Introduction to Water Distribution Systems

Overview

The water distribution system moves water from its source to the building or structure where it is needed. The path the water takes and the types of materials used depend on the building or structure. Plumbers must understand how these water distribution systems work and the different types of materials that are used in these systems.

Module 02112

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02112
Introduction to Water Distribution Systems

Objectives

Successful completion of this modules prepares trainees to:

1. Describe the process by which water is distributed in municipal, residential, and private water systems.
   a. Identify and describe water sources.
   b. Explain water treatment processes.
   c. Describe water distribution systems.
2. Identify the major components of a water distribution system and describe the function of each.
   a. Describe the purpose of backflow preventers.
   b. Identify and describe the various types of valves used in water distribution systems.
3. Explain the relationships between components of a water distribution system.
   a. Identify the major components of a building water system and describe how to determine proper placement.
   b. Explain the requirements for sizing of the main supply lines.

Performance Task

Under the supervision of your instructor, you should be able to do the following:

1. Sketch an isometric drawing of a simple water distribution system and label its components.

Trade Terms

Angle valve
Backing board
Branch
Check valve
Chlorination
Coagulation
Corporation stop
Curb box
Curb stop
Fixture risers
Full flow
Galvanic corrosion
Hammer arrestors
Hose bibb
Pasteurization
pH
Precipitates
Pressure regulator valve
Pressure relief valves
Reservoirs
Service lines
Straight-through flow
Supply stop valves
Thermostatic/pressure balancing valve
Throttled flow
Turbidity
Ultraviolet (UV) light
Vacuum breaker
Water hammer
Water meter
Water supply fixture units (WSFU)
Water table
Well casing

Industry Recognized Credentials

If you are training through an NCCER-accredited sponsor, you may be eligible for credentials from NCCER's Registry. The ID number for this module is 02112. Note that this module may have been used in other NCCER curricula and may apply to other level completions. Contact NCCER's Registry at 888.622.3720 or go to *www.nccer.org* for more information.

CODE NOTE

Codes vary among jurisdictions. Because of the variations in code, consult the applicable code whenever regulations are in question. Referring to an incorrect set of codes can cause as much trouble as failing to reference codes altogether. Obtain, review, and familiarize yourself with your local adopted code. Safety codes are developed by the US Occupational Safety and Health Administration (OSHA).

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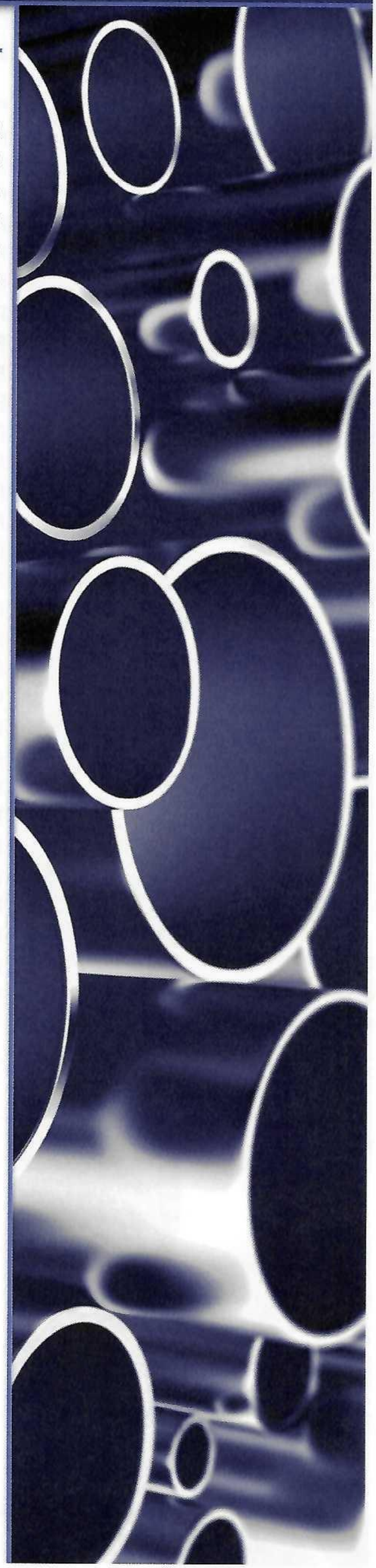

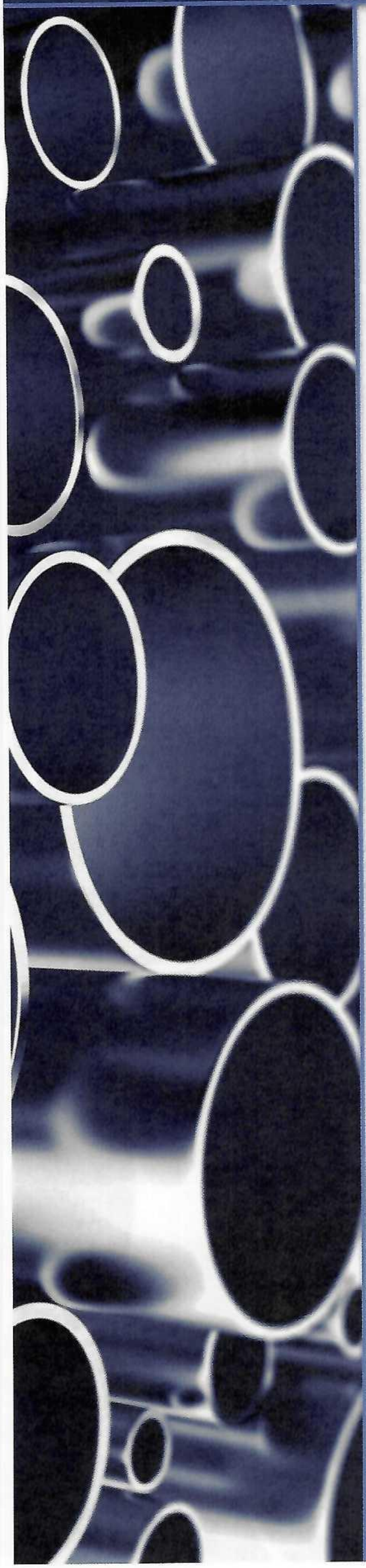

Figures

SECTION ONE

1.0.0 TYPES OF DISTRIBUTION SYSTEMS

Objectives

Describe the process by which water is distributed in municipal, residential, and private water systems.

a. Identify and describe water sources.
b. Explain water treatment processes.
c. Describe water distribution systems.

Trade Terms

Branch: Any part of a piping system other than a riser, main, or stack.

Chlorination: The use of chlorine gas or compounds to disinfect water.

Coagulation: In water treatment processes, a thickening of suspended or dissolved materials into a soft, semi-solid or solid mass.

Corporation stop: A valve that connects the building water service line to the water main.

Curb box: A cylindrical casing placed in the ground over the curb stop, into which a special key-wrench can be inserted to turn off the curb stop. Also given the term buffalo box.

Curb stop: A control valve installed in building water supply lines between the corporation stop and the building.

Galvanic corrosion: Corrosion caused by a weak electrical current that occurs when an electrical path exists between two different metals.

Pasteurization: The practice of heating water and foods to high temperatures to kill harmful bacterial organisms present.

pH: A measure of the acidity or alkalinity of a solution. A pH of 7 is neutral, being neither acidic nor alkaline; higher numbers are more alkaline, lower numbers are more acidic. The symbol comes from the early twentieth-century chemistry term power of hydrogen.

Precipitates: Solid materials resulting from chemical reactions in water solutions that settle out.

Pressure regulator valve: A valve used to reduce water pressure in a building. The valve is activated by changes in pressure within the system.

Reservoirs: Sources of water collected and stored in natural or artificial (man-made) lakes.

Service lines: The main water supply piping, to which branches are connected. Also referred to as feeder lines.

Turbidity: The presence of particles (sand, mud, silt) suspended in water that give the water a cloudy appearance.

Ultraviolet (UV) light: A form of high-energy light with wavelengths shorter than visible light. In water supply systems, it can disinfect water by destroying microorganisms as the water flows through a chamber containing UV lamps.

Water meter: A device for measuring water volume usage by an individual building or customer.

Water table: The level below the ground's surface where soil becomes saturated with water.

Well casing: Outer tube or pipe sunk into the ground after drilling or driving a well to stabilize the hole.

Water supply and distribution play an important role in plumbing systems. Water supply is either private (from a well) or municipal (supplied through a public water distribution system). Components of the water distribution system include the pipes and fittings that carry hot and cold water in a building, the valves used to regulate the flow of water to the fixtures and other outlets, and water heating and treatment equipment.

Any water distribution cycle begins with a water source. Water for a private system comes from a well sunk into an underground water supply that is usually pure enough to drink. Water for municipal systems comes from **reservoirs**, wells, rivers, lakes, and other sources. It is then treated and distributed to homes and buildings.

In municipal systems, city water undergoes a purification process before it reaches the faucet. Water is pumped to a treatment plant where harmful impurities are removed through processing. Chlorine, aluminum sulphate, and activated charcoal are added to the water during this cycle. This water and chemical mixture flows into a mixing basin where paddles thoroughly mix the chemicals into the water. From here, the water moves to a settling basin where impurities separate from the water. Moving from the basin, sand and gravel filter the water to screen out most of the remaining suspended materials. Treatment plants may add chlorine again to make sure that the water is free of harmful bacteria. Some cities also add fluoride to help prevent tooth decay in the general population. A reservoir holds the filtered water until it is pumped into the main supply pipes that lead to building **service lines**. Building piping systems deliver water to sinks, bathtubs, showers, dishwashers, icemakers, hoses, and any other water outlets (*Figure 1*).

1.1.0 Sources of Water

As of 2005, about 14 percent of the US population gets its water from private sources. Most of this water comes from wells. Wells are sunk (dug, driven, drilled, or bored) into the earth to extract the water (*Figure 2*). Dug or driven wells are considered shallow wells. This type of well is generally used where the **water table** is within 20 to 50 feet of Earth's surface. Surface water easily contaminates dug wells. Driven wells are made by forcing a well point into the earth. These wells are practical only where the soil is loose and fairly free of rocks.

Wells that are drilled are considered deep wells and are typically drilled into solid rock. They may extend hundreds of feet down through the earth. They are made using a drilling rig with a rotating diamond-toothed bit that can penetrate the solid subsurface materials. Bored wells are generally shallower and larger in diameter, using an earth auger (drill). These normally do not extend into bedrock. Once the water table is reached and an adequate amount of water volume is found, a **well casing** is inserted to stabilize the sides of the well and to protect it from contamination. Casings are made of various materials and in different diameters ($1\frac{1}{2}$ to 2 inches) and depths, depending on how far the water is beneath the surface.

After the well is established, water is pumped to the surface to a storage tank inside or near the building, where it can be treated and used by the owners. Generally, the deeper the well, the more gallons per minute can be pumped, depending on the level of the water table. The pump pressurizes the water in the storage tank so that it provides enough water for the installed fixtures to work properly.

> **Locating and Drilling a Well**
>
> The first consideration before drilling or driving a well is state and local regulations. Wells may be approved for household, domestic, or commercial use. A local well driller is the best source of answers to the critical questions of what type of well is needed, what permits are required, and the history of water wells in the area. A variety of different aquifers (water channels) and water tables exist in various formations below the ground surface. A history of wells drilled in a particular area provides important information for the well driller to locate the best spot to drill.
>
> Other considerations are the distance from property lines and the position of septic tanks and septic leach fields in relation to the well site. Most codes require at least 100 feet between the well and the leach field. Because the plumber will make connections to both the well and the wastewater disposal, the plumber must work closely with the owner, the well driller, and code officials.

Reservoirs are another source of water. Most reservoirs are made by building dams across rivers or streams. Municipalities can then collect and store water for future use. Reservoirs are particularly important in areas that receive little rainfall for part of the year. Pumps move the water from the reservoir to the water treatment plant.

1.2.0 Water Treatment

Much of the water from open reservoirs, lakes, streams, and some wells is not ready for human use until it has been treated. Water must be tested for the presence of chemicals, **turbidity** (cloudiness resulting from suspended particles), organic

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> **Reclaimed Water**
>
> Reclaimed water is distributed through pipes that are separate from the main water distribution pipes. This dual-piping system keeps contaminants in the reclaimed water from entering the potable water system. In the United States, reclaimed water is always distributed in lavender (light purple) pipes to distinguish it from potable water.
>
> The idea of using reclaimed water is not a new one. Los Angeles County, California has provided treated wastewater for irrigation in parks and golf courses since 1929. But this idea may not be in use for all applications in all locations. In general, each community decides how to collect and reuse reclaimed water and each has established codes for this practice. For example, some communities may use reclaimed water to flush fixtures. Others may restrict its use to landscape irrigation for golf courses or sports stadiums.

