefficiencies. Figure 5-1 below shows the energy flows that constitute water heating energy usage. Hot water draws at the end use points (for example, faucets, showers, and so forth) represent the useful energy consumed. In most cases, hot water that is actually used represents the largest fraction of water heating energy use, although in situations when there are very few hot water draws, standby losses from a standard gas storage water heater and the hot water distribution system can exceed the quantity of useful energy consumed at the end point. Energy impacts associated with the hot water distribution system vary widely based on the type of system, quality of insulation and installation, building and plumbing design, and hot water use patterns. Distribution losses in a typical single-family home may be as much as 30 percent of the total energy used for water heating. Distribution losses in single-family homes with compact hot water distribution systems may be lower than 10 percent of total water heating energy use. In a typical multifamily building, distribution losses can account for more than 30 percent of total water heating energy use. An important consideration for any water heating system is the recovery load (that is, end use plus distribution losses) of the water heating unit minus any contribution from auxiliary heat inputs, such as a solar thermal system.

Figure 5-1: Water Heating Energy Flow Representation



5.2 Residential Water Heating Equipment

There are several types of residential water heaters described below. The most common water heaters in single-family homes are consumer storage or instantaneous water heaters. For multifamily buildings, two options are commonly used: A central domestic hot water system with one or more commercial storage water heaters or one or more boilers coupled with a storage tank to serve the entire building. Alternatively, water heaters are installed in each dwelling unit (similar to single-family).

To comply with the Energy Standards using either the prescriptive or performance approach, the water heater must meet the federal and/or the California Appliance Efficiency Regulations (Title 20).

5.2.1 Instantaneous Water Heaters

Instantaneous water heaters, commonly referred to as *tankless* or *on-demand*, heat water using natural gas, electricity, or propane. These units do not have a tank for storing heated water but instead use a sensor that detects the flow of water over the heat exchanger that initiates the heating element (typical volumes around 0.5 gallons). Instantaneous units are capable of delivering water at a controlled temperature of less than 180^{0}F. The input rating for gas instantaneous water heaters ranges between 50,000 and 200,000 BTU per hour (at least 4,000 BTU per hour per gallon of stored water) with a storage capacity of less than 2 gallons.

Instantaneous water heaters require an electrical connection for controls and the combustion air blower, a direct or power venting system, and a larger gas line (typical input ratings of 140,000 to 200,000 BTU/hr).

Electric instantaneous water heaters are not generally designed for use with solar water heating systems or as heat sources for indirect-fired water heaters. They are also typically inappropriate for use with recirculation systems. Consult manufacturer's literature when considering these applications. Electric instantaneous water heaters are not allowed through the prescriptive approach to compliance but can be installed using the performance approach as long as the total energy budget is not exceeded.

To comply prescriptively with the *Energy Standards*, a user can choose to install a gas or propane instantaneous water heater that meets the minimum efficiency requirements of California's *Title 20 Appliance Efficiency Regulations* Section 1605.1(f) for federally regulated appliances.

5.2.2 Storage Water Heater

5.2.2.1 **Consumer Storage Water Heaters**

Storage water heaters use gas (natural gas or propane), electricity or oil to heat and store water at a thermostatically controlled temperature (less than 180^{0} F) for delivery on demand. Federal appliance efficiency standards differentiate storage water heaters based on whether the rated storage volume is greater than 55 gallons or less than or equal to 55 gallons.

The U.S. Department of Energy (DOE) classifies consumer gas water heaters as having an input of 75,000 BTU per hour or less and has a storage capacity ranging between 20 and 100 gallons. A basic gas storage water heater is composed of a standing pilot ignition system, a burner, a combustion chamber, a flue baffle, a flue, an insulated water tank, a cold water inlet and hot water outlet, a sacrificial anode, a gas valve, a temperature and pressure relief valve, a thermostat, heat traps, and an outer case.

The DOE classifies consumer electric storage water heaters as having an input of 12 kilowatt (kW) or less and have a storage capacity ranging between 20 and 120 gallons. A basic electric storage consumer water heater differs from gas water heaters by using an electric resistance heating element. As noted in this chapter, electric storage water heaters are not allowed through the prescriptive approach to compliance but can be installed using the performance approach as long as the water heating energy budget is not exceeded.

Recently DOE added a new category of water heaters called *grid-enabled water heaters* and is defined as an electric resistance water heater that has a rated storage tank volume of more than 75 gallons and is manufactured on or after April 16, 2015. The water heater must have an activation lock at the point of manufacture and is intended for use only as part of an electric thermal storage or demand response program.

5.2.2.2 **Heat Pump Water Heater (HPWH)**

A heat pump water heater (HPWH) is an electric water heater that works like a refrigerator in reverse. It uses a compressor to transfer heat from the surrounding air to the water tank. It includes all necessary auxiliary equipment such as fans, storage tanks, pumps, or controls. Typically, HPWHs include backup electric resistance elements to ensure hot water delivery when the air temperature is too cold or the hot water demand is too high. Some models entering the market use larger compressors to avoid the need for resistance elements.

The performance of HPWHs depends heavily on air temperature because they rely on extracting heat from the air. Buildings in warm and cold climate zones, and different installation locations such as a garage or vented outdoor closet, all have an impact on performance and must be considered. HPWHs are most efficient in warmer climates, but even in cold climate zones such as Climate Zone 16, HPWHs still use only half as much electricity as conventional electric resistance water heaters. In addition to air temperature sensitivity, HPWH performance is affected by cold water inlet temperatures as introduction and mixing of inlet water during larger draws may trigger second stage electric resistance heating in the tank.

The Northwest Energy Efficiency Alliance (NEEA) Advanced Water Heater Specification was developed to address critical performance and comfort issues of HPWH in colder climates. Tiers are incorporated into this specification recognizing variations in product performance and configuration. An HPWH that meets the NEEA Advanced Water Heater Specification performs significantly better in real world conditions, and an HPWH that meets the NEEA Tier 3 or higher can be used to meet the prescriptive requirement for newly constructed buildings, addition, and alteration.

The list of qualified NEEA HPWH products can be found at https://neea.org/img/documents/qualified-products-list.pdf

5.2.2.3 **Residential-Duty Commercial Water Heater**

This appliance is essentially a commercial water heater that can be legally installed in a residential building. It is defined in the Federal Code of Regulations (10 CFR 431.102) as any gas-fired, electric, or oil storage or instantaneous commercial water heater that meets the following conditions:

1. Uses a single-phase external power supply for models that require electricity.
2. Is not designed to provide outlet hot water at temperatures greater than 180°F.
3. Is not excluded by the specified limitations regarding rated input and storage capacity as described in Table 5-2 below. In other words, a residential-duty commercial water heater must have rate input and rated storage volume **below** the value listed in Table 5-2.

Table 5-2: Capacity Limitations for Defining Commercial Water Heaters Without Residential Applications

Water Heater Type	*Indicator of Nonresidential Application*
Gas-Fired Storage	Rated input >105 kBTU/h; Rated storage volume >120 gallons.
Oil-Fired Storage	Rated input >140 kBTU/h; Rated storage volume >120 gallons.
Electric Instantaneous	Rated input >58.6 kW; Rated storage volume >2 gallons.

Source: U.S. Department of Energy (2014). "Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Test Procedures for Residential and Commercial Water Heaters; Final Rule." http://www.regulations.gov/#!documentDetail;D=EERE-2011-BT-TP-0042-0082

Residential-duty commercial water heaters are rated in uniform energy factor (UEF) and are allowed through the prescriptive approach to compliance but can also be installed using the performance approach as long as the total energy budget is not exceeded.

5.2.2.4 **Hot Water Supply Boiler**

A *hot water supply boiler* is industrial water heating equipment with a heat input rate from 300 to 12,500 kBTU per hour and at least 4,000 BTU per hour per gallon of stored water. A hot water boiler should have either the temperature or pressure control necessary for heating potable water for purposes other than space heating, or the boiler manufacturer's literature should indicate that the intended uses of the boiler include heating potable water for purposes other than space heating. A hot water boiler could be fueled by oil or gas, and it must adhere to the minimum thermal efficiency and maximum standby loss as described in California's *Title 20 Appliance Efficiency Regulations*.

Boilers are typically used for doing both space heating and water heating. Use of a boiler will typically require one or more unfired storage tanks to be installed as part of the system. Careful attention should be given to the layout of these systems due to the potential for high energy losses between the boiler and storage tanks. Boilers are not allowed through the prescriptive approach to compliance but can be installed using the performance approach as long as the water heating energy budget is not exceeded.

5.2.3 Water Heater Maintenance

Water heaters should be maintained according to manufacturer recommendations to ensure proper water heater performance, prolonged useful life, and warranty coverage. If water heaters are not maintained, the useful life of the unit can be shortened and failures that may result may not be covered under the warranty. This section presents the best practices for maintaining the life and efficiency of water heaters.

5.2.3.1 **Maintenance of Instantaneous Water Heaters**

The primary maintenance activities for instantaneous water heaters are flushing the heat exchanger to remove scale buildup and inspecting and cleaning the inlet water filter screen, which helps minimize the amount of debris or sediment that enters the water heater.

Some manufacturers recommend a maintenance schedule, but the maintenance schedule users deploy may vary based on water quality. In areas with hard water, more frequent maintenance (every two years) is recommended. In areas where the water quality is relatively good, water heater maintenance is recommended every three to four years. Frequent inspection of the inlet water filter screen will enable a user to monitor the amount of sediment entering the water heater. If the filter tends to fill with sediment regularly, then more frequent flushing may be required. Users can also reference local water quality data to determine the level of water quality in their area to help guide maintenance schedules.

To assist in flushing the heat exchanger, manufacturers and plumbers recommend the installation of a drain kit (that is, isolation valves). (See Figure 5-2 below.) The installation of isolation valves on instantaneous units is mandatory in the *Energy Standards* (Section 110.3[c]7 and Section150.0 [n]4). Isolation valves enable the unit to be isolated from both the inlet cold water and the outlet hot water lines, thereby allowing the heat exchanger to be flushed using a simple procedure. Integral to the kit are hose bibs that allow the flushing hoses to be attached. Instantaneous water heater that has integrated drain ports for servicing are acceptable to meet the requirements of Section 110.3(c)7 and will not require additional isolation valves.

Manufacturers recommend that a licensed professional flush the heat exchanger to avoid potentially damaging the water heater, though some manufacturers sell flush kits so that homeowners can maintain their own water heater. Flush kits consist of a submersible pump, two short hoses, hose connections, and a 5-gallon bucket. These components can be purchased separately or as a preassembled kit. A solution of white vinegar is widely recommended for flushing the heat exchanger as it is food-grade and very effective at removing scale.

In addition to flushing the heat exchanger, manufacturers recommend periodically inspecting and cleaning the inlet water filter screen, which helps minimize the amount of debris or sediment that enters the water heater. This can be done by running the filter screen under hot water and using a brush to remove debris. Replacement of the inlet water filter screen is not necessary unless it is damaged.

Figure 5-2: Isolation Valves

Source: http://www.brasscraft.com/products.aspx?id=266

5.2.3.2 **Maintenance of Storage Water Heaters**

For storage water heaters, the primary maintenance activities consist of draining the tank, inspecting the anode rod, and replacing the anode rod, if necessary. The recommended frequency of regular maintenance varies by manufacturer. Like instantaneous water heaters, the frequency of maintenance depends on water quality. Most manufacturers recommend draining the tank every six months to once per year to remove sediment that has accumulated in the bottom of the tank. Periodic inspections (every six months to once a year) of the burner, venting system, and temperature and pressure relief valves are also recommended by manufacturers.

Manufacturers typically recommend inspecting the anode rod every two years and replacing it when necessary to prolong tank life, but the frequency of inspection depends on local water conditions. If water is soft or a water softener is used, more frequent inspection of the anode is needed as softened water will corrode the sacrificial anode rod at a much faster rate than unsoftened water. If the setup of the water heater prevents an easy removal of the corroded anode rod, then it might be necessary to completely move the tank from the location to replace the anode rod.

5.2.4 Drain Water Heat Recovery Devices

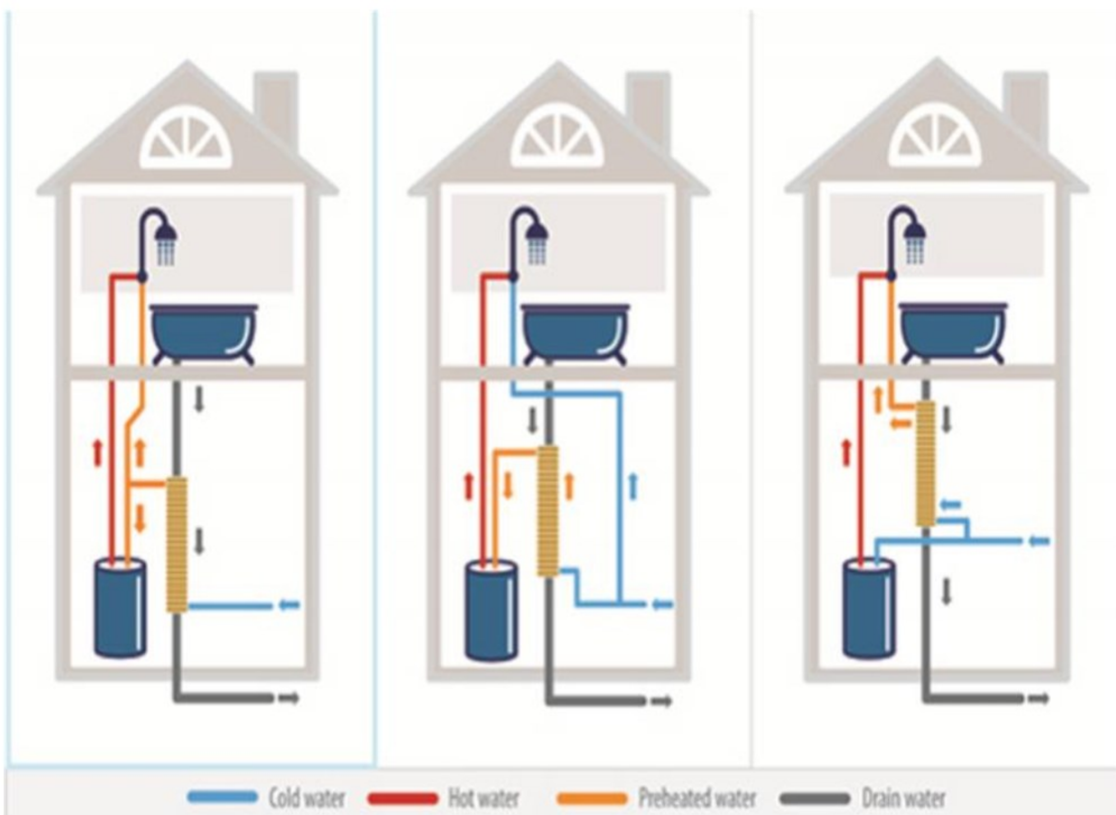
Drain water heat recovery (DWHR) is a technology that captures shower waste heat from the drain line. DWHR devices are counter flow heat exchangers, with cold water entering the building on one side of the device and hot drain water exiting the building on the other.

For the 2019 Title 24 Standards, DWHR is a component of an alternative prescriptive path for multifamily buildings with central water heating. It is also a compliance option for other water heating applications. DWHR technologies are most prevalent and perform best in cold climates in applications with large water heating loads and colder inlet water temperatures. California, being a generally milder climate, will show somewhat diminished performance relative to the preferred applications.

