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5. Water Heating Requirements

5.1 Overview

5.1.1 Water Heating Energy

Water heating energy use is an important end use in low-rise residential buildings. Roughly 90 percent of California households use natural gas fueled water heaters, typically atmospheric gas storage units with tank volumes of 40 to 50 gallons. Roughly 6% of households use electricity to heat water and a few percent use propane (liquefied petroleum gas, or LPG). Standby loss associated with the center flue design represents about 25-35% of a typical gas storage water heater system's annual energy use.

The electricity generation system is comprised of a variety of generation plants including fossil fueled (natural gas and coal), nuclear, hydroelectric, solar, and wind. Approximately two-thirds of the source energy used to produce the electricity is lost in the generation, transmission, and distribution processes. Historically this has played into Title 24's decision to base the water heating budget on the more "source energy" efficient gas water heating system. The Standards require water heating systems to account for hourly usage impacts of the overall efficiency of each fuel type in the form of Time Dependent Valuation (TDV). Natural gas fired system are used as the reference TDV for water heating, except where natural gas is not available which in those cases, in which cases propane is the reference case. Since electric TDV is much higher (per unit of energy content) than gas, electric resistance water heating is essentially precluded unless it is used in conjunction with an adequately sized solar water heating system. One electrical option which can comply with the standards is heat pump water heaters.

Figure 5-1 below shows the energy flows that constitute water heating energy usage. On the right hand side, hot water draws at the end use points represents the useful energy consumed. Hot water that is actually used typically represents the largest fraction of water heating energy use, although in situations with very small draws, standby losses from the typical gas storage water heater can exceed the end use. Distribution system associated energy impacts vary widely based on the type of system, quality of installation, house design, and hot water use patterns. Typical single family water heating system distribution losses may amount to up to 30 percent of energy consumed, while compact single family distribution systems may be less than 10 percent. Multifamily water heating system distribution losses can exceed 30 percent. The heating device must meet this recovery load (end use plus distribution losses) minus any contribution from auxiliary heat inputs, such as a solar thermal system. Total building water heating energy use is comprised of the end use, heater inefficiencies, standby loss, and distribution system inefficiencies.

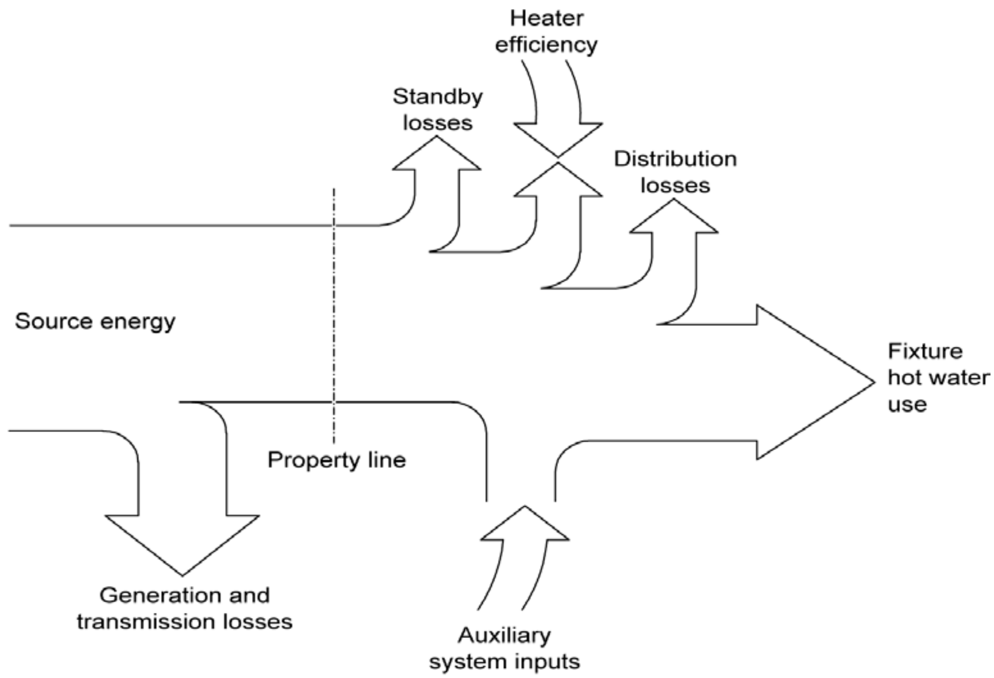


Figure 5-1 – Water Heating Energy Flow Representation

5.1.2 What's New for 2013

The key changes in water heating code from 2013 are listed below and are distinguished between two cases: one or more water heaters serving a single dwelling unit, and a central multi-family design where one or more water heaters serves many dwelling units:

One or more water heating systems serving a single dwelling unit (includes single family homes and dedicated water heating systems serving a single dwelling unit in multi-family and hotel/motel buildings).

1. New Mandatory Requirements:
    a. A 120 V electrical receptacle that is within three feet of the water heater and accessible to the water heater with no obstructions; and,
    b. A Category III or IV vent, or a Type B vent with straight pipe between the outside termination and the space where the water heater is installed; and,
    c. 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, and,
    d. A gas supply line with a capacity of to provide at least 200,000 Btu/hr to the water heater.

2. New Prescriptive Requirements:

a. Increased solar water heating requirement for electric resistance water heating systems. Under the 2013 standards, the minimum solar thermal water heating system size has increased from a solar savings fraction (SSF) of 25% to at least 50%.

3. New Performance Compliance Options:

a. The Point of Use Distribution multiplier now applies to systems with water heaters no more than (5 feet of ¾ inch), (10 feet of ½ inch), or (15 feet of 3/8 inch) of pipe from any point of use are acceptable alternatives. Distances are measured in plan view, allowing for water heaters on either the first or second floor to serve points located on the floor above or below, hence ignoring the direct vertical length of pipe from the water heater. This measure requires HERS verification.

b. HERS verified Compact Distribution System credit has been added as a new compliance option credit. The furthest hot water use point from the water heater must be field-measured and shown to be within a prescribed distance from the water heater. This measure requires HERS verification

c. Additional optional HERS verification elements have been added to offer credits for verified quality pipe insulation installation on both recirculating and non-recirculating distribution systems. This measure requires HERS verification.

d. Central home run manifold systems located within 5 feet of the water heater will receive a small compliance credit. This measure requires HERS verification.

Multi-family central distribution systems (One or more central water heaters serving multiple dwelling units):

1. New Mandatory Requirements:

a. Dwelling unit pipe insulation is now required on all hot water distribution piping greater than ¾ inch diameter, as well as all piping from the water heater to the kitchen. For central multi-family systems, all piping in the recirculation loop must be insulated. This requirement applies to the distribution to each dwelling unit.

2. New Prescriptive Requirements:

a. Demand recirculation controls are the default basis of the performance energy budget for buildings with central recirculation systems.

b. Solar water heating is required for all climate zones. The required solar savings fractions are either 20% or 35%, depending on the climate zone.

c. Water heating recirculation systems are required to be designed with two recirculation loops. This measure must be HERS verified to ensure that two sets of recirculation loops are put in place from either the same or separate water heating equipment. Buildings with 8 units or less are not required to meet this requirement

3. New Performance Compliance Options:

While demand recirculation controls are the basis of the performance energy budget, both temperature modulation controls and time clock controls can be used for performance compliance. Using temperature modulation controls will require additional energy efficiency measures to offset higher energy consumption due to higher recirculation loop pipe heat loss than those for demand controls. Using time clock controls will require even more efficiency

measures to offset relatively high heat losses from recirculation loops using this control strategy.

More detailed recirculation piping system design information, including number of recirculation loops, pipe lengths, diameters, and locations, is required to properly calculate energy consumption due to recirculation pipe heat loss. The prescriptive requirement is to install two recirculation loops, connected to the same or separate water heating equipment. These installation requirements are not applicable to central system serving 8 or fewer units. If just one recirculation loop is used, pipes need to be sized according to hot water demand of all dwelling units. As a result, larger pipes than those in dual loop systems have to be installed, which lead to larger pipe surface area and higher heat loss. Dual recirculation loop designs have to be verified by a HERS rater in order to receive the compliance credit. Systems with more than two recirculation loops will NOT be given additional compliance credit.

In addition to the dual recirculation loop requirement, the Standard also incorporates a performance calculation method to verify user input of recirculation designs. Energy budget of the recirculation system is determined based on an optimized recirculation system design with two recirculation loops and optimized pipe routing. The performance calculation method also generates a default design based on best practices, which is not as good as the optimized design. Both the optimized design and the default design are generated according to building characteristics such as floor area, number of dwelling units, and number of storied. The default design can be used for compliance to avoid providing detailed recirculation system design information. However, note that the default design uses more energy than what is established by the energy budget and, therefore, requires other efficiency measures to make up the difference. A dual loop design with HERS verification is the only possible compliance option to match the performance of the optimized design, For all other user-input designs, the total pipe surface area will be adjusted to match that of the default (best practice) design, if it is smaller.

5.2 Water Heating Equipment

5.2.1 Water Heater Types

There are several different types of equipment used for producing domestic hot water. Any water heater type used for compliance must be recognized under the appliance regulations. The most commonly used water heater for single family homes is either small storage gas or instantaneous (tankless) gas units. For multi-family buildings, two options are commonly used: either one or more commercial storage water heaters or one or more boilers coupled with a storage tank to serve the entire building. Alternatively, individual water heaters are installed in each dwelling unit (similar to single family).

1. Small Storage Gas Water Heaters

Storage water heater means a water heater that heats and stores water within the appliance at a thermostatically-controlled temperature for delivery on demand, and that has an input less than 4,000 Btu per hour per gallon of stored water.