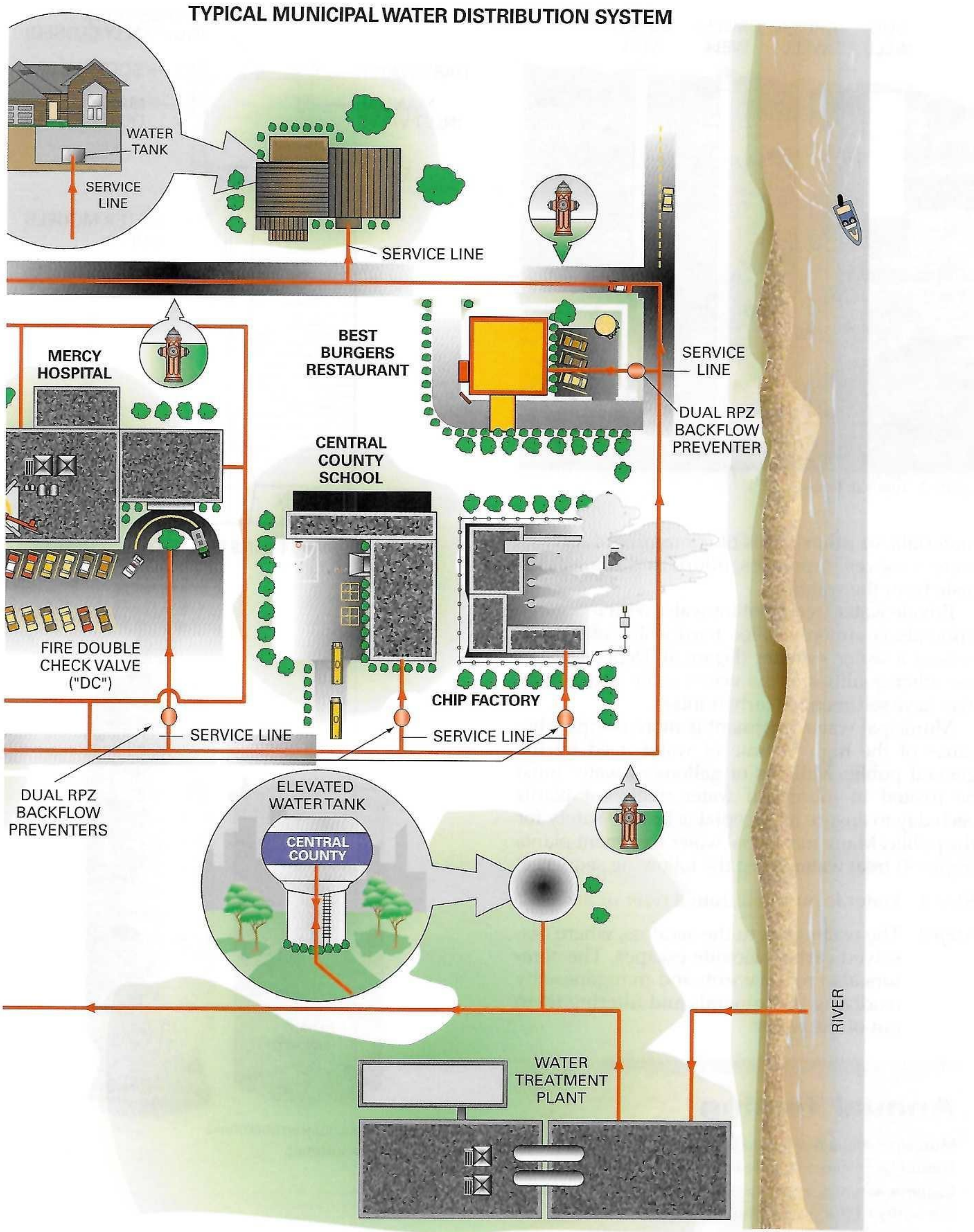

Figure 1 Water distribution.

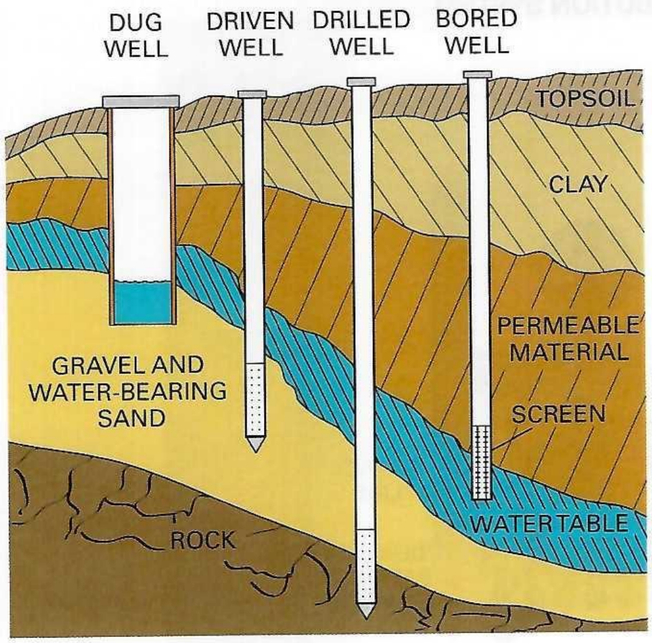

Figure 2 Types of wells.

materials, or other types of contaminants. Treatment removes impurities, odors, and unpleasant taste from the water.

Private water treatment for water with inorganic minerals, commonly called hard water, often consists of a water softener (*Figure 3*). Depending on the other qualities of the water, some homes may also have sediment or carbon filters.

Municipal water treatment is more complex because of the high volume of water used by the general public. Millions of gallons of water must be treated in municipal water treatment plants each day to ensure an acceptable level of safety for the public. Many municipal water treatment plants (*Figure 4*) treat water using the following sequence:

Step 1 Water is pumped from a river or lake.

Step 2 The water goes to the aerators, where dissolved carbon dioxide escapes. The aerators also remove iron and manganese by oxidizing the minerals and filtering them out of the water.

Annual Testing

Municipal wells are tested to ensure safety. Wells should be tested annually to check for levels of bacteria, viruses, and microbes. These tests ensure the purity of the water. Usually, the local health department can do this testing. Many tests are performed, but these tests vary, so check with your municipal authority.

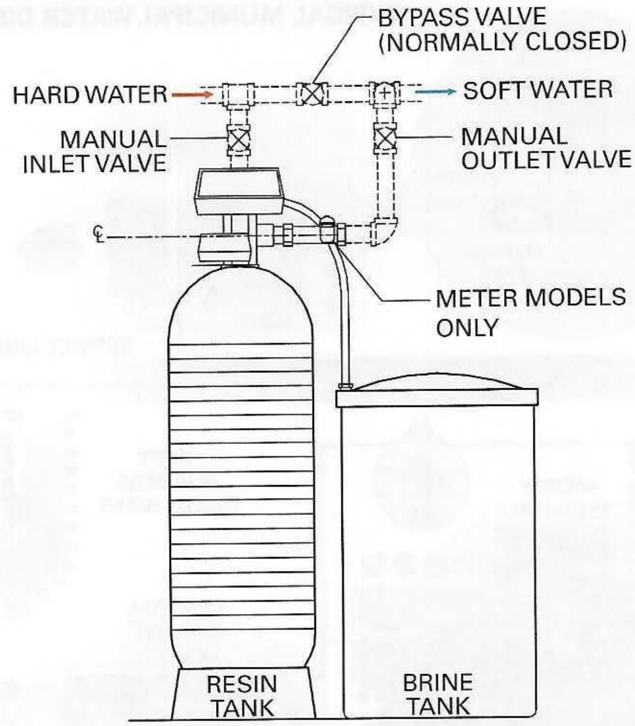

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Figure 3 Water softener.

Water Usage

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According to the Environmental Protection Agency, the average household in the United States spends nearly $500 per year on its water and sewer bill. Each person in the United States consumes 100 gallons per day on average and generates over 50 gallons of wastewater. (About half of the water consumed is for irrigation and goes back into the ground rather than the wastewater stream.) Of this wastewater, 9,000 gallons per year is used to flush away only 230 gallons of waste from water closets, a surprisingly wasteful use of water that has been treated to drinking water standards.

Step 3 The aerated water flows to the clarifier, where lime and soda ash are mixed in to cause **coagulation**, or thickening, which removes **precipitates** of calcium and magnesium. Precipitates are chemical compounds containing these elements that settle out of solution. This process softens the water.

Step 4 Carbon dioxide is injected to recarbonate the water, and to stabilize and increase the acidity (lower the **pH**) of the water slightly. The water flows through rapid (or coarse) sand filters to remove any remaining particles.

Step 5 After the filtering process, the water passes to the tanks, where a chlorine compound (e.g., sodium hydrochloride) is added to disinfect it. At this stage, a fluoride compound is usually added to reduce the occurrence of tooth decay. This treated water is then stored in reservoirs until needed.

Step 6 After water leaves the treatment plant, it flows through pipes called water mains. The water mains usually run under the streets and serve many buildings. Permits are required to make connections to the water mains. In some areas, only municipal workers are authorized to make these connections. In other areas, licensed contractors or plumbers install the connections. The connections bring water from the main to the individual buildings through the building water service line.

1.2.1 Disinfecting a Water Supply System

Untreated water contains innumerable microorganisms. Some of these can cause disease and illness if ingested or inhaled. Plumbers must prevent contamination in a treated water supply system by doing their job properly and carefully. Plumbers must ensure that pipes are stored and handled properly and are not stored in dirty or wet locations, which are ideal breeding grounds for harmful organisms.

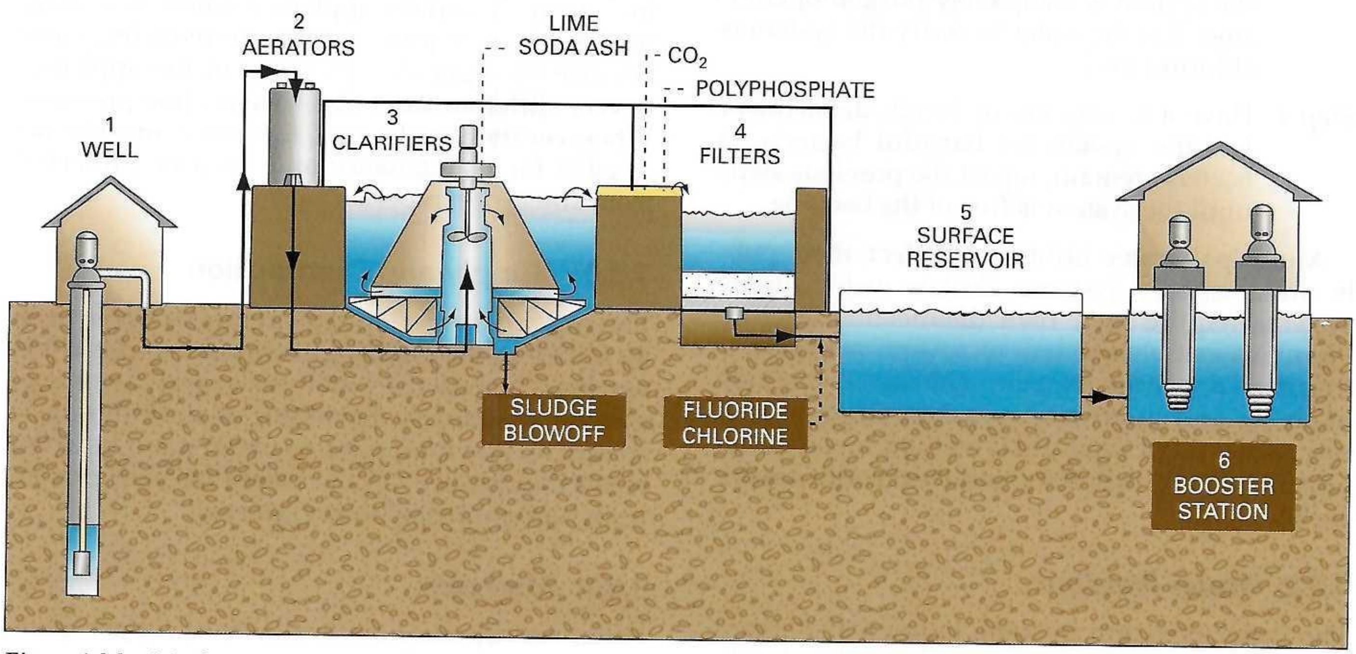

Figure 4 Municipal water treatment plant.

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Water Conservation

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Everyone has a stake in conserving water resources. You can see the effects of water conservation practices in many areas. Hotels, for example, reduce the amount of water used for laundry service by asking guests to reuse towels and sheets. Sinks in public restrooms may include a sensor that automatically turns the water off after a set period. Local governments post water-saving ideas on their websites. Communities and students may participate in the annual World Water Day, a program designed to focus citizens on water conservation. The federal government has programs that encourage conservation. WaterSense, for example, is a program of the Environmental Protection Agency. It provides specifications for water-efficient products, new homes, services, and water-saving tips. The WaterSense label makes it easy for consumers to find products that use at least 20-percent less water than similar non-WaterSense products and perform as well or better than standard models. Look around your community. What other examples of water conservation can you find?

Cap all installed pipe at the end of each workday. When the water supply system has been completely installed, disinfect the system using the following procedure:

Step 1 Flush the completed pipe system with potable water until the water flows clear from all outlets.

Step 2 Fill the entire system with a water/chlorine solution. Valve off the system. Use a solution of at least 50 parts per million (ppm) of chlorine and let the system stand for 24 hours. Alternatively, use a solution of at least 200 ppm of chlorine and let the system stand for 3 hours. Refer to your local code.

Step 3 Flush the system with potable water until the system is completely purged of chlorine. Test the water to verify the system is chlorine-free.

