



SATURN

RESOURCE MANAGEMENT

10.6 WATER-HEATING ENERGY SAVINGS

SWS Detail: 7.02 Water Conservation; 7.03 Water Heating

For safety information on combustion water heaters, see “*Spillage and CO Testing*” on page 285.

The most important tasks in evaluating hot water energy savings are determining the water heater’s insulation level, measuring the shower’s flow rate, and measuring the water temperature.

Table 10-5: Water Heating Consumption According to Family Size

Number of Residents	Annual kWh	Annual Therms	Gallons Per Day
1	2700	180	25
2	3500	230	40
3	4900	320	50
4	5400	350	65
5	6300	410	75
6	7000	750	85

Author’s interpretation of data from single-family homes with existing water heaters from Energy Information Administration, Lawrence Berkeley Laboratory, *Home Energy Magazine*, and others.

10.6.1 Water-Saving Shower Heads and Faucet Aerators

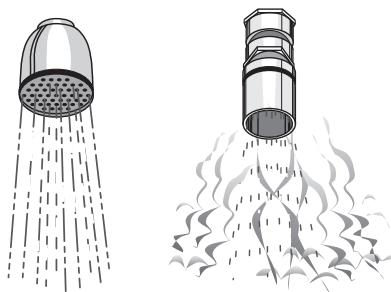
SWS Detail: 7.0201.1 Low-Flow Devices

Most families use more hot water in the shower than for any other use. A low-flow shower head reduces this consumption.

- ✓ Water-saving shower heads must be rated for a flow of 2.5 gallons per minute or less.
- ✓ Water-saving aerators must be rated for a flow of 2.2 gallons per minute or less.

- ✓ Use caution in removing the existing shower head or aerator from old, fragile plumbing fixtures.
- ✓ The shower or faucet flow rate must be satisfactory to the occupants and be documented.
- ✓ Select features that meet any special needs of the occupant: swivel head, hand-held shower, for example.
- ✓ Evaluate water quality for debris that may clog the shower head or aerator.
- ✓ Use a non-hardening thread sealant when installing the device.
- ✓ Check the fixtures after installation for adequate tightness to prevent leakage at the connection.
- ✓ Recycle replaced shower heads and aerators.

Water-saving shower heads: Two styles of water-saving shower heads give consumers a choice between steamy showers and less steamy ones.



Measuring Shower or Faucet Flow Rate

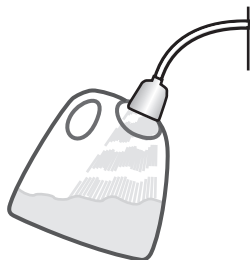
You can determine flow rate by measuring the time needed to fill a one-gallon plastic container. If the one-gallon container fills in less than 20 seconds, your flow rate is more than 3 gallons per minute.

1. Start the shower and set it to the maximum showering rate.
2. Start a stopwatch at the same time you move the container underneath the shower, capturing its entire flow.

- Record the number of seconds and divide 60 by that number to find gallons per minute.

Measuring shower flow rate: If you divide 60 by the number of seconds needed to fill a gallon container, you can calculate flow in gallons per minute.

$$60 \text{ sec} \div \frac{1 \text{ gal}}{15 \text{ sec}} = 4 \frac{\text{gal}}{\text{min}}$$



10.6.2 Water Heater Blankets

SWS Detail: 7.0301.2 Tank Insulation

Install an R-11 insulation blanket on all water heaters **unless the manufacturer's label prohibits it**. Follow these guidelines to avoid fire hazards and to simplify future service.