A DHWR device uses the reclaimed heat to preheat potable cold water that is then delivered either to the shower or the water heater. The device can be installed in either an “equal flow” configuration (with preheated water being routed to both the water heater and the shower) or an “unequal flow” configuration (preheated water directed to either the water heater or shower). Figure 5-3 schematically shows the three installation configurations. The energy harvested from a DWHR device is maximized in an equal flow configuration. They are sold in both vertical design configurations, as shown in Figure 5-3, and in horizontal configurations. The two forms each have advantages and disadvantages, which should be evaluated for each potential installation.

To use these systems to comply with Energy Standards, the design and installation must be HERS-verified and meet the Reference Appendix RA4.4.21 requirements.

Figure 5-3: The Three Plumbing Configurations of DWHR Installation (From left to right: Equal Flow, Unequal Flow - Water Heater, Unequal Flow - Fixture)



Source: Frontier Energy

5.3 Mandatory Requirements for Water Heating

5.3.1 Equipment Certification

§110.3(a)

Manufacturers must certify that their products comply with California's *Title 20 Appliance Efficiency Regulations*, Section 1605.1(f) at the time of manufacture. Regulated equipment that applies to all of the aforementioned system types in Section 5.2 must be listed in the California Energy Commission Appliance Efficiency Database.

5.3.2 Equipment Efficiency

§110.3(b), §110.1

Water heaters are regulated under California's *Title 20 Appliance Efficiency Regulations*, Section 1605.1(f). These regulations align with the federal efficiency standards for water heaters. Consumer water heaters and residential-duty commercial water heaters are both rated in Uniform Energy Factor (UEF). The draw pattern is based on the water heater's design first hour rating for storage water heater, or gallon per minute for instantaneous water heaters. The efficiency requirements for the most common consumer water heaters are given in Table 5-4 below. The efficiency requirements for the residential-duty commercial water heaters are given in Table 5-5 below.

The Energy Commission has developed a water heater efficiency guide to allow quick lookup of the minimum efficiency of the most common types and sizes of water heaters. It is available to download at https://www.energy.ca.gov/sites/default/files/2020-07/2019_WaterHeating_Guide.pdf.

Table 5-4: Minimum Federal UEF Requirements for Consumer Water Heaters

Product class	**Rated storage volume and input rating (if applicable)**	**Draw pattern**	**UEF**
Gas-fired Storage Water Heater	≥20 gal and ≤55 gal	Very Small	0.3456 − (0.0020 × Vr)
Gas-fired Storage Water Heater	≥20 gal and ≤55 gal	Low	0.5982 − (0.0019 × Vr)
Gas-fired Storage Water Heater	≥20 gal and ≤55 gal	Medium	0.6483 − (0.0017 × Vr)
Gas-fired Storage Water Heater	≥20 gal and ≤55 gal	High	0.6920 − (0.0013 × Vr)
Gas-fired Storage Water Heater	>55 gal and ≤100 gal	Very Small	0.6470 − (0.0006 × Vr)
Gas-fired Storage Water Heater	>55 gal and ≤100 gal	Low	0.7689 − (0.0005 × Vr)
Gas-fired Storage Water Heater	>55 gal and ≤100 gal	Medium	0.7897 − (0.0004 × Vr)
Gas-fired Storage Water Heater	>55 gal and ≤100 gal	High	0.8072 − (0.0003 × Vr)
Electric Storage Water Heaters	≥20 gal and ≤55 gal	Very Small	0.8808 − (0.0008 × Vr)
Electric Storage Water Heaters	≥20 gal and ≤55 gal	Low	0.9254 − (0.0003 × Vr)
Electric Storage Water Heaters	≥20 gal and ≤55 gal	Medium	0.9307 − (0.0002 × Vr)
Electric Storage Water Heaters	≥20 gal and ≤55 gal	High	0.9349 − (0.0001 × Vr)
Electric Storage Water Heaters	>55 gal and ≤120 gal	Very Small	1.9236 − (0.0011 × Vr)
Electric Storage Water Heaters	>55 gal and ≤120 gal	Low	2.0440 − (0.0011 × Vr)
Electric Storage Water Heaters	>55 gal and ≤120 gal	Medium	2.1171 − (0.0011 × Vr)
Electric Storage Water Heaters	>55 gal and ≤120 gal	High	2.2418 − (0.0011 × Vr)
Instantaneous Gas-fired Water Heater	<2 gal and >50,000 Btu/h	Very Small	0.80
Instantaneous Gas-fired Water Heater	<2 gal and >50,000 Btu/h	Low/Medium/High	0.81
Instantaneous Electric Water Heater	<2 gal	Very Small/Low/Medium	0.91
Instantaneous Electric Water Heater	<2 gal	High	0.92
Grid-Enabled Water Heater	>75 gal	Very Small	1.0136 − (0.0028 × Vr)

Grid-Enabled Water Heater	>75 gal	Low	0.9984 − (0.0014 × Vr)
Grid-Enabled Water Heater	>75 gal	Medium	0.9853 − (0.0010 × Vr)
Grid-Enabled Water Heater	>75 gal	High	0.9720 − (0.0007 × Vr)

Vr= Rated Storage Volume – the water storage capacity of a water heater (in gallons).

Source: U.S. Department of Energy

Table 5-5: Minimum Federal Uniform Energy Factor Requirements for Residential-Duty Commercial Water Heaters

Product class	Specifications	Draw pattern	UEF
Gas-Fired Storage	>75 kBTU/hr and ≤105 kBTU/hr and ≤120 gal	Very Small	0.2674 − (0.0009 × Vr)
Gas-Fired Storage	>75 kBTU/hr and ≤105 kBTU/hr and ≤120 gal	Low	0.5362 − (0.0012 × Vr)
Gas-Fired Storage	>75 kBTU/hr and ≤105 kBTU/hr and ≤120 gal	Medium	0.6002 − (0.0011 × Vr)
Gas-Fired Storage	>75 kBTU/hr and ≤105 kBTU/hr and ≤120 gal	High	0.6597 − (0.0009 × Vr)
Oil-Fired Storage	>105 kBTU/hr and ≤140 kBTU/hr and ≤120 gal	Very Small	0.2932 − (0.0015 × Vr)
Oil-Fired Storage	>105 kBTU/hr and ≤140 kBTU/hr and ≤120 gal	Low	0.5596 − (0.0018 × Vr)
Oil-Fired Storage	>105 kBTU/hr and ≤140 kBTU/hr and ≤120 gal	Medium	0.6194 − (0.0016 × Vr)
Oil-Fired Storage	>105 kBTU/hr and ≤140 kBTU/hr and ≤120 gal	High	0.6740 − (0.0013 × Vr)
Electric Instantaneous	>12 kW and ≤58.6 kW and ≤2 gal	All draw pattern	0.80

For commercial water heaters, unlike consumer water heaters, these water heaters are not rated in UEF. The required minimum energy efficiency for commercial water heaters are defined as thermal efficiency and standby loss, as shown in Table 5-6 below.

Table 5-6: Minimum Efficiency Requirements for Commercial Water Heaters

Appliance	*Input-to-Volume Ratio*	*Size (Volume)*	*Minimum Thermal Efficiency (%)*	*Maximum Standby Loss*[1,2]
Gas storage water heaters	< 4,000 BTU/hr/gal	any	80	Q/800 + 110(Vr)1/2 BTU/hr
Gas instantaneous water heaters	≥ 4,000 BTU/hr/gal	< 10 gal	80	–
Gas instantaneous water heaters	≥ 4,000 BTU/hr/gal	≥ 10 gal	80	Q/800 + 110(Vr)1/2 BTU/hr
Gas hot water supply boilers	≥ 4,000 BTU/hr/gal	< 10 gal	80	–
Gas hot water supply boilers	≥ 4,000 BTU/hr/gal	≥ 10 gal	80	Q/800 + 110(Vr)1/2 BTU/hr
Oil storage water heaters	< 4,000 BTU/hr/gal	any	78	Q/800 + 110(Vr)1/2 BTU/hr
Oil instantaneous water heaters	≥ 4,000 BTU/hr/gal	< 10 gal	80	–
Oil instantaneous water heaters	≥ 4,000 BTU/hr/gal	≥ 10 gal	78	Q/800 + 110(Vr)1/2 BTU/hr
Oil hot water supply boilers	≥ 4,000 BTU/hr/gal	< 10 gal	80	–
Oil hot water supply boilers	≥ 4,000 BTU/hr/gal	≥ 10 gal	78	Q/800 + 110(Vr)1/2 BTU/hr
Electric storage water heaters	< 4,000 BTU/hr/gal	any	–	0.3 + 27/Vm %/hr

1. Standby loss is based on a 70° F temperature difference between stored water and ambient requirements. In the standby loss equations, Vr is the rated volume in gallons, Vm is the measured volume in gallons, and Q is the nameplate input rate in BTU/hr.
2. Water heaters and hot water supply boilers having more than 140 gallons of storage capacity are not required to meet the standby loss requirement if the tank surface is thermally insulated to R-12.5, if a standing pilot light is not installed, and for gas- or oil-fired storage water heaters, there is a flue damper or fan-assisted combustion.

Source: California Energy Commission, *Title 20 Appliance Efficiency Regulations* (2014)

5.3.3 Isolation Valves

§110.3(c)7

All newly installed instantaneous water heaters (minimum input of 6.8 kBTU/hr) shall have isolation valves on both the incoming cold water supply and the hot water pipe leaving the water heater. Isolation valves assist in the flushing of the heat exchanger and help prolong the life of instantaneous water heaters. Instantaneous water heater that has integrated drain ports for servicing are acceptable to meet the requirements of §110.3(c)7 and will not require additional isolation valves.

5.3.4 High-Efficiency Water Heater Ready

§150.0(n)

To facilitate future installations of high-efficiency equipment, the Energy Standards contain the following mandatory requirements for systems using gas or propane water heaters that serve individual dwelling units.

These requirements are for new construction and additions (if a water heater is installed in the added floor area), and they are not applicable to alterations. Moreover, these requirements are not applicable when installing an electric water heater.

1. A dedicated 125-volt (V) electrical receptacle that is within 3 feet of the water heater and accessible to the water heater with no obstructions, and be connected to a three conductor, 10 AWG branch circuit. In addition, the unused conductor must be labeled and electrically isolated and have a reserved circuit breaker space.
2. A Category III or IV vent or a Type B vent with a straight pipe between the outside termination and the space where the water heater is installed
3. A condensate drain that is no more than 2 inches higher than the base of the installed water heater and allows natural draining without pump assistance
4. A gas supply line with a capacity to provide at least 200,000 BTU/hr to the water heater.

These requirements make it easier for someone to retrofit HPWH or high efficiency gas water heaters in the future. Virtually all high efficiency gas water heaters require an electrical connection and wiring during initial construction stage is much less costly than trying to retrofit it later.

5.3.4.1 **Electrical Receptacle**

The goal of this requirement is to allow easy installation of HPWH when the existing gas water heater needs to be replaced. HPWH typically requires a 240-volt circuit and this requirement allows an electrician to easily convert the 120-volt circuit to a 240-volt circuit.

The electrical receptacle must be installed with 3 feet from the water heater. It should be connected to a dedicated circuit with a 10 AWG copper branch circuit. The ends of the unused conductor must be labeled as “spare” and be electrically isolated.

A reserved single-pole circuit breaker space must be placed in the electrical panel next to the circuit breaker for the branch circuit and labeled with the words “Future 240V Use.”

5.3.4.2 **Venting**

Table 5-7 below summarizes venting requirements for different types of water heaters. Higher efficiency water heaters often require different vent materials due to the presence of acidic condensation from flue gases. The standard Type B vent installed for conventional atmospheric gas water heaters is made of steel and would soon be destroyed by the condensate. As a result, the Energy Standards require that a Type B vent for the water heater can be installed only when there is a straight shot between the water heater and where the vent leaves the building. There should be no bends along the path of the Type B vent, except the portion of the Type B vent outside the building and in the space where the water heater is installed. The installation shall meet all code and manufacturers' guidelines. Because Category III and IV pipes are usually smaller than those for Type B vents, a straight Type B vent can be easily modified into a Category III or IV vent by simply inserting a new vent pipe through the existing Type B vent pipe. A flue pipe that makes bends though the building structure is not easy to retrofit, and, thus, these flues must be either Category III or IV vent pipes. Only stainless steel Category III and IV vents are compatible with typical atmospheric combustion storage water heaters.

Table 5-7: Summary of Acceptable Vent Material by Appliance Category

Appliance Venting Category	*Vent Pressure*	*Condensing or Non-Condensing*	*Common Vent Pipe Material*
Category I: An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent	Nonpositive; atmospheric-vented; gravity-vented; most common category of gas-fired water heaters.	Noncondensing (typically less than 82% efficiency)	Metal double wall "B" vent
Category II: An appliance that operates with a nonpositive vent static pressure and with a vent gas temperature that may cause excessive condensate production in the vent	Nonpositive	Condensing	Special venting material per the product manufacturer
Category III: An appliance that operates with a positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent	Positive (usually created by a blower motor); generally cannot be adjoined to gravity-vented water heater.	Noncondensing (typically less than 82% efficiency)	Stainless steel; these usually require 3" clearance to combustibles and the joints must be sealed air tight.
Category IV: An appliance that operates with a positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent	Positive (usually created by a blower motor); generally cannot be adjoined to gravity-vented water heater.	Condensing	Plastic pipe (PVC, CPVC, ABS, etc.)

5.3.4.3 **Condensate Drain**

The requirement for the condensate drain being placed near the water heater and no higher than the base of the tank allows the condensate to be removed without relying on a sump pump.

5.3.4.4 **Gas Line**

Designing the gas line to provide 200,000 BTU per hour gas supply capacity to the water heater is required to accommodate future retrofit to a gas instantaneous water heater, which usually has a heat input capacity of 199,000 BTU/hr or higher. Similar to the electrical requirement, installing a larger gas line during new construction is inexpensive relative to a future gas line retrofit.

Gas pipe sizing for the building needs to consider piping layout and gas supply requirements for other gas appliances, such as gas clothes dryers, gas furnaces, gas ranges and ovens, and gas fireplace burners. The traditional practice of using a ½-inch gas pipe in a single-family house to serve a storage water heater is **not** in compliance with the mandatory requirement. The minimum gas pipe size for water heaters is ¾-inch. The exact gas piping system should be designed following the California Plumbing Code.

5.3.5 Mandatory Requirements for Hot Water Distribution Systems

5.3.5.1 **Pipe Insulation for All Buildings**

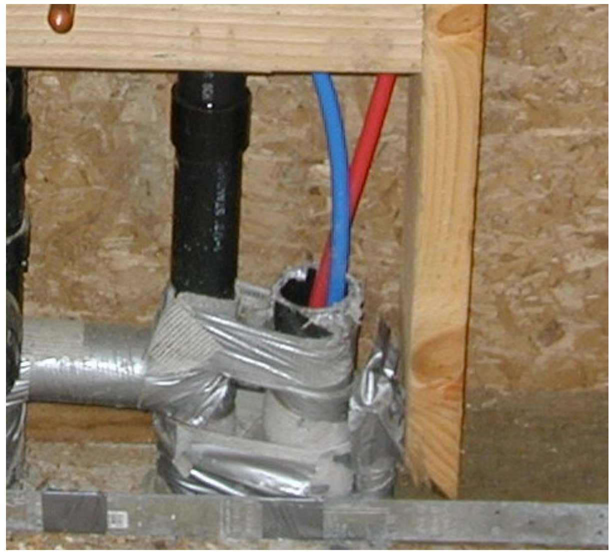
§150.0(j)2

All domestic hot water piping shall be insulated as specified in Section 609.11 of the California Plumbing Code, which requires pipe insulation thickness equal to or more than the diameter of the pipe, up to 2 inches. Above pipe diameter of 2 inches, the insulation thickness must be at least 2 inches. In addition, the following piping conditions shall have a minimum insulation wall thickness of 1 inch:

1. The first 5 feet of hot and cold water pipes from the storage tank or water heater.
2. All piping with a nominal diameter of ¾ inch or larger.
3. All piping associated within a domestic hot water recirculation system regardless of the pipe diameter. This excludes branches off the recirculation loop that are less than ¾ inch diameter or do not serve the kitchen.
4. Piping from the heating source to a storage tank or between tanks.
5. Piping buried below grade.
6. All hot water pipes from the heating source to the kitchen fixtures.