Step 4 Have a testing lab or health department test the system for harmful bacteria. If bacteria remain, repeat the previous steps until the system is free of the bacteria.

Municipal water utilities disinfect their public water supply systems. Private water supply systems require their own disinfection devices. Plumbers can choose one of several methods to disinfect a private system. The most common methods are **chlorination**, **pasteurization**, and **ultraviolet (UV) light**. Each method involves different tools and materials, and local codes govern each method.

1.2.2 Water Pressure

The water pressure in some municipal systems may be either too low or too high for the plumbing system in a building. The plumber has ways to compensate. If the water pressure is too low, a booster system can be installed. One kind of booster has variable capacities to meet increased or decreased demand for water (*Figure 5*). For example, it might have two pumps—one that functions at 33 percent of system capacity, and one that functions at 66 percent. When demand is low, the smaller pump operates. As demand increases, it shuts down and the larger pump starts up. At peak demand periods, both pumps operate.

If the water pressure supplied to the system is too high, the plumber can use a **pressure regulator valve** (*Figure 6*) to lower it and to eliminate sudden pressure changes.

Pressure-reducing valves are located according to the needs of the system. Some codes may require a valve where pressure buildup at any time of the day exceeds 80 pounds per square inch (psi). A certain appliance (such as a dishwasher) may require a pressure-reducing valve because the operating pressure of the appliance is very different from the system's line pressure. Wherever they are located, the valves must be accessible for maintenance and must be protected from abuse or tampering.

1.3.0 Supply and Distribution

The water distribution system moves water from its source to the building or structure where it is needed. The way the water moves and the type of materials used vary depending on the building or structure. It is important to understand how the water distribution system works for both private wells and municipal water systems.

1.3.1 Materials

Water service lines are available in copper, plastic, and steel. Water mains are available in several materials, including cast iron. The cost of pipe

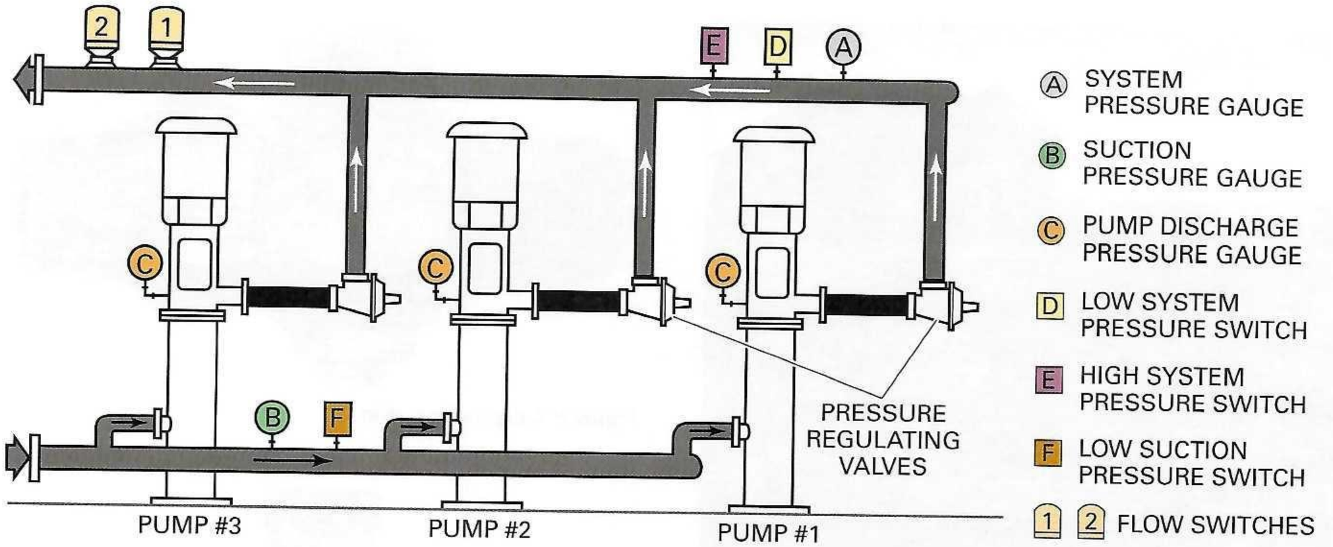


Figure 5 Variable-capacity system.

Figure 6 Water pressure regulator valve.

and its service lifetime often determine the choice of materials. Other considerations include corrosion resistance, chance of freezing weather, working pressure, local plumbing codes, and ease of installation. In many cases, the life expectancy of galvanized and copper tube depends on soil and water conditions. Galvanized pipe is electroplated with zinc to provide a protective coating that resists corrosion or oxidation (rust). Acidic soils, however, tend to act on galvanized pipe. Soil with higher carbon dioxide levels are also acidic and tend to limit the life of copper tube. Hydrogen sulfide is harmful to copper pipe as well. The corrosion caused by this gas breaks down the walls of metal pipe and causes the metal to thin or pit.

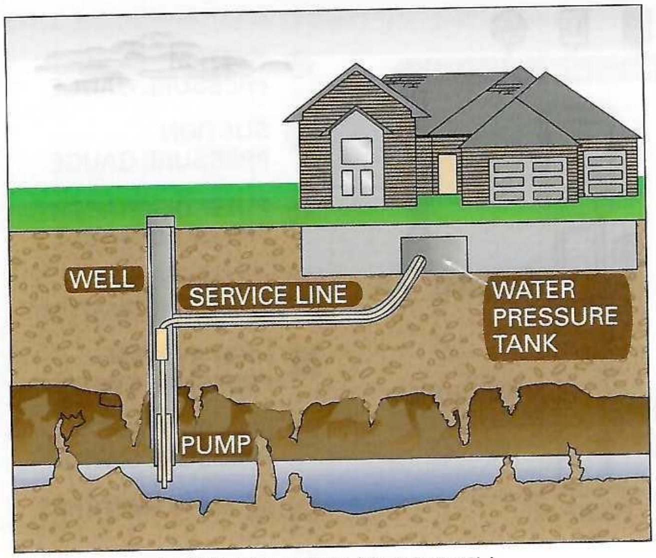
Another consideration in selecting the water supply pipe is the possibility of **galvanic corrosion**. This can develop when an electrically-conductive path connects pipes of different metals, such as copper and galvanized steel. It results from the action of a weak electrical current that flows between the different metals. Plumbers must take steps to reduce the likelihood of galvanic corrosion. You will learn more about corrosion prevention as you advance in your training.

1.3.2 Service Line from a Private Supply

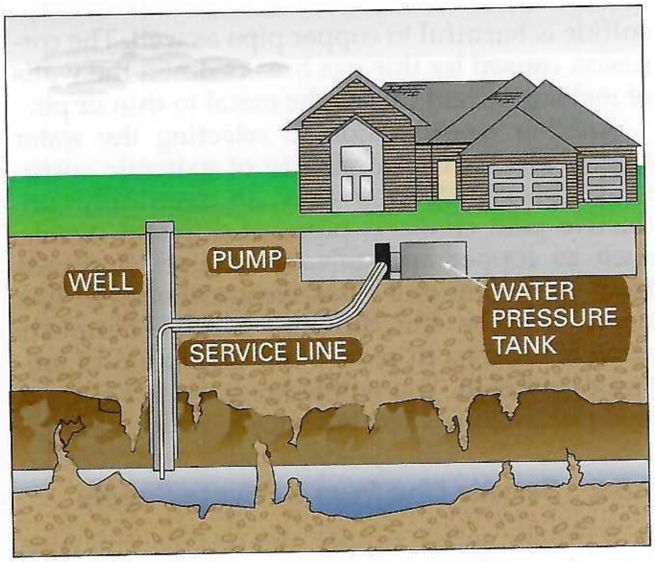
In a private water supply, the service line runs from the well point to the house, and the pump can be located at the well or at the house (*Figure 7*).

The installation of a private water supply system usually requires a well, although it may mean getting water from a spring or a cistern. A private water source is required when access to municipal water supplies is not available, such as in rural areas.

The plumber may be responsible for setting (installing) the pump and completing the water service to the structure, or a certified well driller may do it. In some cases, a pump installer is required to set the pump, provide electrical service, and complete the water service to the pressure tank. These responsibilities overlap a great deal. Each state and plumbing code has specific requirements for water service from a well. In most cases, a water sample must be drawn and tested by appropriate authorities after the well is purged and before the final tie-in.



PUMP LOCATED AT THE WELL



PUMP LOCATED AT THE HOUSE

Figure 7 Well point.

1.3.3 Service Line from a Public Water Main

Water distribution and supply systems in buildings connected to the public water main differ from those used in private water supplies. With private water supplies, pumps are the primary distribution mechanism. For buildings, the building service line is tapped into the water main using a **corporation stop** (*Figure 8*). This is a valve that is threaded into the main without interrupting service to other locations. A short pipe leads from the corporation stop to the **curb stop** (*Figure 9*). The curb stop is a control valve installed in the building water supply line between the corporation stop and the building. The **curb box** is a round casing placed in the ground over the curb stop. The top opening is at ground level. A special key-wrench can be inserted into the curb box to turn off the curb stop in emergencies or for service (*Figure 10*). The curb box, sometimes given the term *buffalo box*, is marked on city plans and drawings. On the property, it can be located by finding the metal marker (*Figure 11*). Because of differences in local procedures and applicable codes, a plumber should contact local municipal, township, or village authorities about connecting to the water main.

The plumber runs the water supply piping from the curb stop to the building's interior and installs a water line between the curb stop and the **water meter** connection (*Figure 12*). The water meter measures the volume of water used (in gallons or cubic feet). Water meters usually belong to the municipality, and a city or county employee must install them. A meter stop valve (*Figure 13*) is installed on the supply-side of the water meter to allow cutoff of the water service to the entire building. A second stop valve on the building side permits removing the meter for servicing. The building main shutoff valve is installed inside the building after the meter is installed (*Figure 14*). This valve allows the service to be turned off and on during construction. Beyond this point, the building supply system delivers water to the fixtures.

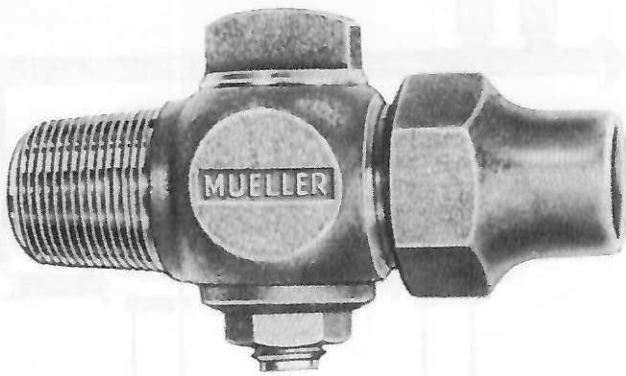


Figure 8 Corporation stop.

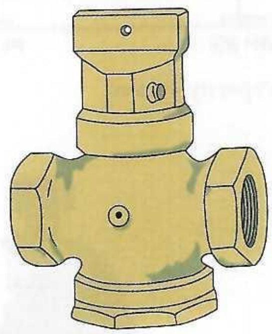


Figure 9 Curb stop.

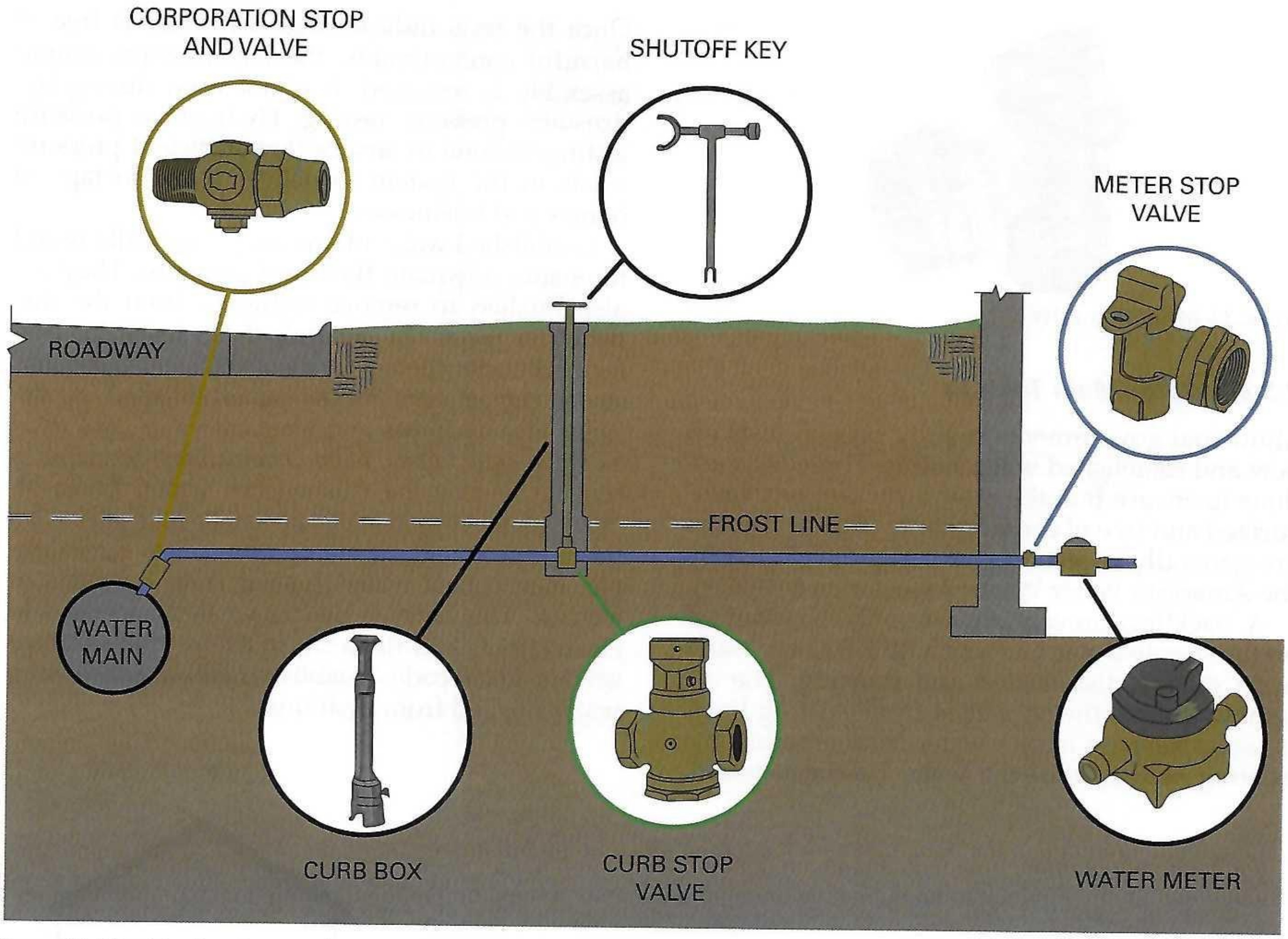


Figure 10 Municipal water supply connection.