Gas Water Heaters

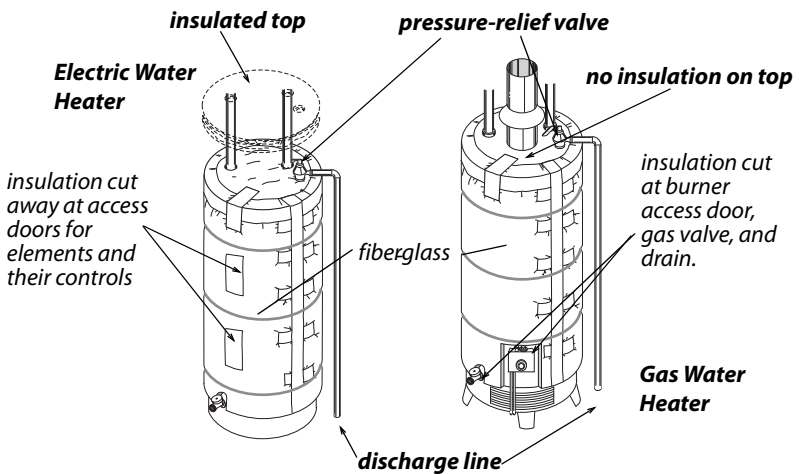
When you install insulation on gas water heaters, use these specifications.

- ✓ Keep insulation at least 2 inches away from the gas valve and the burner access panel. Don't install insulation below the burner access panel.
- ✓ Don't cover the pressure relief valve or discharge line with insulation.
- ✓ Don't insulate the tops of gas-fired water heaters because the insulation can obstruct the draft diverter.
- ✓ Don't insulate Flammable Vapor Ignition Resistant (FVIR) water heaters. The blanket may shift and unintentionally cover the combustion air openings.

Electric Water Heaters

When you install insulation on electric water heaters, use these specifications.

- ✓ Mark the blanket to locate the thermostat and heating element access plates and cut the blanket at these locations.
- ✓ When you cut the blanket for the thermostats, cut the bottom and sides but not the top. This creates a hinge that allows the door in the insulation to swing open and closed.
- ✓ Cover the top of the water heater with insulation.
- ✓ Don't cover the pressure relief valve and discharge line with insulation.
- ✓ If you specify insulation for an existing water heater which has a relief valve but no discharge line, install a discharge line outside the insulation to within 6 inches of the floor.
- ✓ Also install 3 zip-ties over the blanket. One within 6 inches of the top and bottom of the tank, and one in the middle.



Water heater insulation: Insulation should be installed carefully so it doesn't interfere with the burner, elements, draft diverter, FVIR combustion intake, or pressure relief valve and discharge line.

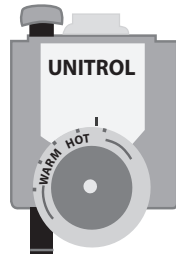
10.6.3 Measuring and Adjusting Hot Water Temperature

Use the following instructions to adjust water temperature.

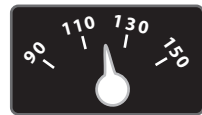
- ✓ Shut off power to an electric water heater before opening thermostat access panels.
- ✓ Measure the water temperature at the nearest faucet to the water heater. Reduce the temperature to 120°F with the client's permission.
- ✓ On electric water heaters, set both upper and lower thermostats to the same temperature.



Setting hot-water temperature: Getting the temperature correct can take a few measurements and re-adjustments.



Gas water heater control



Electric water heater control

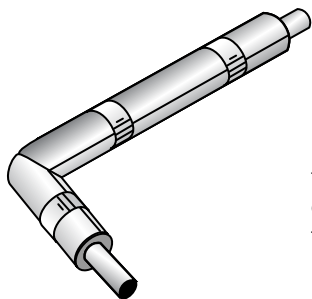
10.6.4 Heat Traps and Water-Heater Pipe Insulation

SWS Detail: 7.0301 Thermal Loss Reduction; 7.0301.1 Pipe Insulation; 7.0302.1 Electric Storage Tank Water Heater; 7.0302.2 Fuel-Fired Storage Tank Water Heater; 7.0302.3 Heat Pump Storage Tank Water Heater; 7.0302.4 Non Heated Storage Tank

Heat traps are piping loops or valves that prevent thermo-siphoning of water in and out of the piping near the water heater. Install heat traps if the water heater has no built-in heat traps.

Install pipe insulation to slow convection of hot water into the water lines near the tank.

- ✓ Interior diameter of pipe sleeve must match exterior diameter of pipe.
- ✓ Insulate the first 6 feet of hot and cold water pipe from the water heater.
- ✓ Use pipe wrap with a minimum thickness of 1 inch and a minimum R-value of 3. Cover elbows, unions and other fittings with the same insulation thickness as the pipe.
- ✓ Corners must be mitered, tight fitting, sealed and secured with appropriate material to prevent failure.
- ✓ Keep pipe insulation 6 inches away from single-wall vent pipe and 1 inch away from Type B vent.
- ✓ Fasten pipe insulation with zip ties, tape, or other approved method.