In addition to insulation requirements, all domestic hot water pipes that are buried below grade must be installed in a waterproof and noncrushable casing or sleeve. The installation shown in Figure 5-4 below would not meet the installation requirements since it is not insulated. In addition, in Figure 5-4 the hot and cold water lines are not separated. Heat transfer will occur, resulting in energy loss and causing condensation on the cold water line.

Figure 5-4: Noncompliant Below-Grade Piping and Hot and Cold Water Lines Separation



Source: Davis Energy Group/Frontier Energy

A. Piping Exempt From the Mandatory Insulation Includes:

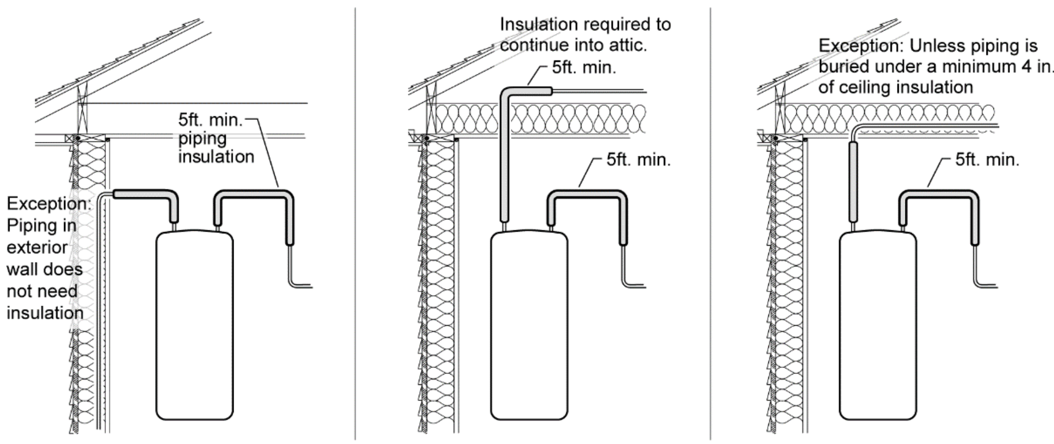
1. Factory-installed piping within space conditioning equipment.
2. Piping that serves process loads, gas piping, cold domestic water piping (other than within 5 feet of the water heater), condensate drains, roof drains, vents, or waste piping.
3. Piping that penetrates framing members. This piping is not required to have insulation where it penetrates the framing. However, if the framing is metal, then some insulating material must prevent contact between the pipe and the metal framing.
4. Piping located within exterior walls that are installed so that piping is placed inside wall insulation. Wall insulation may be an acceptable alternative insulation method for sections of pipes that would otherwise need pipe insulation, as long as the wall insulation in the walls where the pipes are located meets the requirements of QII and the pipes are roughly centered in the wall cavity. (see Reference Appendix RA4.4.1).
5. Piping in the attic continuously buried by at least 4 inches of blown-in ceiling insulation. Piping may not be placed directly in contact with sheetrock and then covered with insulation to meet this requirement.

B. Other installation information:

1. No insulation should be installed closer than 6 inches from the flue. If possible, bend the pipe away from the flue. Otherwise, it may be necessary to stop pipe insulation short of the storage tank. (See the current version of the California Mechanical Code.)
2. All pipe insulation seams must be sealed.

3. Installed piping may not be located in supply or return air plenums. (See the current version of the California Mechanical Code.)
4. Hot and cold water piping, when installed in parallel runs, must be at least 2 inches apart. (See Reference Appendix RA4.)
5. If a fire wall interrupts the first 5 feet of pipe, the insulation may be interrupted at the wall and continued on the other side.
6. Insulation for pipe elbows should be mitered and insulation for tees should be notched. (See Reference Appendix RA4.)

Figure 5-5: Pipe Insulation Requirements First Five Feet From Water Heater



Source: California Energy Commission

Table 5-8: Pipe Insulation Thickness Requirement

Fluid Operating Temperature Range (°F)	Insulation Conductivity			Nominal Pipe Diameter (in inches)				
	Conductivity (in Btu·in/h·ft²·°F)	Mean Rating Temperature (°F)		< 1	1 to <1.5	1.5 to < 4	4 to < 8	8 and larger
Space heating and Service Water Heating Systems (Steam, Steam Condensate, Refrigerant, Space Heating, Service Hot Water)				Minimum Pipe Insulation Required (Thickness in inches or R-value)				
Above 350	0.32-0.34	250	Inches	4.5	5.0	5.0	5.0	5.0
			R-value	R 37	R 41	R 37	R 27	R 23
251-350	0.29-0.32	200	Inches	3.0	4.0	4.5	4.5	4.5
			R-value	R 24	R 34	R 35	R 26	R 22
201-250	0.27-0.30	150	Inches	2.5	2.5	2.5	3.0	3.0
			R-value	R 21	R 20	R 17.5	R 17	R 14.5
141-200	0.25-0.29	125	Inches	1.5	1.5	2.0	2.0	2.0
			R-value	R 11.5	R 11	R 14	R 11	R 10
105-140	0.22-0.28	100	Inches	1.0	1.5	1.5	1.5	1.5
			R-value	R 7.7	R 12.5	R 11	R 9	R 8

Source Excerpt From Table 120.3-A of the Energy Standards

Where insulation is required as described above, 1 inch of insulation is typically required. This requirement applies to domestic hot water pipe (above 105° F) when the pipe diameter is less than 1 inch, the water temperature is between 105°F and 140°F, and the insulation conductivity is between 0.22 and 0.28 BTU-in/hr-ft²-°F (typical of cellular foam pipe insulation material). One and one-half inch insulation is required on pipes 1 inch or greater. For other situations refer to Table 120.3-A.

5.3.5.2 Insulation Protection

§150.0(j)3

If hot water piping insulation is exposed to weather, it must be protected from physical damage, ultraviolet (UV) light deterioration, and moisture. Insulation is typically protected by aluminum, sheet metal, painted canvas, plastic cover, or a water-retardant coating that shields from solar radiation. Adhesive tape should not be used as insulation cover because removal of the tape will damage the integrity of the original insulation during preventive maintenance.

5.3.5.3 Distribution Systems Serving Multiple Dwelling Units – With Recirculation Loops

§110.3(c)5

Multifamily buildings may have water heaters for each dwelling unit but are more likely to have a central water heating system with a recirculation loop that supplies each of the units. This recirculation loop consists of a supply portion of larger diameter pipe connected to smaller diameter branches that serve multiple dwelling units, guest rooms, or common area fixtures and a return portion that completes the loop back to the water heating equipment. The large volume of water that is recirculated during periods of high use creates situations that require the installation of certain controls and servicing mechanisms to optimize performance and allow for lower cost of maintenance. The following paragraphs cover the mandatory requirements for system serving multiple dwelling units and with recirculation loops.

A. Air Release Valves

§110.3(c)5A

The constant supply of new water in combination with the continuous operation of pumps creates the possibility of the pump cavitation due to the presence of air in the water. *Cavitation* is the formation of bubbles in the low-pressure liquid on the suction side of the pump. The cavities or bubbles will collapse when they pass into the higher regions of pressure, causing noise and vibration that may lead to damage to many of the components. In addition, there is a loss in capacity, and the pump can no longer build the same head (pressure). This ultimately affects the efficiency and life expectancy of the pump.

Cavitation shall be minimized either by installing an air release valve or mounting the pump vertically. The air release valve must be located no more than 4 feet from the inlet of the pump. The air release valve must also be mounted on a vertical riser with a length of at least 12 inches.

B. Backflow Prevention

§110.3(c)5B

Temperature and pressure differences in the water throughout a recirculation system can create backflows. This can result in cooler water from the bottom of the water heater tank and water near the end of the recirculation loop flowing backward toward the hot water load and reducing the delivered water temperature.

To prevent this from occurring, the Energy Standards require that a check valve or similar device be located between the recirculation pump and the water heating equipment.

C. Equipment for Pump Priming/Pump Isolation Valves

§110.3(c)5C&D

A large number of systems are allowed to operate until complete failure simply because of the difficulty of repair or servicing. Repair labor costs can be reduced significantly by planning and designing for easy pump replacement when the pump fails. Provision for pump priming and pump isolation valves helps reduce maintenance costs.

To meet the pump priming equipment requirement, a hose bib must be installed between the pump and the water heater. In addition, an isolation valve shall be installed between the hose bib and the water heating equipment. This configuration will allow the flow from the water heater to be shut off, allowing the hose bib to be used for bleeding air out of the pump after pump replacement.

The requirement for the pump isolation valves will allow replacement of the pump without draining a large portion of the system. The isolation valves shall be installed on both sides of the pump. These valves may be part of the flange that attaches the pump to the pipe. One of the isolation valves may be the same isolation valve as in Item C.

D. Connection of Recirculation Lines

§110.3(c)5E

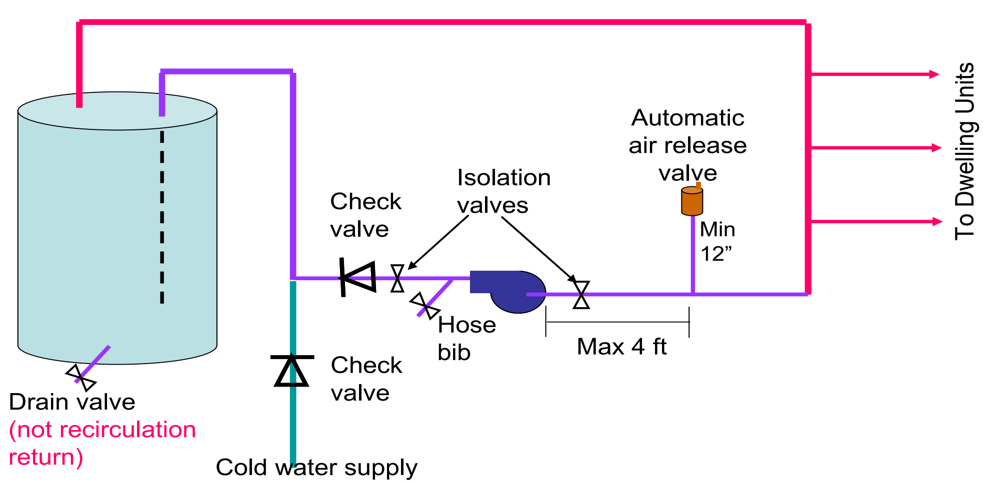
Manufacturer's specifications should always be followed to assure optimal performance of the system. The cold water piping and the recirculation loop piping should never be connected to the hot water storage tank drain port.

E. Backflow Prevention in Cold Water Supply

§110.3(c)5F

The dynamic between the water in the heater and the cold water supply are similar to those in the recirculation loop. Thermosyphoning can occur on this side of this loop just as it does on the recirculation side of the system. To prevent this, the Energy Standards require a check valve to be installed on the cold water supply line. The valve should be located between the hot water system and the next closest tee on the cold water supply line. The system shall comply with the expansion tank requirements as described in the California Plumbing Code.

Figure 5-6: Mandatory Central Recirculation System Installation Requirements



Source: California Energy Commission

Example 5-1 − Distribution Systems

Question:

When I'm insulating the pipes for a recirculating water heating system, I understand that I must insulate the entire length of hot water pipes that are part of the recirculation loop. Do I also need to insulate the runouts?

Answer:

Yes, per the California Plumbing Code domestic hot water piping shall be insulated.

Example 5-2 − Recirculation System Insulation

Question:

Can I get pipe insulation credit for a recirculating water heating system?

Answer:

Not for systems serving a single dwelling unit. Recirculating water heating systems have a mandatory insulation requirement for the recirculating section of the hot water pipes; pipes less than 1 inch must be insulated to 1 inch of insulation. For systems serving multiple dwelling units, using thicker-than-required insulation results in credit within the performance approach. All the circulation loop pipes in one location type (for example, inside, outside, underground) must be insulated to the higher level to qualify.

Example 5-3 − Pipe Insulation

Question:

I thought I was supposed to insulate hot and cold water piping from the water heater for either the first 5 feet or the length of piping before coming to a wall, whichever is less. Did I misunderstand?

Answer:

Yes. The requirement is that you must insulate the entire length of the first 5 ft, regardless of whether there is a wall per Section150.0(j)2. You have two options: (1) interrupt insulation for a fire wall and continue it on the other side of the wall or (2) run the pipe through an insulated wall, making sure that the wall insulation completely surrounds the pipe. The reason for insulating the cold line is that, when heated, the water inside the water heater expands and pushes hot water out the cold-water line. The first several feet of the cold-water pipe near the water heater can be warm and insulation reduces the heat loss from the first 5 feet of the cold-water piping.

5.4 Prescriptive Requirements for Water Heating

5.4.1 Single Dwelling Units

§150.1(c)8

There are five options to comply with the prescriptive water heating requirements for newly constructed single dwelling units. For all five options, the water heater must comply with the mandatory requirements for water heaters. (See Section 5.3.) If a recirculation distribution system is installed, only demand recirculation systems with manual control pumps are allowed. The five options are described below.

Option 1: Install one or more natural gas or propane instantaneous water heater with an input rating of 200,000 BTU per hour or less and no storage tank.

Option 2: Install a single natural gas or propane storage water heater with a rated storage volume 55 gallons or less and an input rating of 75,000 BTU per hour or less. In addition, the dwelling unit shall have installed fenestration products with a weighted average U- factor no greater than 0.24, as well as one of the following requirements

1. Use a compact hot water distribution design, which requires a HERS Rater to verify that the system has been designed and installed in accordance with the Energy Standards (See Reference Appendix RA4.4.16.)
2. Use a drain water heat recovery system, which requires a HERS Rater to verify that the system has been designed and installed in accordance with the Energy Standards (See Reference Appendix RA4.4.21.)

Option 3: Install a single natural gas or propane storage water heater with a rated storage volume greater than 55 gallons and an input rating of 75,000 BTU per hour or less.

Option 4: Install a single heat pump water heater. The storage tank shall be located in the garage or conditioned space. In addition, the building must comply with one of the following:

1. A compact hot water distribution design earning the Basic Compact Design –credit and a HERS-verified drain water heat recovery system.
2. For Climate Zones 2 through 15, a photovoltaic system capacity of 0.3 kW direct current (dc) larger than the requirement specified in Section150.1(c)14.
3. For Climate Zones 1 and 16, a photovoltaic system capacity of 1.1 kWdc larger than the requirement specified in Section150.1(c)14.