Figure 11 Metal marker for curb box.

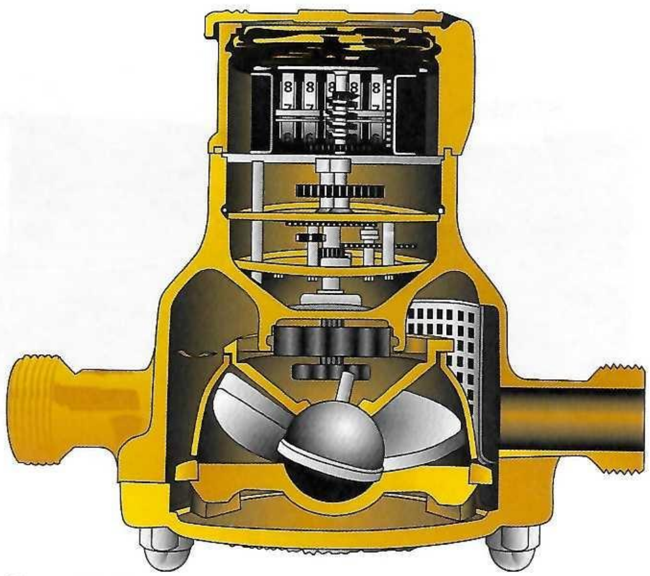


Figure 12 Water meter.

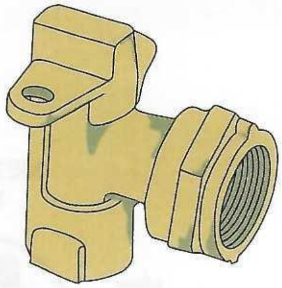


Figure 13 Meter stop valve.

1.3.4 Water Main Testing

Municipal governments require several tests on new and established water mains. These tests are done to ensure that the mains are properly pressurized and free of contaminants. The local codes are generally based on standards developed by the American Water Works Association (AWWA).

A backflow-prevention assembly is required on the supply water line when filling a new water main during disinfection and flushing. The assembly isolates the new lines from existing lines. It keeps the new main's water from entering the existing system until the water has been tested. Once the tests indicate that the water is free of harmful contaminants, the backflow-prevention assembly is removed. It is not used during hydrostatic pressure testing. Hydrostatic pressure testing is done to ensure that sufficient pressure exists in the system to deliver water to taps in homes and businesses.

Established water mains are periodically tested to ensure adequate flow and pressure. They are also flushed to remove sediment from the distribution pipes. In general, these tests are performed under the authority of the local water and sewer department following established guidelines. Fire hydrants and blow-off valves are used as flush-out points. Each community determines how to handle the flushed out water. Local officials must consider public safety and effects on the environment. Some communities, for example, may collect water flushed from hydrants in a truck. The water is de-chlorinated and used to clean streets and flush storm drains and sanitary sewers. Local codes establish methods for reusing water flushed from hydrants.

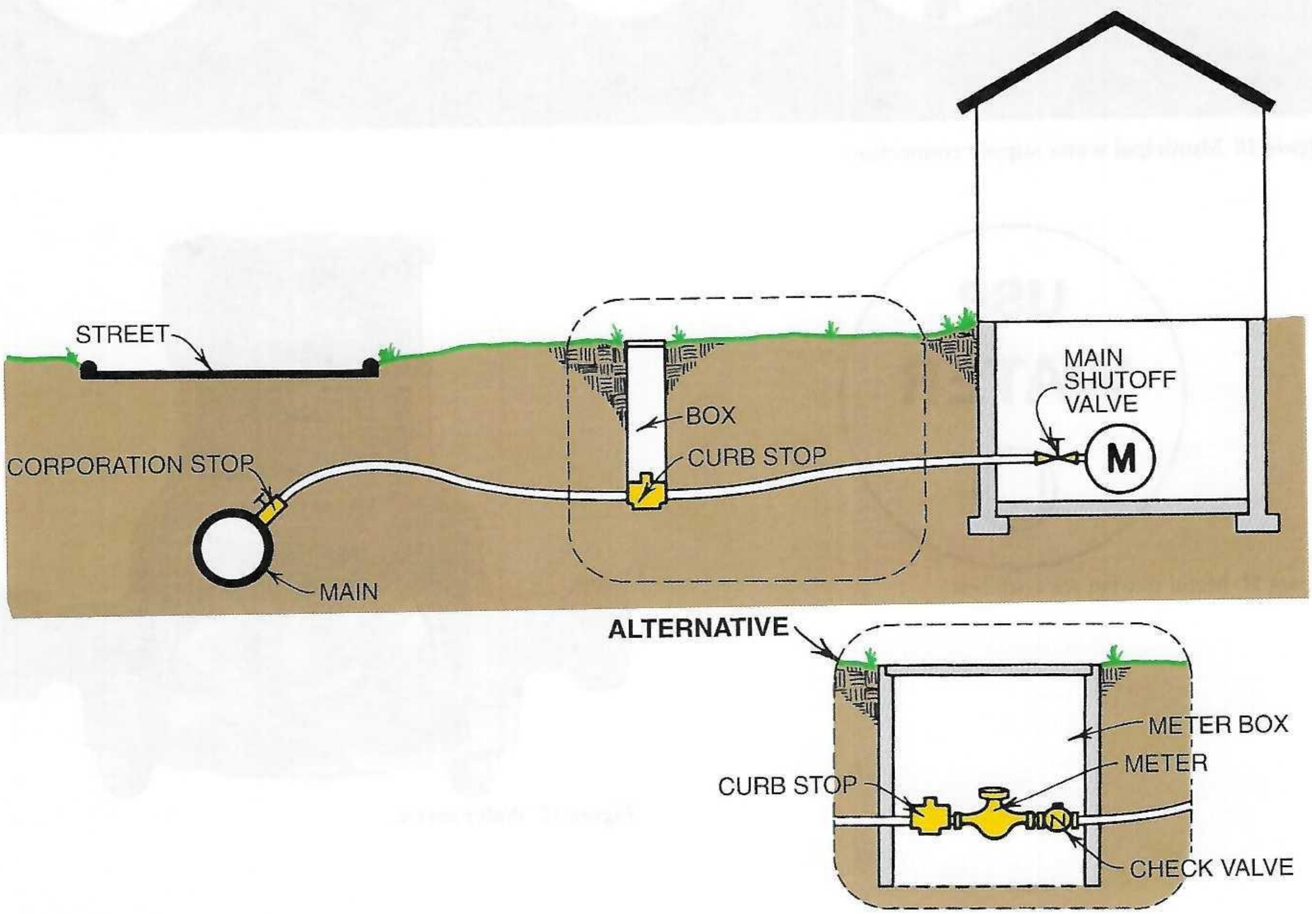


Figure 14 Main shutoff valve.

Frost Protection

Frost protection is an important consideration in many parts of the country. Frost depths, called frost lines, are different for each area. They are determined from historical winter temperature data. The plumber must install the water service line below the frost line to make sure that freezing and thawing temperatures in the earth do not affect the piping. If the water supply line enters the building above grade, it must be insulated to prevent freezing. Check your local code for the frost depth in your area.

Additional Resources

International Plumbing Code, Current Edition. Falls Church, VA: International Code Council.

National Standard Plumbing Code, Current Edition. Falls Church, VA: Plumbing-Heating-Cooling Contractors National Association.

1.0.0 Section Review

1. The deepest types of water wells are generally _____.
   a. dug
   b. drilled
   c. bored
   d. driven

2. To provide water treatment in private systems with water hardness problems, install a _____.
   a. carbon filter
   b. sediment filter
   c. precipitation filter
   d. water softener

3. Using copper tubing for underground applications should be avoided if the _____.
   a. soil is acidic
   b. soil is wet
   c. soil has an absence of hydrogen sulfide
   d. working pressure of the water main is low

Section Two

2.0.0 Water Distribution System Components

Objectives

Identify the major components of a water distribution system and describe the function of each.

a. Describe the purpose of backflow preventers.
b. Identify and describe the various types of valves used in water distribution systems.

Trade Terms

Angle valve: A valve whose internal design is similar to a globe valve's but its outlet direction is 90 degrees from its inlet.

Check valve: A valve that allows liquid to flow in only one direction. Pressure and flow within the inlet line keeps the valve open. Automatic closure of the valve occurs with the reversal of flow, by the weight of the disc mechanism, or by spring action.

Full flow: Describes a valve that does not restrict the flow of a fluid through it compared to the potential flow through the connected piping.

Hose bibb: A faucet with a threaded outlet, typically set at an angle to the inlet pipe, used to connect a hose. Usually located on the outside of a building. Also referred to as a sill cock or bibcock.

Pressure relief valves: Valves normally used for liquid service to prevent over-pressurization of a system or component. May be slow- or fast-acting depending on their purpose and design.

Straight-through flow: A valve flow design that does not restrict flow through the valve. The element that closes the valve is retracted entirely clear of the passage.

Supply stop valves: Valves that are commonly used to disconnect the hot or cold water supplies to water closets and sinks. They are available in either right-angle or straight design, and with globe- or ball-valve internals.

Thermostatic/pressure balancing valves: Mixing valves which sense outlet temperature and incoming hot and cold water pressure, and compensate for fluctuations in hot and cold water temperatures and/or pressures to stabilize its outlet temperatures. Also referred to as temperature and pressure (T&P) relief valves.

Throttled flow: Reduced flow of water through a valve by positioning of the valve's stopping device; increases both the pressure drop across the valve and flow resistance through the valve.

Vacuum breaker: A type of backflow preventer that inhibits backflow caused by lower pressure in a water supply system by opening a vent path in a cross-connected system to prevent siphonage.

The primary purposes of water distribution systems are to supply clean potable water and to provide the means of controlling the volume, pressure, and rate of water delivery.

2.1.0 Contamination Prevention

Backflow is any unwanted flow of used or nonpotable water back into the potable water distribution system. This reverse flow occurs as a result of cross-connection, which is a direct link between a contaminated liquid and a potable water supply. Backflow can occur as a result of an improper or altered plumbing hookup or a garden hose being left in a pool of contaminated water, for example.

These conditions do not in themselves cause a significant hazard, but they create the potential for serious health threats to the public, especially in terms of waterborne diseases. The danger occurs when a break in the water main or other vacuum potential exists somewhere in a water line. If this happens, the source of contamination could be drawn into the water supply line. Backflow prevention is required in many plumbing installations to keep contaminated water or other liquids from flowing back into the potable water system.

2.1.1 Air Gaps

The most reliable means to protect water supply lines from back-siphonage is by the use of air gaps and restricting overflow levels. Air gaps are measured vertically from the lowest end of the potable water outlet to the flood-level rim of the fixture into which it discharges. In a bathroom sink, for example, the faucet outlet is set above the sink's flood-level rim (the point at which water begins to overflow the top of the sink). This is a designed-in air gap. In addition, the sink's top drain returns water to the bottom drain before the water can rise to the faucet. The minimum required air gap is two times the diameter of the potable water outlet but not less than 1 inch. Depending on the application, the required air gap may be dictated by system flow rate or other factors. You can find the specific rules for air gaps and air-gap fixtures in the *American Society of Mechanical Engineers (ASME) Standard A112.1.3, Air Gap Fittings for Use With Plumbing Fixtures, Appliances, and Appurtenances.*

2.1.2 Vacuum Breaker

Basic backflow prevention devices are designed to safeguard against dangerous cross-connections. The **vacuum breaker** (*Figure 15*) in a **hose bibb** (also called a sill cock) connection acts as a backflow preventer by admitting air to the lower-pressure (vacuum), potable-water side while blocking flow from the downstream side of the fitting.