Properly installed pipe insulation: Must be the right size for the pipe, must completely cover the pipe, including bends, and must be fastened tightly to the pipe.

10.7 SELECTING STORAGE WATER HEATERS

SWS Detail: 7.03 Water Heating

Storage water heaters are the most common water heaters found in homes. *For installation instructions, see page 497.*

10.7.1 Determining a Storage Water Heater's Insulation Level

Common storage water heaters consist of a tank, insulation surrounding the tank, and an outer shell. There is typically either 1 or 2 inches of insulation surrounding the tank. The insulation is either fiberglass or polyisocyanurate.

Follow this procedure to determine the water heater's insulation level.

- ✓ Look for a listing of R-value on a label on the water heater.
- ✓ Find a hole in the outer shell where the flue pipe emerges or where plumbing connects. Look around the hole for either fiberglass or polyisocyanurate insulation.
- ✓ If the hole isn't large enough to see the insulation level on an electric water heater, try removing the access panel for the heating element after disconnecting power from the unit.

- ✓ You may just be able to see the gap between the tank and outer shell. If you can't see this gap, use a ruler or probe to push through the insulation along side of a pipe connecting to the tank until the probe hits the steel tank to determine thickness. Make sure that the probe is against the tank and not against a nut welded to the tank.
- ✓ If additional tank insulation is installed, it must be at least R-11. **Don't install insulation if the manufacturer's label on the water heater prohibits it.**

Identifying Tank Insulation

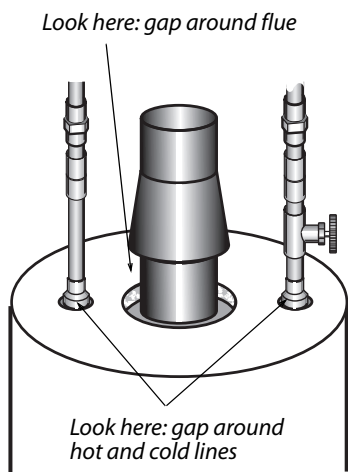


Table 10-6: Insulation R-Values

Insulation/thickness	R
Fiberglass 1 inch	3
Fiberglass 2 inches	6
PIC1 inch	6.5
PIC 2 inches	13
PIC 3 inches	19.5

10.7.2 Storage Water-Heater Selection

SWS Detail: 7.0302.1 Electric Storage Tank Water Heater; 7.0302.2 Fuel-Fired Storage Tank Water Heater; 7.0303.5 Expansion Tank (Potable Water)

Existing gas water heaters, including propane, typically use 200 to 400 therms per year. New gas water heaters use as little as 175 therms per year, resulting in a savings of between 25 and 225 therms per year. Similar savings are possible by replacing elec-

tric water heaters. Consider the following recommendations for specifying water heaters.

- A replacement gas or oil storage water heater should have an energy factor of at least 0.67 and be insulated with at least 2 inches of foam insulation.
- A replacement electric water heater should have an energy factor of at least 0.93 and be insulated with at least 2.5 inches of foam insulation.

10.8 ALTERNATIVE WATER HEATERS

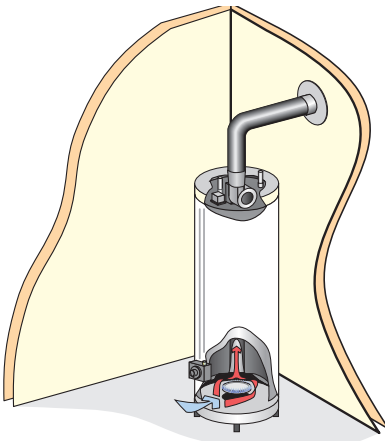
SWS Detail: 7.0302 Water Heater Installation; 7.0303 Distribution Components

Weatherization programs sometimes choose alternative water-heating products to improve efficiency and safety.