Small Storage Water Heater is defined as a water heater that is a gas storage water heater with an input of 75,000 Btu per hour or less, an oil storage water heater with an input of

105,000 Btu per hour or less, an electric storage water heater with an input of 12 kW or less. All small storage water heaters are rated using an Energy Factor. This value represents the combination of the units firing efficiency and standby loss over a 24 hour period.

Application Issues

In California, a vast majority of small water heaters are atmospheric natural gas water heaters, despite the fact that they are relatively inefficient due to high standby losses. Historically these units are the cheapest to install and operate in California. Due to observed California hot water loads that are considerably lower than assumed in the Energy Factor rating test the typical California performance of small storage water heaters is lower than their ratings.

2. Large Storage Gas

Large Storage Gas is a storage gas water heater with input capacity greater than 75,000 Btu/h. They are rated with an AFUE and either a total standby loss numeric value or a percent standby loss..

Application Issues

These units offer higher capacity and generally greater storage volume, and are therefore better suited for high load situations, including combined hydronic space and water heating applications. Many of the products available in this category are higher efficiency. These units typically require an electrical connection for controls and combustion air blowers.

3. Small Storage Electric

A Storage Electric water heater is an electric water heater designed to heat and store water at less than 180°F. Water temperature is controlled with a thermostat. Storage electric water heaters have a manufacturer's specified storage capacity of at least two gallons.

Application Issues

Storage electric water heaters represent less than 6% of the installed residential water heaters in California, and are often found in areas where natural gas is unavailable. For most of the state, relatively inexpensive natural gas is a much more economical water heating approach for the consumer.

4. Storage Heat Pump

A Storage Heat Pump is an electric water heater that uses a compressor to transfer thermal energy from one temperature level to a higher temperature level for the purpose of heating water. It includes all necessary auxiliary equipment such as fans, storage tanks, pumps or controls.

Application Issues

Energy Factors for heat pump water heaters are found in the Energy Commission's Appliance Database under Certified Water Heaters. In recent years, heat pump water heaters have started to gain a greater national presence, since they offer roughly 50% savings relative to a standard storage electric water heater. None of the prescriptive packages allow the use of heat pump water heaters but they can be applied for water heating using the performance approach.

Heat pump water heater performance, more than other water heater types, is sensitive to a variety of factors including: operating mode and set point, hot water loads and load intensity (short, intense draws reduce efficiency), climate, and unit location (environment temperature). Most manufacturers suggest that the unit be installed in space with a volume of at least 700 ft^3 to provide a sufficient quantity of air to allow for more efficient heat pump operation. Indoor located units may offer space conditioning benefits in hotter climate areas, although noise may be a potential concern.

5. Instantaneous (Tankless) Gas

Instantaneous gas water heaters are defined as a water heater that has an input rating of at least 4,000 Btu per hour per gallon of stored water. These units, commonly referred to as gas tankless water heaters, operate their burner in response to water flow heating the water flowing through the heat exchanger (typical volumes around 0.5 gallons). The main efficiency benefit of associated with these units is the elimination of standby losses common to storage water heaters. Virtually all of these units require an electrical connection for controls and combustion air blower.

Application Issues

Instantaneous units are recognized as being optimistically rated by the Energy Factor test, due to the test procedures specification of only six draws during the 24 hour test period. Field data suggests a ~10% degradation in performance due to real world loads and draw patterns. Although performance is sensitive to the number of draw events and average draw volume size, in general instantaneous efficiency is much less sensitive to daily hot water load than storage water heaters. Installation issues related to instantaneous units include the need for a larger gas line (typical input ratings of 140 – 200 kBtu/hr), alternative venting systems, and electrical connection. For retrofits, this can be a major added cost.

Instantaneous water heaters have minimum flow rates for initiating burner firing, resulting in some low flow rate hot water draws not being satisfied. In addition, firing from a cold start requires an additional 15-30 seconds of delay before fully heated water leaves the unit. This has implications in terms of water waste and occupant satisfaction. Care must also be taken in matching tankless unit with recirculation pumps (pumps must be sized to overcome high unit pressure drop) and solar systems (tankless firing becomes intermittent as inlet temperature approach the setpoint temperature). Finally, maintenance of instantaneous units is more critical than for a conventional water heater, especially in areas with hard supply water, due to potential heat exchanger scaling problems. Despite these potential issues, instantaneous sales have increased dramatically over the past ten years, with a recent study suggesting that 25% of new California homes have gas instantaneous water heaters.

Instantaneous water heaters are occasionally installed with small electric storage buffer tanks either internally or downstream of the instantaneous unit to mitigate the potential for cold water sandwich effects, an effect which may cause fluctuating delivery temperatures. If a buffer tank is installed the buffer tank must be modeled as a separate electric water heater. If the buffer tank is installed downstream of the instantaneous system the buffer tank must be listed in the CEC Appliance Directory and the listed wattage of the unit will be entered into the compliance software. For instantaneous units with integral buffer tanks the rated wattage on the manufactures cut sheet should be used.

6. Instantaneous (Tankless) Electric

An Instantaneous Electric water heater is an electric water heater controlled automatically by a thermostat, with a manufacturer's specified storage capacity of less than 2 gallons.

Application Issues

Instantaneous electric 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.

Instantaneous electric units offer several advantages over electric storage water heaters: smaller size, reduction in standby losses, and ability to locate remotely resulting in reduced distribution losses. Countering this is the need for upsized electrical service to handle the demands (up to 30 kW) associated with instantaneous heating of the water. In areas without natural gas, these systems may provide some operating cost savings, however for the majority of California, the abundance and low cost of natural gas creates a difficult environment for this technology to succeed.

7. Hot Water Supply Boiler

A hot water supply boiler is industrial water heating equipment with a heat input rate from 300 kBtu/hr to 12,500 kBtu/hr and at least 4,000 Btu/hr per gallon of stored water. A hot water boiler should have either the temperature and pressure control necessary for heating potable water for purposes other than space heating, or the boiler manufacturer’s literature should indicate that the boilers’ intended uses 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 Standards in effect.

Application Issues

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.

5.2.2 Mandatory Requirements for Water Heaters

8. Equipment Certification

§110.3(a)

Manufacturers must certify that their products comply with the Appliance Efficiency Regulations at the time of manufacture. Regulated equipment which applies to all of the aforementioned system types in Section 5.2.1 must be listed in the California Energy Commission appliance database.

9. Equipment Efficiency

§110.3(b), §110.1

Small water heaters are regulated by federal efficiency standards. The efficiency requirements for such equipment are given in Table 5-1below. Note that on April 16, 2015 the federal standards change, requiring higher efficiencies for most product classes and also classifying storage water heaters into two categories: ≤ 55 gallons volume, and > 55 gallons. The larger volume units will require higher performance. For gas water heaters with > 55 gallon storage volume, the efficiency levels dictate condensing performance, while for electric

storage water heaters > 55 gallons, the efficiency level suggest performance comparable to a heat pump water heater.

Table 5-1 – Minimum Energy Factor Requirements

Type	Size	Energy Factor (EF) (Effective date January 1, 2014)	Energy Factor (EF) (Effective date April 16, 2015)
Gas Storage (≤ 55 gallons)	≤ 75 Btu/hr	0.67-(0.0019*V)	0.675-(0.0015*V)
Gas Storage (> 55 gallons)	≤ 75 kBtu/hr	0.67-(0.0019*V)	0.8012 – (0.00078*V)
Gas Instantaneous	≤ 200 kBtu/hr	0.62	0.82
Oil Storage	≤ 105 kBtu/hr	0.59-(0.0019*V)	0.68-(0.0019*V)
Oil Instantaneous	≤ 210 kBtu/hr	0.59-(0.0019*V)	--
Electric Storage (≤ 55 gallons, exc. table top)	≤ 12 kW	0.97-(0.00132*V)	0.96-(0.0003*V)
Electric Storage (> 55 gallons, exc. table top)	≤ 12 kW	0.97-(0.00132*V)	2.057 – (0.0013 *V)
Electric Table Top	≤ 12 kW	0.93-(0.00132*V)	No change
Electric Instantaneous (exc. table top)	≤ 12 kW	0.93-(0.00132*V)	No change
Heat pump Water Heater	≤ 24 Amps	0.97-(0.00132*V)	See Electric Storage >55 gallons

The energy efficiency of equipment that is larger than the Table 5-1 specifications is regulated by the California Appliance Efficiency Regulations. Energy Factor is not applicable for this equipment, but rather minimums are specified for thermal efficiency and standby loss as shown in Table 5-2.

Table 5-2 – Minimum Energy Factor Requirements - Large 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	–
		≥ 10 gal	80	Q/800 + 110(Vr)1/2 Btu/hr
Gas hot water supply boilers	≥ 4,000 Btu/hr/gal	< 10 gal	80	–
		≥ 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	–
		≥ 10 gal	78	Q/800 + 110(Vr)1/2 Btu/hr
Oil hot water supply boilers	≥ 4,000 Btu/hr/gal	< 10 gal	80	–
		≥ 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.

3. Storage Tank Insulation

§150.0(j)1 Tank Insulation

A minimum R-12 external tank wrap is a mandatory requirement for minimum efficiency storage water heaters.

§110.3(c)4

Any unfired tanks (used as a back-up for solar water heating or as storage for a boiler) must either be insulated externally with R-12 or have a label indicating the tank is internally insulated with R-16. Alternatively, a tank can comply with this mandatory measure if calculations are provided that show that the average heat loss is less than 6.5 Btu/hr-ft² when there is a temperature difference of 80°F between the water in the tank and the ambient air.