A physical separation must always be maintained between private and municipal water systems. Wells and their associated plumbing systems must not be connected to municipal water supplies. Codes specify the degree of danger and the appropriate device that should be used for various applications.

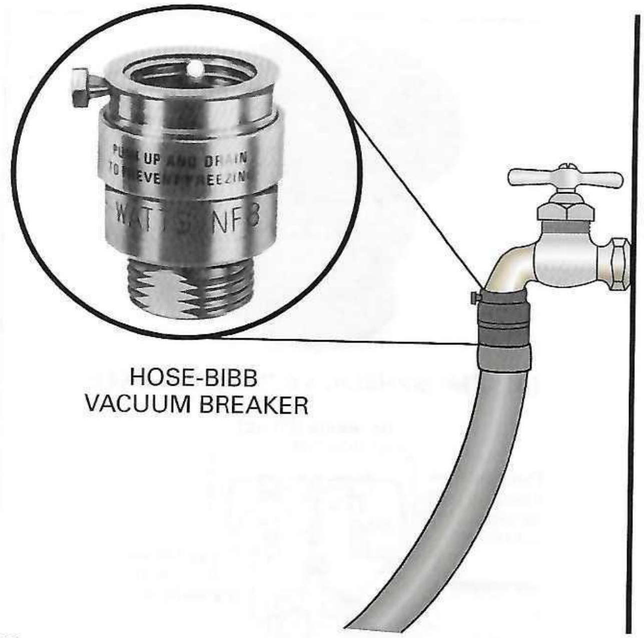


Figure 15 Vacuum breaker.

2.1.3 Other Backflow Preventers

Some backflow preventers protect against both back pressure and back-siphonage, while others can handle only one type of backflow. Backpressure occurs in the water distribution system when a pressure higher than the supply pressure causes a reverse flow into the potable water piping. Back siphonage occurs when contaminated or polluted water flows from a plumbing fixture back into the potable water piping. This can occur when a negative pressure exists in the plumbing fixture. The five most commonly-used mechanical backflow preventers are:

- Atmospheric vacuum breakers
- Pressure-type vacuum breakers
- Dual-check valve backflow preventers
- Double-check valve assemblies
- Reduced-pressure zone (RPZ) principle backflow preventer

Figure 16 shows examples of each of these.

Each type of backflow preventer has specific applications and limitations. These factors must be considered in any type of system design using backflow preventers. Before you select and install any backflow prevention or siphonage prevention device, consult local codes.

Backflow prevention devices must be well-maintained to work effectively. Most devices are field tested before installation and then tested annually. When devices are not working properly, they must be repaired and tested according to the manufacturer's instructions. Testing must be performed by certified personnel.

CAUTION

Some codes require installation of backflow preventers in every new structure, including residences. Always be sure to check architectural plans and all applicable codes before any installation.

2.2.0 Valves

Valves or faucets regulate the flow of water in a water distribution system. They may be used to turn water service on and off, act as throttling devices that control the rate of water flow, regulate the pressure, or prevent a reversal of flow through a line.

RPZ Valves

A reduced-pressure-zone (RPZ) backflow preventer may also be called a reduced pressure zone device (RPZD), RPZ valve, or reduced pressure zone assembly. RPZ valves are designed to prevent backflow and back siphonage. Those qualities make them suitable in applications where backflow into the water supply could cause serious health problems. Local codes outline when, where, and how RPZ valves should be installed. Most codes require these devices in residential applications to prevent back siphonage from outdoor hose bibbs into the household water supply.

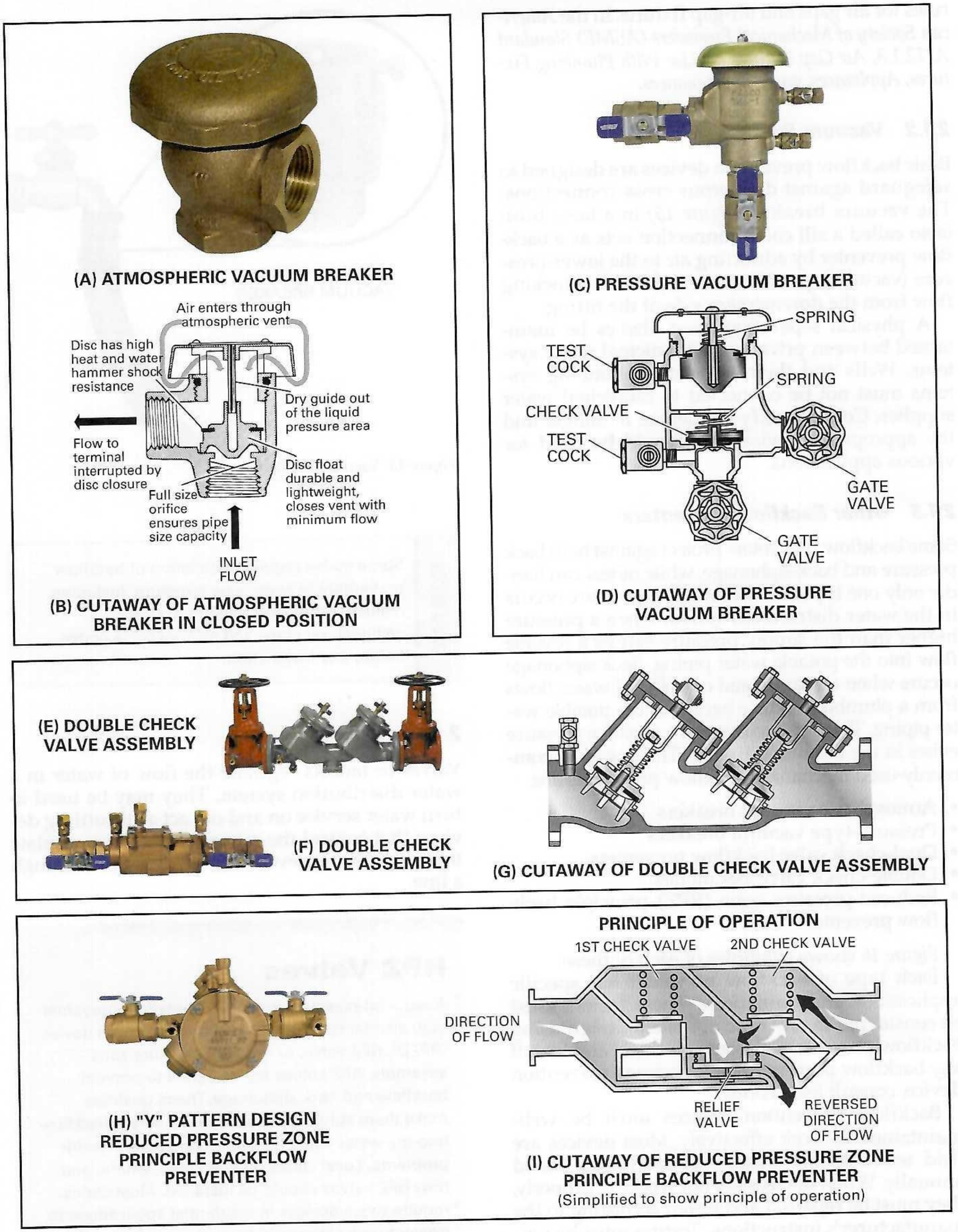


Figure 16 Backflow prevention devices.

Case History

Backflow Accidents

Always install proper backflow prevention devices where they are required by your local code. Be sure to install them according to the manufacturer's instructions. Don't let your community become a horror story like the ones discussed in the following case studies.

Backflow Case Study 1

During a routine maintenance check of a Colorado Middle School's hot water-heating boiler, maintenance workers left a valve open between the potable water line and the boiler. This allowed boiler water containing antifreeze to backflow into the school's potable water system. There was no backflow preventer on the feed line to the boiler.

Nine children were sent to the hospital with flu-like symptoms. The hospital treated the students for ethylene glycol (the ingredient in the antifreeze) poisoning. The school was closed while workers flushed the potable water piping and repaired the leak. Workers were instructed to install a backflow preventer in the potable water line to the hot water heating boiler.

Backflow Case Study 2

A municipal office inspected a cross-connection at a block of high-rise apartments. Officials found that a check valve failed to protect three water heaters. The pressure in a high-pressure cold water pump was fluctuating. When the pressure dropped, antifreeze contaminated the potable water system.

Backflow Case Study 3

A Florida home was mistakenly hooked up to treated wastewater lines instead of drinking water lines. As a result, the resident experienced severe stomach cramping and diarrhea. According to a city report, workers accidentally switched the lines when they failed to dig deep enough to expose the identification tape distinguishing the two water lines.

The city was asked to sanitize the home plumbing over a three-month period and monitor the resident's health for 10 years. As part of an agreement with the state health department, the city was also required to spend nearly $75,000 to improve training, installation procedures, and public education efforts.

It is important for plumbers to understand the terms related to valves. The following are commonly used valve terms:

- *Straight-through flow*—**Straight-through flow** is not restricted as it passes through a valve. The valve shut-off element is positioned entirely clear of the water passage.
- *Full flow*—**Full flow** describes the flow capacity of a valve as essentially equal to the maximum potential flow through the connected piping.
- *Throttled flow*—**Throttled flow** identifies reduced water flow controlled by positioning the valve's shut-off element. Not all types of valves are suitable for throttled flow.

2.2.1 Types of Valves

Plumbers must be familiar with a variety of valves. The following are common types of valves:

- Gate valve
- Globe valve
- **Angle valve**
- Ball valve
- **Check valve**
- Pressure regulator valve
- **Supply stop valve**
- Combination **thermostatic/pressure balancing valve** also called a temperature and pressure (T&P) relief valve
- Tempering valve

These valves are used in different parts of the water distribution system (*Figure 17*).

2.2.2 Gate Valve

A gate valve (*Figure 18*) is a valve in which the flow is controlled by moving a gate or disc that slides in machined grooves at right angles to the flow. The gate is moved by the action of the threaded stem on the control handle.

There are two basic designs of gate valves: rising-stem gate valves (also known as inside screw stem valves) or nonrising-stem valves (also known as outside screw stem valves). A rising-stem gate valve has the stem attached to the gate. The gate and stem rise and descend together as the valve is operated. The stem on a nonrising-stem gate valve is threaded on the lower end into the gate. When the handwheel on the stem is rotated, the gate moves up or down the stem.

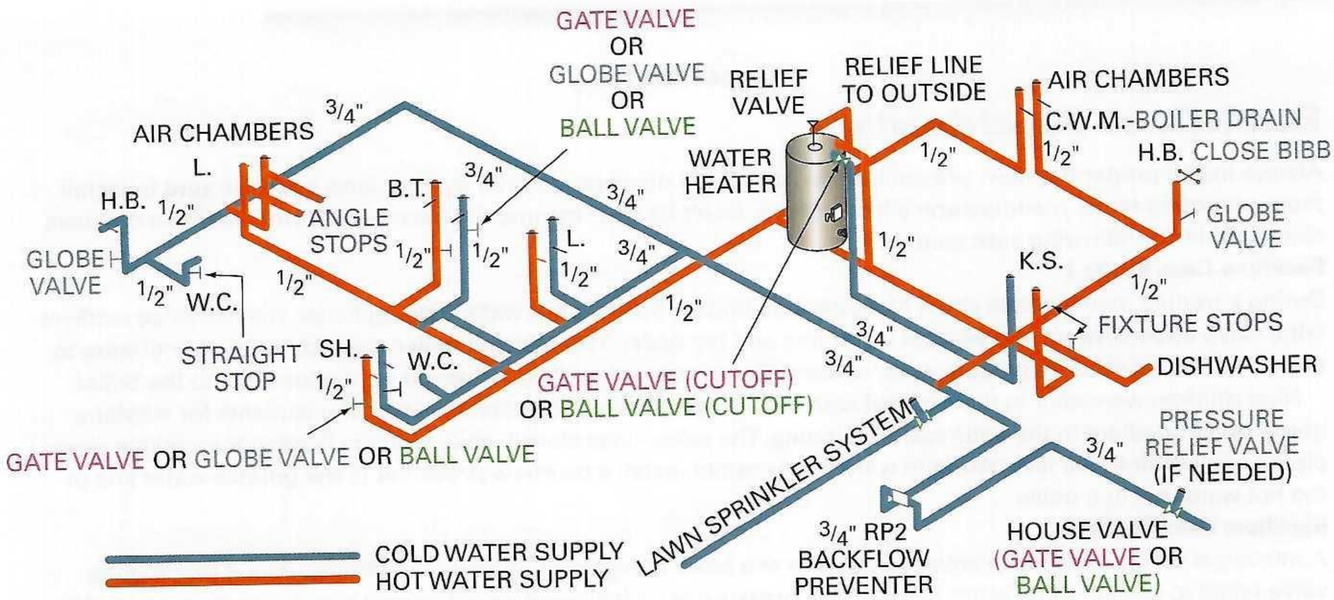


Figure 17 Valves in the distribution system.