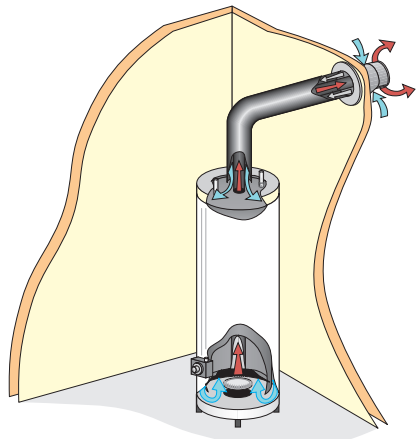
10.8.1 Sidewall-Vented Gas Storage Water Heaters

When gas storage water heaters cause persistent venting problems, specify a sidewall-venting water heater. Two common types of these water heaters are shown here.

- ✓ Choose a sealed-combustion sidewall-vented gas water heater, if possible. Next best is a fan-assisted unit.
- ✓ Install the replacement water heater in accordance with manufacturer specifications, 2012 IRC G2427.8.



Fan-assisted water heater: The fan allows horizontal venting. The water heater may be open combustion or sealed combustion.



Direct-vent water heater: Moves combustion air and flue gases through a concentric pipe system without a draft fan.

10.8.2 On-Demand Gas Water Heaters

SWS Detail: 7.0302.5 Tankless On-Demand/Point-Of-Use Appliances

On-demand gas water heaters are more efficient and cost less to operate compared to conventional gas storage water heaters. However, on-demand gas water are more expensive to install and may have shorter lifespans compared to storage water heaters.

Choose a sealed-combustion on-demand gas water heater, if possible. A fan-assisted on-demand gas water heater is the next best choice.

10.8.3 Heat-Pump Water Heaters

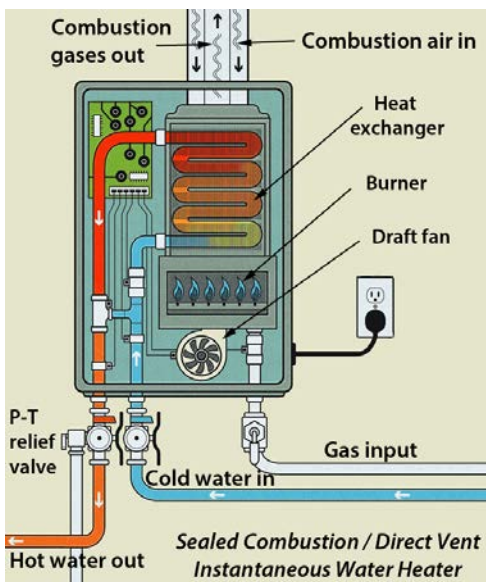
SWS Detail: 7.0302.3 Heat Pump Storage Tank Water Heater

Heat pump water heaters can heat water at up to 2-3 times more efficiently than electric-resistance storage water heaters. Heat

pump water heaters use heat from surrounding air to heat water. They cost much more than conventional electric water heaters but are far less costly to operate.



Heat pump water heater: This heat pump water heater has the heating coil (condenser) surrounded by the domestic water.



Sealed-combustion tankless water heater: These water heaters have a small market share and save around one-third of energy used by the best storage water heaters.

Table 10-7: Comparison of Advanced Water Heaters

Advanced Water Heater Type	\$ Savings*	Expected Lifespan	Major Advantages
High-efficiency storage tank (Oil, gas, electric)	≤\$500	8–15 years	Lowest first cost
Instantaneous Tankless (direct fired)	≤\$1800	5-15 years	Unlimited hot water
Heat pump	≤\$3000	5-15 years	Most efficient electric option
From information supplied by ENERGYSTAR.gov by the Environmental Protection Agency. * Lifetime savings compared to conventional water-heater models and same fuel.			

10.9 WATER-HEATER INSTALLATION

SWS Detail: 7.0302 Water Heater Installation; 7.0302.1 Electric Storage Tank Water Heater; 7.0302.2 Fuel-Fired Storage Tank Water Heater; 7.0302.3 Heat Pump Storage Tank Water Heater; 7.0302.4 Non Heated Storage Tank

Follow these procedures when installing a storage water heater or an alternative water heater.