4. High Efficiency Water Heater Ready

§150.0(n)

In order to facilitate future installations of high efficiency equipment, the Standards has implemented the following requirements for systems using gas or propane water heaters to serve individual dwelling units. These requirements are for new constructions and additions, and they are not applicable to alterations.

a. A 120 V electrical receptacle that is within three feet of the water heater and accessible to the water heater with no obstructions; and,

b. A Category III or IV vent, or a Type B vent with straight pipe between the outside termination and the space where the water heater is installed; and,

c. 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, and,

d. A gas supply line with a capacity of to provide at least 200,000 Btu/hr to the water heater.

These requirements make it easier for someone to retrofit 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.

Table 5-3 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, this standard requires that the only time one can use a Type B vent for the water heater is when there is a straight shot between the water heater and where the vent leaves the building. The installation shall meet all code and manufactures guidelines. 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. 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. Please note that only stainless steel category III and IV vents are compatible with typical atmospheric combustion storage water heaters. 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.

Designing the gas line to provide 200,000 Btu/hr gas supply capacity to the water heater is required to accommodate future retrofit to a tankless (instantaneous) water heater, which usually has a heat input capacity of 199,000 Btu/hr or above. Similar to the electrical requirement, installing a larger gas line during new construction is very 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 as well, such as gas clothes dryers, gas furnaces, gas ranges and ovens, and gas fireplace burners. The tradition practice of using a ½ inch gas pipe in a single family house to serve a storage water heater will NOT be able to meet the new standard requirement. The minimum gas pipe size for water heaters will be ¾ inch. However, the exact gas piping system should be designed following the applicable plumbing code.

Table 5-3 – 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 non-positive vent static pressure and with a vent gas temperature that avoids excessive condensate production in the vent	Non-positive; atmospheric vented; gravity vented; most common category of gas-fired water heaters.	Non condensing (typically less than 82% efficiency)	Metal double wall “B” vent
Category II: An appliance that operates with a non-positive vent static pressure and with a vent gas temperature that may cause excessive condensate production in the vent	Non-positive	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.	Non condensing (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 Distribution Systems

5.3.1 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 building the system will resemble one of the system types described below under dwelling unit distribution systems. In multi-family 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. Any hot water distribution system that is installed that does not meet all of the installation guidelines discussed in this manual and in the Residential Appendix RA3 and RA4 must either have the deficiencies corrected or compliance calculations must be redone using the performance approach assuming that the installed distribution system is sub-standard.

5.3.2 Systems Serving Single Dwelling Unit

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 or branch off into branches, which serve specific rooms, and these

are in turn divided into twigs which serve a particular point of use. This distribution system class includes mini-manifold layouts (see Figure 5-2 which incorporates trunk lines feeding remote manifolds that then distribute via twigs to the end use points. A Standard Distribution System may not 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 5-2 – Mini Manifold Configuration

Installation Criteria and Guidelines

No pumps may be used to recirculate hot water with the Standard system. All applicable mandatory features must be met. When designing a trunk and branch 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 its stored heat within thirty minutes. The other issue to realize is that if a cold line is to get hot water, it will require not only running out all the water in the pipe but up to an additional third of the volume again to heat the pipe enough so that the water at the point of use will be an acceptable temperature. The adopted requirements for installation guidelines are included in RA3 and RA4.

1. Central Parallel Piping System

The primary design concept in a central parallel piping system is an insulated main trunk line runs from the water heater to one or more manifolds, which then feeds individual use points with ½" or smaller plastic piping. The traditional central system with a single manifold (Figure 5-3) must have a maximum pipe run length of 15 ft 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 ft, b) all piping downstream of the mini-manifolds is nominally ½" or smaller.

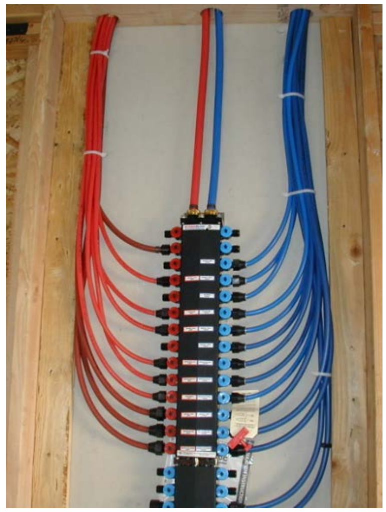


Figure 5-3 – Central Manifold System

Installation Criteria and Guidelines

All applicable mandatory measures must be met. Piping from the manifold cannot be 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 water heater to manifold length, there is a distribution system compliance credit for installations that are HERS-verified to have no more than 5 ft of piping between the water heater and the manifold(s). The manifold feeds individual hot water use points with 3/8 or 1/2 inch PEX) tubing. (Check with local jurisdictions on the use of 3/8 inch piping, since many do not allow it without engineering approval.) The adopted requirements for installation guidelines are included in RA3 and RA4.

2. 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. To use this type of system will requires a combination of good architectural design (water heater location adjacent to hot water use points), an indoor mechanical closet, or the use of multiple water heaters. Figure 5-4 provides an example of the latter approach where three water heaters are installed in close proximity to the use points. For compliance with this credit, HERS verification is required. 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 5-4 below, as measured by the HERS rater. 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 local building department plan check.

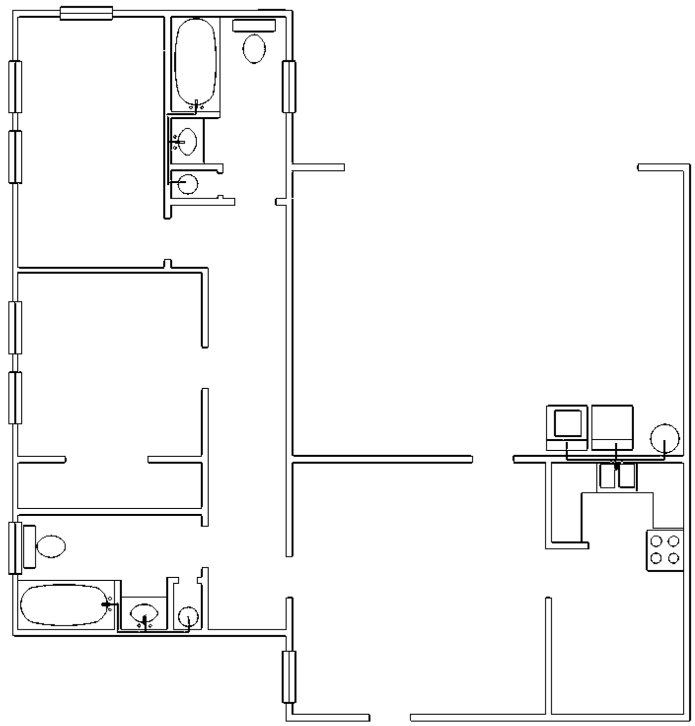


Table 5-4 – Point of Use Distribution System

Size Nominal, Inch	Length of Pipe (feet)
3/8”	15
1/2”	10
3/4”	5

3. Compact Design

A compact distribution system design means that all the hot water use points in a non-recirculating distribution system are within a specified length of piping to the water heater that serves those fixtures. Table 5-5 below specifies the maximum pipe run length that meets the compact design criteria based on floor area served (floor area served = building conditioned floor area divided by the number of water heaters), which recognizes that multiple water heaters may be beneficial in achieving a more compact distribution system. To be eligible, for the compact credit, the length must be physically measured and field-verified by a HERS rater. The adopted requirements for installation guidelines are included in RA3 and RA4.

Typical hot water distribution designs are often much larger than they need to be in terms of pipe length. A big part of the problem is a house design process which doesn’t take into account the location of the water heater relative to bathrooms and kitchen use points. Figure 5-5 below shows a fairly common house layout with the water heater located in the corner of the garage, and hot water use points in each corner of the house.

A much improved house design is shown in Figure 5-6, where the water heater location is in close proximity to the kitchen and bathrooms and laundry area. Early in the design stage, the location of hot water use points can play a big role in achieving the benefits associated with a compact distribution system design.

Figure 5-5 – "Common" Production Home House Layout

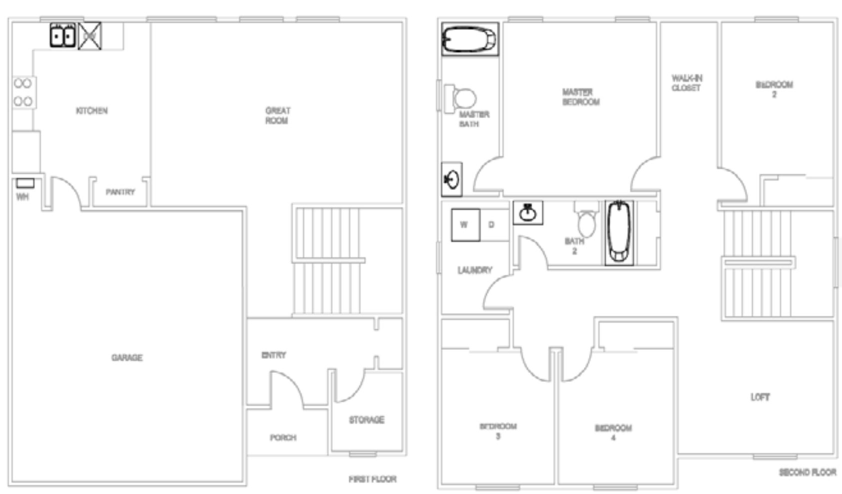


Figure 5-6 – Compact Design Distribution System

Table 5-5 – Compact Distribution System

Floor Area Served (ft^2)	Maximum Water Heater To Use Point Distance (ft)
< 1000	28'
1001 – 1600	43'
1601 – 2200	53'
2201 – 2800	62'
>2800	68'

4. Recirculation System – Non-Demand Control Options

This distribution system type encompasses all recirculation strategies that do not incorporate a demand control strategy 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 pump run time is much more uncertain. Recirculation systems are known to save water (since the hot water is much closer to the use points), 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 ft 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 points of use on the first floor. The adopted requirements for installation guidelines are included in RA3 and RA4

5. 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. 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/or 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 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, flow switch, or occupancy sensor. Pump shut-off must be provided by a combination of a temperature sensing device that shuts off the pump when hot water reaches the location of use, and by a timer which limits 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.