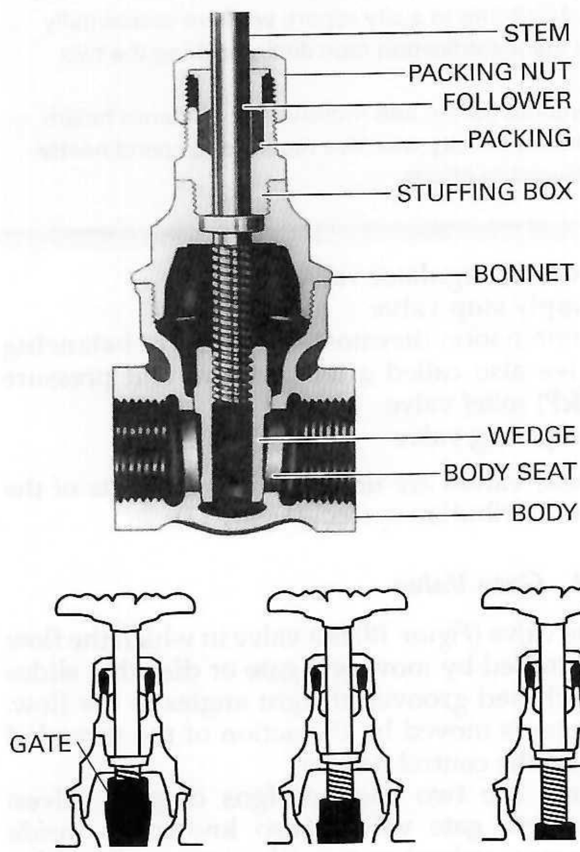


Figure 18 Gate valve.

Gate valves are best suited for main supply lines and pump lines. They provide an unobstructed, full-flow passageway when the gate is fully opened. They can be used on lines containing steam, water, gas, oil, or air. They are unsuitable for precisely throttling fluid flow.

2.2.3 Globe Valve

In a globe valve (*Figure 19*), the flow is controlled by moving a circular or conical disc against a metal seat that surrounds the flow opening. As the handle turns, the stem forces the disc onto the seat or withdraws it by screw action.

Globe valves are useful for general service in systems containing steam, water, gas, or oil, where frequent operation and precise throttled-flow control is required. Inside the globe-shaped body of the valve is a partition. This partition closes off the inlet side of the valve from the outlet side, except for a circular opening called the valve seat. The mating surface of the valve seat is ground smooth so that a proper and complete seal can be made when the valve is in the closed position. Turning the handle clockwise firmly seats the washer or disc between the valve stem and the valve seat, shutting the valve. This stops the flow of gas or liquid. It is a common design practice to install a globe valve so that the high-pressure supply fluid is under the valve seat. This places the stem packing on the downstream, low-pressure side of the valve seat, which lowers the potential for stem-packing leaks.

2.2.4 Angle Valve

The angle valve (*Figure 20*) is similar to the globe valve, but it can serve as both a valve and a 90-degree elbow. Because flow changes direction only once through an angle valve, the angle valve creates less flow resistance and turbulence than the globe valve, in which flow must change direction two times.

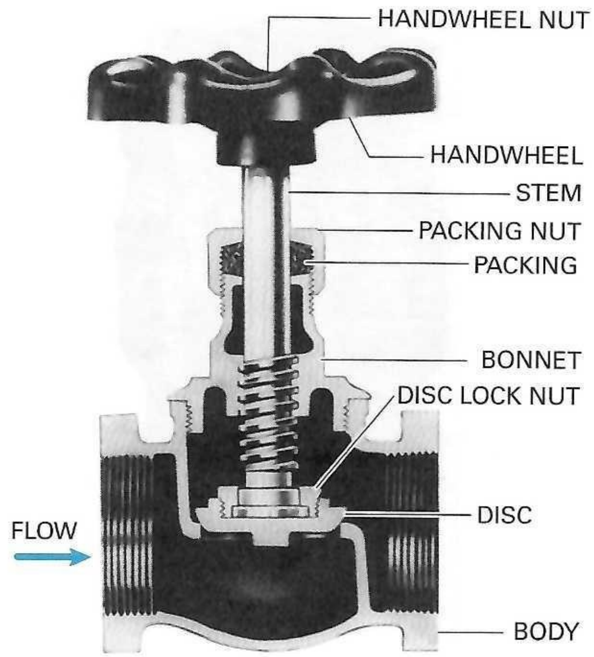


Figure 19 Globe valve.

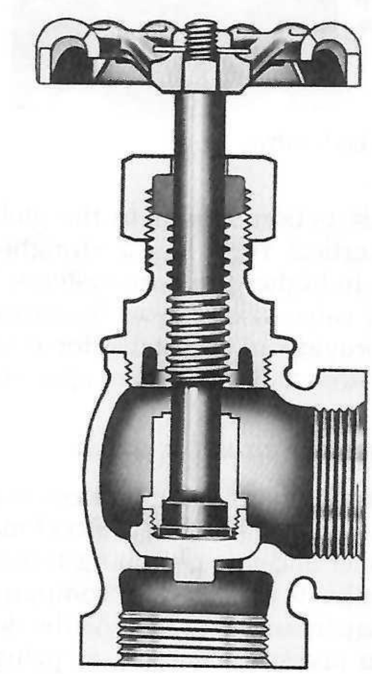


Figure 20 Angle valve.

There are three types of angle valves: conventional, plug-type, or composition discs. Conventional angle valves have a disc that is in close contact with the body seat. These valves are suitable for less severe services but not for precise throttling. Plug-type angle valves have a long taper and a wide seat bearing surface. These valves are ideal for fine-throttling, severe-service operation and are effective in resisting erosion, especially in steam systems. Composition discs have a tight sealing disc against a raised-crown seat. These valves are well suited for moderate pressure service.

2.2.5 Ball Valve

The ball valve (*Figure 21*) is used to control the flow of gases and liquids. Ball valves are installed in piping systems where quick shutoffs for in-line maintenance may be necessary, or in lines used for mixing various liquids and gases. The ball part of the valve is rotated into the open or shut position by a handle on the outside of the valve body. These valves are straight-through valves that allow quick action in controlling the flow in piping systems. If the ball bore is the same size as the connected piping, these valves also provide full-flow capacity. Most ball-valve designs do not provide reliable, fine-throttling control.

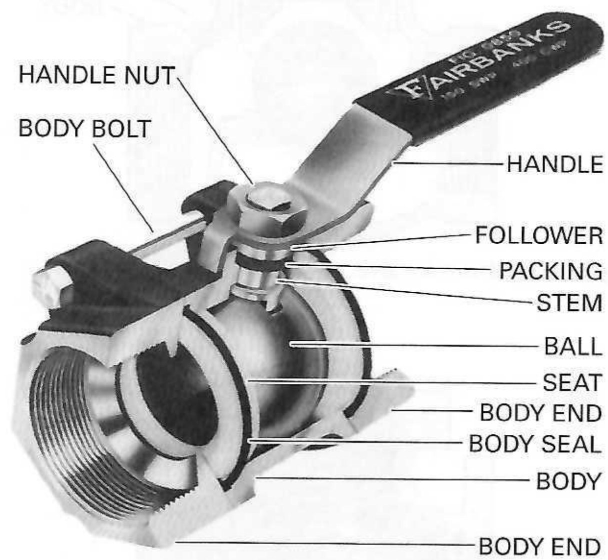


Figure 21 Ball valve.

2.2.6 Check Valve

A check valve prevents reversal of flow in a piping system. Pressure and flow in the upstream line keeps the valve open. The valve automatically closes by the reversal of flow or by the weight of the disc mechanism in no-flow situations. Three types of check valves are available: the ball-check valve, the swing-check valve, and the lift-check valve.

The ball-check valve (*Figure 22*) allows one-way flow in water supply or drainage lines and can be used with extremely low or no backpressure. It seats under the influence of gravity.

The swing-check valve (*Figure 23*) has a low flow resistance that makes it well suited for lines containing liquids or gases with low to moderate pressure. The swing-check valve is available in three different types, depending on the manufacturer: single disc, conventional; dual or split-swing discs; and single disc, angle seating.

The lift-check valve (*Figure 24*) can be used for gas, water, steam, or air. Lift-check valves are recommended for lines that have frequent fluctuations in flow. These valves are available in either horizontal or vertical connection styles, though the check feature in both shown in the figure works by gravity. The horizontal type has an internal construction similar to the globe valve, while the vertical type has a straight-through flow design. In higher-pressure systems, the horizontal check valve disc may act against a spring, which can provide an adjustable force to require a minimum flow and pressure to open the valve.

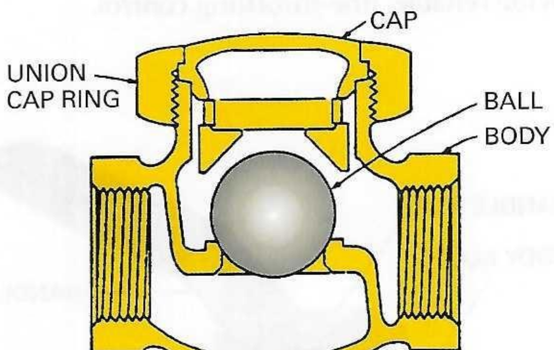


Figure 22 Ball-check valve.

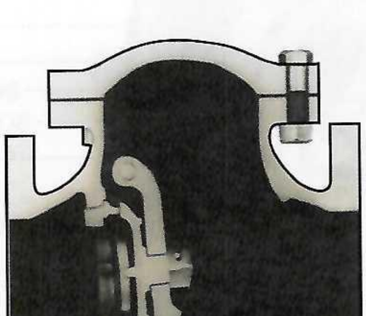


Figure 23 Swing-check valve.

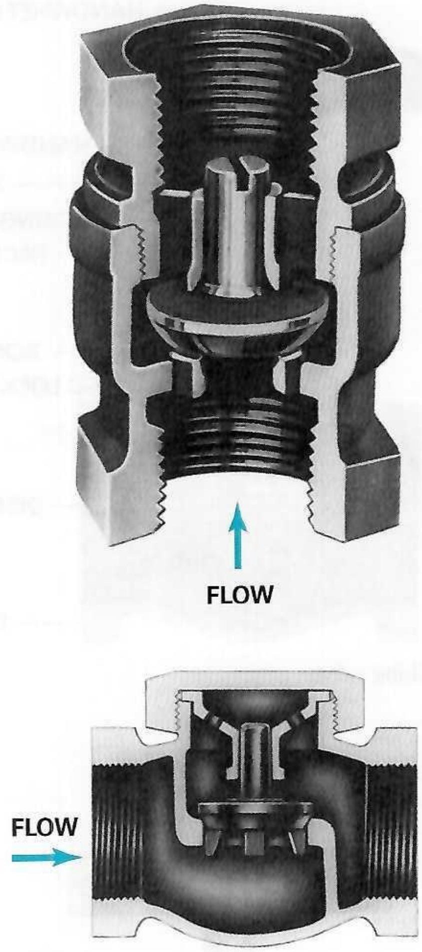


Figure 24 Lift-check valves.

2.2.7 Pressure Regulator Valve

The pressure regulator valve reduces water pressure in a building below that of street main pressure to protect end-use plumbing fixtures from leaks. The valve is activated by comparing delivery and downstream pressures. As the delivery or downstream pressure changes, a spring located in the dome of the valve acts on the diaphragm to move the valve open or shut. In a typical design, the valve opens when the diaphragm presses down away from the valve seat, and it remains open until the pressure in the building reaches a set level. The valve then moves toward the shut position to lower building water pressure. Unless building water demand stops, the valve is always at least slightly open to supply water at the set pressure.

2.2.8 Supply Stop Valve

Supply stop valves, or supply valves, commonly disconnect the hot- or cold-water supply to water closets and sinks. These miniature globe valves make it easy to control the water connection at an individual fixture for repair work. They are available in either right angle or straight design (*Figure 25*). Many manufacturers now offer stop valves with a quarter-turn ball-valve design, which are easier to operate and have longer service lives.

2.2.9 Temperature and Pressure Relief Valve

Temperature and pressure (T&P) relief valves (*Figure 26*) are normally used for liquid service, although safety valves also may be used. T&P relief valves are designed to open on either excessive pressure or temperature, or both. Ordinarily, these pressure relief valves do not have a chamber or a regulator ring for varying or adjusting blowdown, so they operate with a relatively lazy motion. As temperature or pressure increases, they gradually open, releasing up to a cup of water; with a pressure decrease, they gradually close.

2.2.10 Tempering Valve

Hot and cold water can be mixed to reduce the risk of scalding at faucets, such as shower valves, or to reduce sweating at water closet tanks. The best way to do this is to use a tempering valve (*Figure 27*). Tempering valves are available for both residential and commercial/industrial applications. These valves mix the water coming from the water heater to a predetermined temperature. The temperature is set using an adjustable thermostat incorporated into the valve.

Figure 25 Supply stop valves.

Figure 26 Pressure relief valves.

