

Ch. 11 Plumbing Systems

Water Supply

- ✓ Potable Water: water suitable for human drinking
- ✓ Nonpotable: use for irrigation, flushing toilets, and the like
- ✓ Surface water comes from rain and snow that runs off into rivers and lakes.
- ✓ Ground water is that which seeps into the ground until it hits an impervious layer of rock or soil. It then forms a water table that is tapped by drilling. Large regions of subsurface water are called aquifers.
- ✓ Water has many characteristics and can contain many types of chemical, biological, and physical contaminants. One common characteristic of all water is its pH level. pH is a measure of the relative acidity or alkalinity of water. It is based on a scale of 0 to 14 with a pH of 7 being neutral. Anything below 7 is considered acidic and can be corrosive; anything above 7 is considered alkaline.
- ✓ Rainwater is slightly acidic in its natural state, but in many industrialized areas the acid level is greater due to sulfur and nitrogen compounds in the atmosphere. → Acid rain
- ✓ Another common characteristic of water is its hardness. Hardness is caused by calcium and magnesium salts in water. If untreated, hard water can cause clogged pipes and corrosion of boilers. It also makes laundry and other types of washing difficult because it inhibits the cleaning action of soaps and detergents.
- ✓ Water softening process: Hard water is treated through an ion exchange process with a water softener. Hard water is piped into the softener, which contains zeolite. The calcium or magnesium ions are exchanged for the sodium ions in the zeolite. Periodically, the water softener has to be recharged by passing a brine solution through the zeolite.
- ✓ Turbidity is caused by suspended material in the water such as silt, clay, and organic material. Although it is not hazardous, turbidity is unpleasant and can be treated by filtration.
- ✓ Color and odor problems are caused by organic matter, inorganic salt, or dissolved gases. Odor problems can be corrected with filtration through activated carbon. Color problems can be corrected with fine filtration or chlorination.
- ✓ Biological contamination is potentially dangerous to health. Bacteria, viruses, and protozoa can all be present in contaminated water, and testing for them is difficult. One of the most common types is the coliform group that is found in human and animal waste. Biological contamination can be treated with chlorination.
- ✓ Chemical contamination includes hundreds of hazardous materials including chemicals from industrial processes, mining, and pesticides.

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Private Water Supply

- ✓ Private water supplies include wells, springs, or collected rainwater.
- ✓ A rotary bit is used for drilled wells, which is the only method possible for going through rock, and a bored well uses a rotary auger to make the hole.
- ✓ Two of the most important considerations in drilling a well are depth and yield. The depth of a well may range from less than 25 feet, known as a shallow well, to several hundred feet.
- ✓ The yield of a well is the number of gallons per minute (gpm) it provides. A yield from 5 to 10 gpm is about the minimum required for a private residence.
- ✓ As a well is drilled or bored, a pipe casing is lowered into the hole to prevent the hole from caving in and to prevent seepage of surface contamination into the well. The casing is a steel pipe from 4 to 6 inches, perforated casings are used to allow the water to seep into the well from which it is pumped out.

Pumps

- ✓ Suction pumps are only suitable for water tables less than 25 feet, while deep-well jet pumps can operate at depths from 25 to over 100 feet. Turbine pumps are used for high-capacity systems with deep wells. One of the most common types for moderate to deep wells serving private residences or small buildings is the submersible pumps. This type has a waterproof motor and pump that are placed below the water line and pump water to a pressure tank.
- ✓ Jet pumps have the pump and motor aboveground and lift water by the venture principle.
- ✓ Pressure tanks are required to maintain a constant pressure for use in the building and to compensate for brief peak use demand that exceeds the capacity of the pump. Pressure tanks also reduce the amount of time the pump must be running because small quantities of water can be used from the tank without the need for the pump to operate. As the pressure tank is emptied, a pressure gauge sensed the loss and activates the pump.
- ✓ In jet (venture) pump systems, an air volume control sensed the depletion of the tank. When the yield of a well is too low to meet the demand, a larger storage tank may be used to provide water for normal use. During nighttime or low periods of use the pump slowly fills the tank.

Municipal Water System

- ✓ Once the water is treated, it is piped through water mains at a pressure of about 50 pounds per square inch (psi), although they can vary from 40 to 80 psi depending on location and other factors. If the pressure is too high, a pressure-reducing valve is used between the water main and the building water.