5.3.3 Systems Serving Multiple Dwelling Units

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 5-7. Designs of distribution systems within dwelling units are similar to those serving single dwelling units, described in Section 5.4.1.

Central recirculation water heating systems which use temperature, timer or no controls can use a default recirculation system type if performance compliance is used.

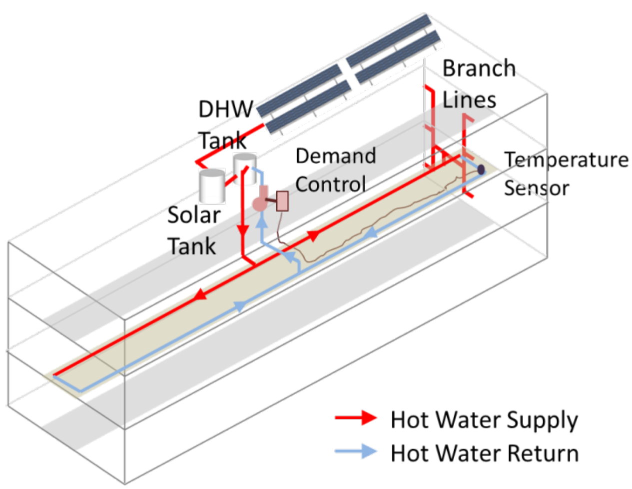


Figure 5-7 – Standard Multi-Family Central Distribution System

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.

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 dynamic control schedules based 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. Qualifying equipment shall be listed with the Commission.

Recirculation systems shall also meet the requirements of §110.3.

2. Multiple Dwell Units: Recirculation Continuous Monitoring Systems

Systems that qualify as a 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 of water heating equipment. The continuous monitoring system shall automatically alert building operators of abnormalities identified from monitoring results. Qualifying equipment or services shall be listed with the Commission.

Recirculation systems shall also meet the requirements of §110.3.

3. Non-recirculating Water Heater System

Multi-unit 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.

5.3.4 Mandatory Requirements for Distribution Systems

1. Pipe Insulation for All Buildings

§150.0(j)2 Pipe Insulation

Pipe insulation is a mandatory requirement in the following cases:

a. The first 5 feet of hot and cold water pipes from the storage tank or water heater.

b. All piping with a nominal diameter of ¾ inch or larger.

c. All piping associated within a domestic hot water recirculation system regardless of the pipe diameter. This excludes branches off of the recirculation loop that are less than ¾ inch diameter or do not serve the kitchen.

d. Piping from the heating source to a storage tank or between tanks.

e. Piping buried below grade.

f. 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 water proof and non-crushable casing or sleeve that allows for installation, removal, and replacement of the enclosed pipe and insulation.

The installation in Figure 5-8 below would not meet the installation requirements since they are not insulated if supplying the kitchen.

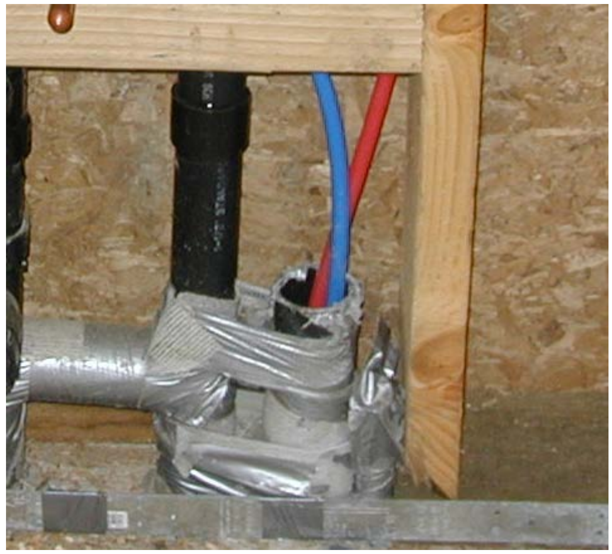


Figure 5-8 – Below Grade Piping

Piping exempt from the mandatory insulation requirement includes:

a. Factory installed piping within space conditioning equipment.

b. Piping that penetrates framing members 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.

c. Piping located within exterior walls which is installed so that piping is placed inside of wall insulation does not need to be insulated if all the requirements for Insulation Installation Quality are met (See Reference Residential Appendix RA4.4.1).

d. Piping located in the attic does not need pipe insulation if it is continuously buried by at least 4 inches of blown ceiling insulation. Piping may not be placed directly in contact with sheetrock and then covered with insulation to meet this requirement.

e. Piping that serves process loads, gas piping, cold domestic water piping (other than within five feet of the water heater), condensate drains, roof drains, vents, or waste piping.

Other installation information:

a. 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 *2007 California Mechanical Code*, Chapter 3, Table 3-3).

b. All pipe insulation seams should be sealed.

c. Installed piping may not be located in supply or return air plenums. (See *2007 California Mechanical Code*, Chapter 3, Table 3-3).

d. Hot and cold water piping, when installed in parallel runs should be a minimum of 2 inches apart. (See RA4).

e. If a fire wall interrupts the first 5 ft of pipe, the insulation may be interrupted at the wall and continued on the other side.

f. Insulation for pipe elbows should be mitered and insulation for tees should be notched. (see RA4).

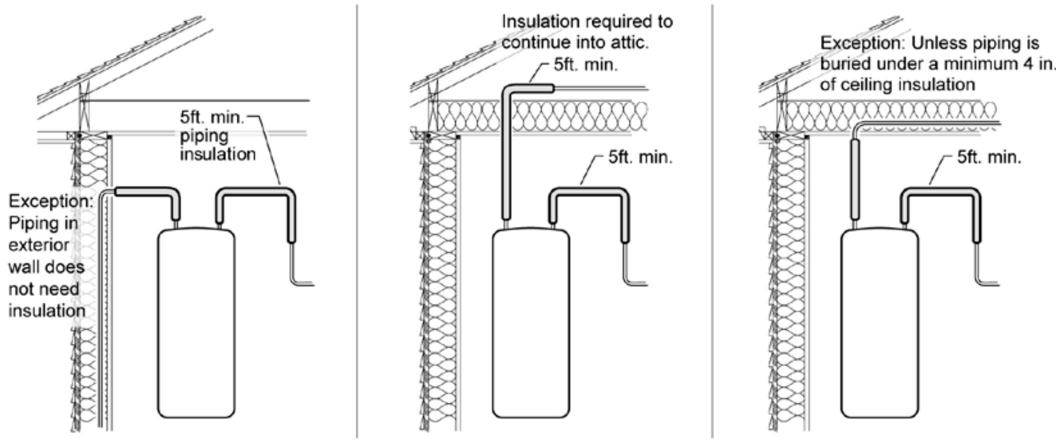


Figure 5-9 – Pipe Insulation Requirements First Five Feet from Water Heater

Standards Table 120.3-A

Where insulation is required as described above, one inch of insulation is typically required. This requirement applies to domestic hot water pipe (above 105° F) when the pipe diameter is 1 inch or smaller, the water temperature is between 105°F and 140°F, and the insulation conductivity 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 greater than 1 inch. For other situations refer to table 120.3-A.

Insulation Protection

§150.0(j)3

If hot water piping insulation is exposed to weather, it must be suitable for outdoor service. For typical cellular foam pipe insulation, this means protection with aluminum, sheet metal, painted canvas, plastic cover, or a water retardant paint coating that shields from solar radiation. Insulation must be protected by an external covering unless the insulation has been approved for exterior use using a recognized federal test procedure.

2. Distribution Systems Serving Multiple Dwelling Units – With Recirculation Loops

§110.3(c)5

Multi-family building may have individual water heaters for each unit, but they are more likely to have a central water heating system with a recirculation loop that supplies each of the units. This recirculation loop is comprised of a supply portion, of larger diameter pipe connected to smaller diameter branches that serve multiple dwelling units, guest rooms, or fixtures and a return portion that completes the loop back to the water heating equipment. The large volume of water which 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 requirements for system serving multiple dwelling units and with recirculation loops; the corresponding compliance form is CF2R-PLMB-03-E.

a. Air Release Valves

§110.3(c)5A

The constant supply of new water in combination with the continuous operation of pump creates the possibility of the pumps cavitation due to 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, which 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). Ultimately this impacts the pump's efficiency and life expectancy.

Cavitation shall be minimized by either the installation of an air release valve or mounting the pump vertically. The air release valve must be located no more than 4 ft from the inlet of the pump. The air release valve must 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 potentials for 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 backwards towards the hot water load and reducing the delivered water temperature.

To prevent this from occurring, the 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 ahead and designing for easy pump replacement when the pump fails. Provision for pump priming and pump isolation valves help reduces 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 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. Note that the system shall comply with the expansion tank requirements as described in the California Plumbing Code Section 608.3.