Option 5: Install a single heat pump water heater that meets the requirements of NEEA Advanced Water Heater Specification Tier 3 or higher. The storage tank shall be located in the garage or conditioned space. In addition, for Climate Zones 1 and 16, a photovoltaic system capacity of 0.3 kWdc larger than the requirement specified in §150.1(c)14 or a compact hot water distribution system earning the Basic Compact Design credit.

If Option 2, 4, or 5 is pursued, then one or more additional building features must be installed as shown above. These features require consideration at the start of the design process and must be coordinated with several players including the designer, general contractor, sub-contractor, and HERS Rater.

The list of qualified product list of NEEA HPWH can be found here:

https://neea.org/img/documents/qualified-products-list.pdf

For more information on HERS-verified compact hot water distribution design, see Section 5.6.2.4. HERS-verified compact hot water distribution designs are included in Options 2 described above.

For more information on HERS-verified drain water heat recovery system requirements, see Example 5-9 below and Section 5.6.2.5 of this chapter. The Reference Appendix contains the requirements for the proper installation of the system (see RA4.4.21). A HERS-verified drain water heat recovery system is included in Options 2 and 4 described above.

Any other water heating system that differs from the five options described in this section does not meet the prescriptive requirements. Other systems can be installed if using the performance approach as described in Section 5.5.

For additions, the prescriptive requirements described above apply only if a water heater is being installed as part of the addition. The prescriptive requirements apply only to the space that is added, not the entire building.

For alterations where an existing water heater is being replaced, the water heater must meet the mandatory equipment efficiency requirements. Pipe insulation requirements do not apply to alteration for the portion of the pipes that are inaccessible. See Chapter 9 for a more detailed explanation for the water heating alteration requirements.

Example 5-4 − Single-Family Home With Multiple Water Heaters

Question:

A newly built 6,000-ft² single-family home has three gas storage water heaters (40-gallon, 30–gallon, and a 100-gallon unit with 80,000 BTU/h input). Does it comply?

Answer:

In most cases, multiple storage water heaters will result in greater energy consumption than the standard design case (one water heater for a new single-family home). As such, a performance calculation is required since the system does not meet the standard requirements and must be shown to meet the water heating energy budget. However, multiple instantaneous gas water heaters are allowed under Option 1 of the prescriptive method and this house can meet compliance by going that route.

Example 5-5 − Alterations

Question:

If my house has an electric-resistance water heater and I plan to upgrade my water heater, do I need to install a gas instantaneous or gas storage water heater?

Answer

No, if natural gas is not already connected to the existing water heater location, then a consumer electric water heater that meets the requirements of California's Appliance Efficiency Regulations can replace the existing water heater. If installing new piping to the water heater, then you will need to comply with the mandatory pipe insulation requirements. See Section 5.3.5.1 for more information on pipe insulation requirement and Chapter 9 for more information on alterations.

Example 5-6− Additions

Question:

I am building an addition to my home that will be a self-contained apartment. Do I need to comply with the prescriptive requirements?

Answer:

If the addition will include a water heater, or if it will be connected to the existing hot water distribution system to supply hot water to the apartment, then you must comply with the standards either through the prescriptive or performance path. If taking the performance approach, you can install any type of water heater as long as it 1) meets the requirements of California's *Appliance Efficiency Regulations* and 2) does not exceed the water heating energy budget for the self-contained building. If you were adding only an additional room with hot water and not a self-contained dwelling, then the water heating budget would be based on the existing building plus addition. (See Section 5.5.)

Example 5-7 – Heat Pump Water Heaters

Question:

For a new home, can I install an electric water heater? Do I have to perform calculations to show compliance?

Answer:

Yes, electric heat pump water heater (HPWH) can be used for both prescriptive and performance compliance. Calculation is not necessary using the prescriptive compliance path. There are 2 prescriptive options (Option 4 and 5 in Section 5.4.1 above) for HPWH. Option 5 is the simplest option, which requires the installation of a NEEA Tier 3 or higher HPWH in the garage or conditioned space. For climate zones 2 through 15, no additional requirement is needed for compliance. For climate zones 1 and 16, an additional 0.3 kWdc is required in addition to the prescriptive photovoltaic requirement. For more details, see Section 5.4.1 above.

For performance compliance, the characteristic of the HPWH must be modeled, such as rated UEF or make and model of the HPWH if it is NEEA rated.

Example 5-8 – Drain Water Heat Recovery

Question:

I'm in the schematic design phase for a single-family home. I intend to include drain water heat recovery in my design and to follow the prescriptive path. What are the primary design issues I should consider?

Answer:

If you follow the prescriptive path, drain water heat recovery aids compliance only if you are specifying a gas or propane storage water heater with a rated storage volume of 55 gallons or less; or a heat pump water heater that does not meet or exceed NEEA Advanced Water Heater Specification Tier 3. For all water heater type, you could follow the performance path and obtain compliance credit within an energy model calculation. In any case, the initial design issues are related to the selection of an appropriate drain water heat recovery model (i.e. horizontal or vertical type, minimum rated effectiveness, and diameter and length), and designing the layout of the system. If your residence is single story, then a horizontally rated unit is required. If your residence has multiple stories, then the unit can be horizontally or vertically rated. In any case, the required minimum rated effectiveness is 42 percent. The diameter of the unit should match the diameter of the drain pipe. Added length improves effectiveness but requires more space. In terms of the system layout, the unit must recover heat from at least the master bathroom shower and must at least transfer that heat either back to all the respective showers or the water heater. If you desire to maximize savings, you should place the unit in a drain line that serves all the showers and you should pipe the preheated water to the cold side of all the shower mixing valves and the make-up water inlet of the water heater. This is known as an *equal flow* configuration, since the preheated water flow rate will match the drain water flow rate.

5.4.2 Multiple Dwelling Units: Multifamily, Motel/Hotels, and High-Rise Residential

§150.1(c)8

There are two options for using the prescriptive approach to compliance for multifamily buildings:

1. A water heater must be installed in each unit that meets the requirements for a single-family building.
2. A central gas or propane-fired water heater or boiler.

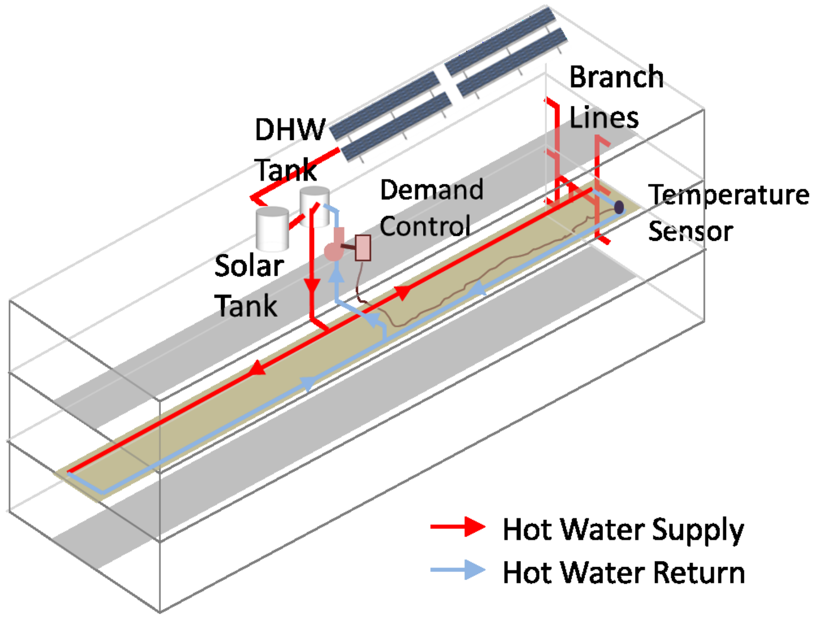
The water heater must have an efficiency that meets the requirements in §110.1 and §110.3 (as listed in Table 5-5). In addition, if a central recirculation system is installed, it shall be installed with demand recirculation controls and a distribution layout with at least two recirculation loops. These prescriptive rules were developed based on studies that found that recirculation pipe heat loss is a major component of energy loss within a central hot water system. Pipe heat loss is affected by the pipe surface area, pipe insulation level, and the temperature difference between the hot water and ambient air. The motivation behind having two loops is to reduce recirculation pipe sizes, thus pipe surface area. This measure reduces energy use and piping materials associated with recirculation systems. Central water heating systems with eight or fewer dwelling units are exempted from needing two recirculation loops.

5.4.2.1 Dual-Loop Recirculation System Design

§150.1(c)8Cii

Figure 5-7 shows a dual-loop design. In a dual-loop design, each loop serves half of the dwelling units. According to plumbing code requirements, the pipe diameters can be downsized compared to a loop serving all dwelling units. The total pipe surface area is effectively reduced, even though total pipe length is about the same as or somewhat greater than that of a single-loop design. For appropriate pipe sizing guidelines, please refer to the California Plumbing Code.

Figure 5-7: Example of a Dual-Loop Recirculation System

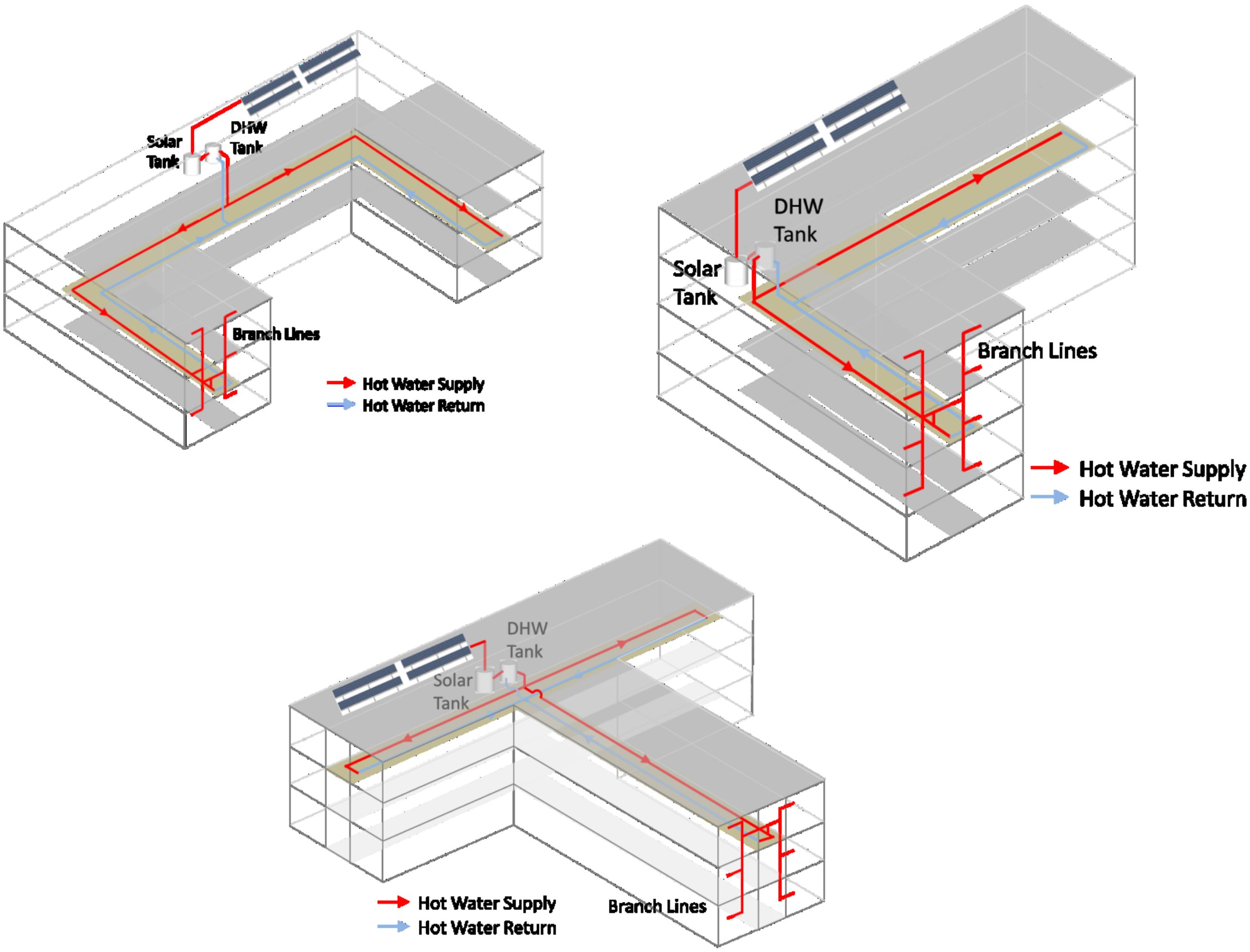


Source: 2013 CASE Initiative: Multifamily Central DHW and Solar Water Heating

Figure 5-7 provides an example of how to implement dual loop design in a low-rise multifamily building with a simple layout. In this example, the water heating equipment is in the middle of the top floor with each recirculation loop serving exactly half of the building. The recirculation loops are located in the middle floor to minimize branch pipe length to each dwelling unit. The figure also illustrates how the solar water heating system and demand controls are integrated.

For buildings with complicated layouts, how to create and locate recirculation loops heavily depends on building geometry. In general, the system should be designed to have each loop serve an equal number of dwelling units to minimize pipe sizes. For systems serving buildings with distinct sections, for example, two wings in an L-shaped building, it is better to dedicate a separate recirculation loop to each of the sections. Very large buildings and buildings with more than two sections should consider using separate central water heating systems for each section. In all cases, simple routing of recirculation loops should be used to keep recirculation pipes and runouts as short as possible. Figure 5-8 provides dual-loop recirculation system designs in buildings with complicated shapes.

Figure 5-8: Examples of Dual-Loop Recirculation System Designs in Buildings of Complicated Shapes



Source: 2013 CASE Initiative: Multifamily Central DHW and Solar Water Heating

Location of water heating equipment in the building also needs to be carefully considered to properly implement the dual-loop design. The goal is to keep overall pipe length as short as possible. As an example, for buildings in regular shapes, locating the water heating equipment at the center of the building footprint rather than at one end of the building helps minimize the pipe length needed to connect the water heating equipment to the two loops. If a water heating system serves several building sections, the water heating equipment would preferably nest between these sections.

With the new prescriptive solar water heating requirement this cycle, it is especially important to consider the integration between the hot water recirculation system and the solar water heating system. Based on feedback from industry stakeholders, most solar water heating systems are configured only as a preheater of the primary gas water heating equipment. In other words, recirculation hot water returns are usually plumbed back to the gas water heating storage tanks, not directly into the solar tank. This means recirculation loop designs should be based mostly on the building layout and are relatively independent of the solar water heating system. On the other hand, gas water heating equipment and solar tanks should be located close to each other to avoid heat loss from pipes connecting the two systems. The preferred configuration is to place both the gas water heating equipment and solar tanks on the top floor near the solar collector so that the total system pipe length can be reduced. As noted before, minimizing pipe length helps reduce domestic hot water system energy use as well as system plumbing cost.

5.4.2.2 Demand Recirculation Control

The prescriptive requirement for domestic hot water systems serving multiple dwelling units requires the installation of a demand recirculation control to minimize pump operation and heat loss from pipes. They are different from the demand controls used in single dwelling units. Demand controls for central recirculation systems operate by sensing hot water demand and recirculation return temperatures. The temperature sensor should be installed at the farthest end of the recirculation loop close to the last branch pipe.

Any system not meeting these prescriptive requirements must instead meet the standard design building energy budget that is established by the energy efficiency performance of a gas instantaneous water heater that meets the requirements of California's *Title 20 Appliance Efficiency Regulations* or must follow the performance compliance method for the building as a whole.