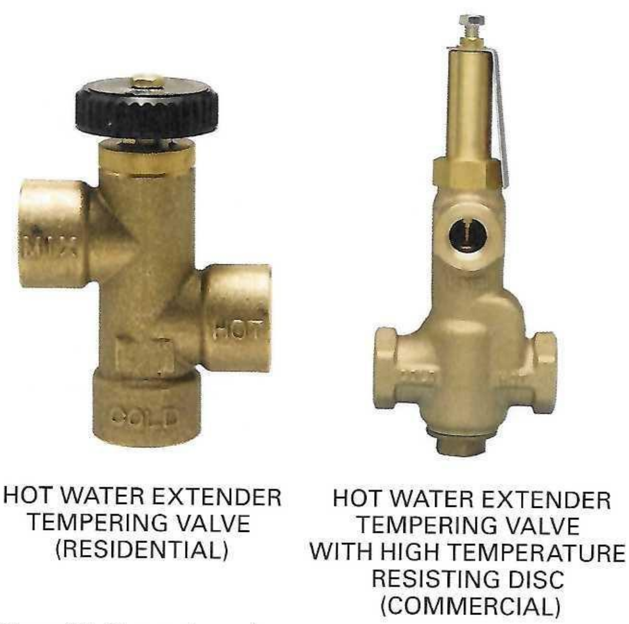


Figure 27 Tempering valves.

Additional Resources

Advanced Home Plumbing, 1997. Black & Decker Home Improvement Library. Minnetonka, MN: Cowles Creative Publishing, Inc.

Air Gap Fittings for Use With Plumbing Fixtures, Appliances, and Appurtenances, Standard A112.1.3, Current Edition. American Society of Mechanical Engineers (ASME)

International Plumbing Code, Current Edition. Falls Church, VA: International Code Council.

National Standard Plumbing Code, Current. Falls Church, VA: Plumbing-Heating-Cooling Contractors National Association.

2.0.0 Section Review

1. For the purposes of preventing cross-connections in drinking water systems, which of the following is *not* a backflow preventer?
   a. Vacuum breaker
   b. Ball check valve
   c. RPZ valve
   d. Air gap

2. Which of the listed valve types is considered a straight-through flow valve?
   a. Angle stop valve
   b. Globe valve
   c. Check valve
   d. Ball valve

SECTION THREE

3.0.0 BUILDING WATER DISTRIBUTION

Objectives

Explain the relationships between components of a water distribution system.

a. Identify the major components of a building water system and describe how to determine proper placement.
b. Explain the requirements for sizing of the main supply lines.

Performance Task

1. Sketch an isometric drawing of a simple water distribution system and label its components.

Trade Terms

Backing board: A short plank of wood installed between wall framing (or sometimes the unfinished side of the wall interior) used to mount fixture risers and stub-outs behind the fixture.

Fixture risers: Vertical sections of pipe located inside the wall to connect the fixture to the supply pipe beneath the flooring.

Hammer arrestors: Devices installed in a piping system to absorb water hammer by gradually stopping the flow of water against an air or gas cushion.

Water hammer: A loud thumping that results when the piping system deflects against supports as it absorbs the energy in flowing water when it suddenly stops.

Water supply fixture units (WSFU): Design factors to determine the load that different plumbing fixtures produce on the supply side of a plumbing system.

In a typical residential or light commercial building, there are many common fixtures a plumber will frequently install. Each of these has specific purposes and they involve certain considerations when locating and installing them.

3.1.0 Placing Major System Components

Plumbing a small building such as a residence follows the sequence of: main supply installed, locating major components, locating the architectural fixtures, running the DWV piping, running the water service and branch lines, installing risers and stub outs, and finally connecting fixtures. (This list does not include inspections or tests that are required by code.) Once the water supply piping is installed to bring the water from the main into the building, the next step is to locate and install the water heater, hose bibbs, water softener (if needed), and other fixtures. Architects will usually place these components in building plans to efficiently serve their purposes (*Figure 28*). However, the actual location of the major service components will often be left to the plumber depending on as-built circumstances.

3.1.1 Locating the Water Heater

Unless the plans show otherwise, place the water heater in the most efficient location, which is usually as close as possible to the greatest number of hot water outlets. This minimizes the length of hot water piping that runs between the heater and the fixtures. You should also consider the location of the gas supply if installing a gas water heater, or the electrical service entry if installing an electric water heater.

3.1.2 Locating the Water Softener

If the plumbing system includes a water softener, you must first determine the expected use of various fixtures. Not all fixtures or outlets require access to softened water. For example, the hot water supply, including the hot water heater, should always be treated, but the hose bibbs may be served by unsoftened water. Makeup water for a hot-water heating system should also be softened. These decisions affect the placement of pipe runs.

3.1.3 Locating Hose Bibbs

An exterior water outlet, also called a hose bibb or sill cock (*Figure 29*), is frequently required in residential structures. The piping runs serving hose bibbs may be long, and they should bypass the water softener and even the pressure regulating valve, if present. Locating hose bibbs depends on factors such as the size of the structure, accessibility of the basement or crawl space (if any), and intended use.

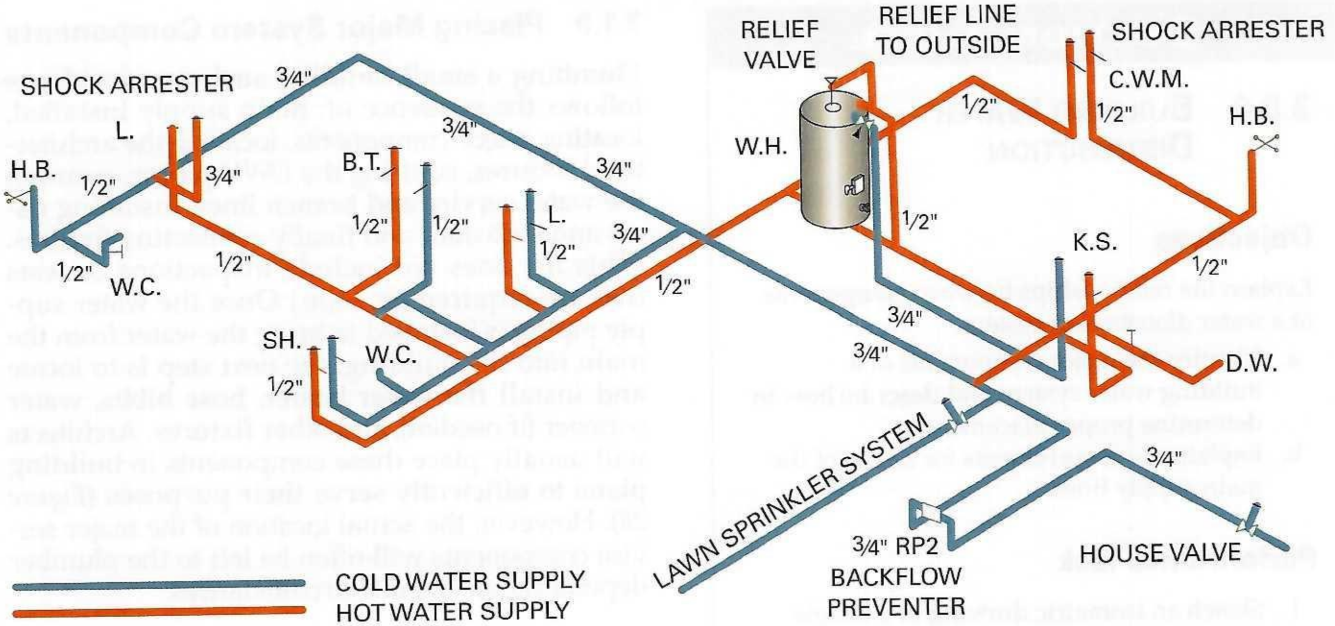


Figure 28 Sample domestic water distribution piping system.

Figure 29 Hose bibbs.

3.1.4 Locating Fixtures

After locating the water heater, hose bibbs, and water softener, identify the locations of the other water-using fixtures. For a residence, these will include the water closets, bathtubs, showers, vanity sinks, kitchen sink, and water supplies to ice makers, if required. Refer to the architect's plan, since the locations of these are fixed by the building design. The plumber is responsible for providing the most efficient water distribution system while minimizing cost of materials and time of installation.

When plumbers are installing the plumbing for a structure, they must first install the DWV system. Due to the large size of the pipe and limited flexibility in installation, and because it cannot be moved once it is installed, proper layout of the DWV can eliminate most problems. Water supply piping is located in relation to the already installed DWV piping, not to the walls or corners of the building.

3.2.0 Supply Piping

You must correctly size the supply pipe to the fixtures and appliances and use sizing tables supplied by the applicable plumbing codes. These tables estimate the anticipated demand for water as measured by **water supply fixture units (WSFU)**. The following must be taken into account when sizing supply piping:

- Type of flush devices used on different fixtures
- Water pressure in pounds per square inch (psi) at the source
- Length of pipe in the building
- Types and number of different fixtures installed
- Total number of fixtures in use at any one time

3.2.1 Main Supply Lines

The service lines are the main water supply lines. These lines are also known as main feeder lines. For residential installations, the main feeder line beyond the water heater must be sized to supply the required flow and pressure. Smaller pipe sizes can save both energy and money. Larger pipe sizes carry more water, but water left in the piping system when the fixture is turned off cools down. When the user turns on the faucet again, more cool water must clear the pipe before hot water reaches the fixture. This wastes water and energy. For this reason, hot water service lines are typically $^1/_2$ inch in domestic service (refer to *Figure 27*).

For hot water distribution systems, one effective method to conserve energy and water is through the use of a hot water recirculation system, which is usually needed when the fixtures are a long distance from the hot water source. At the end of the hot water line, a tee and a pump can be installed to return water into the cold side or into the drain valve opening of the heater. A check valve needs to be installed on the incoming cold water so the return water flows in only one direction.

When you are installing cold water lines, you must consider possible connections to hose bibbs and plan efficiently to save pipe and time. Cold water that is used at the hose bibbs for lawn sprinklers and other outdoor applications should not be softened.

CAUTION

Keep the water supply piping as clean as possible before installing and using it. Clean, dry storage of pipes helps prevent contamination. Cap all ends of pipe at the end of each workday.

3.2.2 Branch Lines and Risers

Once the runs of the main hot- and cold-water feeder lines are established, determine the branch piping that serves individual fixtures and appliances in the building. Branches are any part of the piping system other than the risers, main, or stack. Then locate the **fixture risers** and fixture stub-outs. Water supply piping is also located in relation to drains and fixture controls for the fixtures. When plumbers are installing water supply piping, they need to recheck the location of the drains to make sure that they are positioning the piping correctly.

Construct a fixture riser that goes inside the wall as the connection from the fixture to the supply pipe beneath the flooring. Assemble fixture risers and stub-outs, and mount them on a **backing board** inside the wall behind the fixture (*Figure 30*). When the water supply lines have been located at the fixtures and the stubouts assembled, the assembly is placed through the access hole in the floor. Plumbers should always use approved submittal data to determine measurements when installing fixture risers and stub-outs.

In large water lines or where fixture controls have quick-closing valves, you should install **hammer arrestors** (*Figure 31*) to absorb the energy when the flow of water suddenly stops, called **water hammer**. They are usually placed near the fixture as an extension of the water pipe riser. If hammer arrestors are not installed, are installed incorrectly, or fail, water hammer may occur when a quick-closing fixture control is used. Hammering could eventually lead to pipe, joint, or valve failure in the water distribution system.

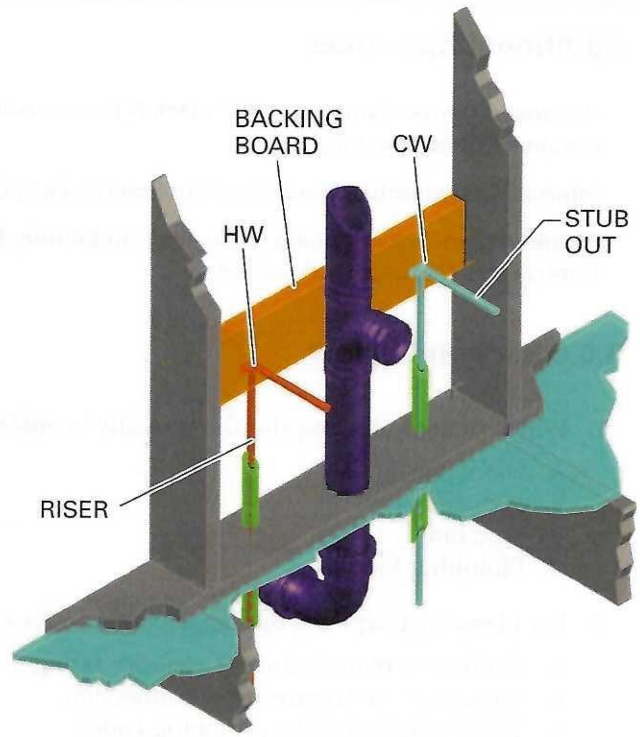


Figure 30 Installation of fixture riser and stubouts.

Figure 31 Hammer arrestor.

Additional Resources

Advanced Home Plumbing, 1997. Black & Decker Home Improvement Library. Minnetonka, MN: Cowles Creative Publishing, Inc.

International Plumbing Code, Current Edition. Falls Church, VA: International Code Council.

National Standard Plumbing Code, Current Edition. Falls Church, VA: Plumbing-Heating-Cooling Contractors National Association.