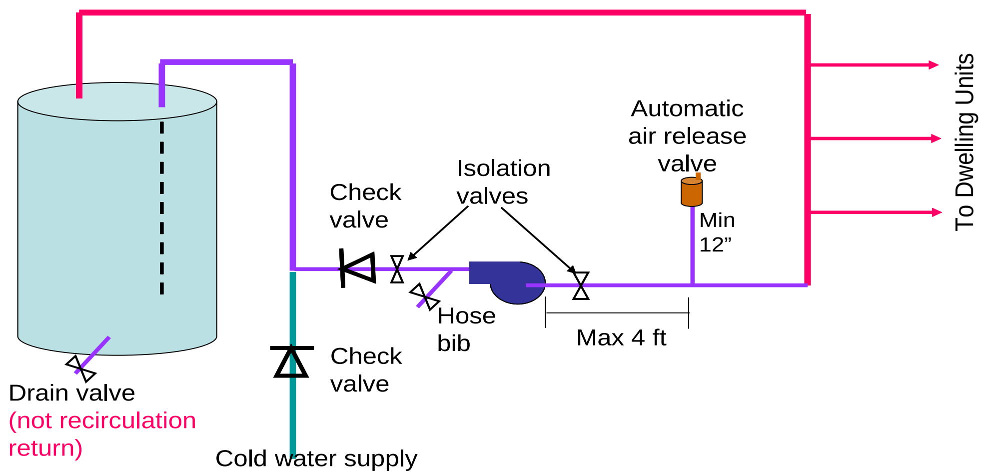


Figure 5-10 – Mandatory Central System Installation Requirements

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

No. Since the water in runouts does not recirculate, they do not need to be insulated.

Example 5-2 - Recirculation system insulation

Question

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

Answer

No, 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 (e.g., 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 ft 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 (§150.0(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 this insulating the cold line requirement is that when heated, 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.

5.3.5 Distribution System Compliance Limitations

1. Pipe Insulation

Insulation must meet the level required in the mandatory requirements. Note that pipes buried within ceiling or wall insulation can meet the mandatory requirements. The adopted requirements for installation guidelines are included in RA3 and RA4

2. Heat Tape

*If h*eat tape – electric resistance heating tape wrapped around hot water pipes – may be used only for freeze protection and cannot be used instead of mandatory pipe insulation (see §150.0(j)) or pipe insulation receiving distribution credit.

5.4 Prescriptive Water Heater and Distribution System Requirements

5.4.1 Single Dwelling Units

150.1(c)8

The conventional approach to meeting the prescriptive requirements of Package A for systems serving individual dwelling units the system would be to use either a small storage or instantaneous gas water heater as prescribed in the water heater Section 5.1. The distribution type options for a complying system would include either a conventional trunk and branch system or an on-demand recirculation system with manual controls. Both distribution systems must meet all of the mandatory requirements previously mentioned in this chapter. Other distribution system types do not meet the prescriptive requirement.

The other option under the prescriptive compliance method is to use the performance method for water heating only as defined in §150.1(b)1 and which is discussed in full in the performance compliance section later in this chapter. This path requires inputting the building square footage and detailing the water heater and distribution system information into the building performance compliance tool.

§150.1(c)8

With the changes in the 2013 standards there are actually three prescriptive options for domestic hot water heating in single family residences depending upon whether natural gas service is available at the site.

1. A system with a single gas or propane storage type water heater must have:
    a) A gas input rating ≤ 75,000 Btu/h,
    b) If the water heater's efficiency only meets the minimum federal efficiency standards, the tank must be wrapped with an R-12 water heating blanket [a mandatory requirement in §150.0(j)1].
    c) If the system uses a trunk and branch distribution system then all pipes from the water heater to the kitchen must be insulated and all pipe with a diameter equal to or greater than ¾ of an inch must be insulated.
    d) If this system has a recirculation pump then the control must be demand based with manual controls (pump only runs upon user direct activation until water temperature equals temperature setpoint). All portions of the distribution system that recirculate water must be insulated.
    e) All applicable mandatory requirements in Section 110.3 and 150.0(j,n) must be met.
2. A system with a single gas or propane instantaneous water heater without a storage tank must have:
    a) A gas input rating ≤ 200,000 Btu/h,
    b) No supplemental storage tank is installed,
    c) Uses a trunk and branch distribution system then all pipes from the water heater to the kitchen must be insulated and all pipe with a diameter equal to or greater than ¾ of a inch must be insulated.
    d) All applicable mandatory requirements in Section 110.3 and 150.0(j,n) must be met
3. An electric resistance storage or instantaneous water heater can be used if all of the following conditions are met:
    a) Natural gas is unavailable at the site
    b) The water heater is located within the building envelope
    c) For storage electric and instantaneous a trunk and branch distribution system must have all pipes from the water heater to the kitchen and must be insulated

and all pipe with a diameter equal to or greater than ¾ of an inch must be insulated.

d) All applicable mandatory requirements in Section 110.3 and 150.0 must be met

e) A solar water heater is installed which is designed to provide a solar fraction of 50% (provides 50% of the heating load) and is installed as specified in the Reference Residential Appendix RA4. The details of the solar water heating prescriptive requirements are described in more detail in Section 5.6.3 later on in this chapter.

f) No supplemental storage tank is installed

g) No recirculation system can be installed with electric instantaneous water heaters.

If a water heater is installed in combination with a booster heater used to either eliminate cold surges when an instantaneous water heater is the primary system, or used to reheat water in a portion of the system the booster heater must be included in compliance. All booster heaters must be treated a separate electric instantaneous water heaters. To comply, performance compliance must be used to demonstrate the installed system uses no more energy than what is allowed under the standards.

Questions and Answers – Single Family Systems

Example 5-4 - Single family with multiple water heaters

Question

A 6,000-ft² single family residence has 3 storage gas water heaters (40 gallon, 30 gallon and a 100-gallon unit with 80,000 Btu/h input). Does it comply?

Answer

A performance calculation is required since the system does not meet the standard requirements and must be shown to meet the water heating budget of §150.1(b)1. In most cases, adding a second storage water heater will result in greater energy consumption than the standard design case.

Example 5-5 - Single family with large storage gas water heater

Question

A single family residence has a 76,000 Btu/hr input 50-gallon gas water heater with an on-demand recirculating distribution system (with manual push button control).Does it comply with the prescriptive requirements?

Answer

Since the input rating is greater than 75,000 Btu/hr the unit is considered a large storage gas water heater. Compliance will have to be determined using the performance approach. If the water heater had an input rating less than 75,000 Btu/ hr it would qualify, since the proposed distribution system. Qualifies as long as all mandatory measures are met.

Example 5-6 - Single family with point of use distribution system

Question

A 1,800 ft² single family residence has two identical 30-gallon gas storage tank water heaters and a distribution system that meets the point of use criteria. Does this comply?

Answer

Because there are two water heaters, this system does not meet the standard prescriptive water heating systems requirements of §150.1(f)8, regardless of the distribution system. To evaluate this design, it must be modeled using the performance approach.

Example 5-7 - Home Using Electric Water Heaters

Question

We plan to install a heat pump water heater in a single family home. Since heat pump water heaters have electric-resistance heating elements, are they considered as electric-resistance water heaters and subject to solar water heating requirements? How about for systems using a gas water heater as the primary water heater, but using under-sink electric heaters as booster heaters?

Answer

Heat pump water heaters are considered electric water heaters, but have different requirements for new construction and alterations when using the prescriptive approach New construction homes following prescriptive compliance method can install a heat pump water heater as the primary water heater if natural gas is not available to the home. A solar water heater with a minimum solar fraction of 0.5 must also be installed for prescriptive compliance. Upgrading an existing electric water heater to a heat pump water heater is not subject to the solar water heating requirement. Alternatively, one can model the heat pump water heater using the performance approach and likely not require the solar water heater.

When the primary water heater is a gas water heater, installing a solar water heater is not required for compliance purposes, even when small point-of-use electric water heaters are installed.

5.4.2 Multiple Dwelling Units: Multi-family, Motel/Hotels and High-Rise Nonresidential

§150.1(c)8

When using the prescriptive approach on multi-family buildings two options exist. Either individual water heaters must be installed in each unit that meet the requirements for single family building or a central gas or propane fired water heater or boiler is required. The water heater must have an efficiency that meets the requirements in Sections 110.1 and 110.3 in the standards (as listed in Table 5-1 or Table 5-2 earlier in this chapter). In addition if a central recirculation system is installed it shall be installed with controls and a distribution layout that will include demand recirculation controls and at least two recirculation loops. These new prescriptive rules were added 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 temperature difference between the hot water and ambient, pipe insulation level, and pipe surface area. The motivation behind having two loops is to reduce recirculation pipe sizes, thus pipe surface areas. This measure reduces energy uses and piping materials associated with recirculation systems. Central water heating systems with eight or fewer dwelling units are exempted from needing two recirculation loops.

1. Solar Water Heating Requirements

A new requirement for multi-family buildings with a central distribution system is that a solar water heating system be installed. Section 5.6 is entirely dedicated to solar water heating, and it includes detailed descriptions on associated mandatory and prescriptive requirements. The installed solar heating collectors must be certified by the Solar Rating and Certification Corporation (SRCC). Minimum solar fractions for each climate zone are listed below in Table 5-6, and documented on the corresponding compliance form.

Table 5-6 – Required Performance of Solar Systems Installed in Multi-family Buildings with Central Distribution Systems

Climate Zone	Minimum Solar Fraction
1-9	0.20
10-162	0.35

2. Duel Loop Recirculation System Design

150.1(c)8Cii

A dual-loop design is illustrated in Figure 5-11. 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 that of a single-loop design. For appropriate pipe sizing guidelines, please refer to the Universal Plumbing Code.