Example 5-9 - Multifamily With Individual Water Heater

Question:

We are building a 20-unit multifamily building with individual water heater in each dwelling. Can electric water heaters be used?

Answer:

When there is a water heater in each multifamily dwelling, the requirement is the same as a single-family home. In this situation electric heat pump water heaters (HPWH) can be used for both prescriptive and performance compliance. For more details, see Example 5-7 and Section 5.4.1 above.

Example 5-10 − Multifamily Recirculation System

Question:

We are building an eight-unit, 7,800 ft² multifamily building with a 200-gallon storage gas water heater and a time- and temperature-controlled recirculation system that has 1 inch of insulation on all the piping. The system serves all the units. Do I have to perform calculations to show compliance?

Answer:

Water-heating calculations are required since the standard design assumption uses demand recirculation for the control strategy for central recirculation. Furthermore, solar water heating is a prescriptive requirement for all multifamily buildings with central recirculation systems.

Example 5-11 − Multifamily Large Water Heater

Question:

We are building a 10-unit apartment building with a single large water heater. We do not plan to install a recirculation pump and loop. Does this meet the prescriptive requirements?

Answer:

No. Since it is unlikely that a nonrecirculating system will satisfactorily supply hot water to meet the tenants' needs, either a recirculating system or individual water heaters must be installed to meet the prescriptive requirements. There is an exception for multifamily buildings of 8 units or fewer.

5.5 Performance Approach Compliance for Water Heating

5.5.1 Energy Budget Calculation

The computer performance approach allows for the modeling of water heating system performance by taking into account building characteristics, climate, system type, efficiency, and fuel type. The standard design water heating budget is defined by the corresponding prescriptive requirements. The performance method allows for modeling alternative water heater and distribution system combinations. Some of these options will offer compliance credits, and others will result in penalties.

5.5.2 Systems Serving a Single Dwelling Unit

In the case of single dwelling units, any type or number of water heaters supported by the software can be installed. The calculated energy use of the proposed design is compared to the standard design energy budget based on either a single gas instantaneous water heater for gas water heaters with a standard distribution system, or a HPWH with compact distribution system and drain water heat recovery. Adding multiple water heaters to a single-family design will generally result in an energy penalty in the water heating budget that must be offset elsewhere in the total energy budget.

A standard distribution system serving a single dwelling unit does not incorporate a pump for hot water recirculation and does not take credit for any additional DHW design features. All mandatory pipe insulation requirements must be met, such as insulating all pipes running to the kitchen. Alternative distribution systems are compared to the standard design case by using distribution system multipliers (DSMs), which effectively rate alternative options.

Table 5-9 lists all the recognized distribution systems that can be used in the performance approach with the assigned distribution multiplier. The standard distribution system has a multiplier of 1.0. Distribution systems with a multiplier less than 1 represent an energy credit, while distribution systems with a multiplier greater than 1 are counted as an energy penalty. For example, pipe Insulation with HERS Inspection Required (PIC-H) has a multiplier of 0.8. That means that it is modeled at 20 percent less distribution loss than the standard distribution system. For more information or installation requirements on any of the systems, refer to Section 5.6.

Table 5-9: Applicability of Distribution Systems Options Within a Dwelling Unit

Distribution System Types	*Assigned Distribution System Multiplier*	*Systems Serving a Single Dwelling Unit*	*Multifamily With Central Recirculation Systems*
No HERS Inspection Required Trunk and Branch -Standard (STD)	1.0	Yes	Yes
No HERS Inspection Required Compact Design – Basic (CHWDS)	0.7	Yes	--
No HERS Inspection Required Parallel Piping (PP)	1.1	Yes	--
No HERS Inspection Required Point of Use (POU)	0.3	Yes	--
No HERS Inspection Required Recirculation: Non-Demand Control Options (R-ND)	9.8	Yes	--
No HERS Inspection Required Recirculation with Manual Demand Control (R-Dman)	1.75	Yes	Yes
No HERS Inspection Required Recirculation with Motion Sensor Demand Control (R-DAuto)	2.6	Yes	--
HERS Inspection Required Pipe Insulation (PIC-H)	0.85	Yes	Yes
HERS Inspection Required Parallel Piping with 5' maximum length (PP-H)	1	Yes	--
HERS Inspection Required Compact Design - Expanded (CHWDS-H)	0.3 – 0.7[1]	Yes	--
HERS Inspection Required Recirculation with Manual Demand Control (R-Drmc-H)	1.6	Yes	--
HERS Inspection Required Recirculation with Motion Sensor Demand Control (RDRsc-H)	2.4	Yes	--

1. The multiplier for the Compact Design – Expanded credit varies depending on the home's floorplan and water heater location. See Section 5.6.2.4 for more information.

5.5.3 Systems Serving Multiple Dwelling Units

For systems serving multiple dwelling units with a recirculating pump, the standard distribution system design is based on a central recirculation system with two recirculation loops that are controlled by a demand control technology. Systems designed with other options are allowed, but they require compliance verification through performance calculation.

Central recirculation systems using only one recirculation loop are expected to have larger pipe surface areas than those of dual-loop designs, according to plumbing code requirements for pipe sizing. For large buildings, it may be better to use more than one recirculation loop with each serving a small portion of the building, even though additional credit for designs with more than two recirculation loops is not provided.

If demand control is not used, temperature modulation controls and/or continuous monitoring should be used as an alternative compliance method. Recirculation timer controls are not given any control credits because field studies revealed that they are usually not properly configured to achieve the intended purposes. Buildings with uncontrolled recirculation systems will have to install other efficiency measures to meet compliance requirements through the performance method.

Systems with all pipes insulated can claim compliance credit. The amount of credit is increased if the insulation is verified by a HERS Rater. Increasing recirculation pipe insulation by 0.5 inch above the mandatory requirements can also result in compliance credit through performance calculation.

5.5.4 Treatment of Water Heater Efficiency

For information on how water heater efficiency is considered in terms of modeling energy performance using the compliance software tool, please refer to the *Residential Alternative Calculation Method (ACM) Reference Manual*.

5.5.5 Compliance Issues

Water heating is becoming more important to overall building compliance as building envelope performance and mechanical efficiency improve. When the performance approach is used, a high-efficiency water heater and an efficient distribution system can significantly affect the overall performance margin of a building, especially in the milder climates like Climate Zones 4 through 9, where water heating typically represents a larger fraction of the overall energy budget.

Asking for a cut sheet on the installed equipment to verify efficiency is a simple shortcut to checking compliance. When used in a combined hydronic system, it is important to check the capacity of the system to verify that both space and water heating loads can be met.

5.6 Distribution Systems

5.6.1 Types of Water Heating Distribution Systems

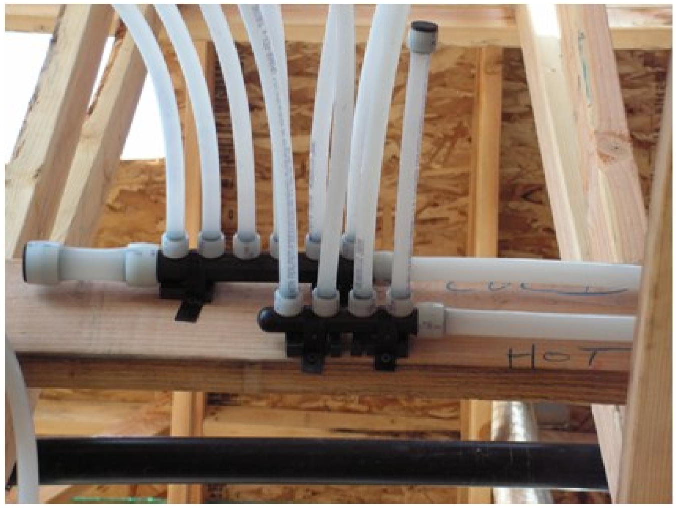
The water heating distribution system is the configuration of piping (and pumps and controls in the case of recirculating systems) that delivers hot water from the water heater to the end-use points within the building. For systems designed for single-family buildings or individual dwelling units in a multifamily building, the system will resemble one of the system types described below under dwelling unit distribution systems. In multifamily buildings, the use of a central water heater and central recirculation distribution system that brings hot water close to all the dwelling units is also common. A description of the recognized systems for serving single and multiple dwelling units are listed in the following two sections. The installation of a hot water distribution system that does not meet all the installation guidelines discussed in this compliance manual and in the Reference Appendix RA3 and RA4 must have either the deficiencies corrected or compliance calculations using the performance approach assuming that the installed distribution system is substandard. In all cases, the locations of the water heaters and fixtures should be given consideration at the beginning of building design. By minimizing the length of distribution piping, energy use, water waste, wait time for hot water and construction cost can all be reduced.

5.6.2 Systems Serving a Single Dwelling Unit

5.6.2.1 **Standard Distribution System (Trunk-and-Branch and Mini-manifold Configurations)**

The most basic plumbing layout and assumed as the reference design in the performance approach, is represented by the conventional trunk-and-branch layout. This layout of a trunk-and-branch system may include one or more trunks, each serving a portion of the building. The trunks are subdivided by branches that serve specific rooms, and these are in turn divided into twigs that serve a particular point of use. This distribution system class includes mini-manifold layouts (Figure 5-9), which incorporate trunk lines that feed remote manifolds that then distribute water via twigs to the end-use points. A standard distribution system cannot incorporate a pump for hot water recirculation. Piping cannot be run up to the attic and then down to points of use on the first floor.

Figure 5-9: Mini-manifold Configuration



- *Installation Criteria and Guidelines*

No pumps may be used to recirculate hot water with the standard distribution system. All applicable mandatory features must be met. When designing a trunk-and-branch system, the concern is keeping all segments of the system as short and as small a diameter as possible. Even an insulated pipe will lose most of the stored heat within 30 minutes. The other issue to consider is that if hot water gets into a cold water line, all the water in the pipe must be discharged, and up to an additional third of the volume of hot water will be needed to heat the pipe so that the water arriving at the point of use will be the desirable temperature. The requirements and guidelines for the installation of the standard distribution system are included in Reference Appendix RA3 - Residential Field Verification and Diagnostic Testing Protocols and RA4 - Eligibility Criteria for Energy Efficiency Measures.

5.6.2.2 **Central Parallel Piping System**

The primary design concept in a central parallel piping system is an insulated main trunk line that runs from the water heater to one or more manifolds, which then feeds use points with ½" or smaller plastic piping. The traditional central system with a single manifold must have a maximum pipe run length of 15 feet between the water heater and the manifold. With the advent of mini-manifolds, the central parallel piping system can now accommodate multiple mini-manifolds in lieu of the single central manifold, provided that a) the sum of the piping length from the water heater to all the mini-manifolds is less than 15 feet and b) all piping downstream of the mini-manifolds is nominally ½ inch or smaller.

- *Installation Criteria and Guidelines*

All applicable mandatory measures must be met. Piping between the water heater and the manifold must be insulated, and all branch piping pass the framing member from the manifold must be insulated. Piping from the manifold cannot run up to the attic and then down to points of use on the first floor. The intent of a good parallel piping design is to minimize the volume of water entrained in piping between the water heater and the end-use points, with a focus on reducing the length of the 3/4-inch or 1-inch line from the water heater to the manifold(s). To encourage reducing the pipe length between the water heater and manifold, there is a distribution system compliance credit for installations that are HERS-verified to have no more than 5 feet of piping between the water heater and the manifold(s). The manifold feeds hot water use points with 3/8 or 1/2 inch PEX tubing. (Check with enforcement agencies on the use of 3/8-inch piping in the event that it is prohibited without engineering approval.) The adopted requirements for installation guidelines are included in RA3 and RA4.

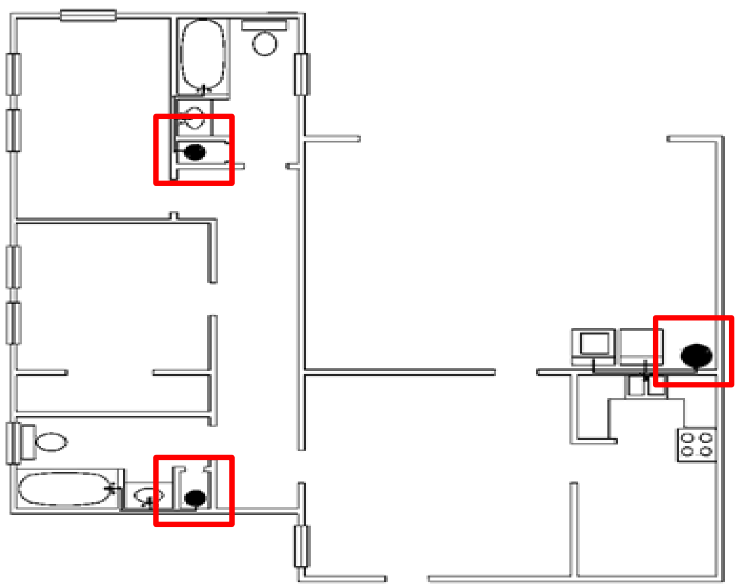
5.6.2.3 **Point of Use**

A *point-of-use distribution system design* significantly reduces the volume of water between the water heater and the hot water use points. Use of this type of system requires a combination of good architectural design (that is, water heater location adjacent to hot water use points), an indoor mechanical closet, or the use of multiple water heaters. Figure 5-10 provides an example of the latter approach where three water heaters are installed close to the use points. This system is not applicable to systems serving multiple dwelling units.

- *Installation Criteria and Guidelines*

All applicable mandatory features must be met, and the distance between the water heater and any fixture using hot water cannot exceed the length specified in Table 5-10 below. The adopted requirements for installation guidelines are included in RA3 and RA4. All water heaters and hot water fixtures must be shown on plans submitted for a local building department plan check.