- ✓ A replacement water heater must have a pressure-and-temperature relief valve with a discharge line that terminates less than 6 inches from the floor into a floor drain or drain pan.
- ✓ The discharge pipe should be made of rigid metal pipe or approved high-temperature plastic pipe.
- ✓ Install dielectric unions as required and a backflow preventer as part of a water heater replacement if any of these components are missing from the existing installation.

- ✓ Install an expansion tank for all storage water-heater replacements when needed.
- ✓ If leakage would cause damage to the home, install an emergency drain pan with sides that extend a minimum of 4 inches above the floor under a replacement water.
- ✓ Install a $3/4$ -inch drain line to the tapping on drain pan. Terminate the drain line in a floor drain or outdoors, at least 6 inches above grade.
- ✓ Install heat traps on the water heater's inlet and outlet piping if the manufacturer hasn't provided traps.
- ✓ Adjust water temperature to 120° F or to the lowest setting acceptable to occupants.

10.10 COMPARING WATER HEATERS

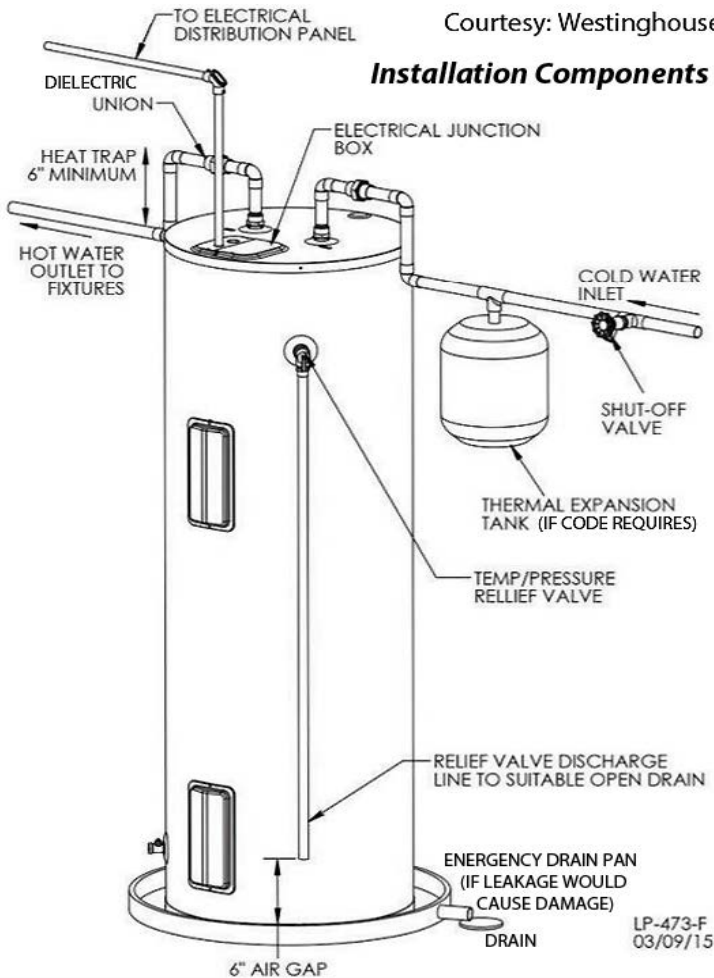
The choice of fuel and model for a storage water heater isn't easy and it involves many factors including safety, reliability, efficiency, and installed cost. See [Residential Energy Dynamics](#) free comparison tool.

10.10.1 Safety Comparison

Conventional direct-fired gas water heaters vent their combustion by-products to a gravity vented chimney. They can spill products of combustion into the living space, especially if the chimney isn't tall enough, warm enough, or sized properly. Sharing of a main chimney with another combustion appliance can cause venting problems. If the furnace or boiler is replaced with a sealed-combustion or horizontal-vented model, the chimney may then be too big for the remaining combustion water heater.

Courtesy: Westinghouse

Installation Components



Storage water heater installation: The SWS requires these components on new-water-heater installations.

Electric water heaters have no chimney and need no combustion air, which makes them safer for buildings with low natural air leakage, compared to gas storage water heaters.