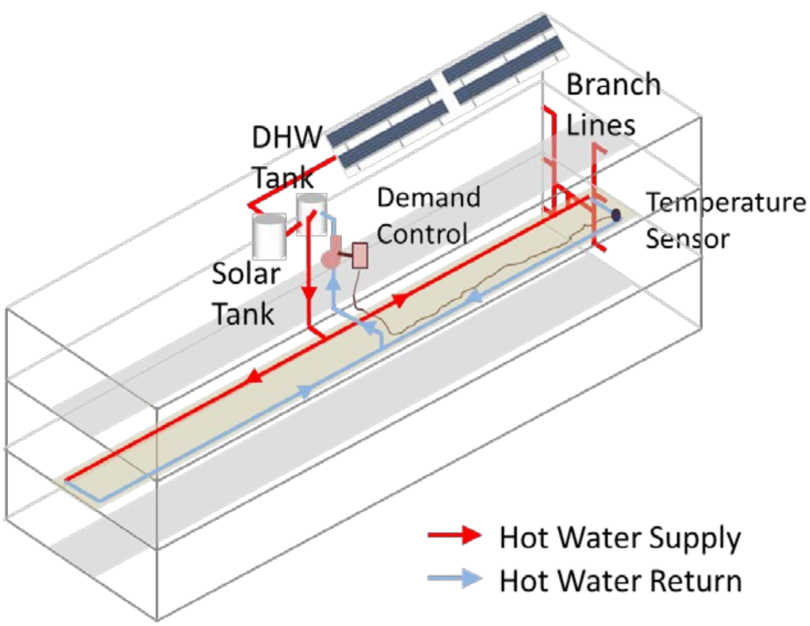
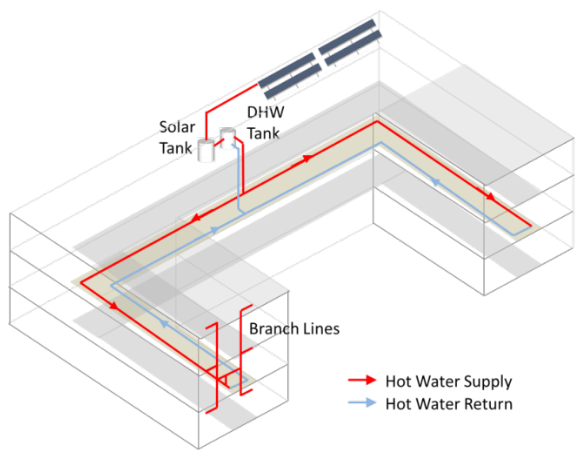
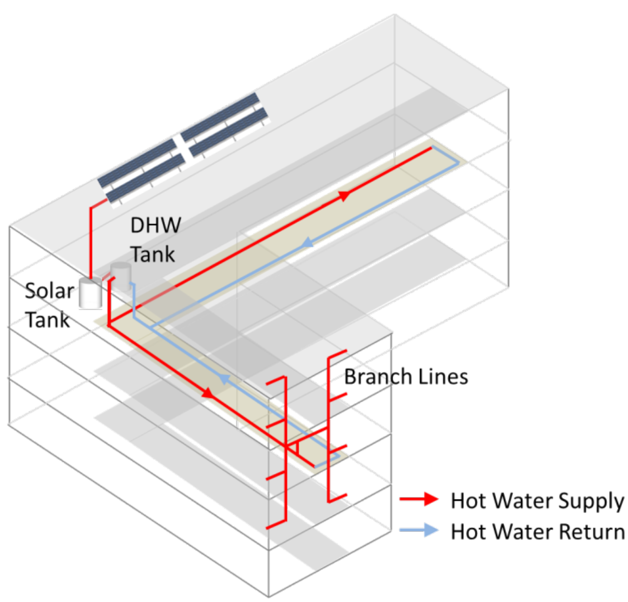


Figure 5-11 – Example of a Dual-Loop Recirculation System

Figure 5-12 provides an example of how to implement duel-loop design in a low-rise multi-family building with a simple layout. In this example, the water heating equipment is located in the middle of top floor with each recirculation loop serve exactly half of the building. The recirculation loops are located in the middle floor to minimize branch pipe length to each dwelling units. The figure also illustrates how the solar water heating system and demand control 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 the equal number of dwelling units in order to minimize pipe sizes. For systems serving buildings with distinct sections, e.g. 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 as short as possible. Figure 5-12 provides dual-loop recirculation system designs in buildings with complicated shapes.





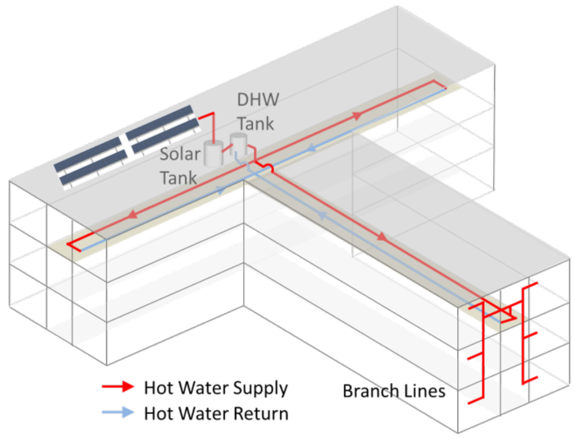


Figure 5-12 – Examples of dual-loop recirculation system designs in buildings of complicated shapes

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 building in regular shapes, locating the water heating equipment at the center of the building footprint rather than at one end of the building helps to minimize the pipe length needed to connect the water heating equipment to the two loops. If a water heating system serves several distinct building sections, the water heating equipment would preferably nest in 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 feedbacks from industry stakeholders, most solar water heating systems are only configured as a pre-heater 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 mostly based 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 closed 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 reduced DHW system energy use as well as system plumbing cost.

3. Demand Recirculation Control

The prescriptive requirement for DHW systems serving multiple dwelling units requires the installation of a demand recirculation control to minimize pump operation. Please note that they are different from the demand control used in single dwelling unit, as described in the section 0. Demand controls for central recirculation systems are based on hot water demand and recirculation return temperatures. The temperature sensor should be installed at the last branch pipe along the recirculation loop.

Any system not meeting these prescriptive requirements must instead meet the *Standard Design Building* energy budget as described in §150.1(b)1, or must follow the performance compliance method for the building as a whole.

Example 5-8 - Multi-family with individual water heater

Question

A 10-unit multi-family building has separate gas water heaters for each dwelling unit. Five units have 30-gallon water heaters, and 5 units have 50-gallon water heaters. Does this comply?

Answer

The Standard provides two prescriptive compliance paths for domestic hot water heating systems in multi-family buildings. One is to use a central water heating system. The other is to use separate gas waters for each dwelling unit, as in this example. In order to use this compliance method, all dwelling units must use residential water heaters (heat input of less than 75,000 Btu/hr) with EF ratings equal or higher than corresponding Title 20 appliance standard requirements. .

Example 5-9 - Multi-family recirculation system

Question

We are building an 8-unit, 7,800 ft² multi-family building with a 200 gallon storage gas water heater with 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. There is also the concern that solar water heating is required for all multi-family building with central recirculation systems.

Example 5-10 - Multi-family 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 non-recirculating 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 multi-family buildings of eight units or less. using the performance approach

5.5 Water Heating System Performance Compliance

1. Energy Budget Calculation

The computer performance approach allows for the modeling of water heating system performance taking into account building floor area, 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 some result in penalties.

2. Systems Serving Single Dwelling Unit

In the case of single family buildings, any type or number of water heaters can theoretically be installed. The calculated energy use of the proposed design is compared to the standard design energy budget based on a single small storage water heater with a Standard hot water distribution system. 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 overall Title 24 compliance.

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 design features eligible for energy credits. As per the prescriptive requirements, all mandatory pipe insulation requirements must be met such as all pipe lengths running to the kitchen must be insulated. Alternative distribution systems are compared to the standard design case by using distribution system multipliers (DSMs), which effectively rate alternative options.

Table 5-7 provides a listing of all the recognized distribution systems that can be used in the performance approach with their assigned distribution multiplier. The standard distribution system has a multiplier of 1.0. Distribution systems with a multiplier less than 1.0 represent an energy compliance credit, while distribution systems with a multiplier greater than 1.0 are counted as an energy compliance penalty. For example, pipe insulation with a 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 5.3.

Table 5-7 – Applicability of Distribution Systems Options within a Dwelling Unit

Distribution System Types	**Assigned Distribution System Multiplier**	**Systems Serving a Single Dwelling Unit**	**Multi-family with central recirculation systems**
No HERS Inspection Required			
Trunk and Branch -Standard (STD)	1.0	Yes	Yes
Pipe Insulation (PIA)	0.9	Yes	Yes
Parallel Piping (PP)	1.05	Yes	--
Insulated and Protected Pipe Below Grade (IPBG)	1.4	Yes	--
Recirculation: Non-Demand Control Options (R-ND)	7.0	Yes	--
Recirculation with Manual Demand Control (R-Dman)	1.15	Yes	Yes
Recirculation with Motion Sensor Demand Control (R-DAuto)	1.3	Yes	--
Optional Cases: HERS Inspection Required			
Pipe Insulation (PIC-H)	0.8	Yes	Yes
Parallel Piping with 5' maximum length (PP-H)	0.95	Yes	--
Compact Design (CHWDS-H)	0.7	Yes	--
Point of Use (POU-H)	0.3	Yes	--
Recirculation with Manual Demand Control (R-Drmc-H)	1.05	Yes	--
Recirculation with Motion Sensor Demand Control (RDRsc-H)	1.2	Yes	--
Non Compliant Installation Distribution Multiplier	1.2	Yes	Yes

Note: any system that does not meet the installation requirements listed in RA3 and RA4 for the specific system type in any way must either have the installation corrected or have the compliance run redone using the Non Compliance installation distribution multiplier.