Figure 5-10: Point-of-Use Distribution System



Source: 2019 CASE Initiative: Compact Hot Water Distribution

Table 5-10: Point-of-Use Distribution System

Size Nominal, Inch	Length of Pipe (feet)
3/8”	15

1/2”	10
3/4”	5

5.6.2.4 Compact Hot Water Distribution System - Basic Credit and HERS-Verified Compact Hot Water Distribution System - Expanded Credit

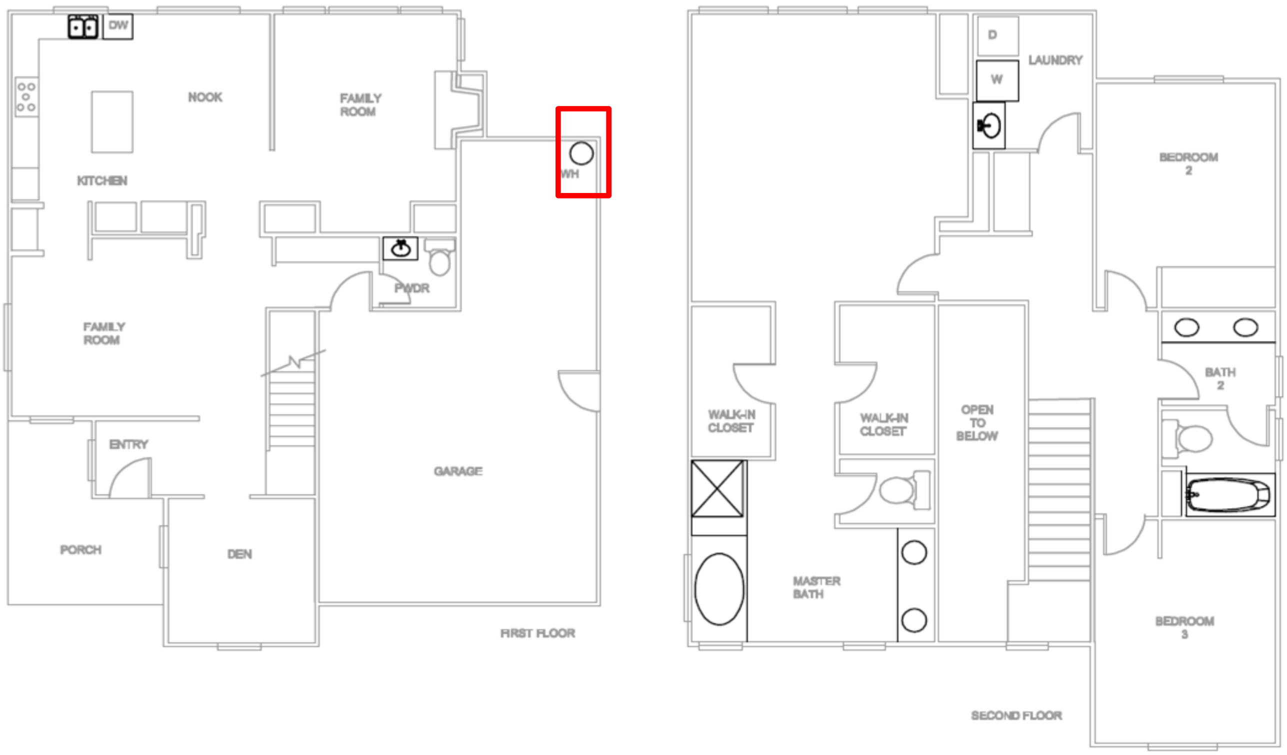
The intent of a compact hot water distribution system design is to reduce the size of the plumbing layout by bringing the water heater closer to hot water use points than is typical in standard homes. Through this process, energy and water will be saved, and homeowners will experience reduced hot water waiting times. This compliance option is applicable only to new single-family home and low-rise multifamily apartments where each dwelling unit is served by a dedicated water heater.

Installed hot water distribution systems are often much larger than needed in terms of excessive pipe length and oversized pipe diameter. A design consideration that often is overlooked is the location of the water heater relative to hot water use points. Figure 5-11 below shows a common production home layout with the water heater in the corner of the garage and hot water use points in each corner of the house.

A more effective hot water distribution system design is shown in Figure 5-12. In the figure, the location of the water heater is near the kitchen, bathrooms and laundry area. The location of hot water use points plays an integral role in achieving the benefits associated with a compact distribution system design.

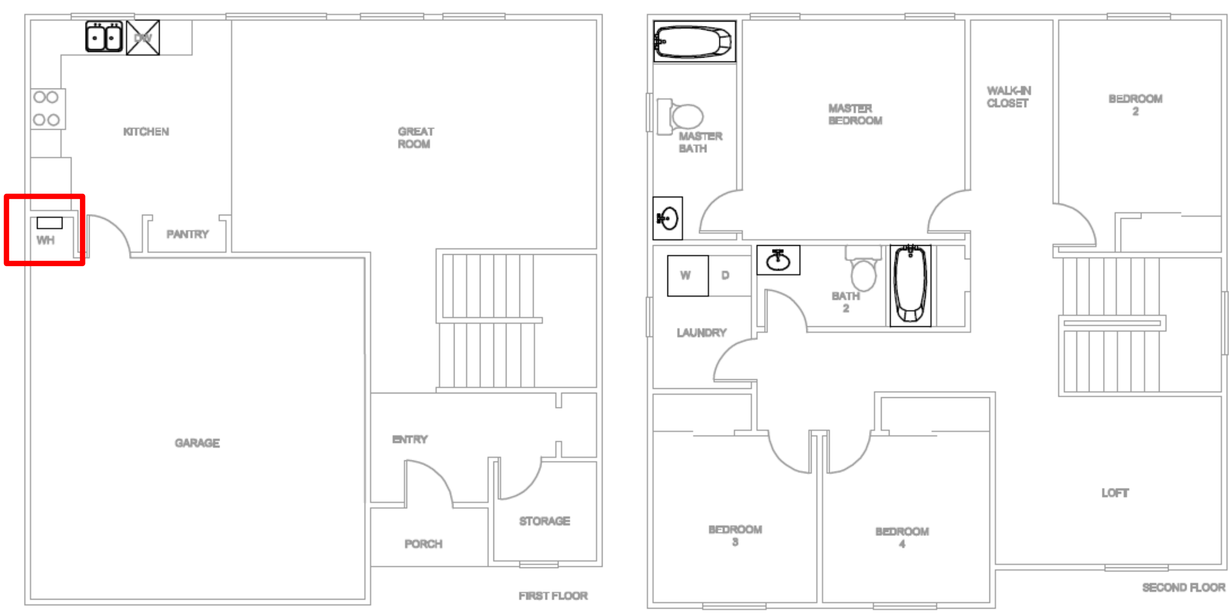
Eligible compact hot water distribution designs can generate a compliance credit using the performance approach. There are two versions of the Compact Design credit. Basic Credit does not require HERS verification, while Expanded Credit requires field verification by a HERS Rater. Qualification for both credits is based on using a plan view, straight-line measurement to calculate a “Weighted Distance” to key hot water use points including the master bath, kitchen, and remaining furthest hot water fixture from the water heater. (In some multifamily situations, there may not be another use point beyond the master bath and kitchen, resulting in the third term being ignored.) If this resulting Weighted Distance is less than a Qualification Distance (dependent on floor area, number of stories in the dwelling unit, and number of water heaters), then the plan is eligible for the Basic Credit. The Basic Credit does not require any further verification steps to secure the compliance credit. If the builder chooses to pursue an Expanded Credit, additional energy savings will be recognized under the performance method, however there are several HERS-verification requirements that must be met.

Figure 5-11: "Common" Production Home House Layout



Source: 2019 CASE Initiative: Compact Hot Water Distribution

Figure 5-12: Compact Design Distribution System



Source: 2019 CASE Initiative: Compact Hot Water Distribution

- Weighted Distance Calculation Method

Calculation of the Weighted Distance metric depends on whether it is a standard non-recirculating distribution system or a house with a recirculation distribution system.

The basis of the calculation is a plan-view, straight line measurement from the water heater to the center of the use point fixture in three rooms of the house. It is calculated using the following equation.

*Weighted Distance = x * d_MasterBath + y * d_Kitchen + z * d_FurthestThird*

where,

x, y, and z = Weighted Distance coefficients (unitless), see Table 5-11.

d_MasterBath = The plan view, straight line distance from the water heater to the furthest fixture served by that water heater in the master bathroom (feet).

d_Kitchen = The plan view, straight line distance from the water heater to the furthest fixture served by that water heater in the kitchen (feet).

d_FurthestThird = The plan view, straight line distance from the water heater to the furthest fixture served by that water heater in the furthest room[1] in the house (feet).

Table 5-10 shows the values for the coefficients depending on the type of distribution system.

Table 5-11: Weighted Distance Coefficients

Distribution System	x	y	z
Non-Recirculating	0.4	0.4	0.2
Recirculating	0.0	0.0	1.0

Note that the calculations are based on horizontal plan view distance measurements from the center of the water heater to the center of the use point in the designated location. Vertical length (For example, the vertical distance from the first to second floor) is neglected in the calculations. Use points that are located on floors different than the water heater would have their location translated to the appropriate floor.

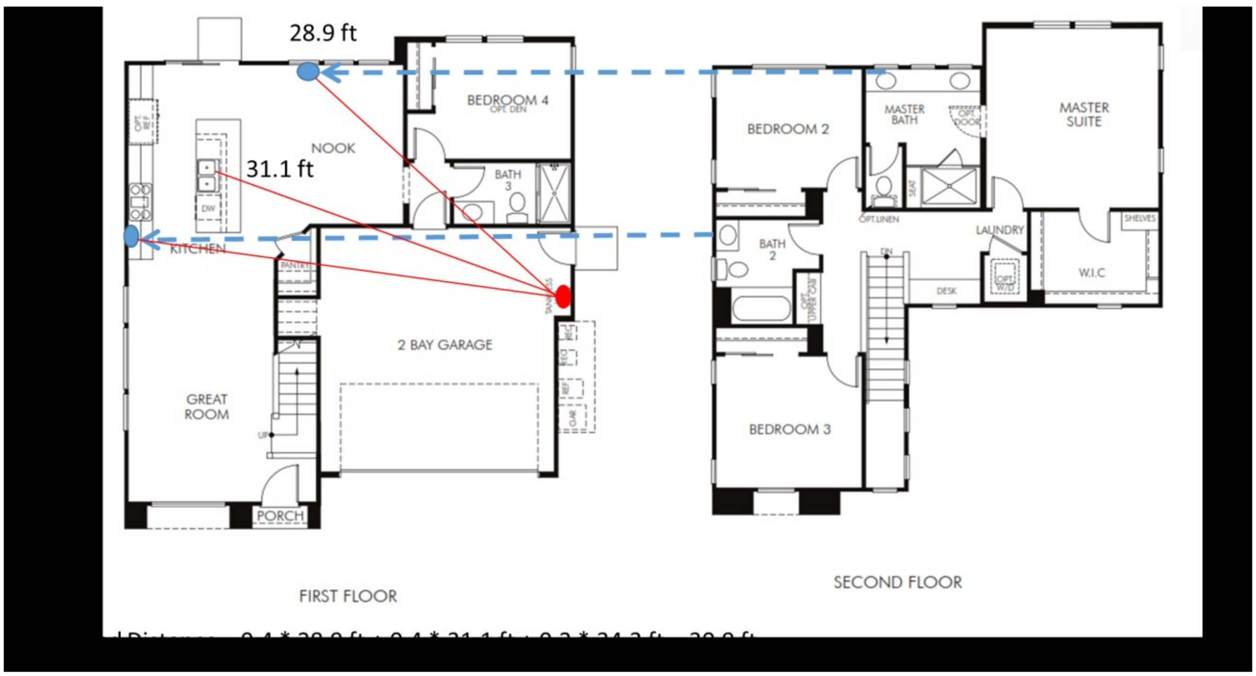
In houses with multiple water heaters, the Weighted Distance “z term” calculation is performed for each water heater to arrive at a FurthestThird term averaged over each of the “n” water heaters installed. For a non-recirculating distribution system, the resulting Weighted Distance calculation would include the Master Bath, the Kitchen and an average of the FurthestThird term for each of the installed water heaters. (For recirculating systems, similarly the FurthestThird term would represent an average across the “n” water heaters.)

[1] Because the master bath and kitchen represent unique defined use points, the d_FurthestThird fixture must not be located in either of these rooms. The laundry room is excluded and should not be used as the furthest third room. In some multifamily cases, there may not be another qualifying use point, in which case the d_FurthestThird term equals zero.

The calculated Weighted Distance input cell would be activated in the compliance software if the user selected either the Basic CHWDS Credit or the Expanded Credit.

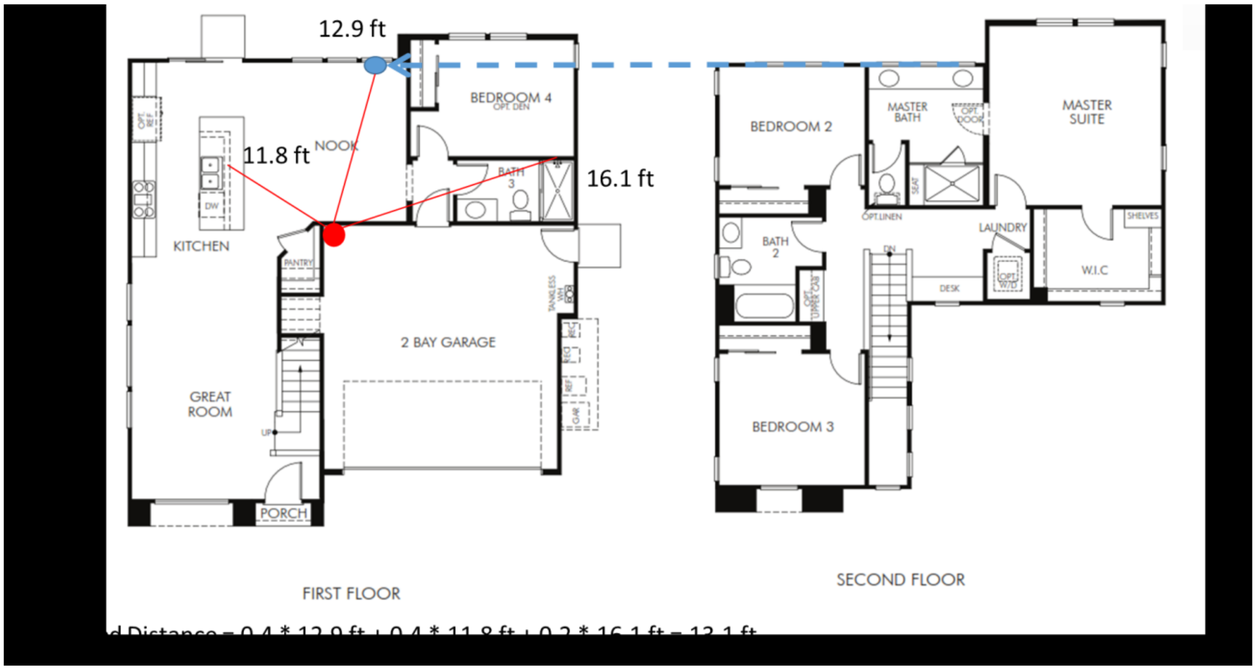
Figure 5-13 shows an example weighted distance calculation for an 1,814 square foot two-story house with a standard non-recirculating distribution system. The design locates the water heater on the exterior wall, as shown by the red oval. The dotted blue lines and ovals represent translating the fixtures on the second floor to the first floor, neglecting the vertical distance. The red lines and listed distances represent the distance from the water heater to each fixture used in the calculation. The Weighted Distance calculation for this example is shown below Figure 5-13. Figure 5-14 shows a similar calculation for a centrally located water heater.

Figure 5-13: Weighted Distance Calculation for the 1,814 Plan with a Conventionally Located Water Heater



Source: 2019 CASE Initiative: Compact Hot Water Distribution

Figure 5-14: Weighted Distance Calculation for the 1,814 Plan with a Centrally Located Water Heater



Source: 2019 CASE Initiative: Compact Hot Water Distribution

5.6.2.5 **Drain Water Heat Recovery System**

A drain water heat recovery system recovers heat that would otherwise be lost down the drain during showers, and transfers that heat back to the water heater, shower mixing valve, or both. These systems can help users comply with the water heating requirements in the Energy Standards using either the prescriptive or performance approach. To use these systems to comply with Energy Standards, the design and installation must be HERS-verified and meet the Reference Appendix RA4.4.21 requirements.

5.6.2.6 **Recirculation System – Non-Demand Control Options**

This type of distribution system encompasses all recirculation strategies that do not incorporate a demand control to minimize recirculating pump operation. Under this category, recirculation system types include uncontrolled continuous recirculation, timer control, temperature control, and time/temperature controls. The intent is to clearly distinguish between recirculation system control options that result in very little daily pump operating time (demand control strategies) and the other strategies where the pump runs either continuously, or the run time is much more uncertain. Recirculation systems are known to save water, but the energy impact can be very high in a poorly designed and/or controlled system.