Electric water heaters have no products of combustion. However, because their recovery capacity is generally much slower than gas water heaters of the same size, there is a greater chance of someone trying to compensate for a cold shower by setting

the electric water heater to an unsafely high temperature where occupants could be scalded.

10.10.2 Reliability Comparison

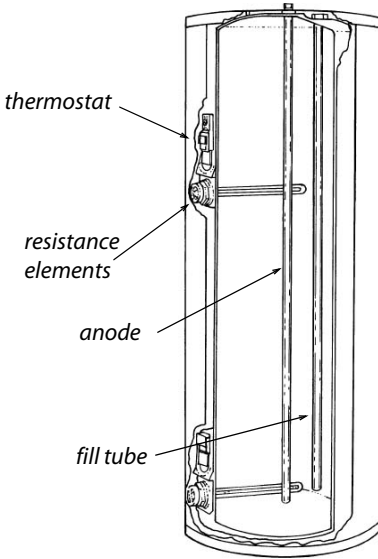
Storage water heaters are popular because they are inexpensive and reliable. Both gas and electric storage water heaters are simpler and more reliable than more expensive and complex water heaters. The lifespan of storage water heaters depends on local water quality and the quality of the water heater's storage tank.

Most heaters have glass-lined steel tanks which are typically warranted for five years. All types of heaters are available with larger or additional sacrificial anodes, which are pieces of metal that corrode before the tank does, thereby extending the tank life and maybe the warranty. If you buy a ten-year guarantee heater instead of a five-year guarantee heater, this choice might reduce the future cost of replacement and possible water damage from eventual storage-tank leaks.

10.10.3 Efficiency and Energy Cost Comparison

Conventional gas storage water heaters are rated at about 80% steady-state efficiency. However, whenever a storage water heater isn't firing, it's losing heat up the chimney. This happens when cold air, flowing through the heater, is warmed by the heater and escapes up the flue. This off-cycle heat loss reduces annual efficiency drastically and may result in the water heater's energy factor (EF) being less than 0.60.

The exact EF for a particular storage water heater is difficult to estimate because of many factors including: chimney height, chimney diameter, wind, the home's air-tightness, outdoor temperature, and water heater temperature setpoint. Considering these variables, the actual EF can vary from 0.60 to 0.40 or even lower. Nevertheless, gas storage water heaters cost less to operate than electric water heaters with the same insulation level.



Standard electric storage water heater: Electric water heating is more expensive than gas or oil but safer. Electric water heaters should have at least 2 inches of foam insulation.

As a heating fuel, electricity is approximately 2.5 times as expensive as natural gas. However, electric water heaters have no chimney and therefore no chimney losses. Electric water heaters do lose heat through the insulation jacket, which results in an EF of around 0.90. Heat-pump water heaters have an operating efficiency of over 200% (COP = 2.3) because they heat water with heat from the surrounding air. But because the electricity production and transmission system in the U.S. is about 31% efficient, the overall energy use and cost for heating water with electricity is still higher than with gas.

10.11 MULTIFAMILY WATER HEATING

SWS Detail: 7.0303 Distribution Components; 5.0203.1 Boilers

Multifamily water heating is much more complex than single family water heating. Particularly in large multifamily buildings, a water heating system may deliver zero gallons to several thousand gallons of hot water an hour.

10.11.1 Multifamily Water-Heating Choices

SWS Detail: 7.0302.4 Non Heated Storage Tank; 7.0302.5 Tankless On-Demand/Point-Of-Use Appliances

To provide hot water efficiently, this huge range of demand requires a system that resupply hot water slowly to a storage tank during low demand and also provide 15 to 50 gallons per minute during high demand. A staged array of on-demand water heaters has become very popular for multifamily water heating in the past 20 years.