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 which are controlled by a demand control technology. Systems designed with other options are allowed. But they require compliance verification through performance calculation.

Table 5-8 – Applicability of Distribution Systems Options within a Dwelling Unit Applicability of Distribution Systems Options for Central Distribution Systems in Multi-family Buildings

Distribution System Type	Residential Reference Joint Appendices
Demand Recirculation	Defined RA4
Demand Recirculation With HERS verification	Defined RA3
Temperature Modulation	Defined RA4
Constant Monitoring	Defined RA4
Default (Other)	Added for ACM rules
Pipe Insulation	Defined in RA3 and RA4

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 the Standard does not provide additional credit for designs with more than two recirculation loops.

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.

5.5.1 Treatment of Water Heater Efficiency

1. Small Storage Water Heaters

Small storage gas and electric water heaters are modeled to reflect the dependency of their rated performance on the actual hot water recovery load (the estimated energy load on the water heater based on the CEC draw schedule). This “load dependent Energy Factor” relationship decreases the water heater efficiency at loads lower than the EF test level and increases it for loads exceeding the EF test level.

2. Large Storage Water Heaters

For large storage water heaters, energy use due to hot water demand and distribution loss are calculated and listed according to thermal efficiency. The total water heater energy use is documented by also includes standby loss, which is reported either as a percentage or numeric value in Btu/hr. Both values are calculated based on a relationship of standby looses (which include thermal and electricity) compared to the total energy storage capacity of the water heater Heat Pump Water Heaters

Heat pump water heaters are modeled based on their rated EF. In addition to recognizing the performance impact of loads on annual efficiency, the heat pump water heater model also includes a climate zone adjustment to reflect changes to heat pump efficiency with the ambient temperatures in that climate zone.

3. Instantaneous Gas Water Heaters

A PIER-sponsored evaluation of instantaneous (or tankless) gas water heaters was completed to assess whether the rated Energy Factor for these units accurately describes real world system performance. Results of the study indicate that the Energy Factor test procedure underestimates the impact of small volume hot water draws and heat exchanger cycling on annual system performance. Based on these findings, the 2008 Standards applied a 0.92 derating factor on the nominal EF of all gas instantaneous water heaters. This derating was validated by further PIER field research completed in 2011.

Instantaneous water heaters are occasionally installed with small electric storage buffer tanks downstream of the tankless unit to mitigate the potential for cold water sandwich effects. If one of these units is installed, both the buffer tank and the instantaneous water heater must be modeled. The buffer tank must be listed in the CEC Appliance Directory and the listed standby wattage is used to model the buffer tank as a separate electric point of use water heater. In cases where the buffer tank in built into the instantaneous gas water heater the wattage of heating coil in the buffer tank must be modeled in the same manner as if the buffer tank where separate.

4. Solar Water Heating Systems

Solar water heating can be used in compliance with single family or multi-family buildings. For treatment of solar water heating systems, please refer to Section 5.6.5.

5.5.2 Compliance Issues

Water heating is becoming more and more important to overall compliance as building envelope performance and mechanical efficiency improved. When the performance approach is used, a high efficiency water heater can significantly impact 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 house energy budget.

Asking for a cut sheet on the installed equipment to verify efficiency is a simple shortcut to checking compliance. Also note that 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 both be met

5.6 Solar Water Heating

The Water Heating Calculation Method allows water heating credits for solar water heaters. Solar systems save energy by using non-delectable resources to offset the use of conventional energy sources.

For single-family solar systems, All systems must be Solar Rating and Certification Corporation (SRCC) approved. Accepted testing procedures include either fully approved system with OG-300 test results or built up system that use the collector (OG-100) rating. For

multi-family, only systems with OG-100 collectors can be installed. For more detailed instructions on installation of solar water heaters refer to RA4.4. The sort able database of SRCC-certified is located on the SRCC website[1].

Figure 5-13 summarizes the process flow for demonstrating compliance via both the prescriptive and performance compliances.

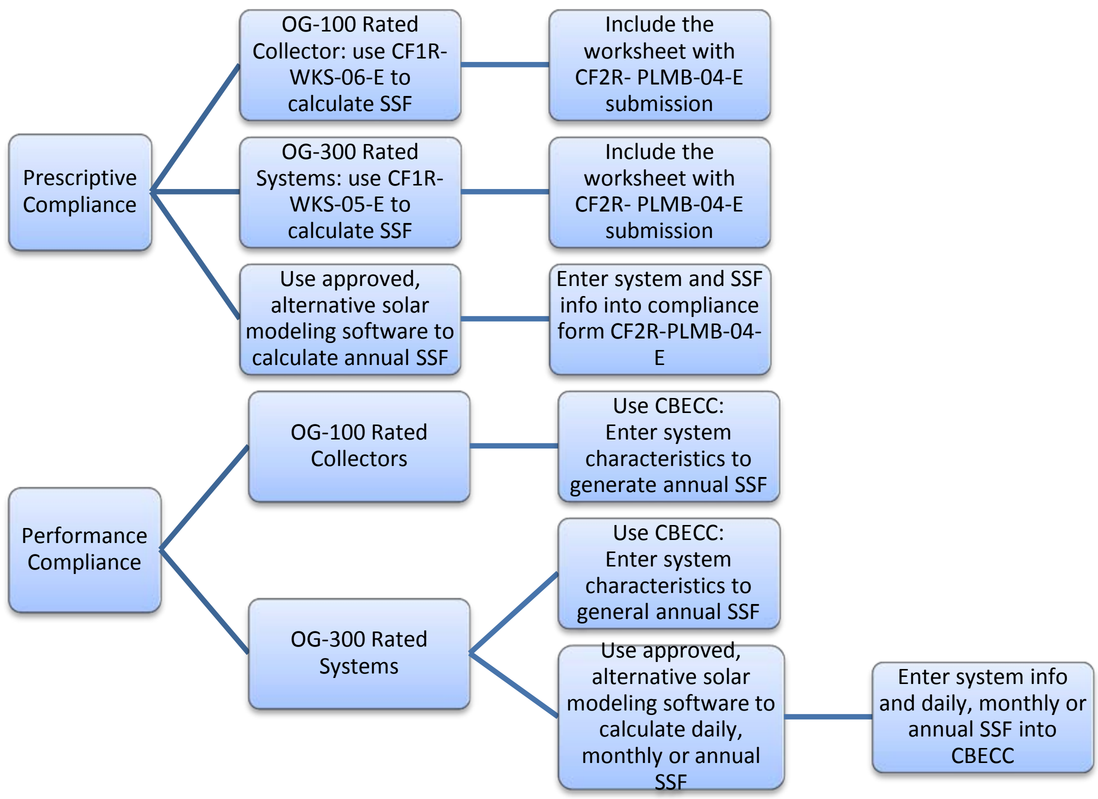


Figure 5-13 – Compliance Process for Solar Water Heating System

Under the prescriptive compliance path, to calculate SFF for OG-300 systems go to the following link.

http://www.gosolarcalifornia.org/solarwater/nshp/swh_calc_systems.php

and complete the use the compliance worksheet. To do this you will need the Solar Energy Factor (SEF) value from the SRCC website listed previoulsy. To calculate SSF for OG-100 collectors under the prescriptive compliance use the compliance tool at the following link:

http://www.gosolarcalifornia.org/solarwater/nshp/swh_calc_collectors.php

and complete the worksheet.

Regardless of the system type installed and compliance method chosen, mandatory requirements for pipe insulation and storage tank insulation apply as described in Section 0.

[1] https://secure.solar-rating.org/Certification/Ratings/RatingsSummaryPage.aspx

5.6.1 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 state architect determines that service water heating is economically or physical infeasible. See the Compliance Options section below for more information about solar water heating systems.

5.6.2 Solar Ready Buildings Requirements

150.0(r),110.1

There are new mandatory requirements for all buildings to be "solar ready." The motivation behind having solar ready requirements is to encourage more future installations of both 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 the "Solar Ready Requirements" chapter of the compliance manual. In summary, the elements to being solar ready include:

- Designated solar zone
- Designated conduit and plumbing paths
- Documentation for solar zone and paths on construction plans, and
- Adequate electric busbar and panel capacity

5.6.3 Prescriptive Requirements

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

1. Single Family

Solar water heating is prescriptively required for systems serving single family dwelling units with electric water heaters. Where no natural gas is available the standards allow the use of either electric-resistance storage or instantaneous water heater systems to serve single family dwelling units but only with the use of solar water heating. To use this prescriptive option all of the following requirements and conditions must be met:

a. If natural gas is unavailable to the home; and
b. The water heater is located within the building envelope; and
c. Recirculation pumps are not used; and
d. The water heating system includes a solar water-heating system with a minimum SSF of 0.50.

In meeting the solar thermal system criteria the system or collectors must be certified by Solar Rating and Certification Corporation (SRCC) as described above in the introduction to 5.5. Either OG-100 or OG-300 systems can be installed. Installation of a solar water heating system exempts single family homes from needing to set aside solar zone for future solar PV or solar water heating installation (§110.10(b)1A).