Installation Criteria

All piping used to recirculate hot water must be insulated to meet the mandatory requirements. Since the standards require pipe insulation for recirculating systems, these systems are not eligible for the pipe insulation credit. For systems serving a single dwelling unit, the recirculating loop within a dwelling unit must be laid out to be within 8 feet of all hot water fixtures served by the recirculating loop. As with all recirculation systems, an intelligent loop layout (loop in-board of hot water use points) and proper insulation installation are essential in obtaining desired performance. Piping in a recirculation system cannot be run up to the attic and then down to the points of use on the first floor. The adopted requirements for installation guidelines are included in Reference Appendices RA3 and RA4.

5.6.2.7 **Recirculation System – Demand Control**

A *demand-control recirculation system* uses brief pump operation in response to a hot water demand “signal” to circulate hot water through the recirculation loop. The system must have a temperature sensor, typically located at the most remote point of the recirculation loop. Some water heaters have temperature sensors located within the water heater. The sensor provides input to the controller to terminate pump operation when the sensed temperature rises. Typical control options include manual push button controls or occupancy sensor controls installed at key use areas (bathrooms and kitchen). Push button control is preferred from a performance perspective, since it eliminates “false signals” for pump operation that an occupancy sensor could generate. The adopted requirements for installation guidelines are included in Reference Appendices RA3 and RA4.

Installation Criteria

All criteria listed for continuous recirculation systems apply. Piping in a recirculation system cannot be run up to the attic and then down to points of use on the first floor.

Pump start-up must be provided by a push button or occupancy sensor. Pump shutoff must be provided by a temperature sensing device that shuts off the pump when the temperature sensor detects no more than 10 degree rise above the initial temperature of water in the pipe or when the temperature reaches 102 degrees F. Moreover, the controls shall limit the maximum pump run time to five minutes or less.

For a system serving a single dwelling, push buttons and sensors must be installed in all locations with a sink, shower, or tub, with the exception of the laundry room.

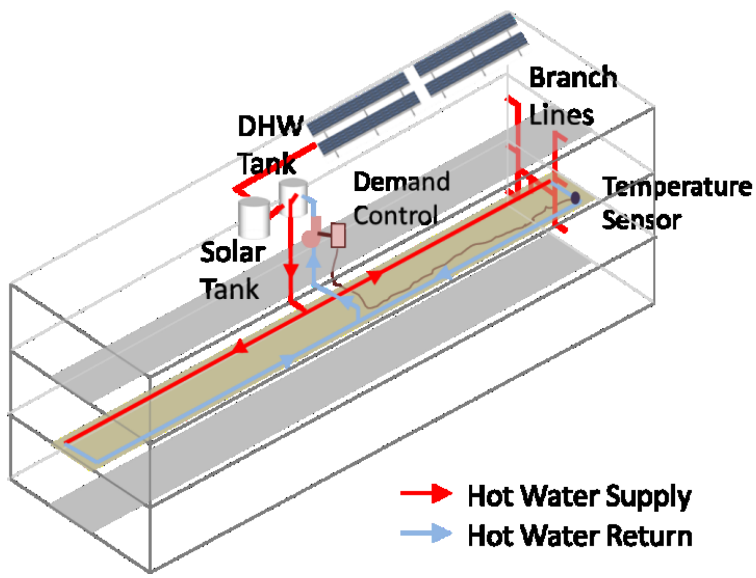
Plans must include a wiring/circuit diagram for the pump and timer/temperature-sensing device and specify whether the control system is manual (push button or flow switch) or other control means, such as an occupancy sensor.

5.6.3 Systems Serving Multiple Dwelling Units

5.6.3.1 **Multiple Dwelling Units: Central Demand Recirculation System (Standard Distribution System)**

The standard distribution system for water heaters serving multiple dwelling units incorporates recirculation loops, which bring hot water to different parts of the building, and a demand control, which automatically shuts off the recirculation pump when the recirculation flow is not needed. In summary, central recirculation systems include three components, recirculation loops, branch pipes, and pipes within dwelling units. Recirculation loops are used to bring hot water close to all dwelling units but are not expected to go through each dwelling unit. Branch pipes are used to connect pipes within dwelling units and the recirculation loops. This concept is illustrated in Figure 5-15. Designs of distribution systems within dwelling units are similar to those serving single dwelling units, described in Section 5.6.2.

Figure 5-15: Standard Multifamily Central Distribution System



Source: 2013 CASE Initiative: Multifamily Central DHW and Solar Water Heating

Demand controls for central recirculation systems are automatic control systems that control the recirculation pump operation based on measurement of hot water demand and hot water return temperatures.

5.6.3.2 Multiple Dwelling Units: Recirculation Temperature Modulation Control

A recirculation temperature modulation control shall reduce the hot water supply temperature when hot water demand is determined to be low by the control system. The control system may use a fixed control schedule or a dynamic control schedule based on measurements of hot water demand. The daily hot water supply temperature reduction, which is defined as the sum of temperature reduction by the control in each hour within a 24-hour period, shall be more than 50 degrees Fahrenheit to qualify for the energy savings credit.

Recirculation systems shall also meet the requirements of Section110.3.

5.6.3.3 Multiple Dwelling Units: Recirculation Continuous Monitoring Systems

Systems that qualify as recirculation continuous monitoring systems for domestic hot water systems serving multiple dwelling units shall record no less frequently than hourly measurements of key system operation parameters, including hot water supply temperatures, hot water return temperatures, and status of gas valve relays for water-heating equipment. The continuous monitoring system shall automatically alert building operators of abnormalities identified from monitoring results.

Recirculation systems shall also meet the requirements of Section110.3.

5.6.3.4 **Non-recirculating Water Heater System**

Multifamily buildings may also use systems without a recirculation system, if the served dwelling units are closely located so that the branch pipes between the water-heating equipment and dwelling units are relatively short. Long branch lines will lead to excessive energy and water waste.

5.7 Combined Hydronic System

5.7.1 Combined Hydronic

Combined hydronic space heating systems use a single heat source to provide space heating and domestic hot water. The current modeling of these system types is fairly simplistic, treating water heating performance separately from the space-heating function.

5.8 Showerheads

5.8.1 Certification of Showerheads and Faucets

Maximum flow rates have historically been set by the *Appliance Efficiency Regulations*, and all faucets and showerheads sold in California must meet these standards. California’s *Title 20 Appliance Efficiency Regulations* contain the maximum flow rate for showerheads and lavatory and kitchen faucets. Current flow requirements contained in the Title 24 Part 11 CALGreen Code set more efficiency levels. Installations of showerheads and faucets are mandatory under the CALGreen Code.

5.9 Solar Water Heating

The water heating calculation method allows water heating credits for solar water heaters. Solar thermal systems save energy by using renewable resources to offset the use of conventional energy sources.

For single-dwelling solar thermal systems, systems must be Solar Rating and Certification Corporation (SRCC) or IAPMO R&T approved. Accepted testing procedures include either a fully approved system with OG-300 test results or a built up system that uses the collector (OG-100) rating. For multifamily buildings, only systems with OG-100 collectors can be installed. For detailed instructions on installation of solar water heaters, refer to Reference Appendix RA4.4.21.

The database of SRCC-certified equipment is on the SRCC website at the following link:

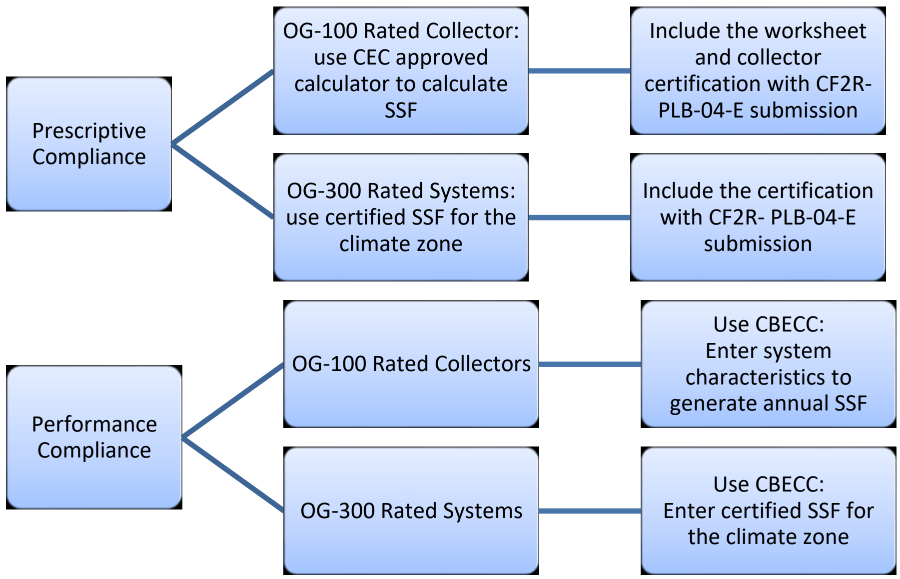
http://www.solar-rating.org/certification_listing_directory/index.html

The database of IAPMO R&T-certified equipment is on the IAPMO R&T website at the following link:

http://www.iapmort.org/Pages/SolarCertification.aspx

Figure 5-16 summarizes the process flow for demonstrating compliance via the prescriptive and performance approaches for solar thermal systems.

Figure 5-16: Compliance Process for Solar Thermal System



Regardless of the system type installed and compliance method chosen, mandatory requirements for pipe insulation apply as described in Section 5.3.5.1.

5.9.1 Solar or Recovered Energy in State Buildings

§110.3(c)6

Low-rise residential buildings constructed by the State of California shall have solar water-heating systems. The solar system shall be sized and designed to provide at least 60 percent of the energy needed for service water heating from site solar energy or recovered energy. There is an exception when buildings for which the Division of the State Architect determines that service water heating is economically or physically infeasible. See the Compliance Options section below for more information about solar water heating systems.

5.9.1.1 Solar-Ready Buildings Requirements

§150.0(r) §110.1

There are mandatory requirements for all buildings to be "solar ready." The motivation behind having solar-ready requirements is to encourage future installations of photovoltaic and solar water-heating systems, even if these systems are not installed during the time of new construction. Details on these solar ready requirements are in Chapter 7 − “Solar Ready Requirements” of this compliance manual. In summary, the elements to being solar-ready include:

1. A designated solar zone.
2. Designated conduit and plumbing paths.
3. Documentation for solar zone and paths on construction plans.
4. Adequate electric busbar and panel capacity.

5.9.2 Prescriptive Requirements for Solar Water Heating

This section discusses when solar water heating is required prescriptively for systems serving multiple-dwelling units.

5.9.2.1 **Multifamily, Motel/Hotels, and High-Rise Nonresidential**

§150.1(c)8Ciii

Solar water heating is prescriptively required for water heating systems serving multiple dwelling units, whether they are multifamily, motel/hotels, or high-rise nonresidential buildings. The minimum solar fraction depends on the climate zone (CZ). For multifamily buildings only, it also depends on whether compliant DWHR is installed. See Tables 5-12 and 5-13 below. The drain water heat recovery system shall be field verified as specified in the Reference Appendix RA3.6.9 and shall be compliant with the eligibility criteria in RA4.4.21.

Table 5-12: Required Performance of Solar Systems Installed in Motel/Hotels and High-Rise Nonresidential Buildings With Central Distribution Systems

Climate Zone	*Minimum Solar Fraction*
1-9	0.20
10-16	0.35

Table 5-13: Required Performance of Solar Systems Installed in Multifamily Buildings With Central Distribution Systems

Climate Zone	*Minimum Solar Fraction if no DWHR*	*Minimum Solar Fraction if Compliant DWHR Installed*
1-9	0.20	0.15
10-16	0.35	0.30

The regulations do not limit the solar water heating equipment or system type as long as they are SRCC-certified and meet the orientation, tilt, and shading requirement specified in Reference Appendix RA4.4. Installation of a solar water heating system exempts multifamily buildings from needing to set aside solar zone for future solar PV and solar water heating installation as specified in §110.10(b)1B. The following paragraphs offer some high-level design considerations for multifamily building solar water heating systems.

A high-priority factor for solar water heating system design is component sizing. Proper sizing of the solar collectors and solar tank ensures that the system takes full advantage of the sun's energy while avoiding the problem of overheating. While the issue of freeze protection has been widely explored (development of various solar water heating system types is a reflection of this evolution), the issue of overheating is often not considered as serious as it should be, especially for climate conditions with relatively high solar insolation level such as California. This is especially critical for multifamily-sized systems, due to load variability.

The solar water heating sizing requirements for the standards are conservative. For example, the highest solar fraction requirement in the *2013 Energy Standards* was at 50 percent. Stakeholders further suggested that industry standard sizing for an active system is 1.5 square feet of collector area per gallon capacity of the solar storage tank. For more detailed guidance and best practices, there are many publicly available industry design guidelines. Two such resources developed by/in association with government agencies are:

1. *Building America Best Practices Series: Solar Thermal and Photovoltaic Systems* http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/41085.pdf.
2. *California Solar Initiative – Thermal: Program Handbook* http://www.cpuc.ca.gov/NR/rdonlyres/CB11B92E-DFFF-477B-BFA9-F1F04906F9F9/0/CSIThermal_Handbook201209.pdf.

Because of the solar water heating requirements and the prevalence of recirculation hot water systems in multifamily buildings, it is essential to emphasize the importance of proper integration between the hot water recirculation system and the solar water heating system. Industry stakeholders recommended the recirculation hot water return to be connected back to the system *downstream* of the solar storage tank. This eliminates the unnecessary wasted energy used to heat up water routed back from the recirculation loop that may have been sitting in the solar water tank if no draw has occurred over a prolonged period.

Another design consideration is the layout and placement of collectors and solar tank. The idea here, similar to the discussions on recirculation system design in Section 5.6, is to minimize the length of plumbing, thus reducing pipe surface areas susceptible to heat loss and piping materials needed. This calls for the shortest feasible distance between the collectors themselves; furthermore, since solar tanks are typically plumbed in series just upstream of the conventional/auxiliary water heating equipment, the distance between collectors and solar tank should also be as short as possible.

5.9.3 Performance Approach Compliance for Solar Water Heating

Solar water heating systems with a solar fraction higher than the specified prescriptive minimum can be used as a tradeoff under the performance approach. Figure 5-14 shows the compliance process needed for demonstrating compliance with solar water heating modeling. The CBECC-Res API integrates the capability of calculating an annual solar fraction. Users now input collector and system component specifications to calculate a corresponding solar fraction for the proposed system.

5.10 Swimming Pool and Spa Heating

5.10.1 Swimming Pool and Spa Types

The Energy Standards include many additional requirements for residential swimming pool filtration equipment, which affect pump selection and flow rate, piping and fittings, and filter selection. These standards are designed to reduce the energy used to filter and maintain the clarity and sanitation of pool water.

5.10.2 Mandatory Requirements for Pools and Spas

Before any pool or spa heating system or equipment may be installed, the manufacturer must certify to the Energy Commission that the system or equipment complies with §110.4 and §110.5. The requirements include minimum heating efficiency according to the *Appliance Efficiency Regulations*, an on-off switch outside the heater, permanent and weatherproof operating instructions, no continuous pilot light, and no electric resistance heating. (See exceptions below.)

§110.5

Pool and spa heaters may not have continuously burning pilot lights.

§110.4

Outdoor pools and spas with gas or electric heaters shall have a cover installed. The cover should be fitted and installed during the final inspection.

There are two exceptions for electric heaters, which may be installed for:

1. Listed package units with fully insulated enclosures (for example, hot tubs), and with tight-fitting covers, insulated to at least R-6.
2. Pools or spas getting 60 percent or more of the annual heating from site solar energy or recovered energy.