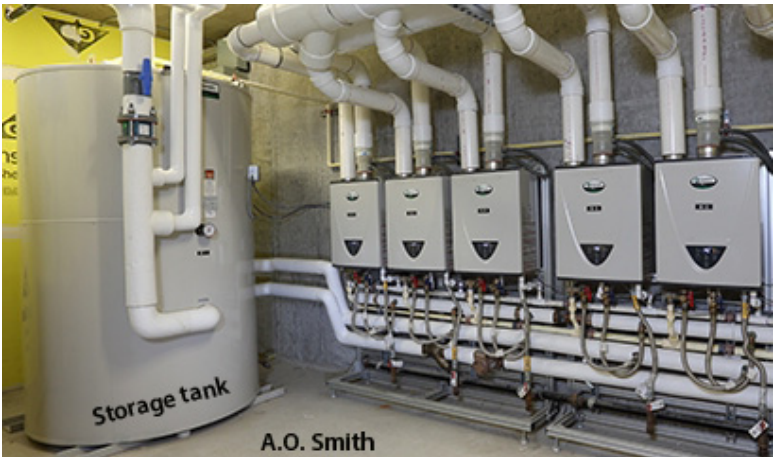
Multiple Storage Water Heaters

Many multifamily buildings use multiple large size (80 gallons) storage water heaters. The lifespan of these units can be as little as 7 years. This creates an annual replacement cycle that decreases reliability and increases the per-gallon cost of hot water.

Water Heating with a Single Boiler

Asking a single boiler to cover this range of demand requires either a modulating boiler or a huge storage tank or both to cover the range between peak usage and the minimum. The problems of providing for this demand variability with a single boiler, which may also provide space heating are these.

- A single heat exchanger can't really operate efficiently with such a wide variability of demand.
- If the boiler malfunctions, nobody has hot water.
- The mismatch between supply and demand are greater because of the boiler's responsibility for space heating.
- The control system is necessarily more complex than a simple staging control system.



Popular multifamily water-heating solution: On-demand water heaters heat water for a storage tank and for demand in a medium-sized multifamily building.

Staged On-Demand Water Heaters

Multifamily-building managers are now choosing staged on-demand water heaters to solve the problems of multiple storage water heaters or a single boiler.

The control systems for these on-demand systems regulate the number of units that fire based on demand. Because of the staging, the system can provide excess capacity for reliability in the event of unit failure without an efficiency penalty. And, the control system can spread the operating time equally among the units for further reliability.

10.11.2 Multifamily Storage Tanks

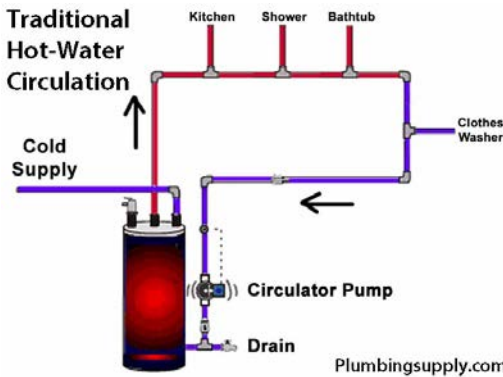
The design and selection of a multifamily hot-water storage tanks depends on the following factors among others.

- Peak hot-water demand.
- The capacity of the water heater(s).
- The budget of the building manager.

- Space available for installation.

The tank should have these features.

- ✓ R-12.5 or greater R-value.
- ✓ Glass or plastic anti-corrosion coating.
- ✓ 20-year warranty.
- ✓ Size selection to meet available footprint in mechanical area.



Hot-water re-circulation: Most multifamily hot-water circulation systems return cold water to the water heater and supply hot water to the distribution pipes.

10.11.3 Circulation Systems

SWS Detail: 7.0303.6 Recirculation System Temperature Modulation Controls; 7.0301.1 Pipe Insulation

The circulation pump moves water to provide hot water in pipes near the faucets and showers. The pump compensates for heat loss through pipes.

The pump should provide hot water to the farthest fixture from the tank at a temperature no cooler than 90°. The engineer must calculate the pipes' heat loss to size the pump correctly.

Types of Circulation Systems

Circulation pumps move hot water through the hot-water distribution pipes to provide hot water at or near every plumbing fixture. Circulation systems reduce wasted water that drains away while occupants wait for the hot water to arrive. The pump supplies freshly heated water near the fixture to counteract the pipes' steady heat loss. Two types of circulation systems are common.

1. Circulation that uses a return pipe.
2. Circulation that doesn't use a return pipe.

The circulation system without a return pipe is called demand circulation. Demand circulation is newer and less common, requiring controls in every dwelling unit. Large single family and small multifamily buildings are the primary users.