3.0.0 Section Review

1. Which of the following should normally be installed first when plumbing a building?
   a. DWV piping
   b. Fixture risers
   c. Stub outs
   d. Plumbing fixtures

2. For planning purposes, the capacity of a water system or its demand is based on _____.
   a. the fixture manufacturer's capacity rating
   b. the size of the fixture water connection
   c. WSFU established by plumbing codes
   d. the plumber's professional experience

SUMMARY

Water comes from a private source, such as a well, or a municipal source, such as a public water distribution system. While well water is usually drinkable, water supplied by municipalities must be treated to remove harmful impurities. Both private and public water-service lines move water from its source to homes and other buildings. These lines, or pipes, may be made of copper, plastic, or steel. Factors such as weather, resistance to corrosion, working pressure, applicable codes, ease of installation, cost, and life expectancy determine the choice of pipe materials. Pumps move water from wells into the water distribution system. Plumbers choose the correct pump based on the depth of the well, the rate at which the water is pumped, and the total distance the water must travel.

The flow of water in a water distribution system is regulated by valves or faucets, which are used to turn water on and off, to control the rate of water flow, to regulate the pressure, or to prevent a reversal of flow through a line. After a water supply to a home or other building is set up, plumbers install the water heater, hose bibbs, water softener (if needed), and fixtures. Plumbers must locate and connect these items efficiently to avoid softening water that does not need to be softened and to save on materials and time.

Review Questions

1. All of the followings are types of wells *except* _____.
   a. drilled
   b. bored
   c. dropped
   d. driven

2. One of the main functions of a municipal water treatment plant clarifier is to _____.
   a. oxidize minerals for filtering
   b. increase the CO_2 levels to acidify the water
   c. add chlorine and fluorine to the water
   d. remove precipitated calcium and magnesium compounds

3. How could a plumber increase the pressure of water inside a building?
   a. Install a pressure regulator valve
   b. Install a booster pump
   c. Increase the size of the supply piping
   d. Reduce the size of the supply piping

4. A building's supply line must connect to a municipal water main by means of a _____.
   a. curb stop valve
   b. corporation stop valve
   c. meter stop valve
   d. supply stop valve

5. The main purpose of a curb stop valve is to _____.
   a. provide a convenient shut off point for water supplying a building
   b. provide a convenient point to connect a building supply to a water main
   c. isolate a water meter for maintenance
   d. isolate a pressure regulating valve or water softener

6. The most reliable method to prevent of a contaminated source into a potable water system is by means of a(n) _____.
   a. air gap
   b. vacuum breaker
   c. dual-check valve backflow preventer
   d. RPZ valve

7. Which is a true statement about gate valves?
   a. Gate valves open by rotating the flat disc parallel to the water stream.
   b. Gate valves are excellent for precise flow throttling.
   c. A gate valve is a full-flow, straight-through flow valve.
   d. The flow of water through the valve makes two sharp turns.

8. Which type of valve provides the benefits of both a globe valve and a 90-degree pipe elbow?
   a. Gate valve
   b. Angle valve
   c. Ball valve
   d. Check valve

9. Which of the following statements is true about check valves?
   a. Check valves have a handwheel actuator.
   b. Check valves shut on a reversal of flow.
   c. Check valves are motor-operated.
   d. Only gravity is required to operate all check valves.

10. A standard pressure-regulator valve senses _____.
    a. delivery pressure
    b. downstream pressure
    c. both delivery and downstream pressures
    d. atmospheric pressure

11. Which is the preferred method for reducing the potential for scalding accidents at sinks and in showers?
    a. Lowering hot water heater temperature to 120°F
    b. Installing a tempering valve in the fixture's hot and cold water supplies
    c. Requiring that use of the fixtures involves a responsible individual
    d. Installing a flow restrictor on the hot-water supply line

12. A building's hot water heater will usually be located _____.
    a. as close as possible to the entry point of the building's service water line
    b. in an out-of-the-way place
    c. at the end of the cold-water service line
    d. as close as possible to the largest number of hot-water fixtures

13. The plumbed locations of the standard hot and cold water fixtures normally found in a building are determined by _____.
    a. the plumber
    b. the architect
    c. the location of the DWV piping
    d. national and local codes

14. Which of the following is true when using larger piping when plumbing a building?
    a. Larger piping lowers delivery pressure more than smaller piping.
    b. Larger piping holds heat better than smaller piping.
    c. Larger hot-water piping wastes water.
    d. Larger piping reduces water hammer.

15. Water hammer is mainly caused by _____.
    a. quick-closing valves
    b. loosely-hung piping
    c. long piping runs
    d. small-diameter pipes

Trade Terms Quiz

Fill in the blank with the correct term that you learned from your study of this module.

1. A(n) ________ is a device that measures the amount of water used.
2. The use of a(n) ________, which acts as a backflow preventer, prevents a vacuum in a water supply from causing backflow.
3. A(n) ________ is any part of the piping system other than the riser, main, or stack.
4. A(n) ________ is a valve on the outside of a building with a threaded outlet, usually set at an angle, that connects to a hose.
5. A(n) ________ is inserted into a drilled or bored well to protect the well from contamination.
6. A buffalo box is properly called a(n) ________.
7. ________, or feeder lines, are the main water supply lines, to which branches are connected.
8. A special key can be inserted into a(n) ________ to stop the flow of water during servicing or in case of an emergency.
9. ________ in waster water treatment is the thickening of liquid mixtures into soft or solid masses.
10. A(n) ________ connects the building water service line to the water main.
11. Fixture risers and stub-outs are mounted on a(n) ________.
12. Deterioration to metal pipe caused by an electric current or a chemical reaction that occurs between different types of metals is ________.
13. ________ are a measure used to properly size pipes in water distribution systems.
14. The acidity of water is identified by its ________ value.
15. When water is allowed to flow without restriction through a valve, the flow is typically referred to as ________.
16. ________ are vertical pipes on the interior portion of the wall that connect the fixture to the supply pipe.
17. The surface of the region of saturated soil underground is the ________.
18. ________ are commonly used to shut off the water supply to water closets and sinks.
19. A(n) ________ relieves water based on the sensed temperature and/or pressure of the connected fixture.
20. A(n) ________ is used to reduce water pressure in a building.
21. A(n) ________ is similar to the globe valve but can serve as both a valve and a 90-degree elbow.
22. A(n) ________ allows liquid to flow in only one direction.
23. ________ is the controlled rate of flow through a valve.
24. ________ are natural or artificial bodies of water used for water storage.
25. ________ are solids that appear and settle out due to chemical changes in water solutions.

26. The flow capacity of valves that is essentially the same as the potential flow through the connected piping is described as ______.

27. ________ is the measure of the cloudy appearance of water due to suspended materials.

28. The banging of pipes when water flow is shut off can be eliminated by using ________.

29. Three methods for disinfecting water are ________, ________, and ________.

30. ________ on hot water heaters gradually open and shut as water pressure changes near the valve setpoint.

31. The loud noises in piping systems that result from the pipes flexing as they absorb the energy of moving water when it is suddenly shut off are called ________.

Trade Terms

- Angle valve
- Backing board
- Branch
- Check valve
- Chlorination
- Coagulation
- Corporation stop
- Curb box
- Curb stop
- Fixture risers
- Full flow
- Galvanic corrosion
- Hammer arrestors
- Hose bibb
- Pasteurization
- pH
- Precipitates
- Pressure regulator valve
- Pressure relief valves
- Reservoirs
- Service lines
- Straight-through flow
- Supply stop valves
- Thermostatic/pressure balancing valve
- Throttled flow
- Turbidity
- Ultraviolet (UV) light
- Vacuum breaker
- Water hammer
- Water meter
- Water supply fixture units (WSFU)
- Water table
- Well casing

Trade Terms Introduced in This Module

Angle valve: A valve whose internal design is similar to a globe valve's but its outlet direction is 90 degrees from its inlet.

Backing board: A short plank of wood installed between wall framing (or sometimes the unfinished side of the wall interior) used to mount fixture risers and stub-outs behind the fixture.

Branch: Any part of a piping system other than a riser, main, or stack.

Check valve: A valve that allows liquid to flow in only one direction. Pressure and flow within the inlet line keeps the valve open. Automatic closure of the valve occurs with the reversal of flow, by the weight of the disc mechanism, or by spring action.

Chlorination: The use of chlorine gas or compounds to disinfect water.

Coagulation: In water treatment processes, a thickening of suspended or dissolved materials into a soft, semi-solid or solid mass.

Corporation stop: A valve that connects the building water service line to the water main.

Curb box: A cylindrical casing placed in the ground over the curb stop, into which a special key-wrench can be inserted to turn off the curb stop. Also given the term buffalo box.

Curb stop: A control valve installed in building water supply lines between the corporation stop and the building.

Fixture risers: Vertical sections of pipe located inside the wall to connect the fixture to the supply pipe beneath the flooring.

Full flow: Describes a valve that does not restrict the flow of a fluid through it compared to the potential flow through the connected piping.

Galvanic corrosion: Corrosion caused by a weak electrical current that occurs when an electrical path exists between two different metals.

Hammer arrestors: Devices installed in a piping system to absorb water hammer by gradually stopping the flow of water against an air or gas cushion.

Hose bibb: A faucet with a threaded outlet, typically set at an angle to the inlet pipe, used to connect a hose. Usually located on the outside of a building. Also referred to as a sill cock or bibcock.

Pasteurization: The practice of heating water and foods to high temperatures to kill harmful bacterial organisms present.

pH: A measure of the acidity or alkalinity of a solution. A pH of 7 is neutral, being neither acidic nor alkaline; higher numbers are more alkaline, lower numbers are more acidic. The symbol comes from the early twentieth-century chemistry term power of hydrogen.

Precipitates: Solid materials resulting from chemical reactions in water solutions that settle out.

Pressure regulator valve: A valve used to reduce water pressure in a building. The valve is activated by changes in pressure within the system.

Pressure relief valves: Valves normally used for liquid service to prevent over-pressurization of a system or component. May be slow- or fast-acting depending on their purpose and design.

Reservoirs: Sources of water collected and stored in natural or artificial (man-made) lakes.

Service lines: The main water supply piping, to which branches are connected. Also referred to as feeder lines.

Straight-through flow: A valve flow design that does not restrict flow through the valve. The element that closes the valve is retracted entirely clear of the passage.

Supply stop valves: Valves that are commonly used to disconnect the hot or cold water supplies to water closets and sinks. They are available in either right-angle or straight design, and with globe- or ball-valve internals.

Thermostatic / pressure balancing valves: Mixing valves which sense outlet temperature and incoming hot and cold water pressure, and compensate for fluctuations in hot and cold water temperatures and/or pressures to stabilize its outlet temperatures. Also referred to as temperature and pressure (T&P) relief valves.

Throttled flow: Reduced flow of water through a valve by positioning of the valve's stopping device; increases both the pressure drop across the valve and flow resistance through the valve.

Turbidity: The presence of particles (sand, mud, silt) suspended in water that give the water a cloudy appearance.

Ultraviolet (UV) light: A form of high-energy light with wavelengths shorter than visible light. In water supply systems, it can disinfect water by destroying microorganisms as the water flows through a chamber containing UV lamps.

Vacuum breaker: A type of backflow preventer that inhibits backflow caused by lower pressure in a water supply system by opening a vent path in a cross-connected system to prevent siphonage.

Water hammer: A loud thumping that results when the piping system deflects against supports as it absorbs the energy in flowing water when it suddenly stops.

Water meter: A device for measuring water volume usage by an individual building or customer.

Water supply fixture units (WSFU): Design factors to determine the load that different plumbing fixtures produce on the supply side of a plumbing system.

Water table: The level below the ground's surface where soil becomes saturated with water.

Well casing: Outer tube or pipe sunk into the ground after drilling or driving a well to stabilize the hole.

Additional Resources

This module is intended as a thorough resource for task training. The following reference works are suggested for further study.

Advanced Home Plumbing, 1997. Black & Decker Home Improvement Library. Minnetonka, MN: Cowles Creative Publishing, Inc.

Air Gap Fittings for Use With Plumbing Fixtures, Appliances, and Appurtenances, Standard A112.1.3, Current Edition. American Society of Mechanical Engineers (ASME)

International Plumbing Code, Current Edition. Falls Church, VA: International Code Council.

National Standard Plumbing Code, Current Edition. Falls Church, VA: Plumbing-Heating-Cooling Contractors National Association.

Figure Credits

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Culligan International, Figure 3

US Environmental Protection Agency, 02112_SA01

Watts, Figures 6, 19, 21, 26

Mueller Industries, Inc., Figure 8

FEBCO, Figures 16 (photos of atmospheric vacuum breaker, pressure vacuum breaker, double-check valve assembly, and reduced- pressure zone principle backflow preventer), 28, 31

US EPA Office of Ground Water and Drinking Water, Figure 16 (cutaway drawings of pressure vacuum breaker, double-check valve, and reduced-pressure zone principle backflow preventer)

Watts Regulator Company, Figure 16 (cutaway drawing of atmospheric vacuum breaker)

Brass Craft, Figure 25

Jonathan Byrd/Ivey Mechanical, Figure 29

Sioux Chief Manufacturing Co., Inc., Figure 30

Section Review Answer Key

Section 1.0.0

Answer	Section Reference	Objective
1. b	1.1.0	1a
2. d	1.2.0	1b
3. a	1.3.1	1c

Section 2.0.0

Answer	Section Reference	Objective
1. b	2.1.1	2a
2. d	2.2.5	2b

Section 3.0.0

Answer	Section Reference	Objective
1. a	3.1.4	3a
2. c	3.2.0	3b

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