5.10.2.1 **Pool Pump Requirements**

For maximum energy efficiency, pool filtration should be operated at the lowest possible flow rate for a period that provides sufficient water turnover for clarity and sanitation. Auxiliary pool loads that require high flow rates, such as spas, pool cleaners, and water features, should be operated separately from the filtration to allow the filtration flow rate to be kept to a minimum.

§150.0(p)1

All pumps and pump motors shall comply with the specifications of the *Appliance Efficiency Regulations*.

The pool filtration flow rate may not be greater than the rate needed to turn over the pool water volume in 6 hours or 36 gallon per minute (gpm), whichever is greater. This means that for pools of less than 13,000 gallons, the pump must be sized to have a flow rate of less than 36 gpm, and for pools of greater than 13,000 gallons, the pump must be sized using the following equation:

$$\text{Max Flow Rate (gpm)} = \frac{\text{Pool Volume (gallons)}}{\text{360min.}}$$

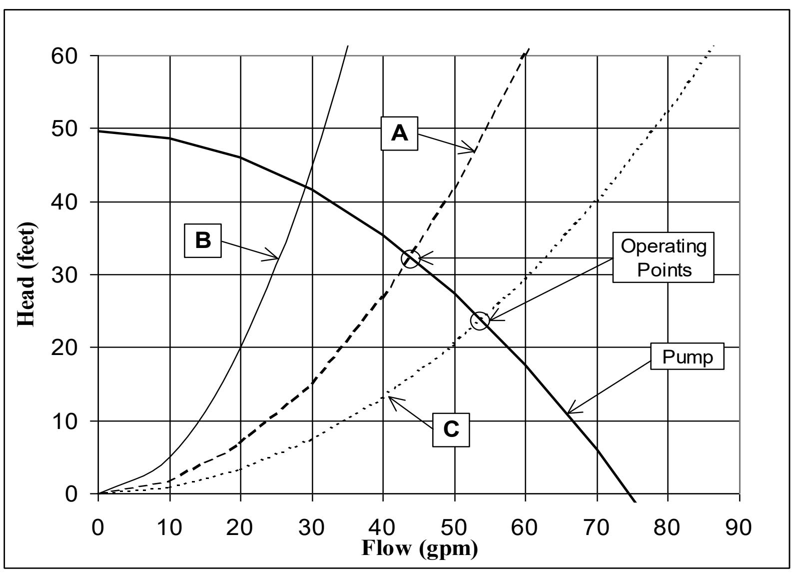
These are maximum flow rates. Lower flow rates and longer filtration times are encouraged and will result in added energy savings.

Pools with auxiliary pool loads must use either a multispeed pump or a separate pump for each auxiliary pool load. For example, if a spa shares the pool filtration system, either a multispeed pump must be used or a separate pump must be provided to operate the spa. If the pool system can be served by one pump of less than 1 total horsepower (hp) in capacity, the pump may be single-speed.

Filtration pump motors with a capacity of 1 hp or more must be multispeed.

All pool pumps sold in California must be tested and listed with the Energy Commission according to the *Appliance Efficiency Regulations*. Pump manufacturers must list flow rate, power, and energy factor at each of three system curves. (See Figure 5-17.) For pools equal to or less than 17,000 gallons, a pump must be chosen such that the flow rate listed for Curve A is less than the 6-hour turnover rate. For pools greater than 17,000 gallons, a pump must be chosen such that the listed flow rate at Curve C is less than the 6-hour turnover rate.

Figure 5-17: System Test Curves



5.10.2.2 **Pool Pump Controls**

Pool controls are a critical element of energy efficient pool design. Modern pool controls allow for auxiliary loads such as cleaning systems, solar heating, and temporary water features without compromising energy savings.

§110.4(b)

A time switch or similar control mechanism must be installed as part of the pool water circulation control system that will allow all pumps to be set or programmed to run only during the off-peak electric demand period and for the minimum time necessary to maintain the water in the condition required by applicable public health standards.

§150.0(p)1

Multispeed pumps must have controls that default to the filtration flow rate when no auxiliary pool loads are operating. The controls must also default to the filtration flow rate setting within 24 hours and must have a temporary override capability for servicing.

5.10.2.3 **Pool Pipe, Filter, and Valve Requirements**

Correct sizing of piping, filters, and valves reduces overall system head, reduces noise and wear, and increases energy efficiency. Other mandatory requirements include leading straight pipe into the pump, directional inlets for mixing, and piping to allow for future solar installations.

§110.4(b) and §150.0(p)2

Pool piping must be sized according to the maximum flow rate needed for all auxiliary loads. The maximum velocity allowed is 8 feet per second (fps) in the return line and 6 fps in the suction line. Table 5-14 shows the minimum pipe sizes required by pool volume based on a 6-hour turnover filtration flow rate. These pipe sizes would need to be increased if there are auxiliary loads that operate at greater than the filtration flow rate. Conversely, they could be reduced if the pump is sized for greater than a 6-hour turnover filtration flow rate.

Table 5-14: Hour Turnover Pipe Sizing

Pool Volume (gallons)	*Pool Volume (gallons)*	*Minimum Pipe Diameter (in)*	*Minimum Pipe Diameter (in)*
Min	Max	Return	Suction
-	13,000	1.5	1.5
13,000	17,000	1.5	2.0
17,000	21,000	2.0	2.0
21,000	30,000	2.0	2.5
30,000	42,000	2.5	3.0
42,000	48,000	3.0	3.0
48,000	65,000	3.0	3.5

There must be a length of straight pipe that is greater than or equal to at least 4 times the pipe diameters installed before the pump. That is, for a 2-inch suction pump, there must be at least 8 inches of straight pipe before the pump strainer basket.

Traditional hard 90º elbows are not allowed. All elbows must be sweep elbows or a type of elbow that has a pressure drop less than the pressure drop of straight pipe with a length of 30 times the pipe diameters. For example, a 2-inch elbow must have a pressure drop less than a 5-foot length of a 2-inch straight pipe.

Field verification of sweep elbows may be performed by checking that the distance “w” of the installed sweep elbow is greater than that for a hard 90 elbow. (Refer to Figure 5-16.) The difference in measurement between the radial edge of one sleeve to the perpendicular side of the elbow is found to be distinct between sweep elbows and hard 90s. There is sufficient difference in distance “w” such that all sweep elbows exceed the minimum values listed in Table 5-15.

Figure 5-18 below illustrates “w” the dimension between the elbow sleeves, and Table 5-14 shows the minimum distances “w” for an acceptable sweep elbow.

Figure 5-18: Measuring “W” at the Pool Site

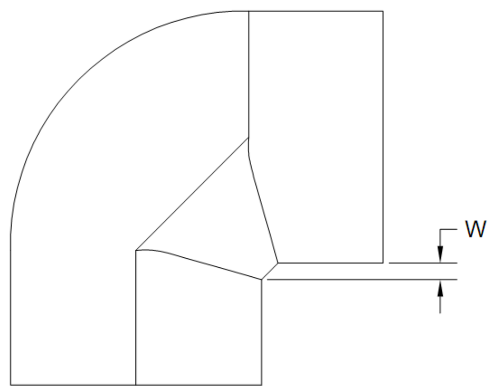


Table 5-15: Pool Site Measurement for Sweep Elbows

Pipe Diameter	*Minimum W (inch)*
1.5	3/8
2	1/2
2.5	5/8
3	3/4
4	1

Filters shall be sized using NSF/ANSI 50 based on the maximum flow rate through the filter. The filter factors that must be used are in ft²/gpm:

a. Cartridge 0.375
b. Sand 15
c. Diatomaceous Earth 2

Backwash valves must be sized to the diameter of the return pipe or 2 inches, whichever is greater. Multiport backwash valves have a high-pressure drop and are discouraged. Low-loss slide and multiple three-way valves can provide significant savings.

The pool must have directional inlets to adequately mix the pool water.

If a pool does not use solar water heating, piping must be installed to accommodate any future installation. Contractors can choose one of three options to allow for the future addition of solar heating equipment:

1. Provide at least 36 inches of pipe between the filter and the heater to allow for the future addition of solar heating equipment.
2. Plumb separate suction and return lines to the pool dedicated to future solar heating.
3. Install built-up or built-in connections for future piping to solar water heating. An example of this would be a capped off tee fitting.

Example 5-12 − Pool Covers

Question:

My pool has both a solar heater and a gas heater. Do I need to install a pool cover?

Answer:

Yes. A cover is required for all pools with gas or electric heaters, regardless of whether they also have a solar heater.

Example 5-13 − Pool Pump

Question:

I have a 25,000-gallon pool and want to use a two-speed pump with a Curve C flow rate of 79 gpm on high speed and 39 gpm on low speed. Is this okay, and what size piping must I installed?

Answer:

The maximum filtration flow rate for a 25,000-gallon pool is 69 gpm by using equation [Max Flow Rate (gpm) = Pool Volume (gallons) / 360 minutes], so the pump is adequately sized, as long as a control is installed to operate the pump on low-speed for filtration. The maximum pipe size must be based on the maximum flow rate of 79 gpm. Referencing Table 5-9, you must use 2.5-inch suction and 2-inch return piping.

5.11 Compliance and Enforcement

Chapter 2 of this compliance manual addresses the compliance and enforcement process generally and discusses the roles and responsibilities of each of the major parties, the compliance forms, and the process for field verification and/or diagnostic testing. This section highlights compliance enforcement issues for water heating systems.

5.11.1 Design Review

The design review verifies that the certificate of compliance matches the plans and specifications for the proposed building. The certificate of compliance has a section where special features are listed. The following are water heating features that should be listed in this section of the certificate of compliance:

1. Any system type other than one water heater per dwelling unit
2. Non-NAECA large water heater performance
3. Indirect water heater performance
4. Instantaneous gas water heater performance
5. Distribution system type and controls
6. Solar system
7. Combined hydronic system

If any of these measures are called out on the certificate of compliance, special attention should be given to make sure that identical information is located on the plan set. Highlighting key concerns or adding notes will allow field inspectors to quickly catch any measures that should be installed that made a significant difference in compliance.

5.11.2 Field Inspection

During construction, the contractor or the specialty contractors or both complete the necessary sections of the certificate of installation. For water heating, there is only one section to be completed where information about the installed water heating system is entered if complying prescriptively with the installation of a gas instantaneous, gas storage above 55 gallons, or a NEEA Tier-3 rated heat pump water heater. Additional documents will be needed to comply prescriptively for all other options. (See Appendix A.)

Inspectors should check that the number and types of water heating systems indicated on the installation certificates match the approved certificate of compliance. The distribution system is also significant and must correspond to plan specifications.

5.11.3 HERS Field Verification and/or Diagnostic Testing

5.11.3.1 **Single Family and Multifamily With Individual Dwelling Water Heaters**

HERS verification is required for all hot water distribution types that include options for field verification. The first type is alternative designs to conventional distribution systems that include parallel piping, demand recirculation, and automatic and manual on-demand recirculation. The second type is for compact distribution systems earning the expanded credit, which can be used only when verified by field verification. For all of the cases where HERS verification is required, the HERS Rater must verify that the eligibility requirements in RA3.6 for the specific system are met.

In addition, HERS-verified drain water heat recovery is an option for prescriptive compliance and as a compliance credit for the performance approach.

As previously described in this chapter, if a user wishes to comply prescriptively with the Energy Standards and installs a minimally compliant gas storage water heater (55 gallons or less), then either the compact distribution design (expanded credit) or a compliant drain water heat recovery system must be installed, both of which require HERS verification.

5.11.3.2 Multifamily With Central Water Heating Systems

The HERS verification for water heating that applies to central domestic hot water recirculation systems in multifamily buildings is the verification of multiple distribution lines for central recirculation systems, and the verification of drain water heat recovery systems.

5.12 Glossary/Reference

5.12.1 General Glossary/Reference for Water Heating

Relevant terms are defined in Reference Joint Appendix JA1.

The following are terms that are either not defined in JA1 or expansions to the Appendix I definitions.

A. ***External tank insulation*** can be applied to the exterior of storage type water heater tanks. When installed, water heater insulation should be applied to completely cover the exterior of the water heater but should not conceal controls or access ports to burners, obstruct combustion air openings, or interfere in any way with safe water heater operation. Insulation of top and bottom surfaces is not necessary.

B. ***Recovery energy*** is the energy used to heat water.

C. ***Recovery load*** is the load on the water heater due to hot water end uses and distribution losses.

D. ***Single dwelling unit*** is a residence with a dedicated water heater. Single dwelling units can be a single-family home or an individual dwelling unit in a multifamily building, as long as each unit has a dedicated water heater.

E. ***Thermal efficiency*** is defined in the *Appliance Efficiency Regulations* as a measure of the percentage of heat from the combustion of gas or oil that is transferred to the hot water as determined using the applicable test methods.

F. ***Uniform energy factor (UEF)*** of water heater is the uniform energy descriptor used to describe the overall water heater efficiency as determined using the applicable test method in the *Appliance Efficiency Regulations*. Typical gas storage water heaters have typical UEFs of about 0.60-0.76, electric storage water heaters approximately 0.90, and gas instantaneous units approximately 0.80-0.94. It replaced the “energy factor” metric previously used for residential water heaters.

5.12.2 General Glossary/Reference for Swimming Pool and Spa

A. ***Flow rate*** is the volume of water flowing through the filtration system in a given time, usually measured in gallons per minute.

B. ***Nameplate power*** is the motor horsepower (hp) listed on the nameplate and the horsepower by which a pump is typically sold.

C. ***Pool pumps*** usually come with a leaf strainer before the impeller. The pumps contain an impeller to accelerate the water through the housing. The motors for residential pumps are included in the pump purchase but can be replaced separately. The pumps increase the "head" and "flow" of the water. Head is necessary to move fluid through pipes, drains, and inlets, push water through filters and heaters, and project it through fountains and jets. Flow is the movement of the water used to maintain efficient filtering, heating, and sanitation for the pool.

D. ***Return*** refers to the water in the filtration system returning to the pool. The return lines or return side, relative to the pump, can also be defined as the pressure lines or the pressure side of the pump. Water in the returns is delivered back to the pool at the pool inlets.

E. ***Service factor.*** The service factor rating indicates the percentage above nameplate horsepower at which a pump motor may operate continuously when full-rated voltage is applied and ambient temperature does not exceed the motor rating. Full-rated pool motor service factors can be as high as 1.65. A 1.5 hp pump with a 1.65 service factor produces 2.475 hp (total hp) at the maximum service factor point.

F. ***Suction*** created by the pump is how the pool water gets from the skimmers and drains to the filtration system. The suction side and suction lines refer to the vacuum side of the pump. It is at negative atmospheric pressure relative to the pool surface.

G. ***Total dynamic head (TDH)*** refers to the sum of all the friction losses and pressure drops in the filtration system from the pools drains and skimmers to the returns. It is a measure of the system's total pressure drop and is given in units of either psi or feet of water column (sometimes referred to as "feet" or "feet of head").

H. ***Total motor power*** or T-hp, refers to the product of the nameplate power and the service factor of a motor used on a pool pump.

I. ***Turnover*** is the act of filtering one volume of the pool.

J. ***Turnover time*** (also called *turnover rate*) is the time required to circulate the entire volume of water in the pool or spa through the filter. For example, a turnover time of 6 hours means an entire volume of water equal to that of the pool will be passed through a filter system in six hours.

$$Turnover\ Time = \frac{Volume\ of\ the\ pool}{Flow\ Rate}$$