The collector installation must also meet the installation requirements detailed in RA-4.4. These requirements specify that systems complying with the OG-300 system must be installed to the following guidelines:

a. Face within 35 degrees of due south; and

b. Have a tilt slope of at least 3:12; and

c. Be un-shaded by buildings or trees. See the residential appendix RA4.4 for details.

For built up systems using components and the OG-100 collector rating the collectors must be installed to match the specification entered when the solar thermal system was modeled.

For compliance with either option, you will need to print out the results and submit along with the completed compliance form.

5.6.4 Multi-family, 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 multi-family, motel/hotels or high-rise nonresidential buildings. The minimum SSF is dependent on the climate zone: 0.20 for CZ 1 through 9, and 0.35 for CZ 10 through 16. 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 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 (§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 take 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 seriously 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, the highest SSF requirement called for by the 2013 Title 24 at 50%. Stakeholders further suggested that industry standard sizing for an active system is 1.5 ft^2 collector area per gallon capacity for solar 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 *Building America Best Practices Series: Solar Thermal and Photovoltaic Systems*[2] , and *California Solar Initiative – Thermal: Program Handbook*[3].Because of the new solar water heating requirement and prevalence of recirculation hot water systems in multifamily buildings, it is essential to re-iterate 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

[2] http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/41085.pdf

[3] http://www.cpuc.ca.gov/NR/rdonlyres/CB11B92E-DFFF-477B-BFA9-F1F04906F9F9/0/CSIThermal_Handbook201209.pdf

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 of time.

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 5.3.3, 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 with, just upstream of the conventional/auxiliary water heating equipment, the distance between collectors and solar tank should also be as short as practically possible.

5.6.5 Performance Compliance

Solar water heating systems with SSF higher than the specified prescriptive minimum or required mandatory level can be used as a tradeoff under the performance approach. Figure 5-13 shows the compliance process needed for demonstrating compliance with solar water heating modeling. The new CEC compliance software integrates the capability of calculating an annual SSF. Users now input collector and system component specifications to calculate a corresponding SSF for the proposed system. The SSF along with other system parameters should be entered into compliance form which will be used to populate the certificate of compliance.

5.7 Swimming Pool and Spa Heating

5.7.1 Swimming Pool and Spa Types

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

5.7.2 Mandatory Requirements

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 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:

a. Listed package units with fully insulated enclosures (e.g., hot tubs), and with tight-fitting covers, insulated to at least R-6.

b. Pools or spas getting 60 percent or more of their annual heating from site solar energy or recovered energy.

1. Pool Pump Requirements

For maximum energy efficiency, pool filtration should be operated at the lowest possible flow rate for a time 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 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 multi-speed pump or a separate pump for each auxiliary pool load. For example, if a spa shares the pool filtration system, either a multi-speed 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-hp in capacity, the pump may be single speed.

Filtration pump motors with a capacity of 1 total-hp or more must be multi-speed.

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 5-14). 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.

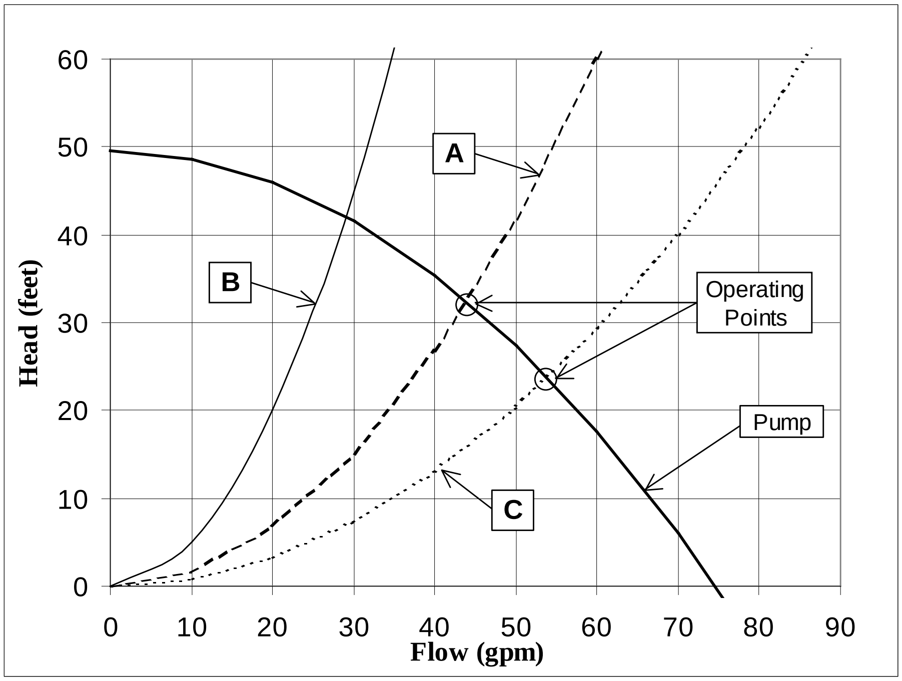


Figure 5-14 – System Test Curves

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. Solar system that requires pumps to during peak hours must also have control mechanism installed

§150.0 (p)1

Multi-speed 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.

3. Pool Pipe, Filter, and Valve Requirements

System design for residential pools was introduced in 2008. 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(p)2

Pool piping must be sized according to the maximum flow rate needed for all auxiliary loads. The maximum velocity allowed is 8 fps in the return line and 6 fps in the suction line. Table 5-9 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 5-9 – Hour Turnover Pipe Sizing

Pool Volume (gallons)		**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 inches 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's strainer basket.

Traditional hard 90^o 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 pipe diameters. For example, a 2 inch elbow must have a pressure drop less than a 5-foot length of 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 5-15). 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 90's. There is sufficient difference in distance "w" such that all sweep elbows exceed the minimum values listed in Table 5-10.

Figure 5-15 below illustrates "w" the dimension between the elbow sleeves and Table 5-10 shows the minimum distances "w" for an acceptable sweep elbow.

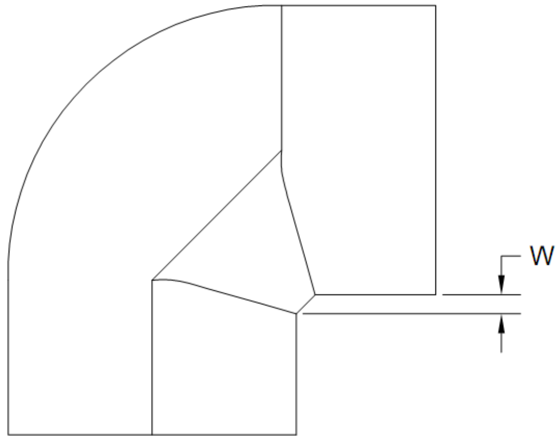


Figure 5-15 – Measuring "w" at the Pool Site.

Table 5-10 – 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 ft^2/gpm):

Cartridge	0.375
Sand	15
Diatomaceous Earth	2

Backwash valves must be sized to the diameter of the return pipe or two inches, whichever is greater. Multiport backwash valves have a high pressure drop and are discouraged. Low-loss slide and multiple 3-way valves can provide significant savings.

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

If a pool does not currently use solar water heating, piping must be installed to accommodate any future installation. Contractors can choose 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 5-11 - 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 5-12 - 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.

5.8 Combined Hydronic System

5.8.1 Combined Hydronic

Combined hydronic space heating systems utilize a single heat source to provide both 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. Section 4.7.1 provides an explanation of combined hydronic systems.

5.9 Shower Heads

5.9.1 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 contains 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 and must be met.

5.10 Compliance and Enforcement

Chapter 2 addresses the compliance and enforcement process in a general manner 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.

5.10.1 Design Review

The initial compliance documentation consists of the Certificate of Compliance and Installation Certificate. These documents are included on the plans and specifications. 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 in 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.

5.10.2 Field Inspection

During the construction process, the contractor and/or the specialty contractors complete the necessary sections of the Installation Certificate. For water heating there is only one section to be completed where information about the installed water heating system is entered.

Inspectors should check that the number and types of water heater systems indicated on the installation certificate, corresponds to the approved Certificate of Compliance. The distribution system is also significant and must correspond to plan specifications.

5.10.3 Field Verification and/or Diagnostic Testing

1. Single Family

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 which include parallel piping, demand recirculation, automatic and manual on demand recirculation. The second type is for distribution systems that can only be used when verified by field

verification. These include, compact design, and point of use. For all of these cases the field inspector must verify that the eligibility requirements for the specific system are met.

The one water heating system distribution credit that is different is the pipe insulation credit. This credit applies if all pipes in a distribution system are insulated and can only be applied to non-recirculating systems. If this credit is taken in combination with installation credit then field verification is required. To meet the installation requirements hot water pipes located in insulated walls or buried in the attic insulation comply with the requirements – without pipe insulation. In this case, a field inspector must verify that the eligibility requirements for pipe insulation have been met.

2. Multi-family

The only field inspector verification for water heating that applies to central domestic hot water recirculation systems in multi-family buildings is the verification of multiple distribution lines for central recirculation systems.

5.11 Glossary/Reference

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.

Energy Factor (EF) of a water heater is a measure of overall water heater efficiency for most residential water heaters, as determined using the applicable test method in the Appliance Efficiency Regulations. Typical gas storage water heaters have typical EFs of about 0.60-0.70, electric storage water heaters approximately 0.90, and gas instantaneous units approximately 0.80-0.94.

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.

Recovery energy is the energy used to heat water.

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

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.

5.11.1 Swimming Pool and Spa

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

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

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 us 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.

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.

Service Factor. The service factor rating indicates the percent 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.

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.

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”).

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.

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

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.

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