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Water Supply Design

Supply Systems

- ✓ There are two primary types of water supply systems: the upfeed and the downfeed. The choice between the two is usually based on the height of the building and the pressure required to operate the fixtures.
- ✓ Water supplied from a city main or from a pressure tank with a private well comes from the pipe under a certain pressure: in city mains it is about 50 psi. This pressure must be sufficient to overcome friction in the piping, fitting, meter, and static head, and still be high enough to operate fixtures.
- ✓ A flush valve requires from 10 to 20 psi to operate properly a shower needs about 12 psi.
- ✓ The static head is the pressure required to push water vertically, or the pressure caused at the bottom of a column of water. It requires 0.433 psi to lift up water 1 foot. 1 psi will lift water 2.3 feet.
- ✓ An upfeed system uses pressure in the water main directly to supply the fixtures. Because there is always some friction in the system and some pressure must be available to work the highest fixtures, the practical limit is about 40 to 60 feet.
- ✓ If the building is too tall for an upfeed system, a downfeed system is most often used. In this case, water from the main is pumped to storage tanks near the top of the building or at the top of the zone served and flows by gravity to the fixtures. The pressure at any fixture or point in the system is determined by the distance from the outlet of the tank to the fixture, using the equivalency of 0.434 psi for every foot.
- ✓ The height of the zone served by a downfeed system is determined by the maximum allowable pressure on the fixtures at the bottom of the zone, allowing for friction loss in the piping.
- ✓ Conversely, the pressure at the fixtures at the top of a downfeed system is also of concern because there must be a minimum pressure to make fixtures work properly.

Components and Materials

- ✓ A water supply system is comprised of piping, fitting, valves, and other specialized components.
- ✓ Piping can be copper, steel, plastic, or brass.
- ✓ Copper is most commonly used because of its corrosion resistance, strength, low friction loss, and small outside diameter.
- ✓ Where the water is not corrosive, steel or galvanized steel pipe can be used, but these materials are more difficult to assemble because of their screw fitting.
- ✓ Steel pipe is available in different wall thicknesses that are indicated by schedule numbers. Schedule 40 pipe is the most commonly used.

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- ✓ Copper is available in three grades: K, L, M. DWV copper is also used for drainage, waste, and vent piping that is not subject to pressure as supply pipe is, but it is rarely used. Type K has the thickest walls and comes in straight lengths (hard temper) or in coils (soft temper). It is used for underground supply pipe where greater strength is required. Type L has thinner walls than type K and also comes in straight lengths or coils. It is the grade most commonly used for the majority of the plumbing system in a building. Type M is the thinnest of the three types and is available in straight length (hard temper) only. It is used where low pressure is involved, such as branch supply lines, chilled water systems, exposed lines in heating systems, and drainage piping.
- ✓ Plastic pipe has generally gained acceptance as a material suitable for supply piping, although some codes still restrict its use.
 - PE
 - ABS
 - PVC
 - PVDC – suitable for hot water
- ✓ Supply piping is connected with a variety of fittings, valves, and other components to form a complete system. Fittings connect pipes where lengths must be joined. Where a change in direction occurs, where three pipes join, and where a change in size occurs.
- ✓ A union is a special fitting that connects two rigid sections of pipe and that can be easily unscrewed to allow for repairs or additions to the piping system. Unions are also used between piping and devices such as water heaters that may need to be replaced. Adapters are also available that allow two different piping materials to be joined.
- ✓ Fittings for steel and brass are made from malleable iron, cast iron, and brass and are threaded to receive the threaded pipe.
- ✓ Copper and plastic fittings are slightly larger than the pipe to allow it to be slipped in. Copper joints are sealed by soldering, sometimes called sweating, and plastic pipes are sealed by using a solvent that “melts” the plastic together.
- ✓ Valves are used to control water flow. They are located at risers, horizontal branch lines, and pipe connections to fixtures and equipment, such as water heaters and sinks. Valves allow selective shutdown of the system for repairs without affecting the entire building.
- ✓ The globe valve is used where water flow is variably and frequently controlled, such as with faucets or hose bibs. The friction loss in this type of valve is high.
- ✓ A gate valve seats a metal wedge against two metal parts of the valve. It is used where control is either completely on or off. Because there are no turns, it has a low friction loss.
- ✓ A check valve works automatically and allows water flow in only one direction where, for example, backflow might contaminate a potable water supply.

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- ✓ Air chambers and shock absorbers are used to prevent water hammer. This is the noise caused when a valve or faucet is closed quickly, causing the water moving in the system to stop abruptly and the pipes to rattle.
- ✓ Pressure reducers, sometimes called pressure regulators, are required on fixtures if the supply pressure is too high, over about 60 psi. Because most fixtures only require from 5 to 15 psi to operate, higher pressures can cause excessive wear on the fixture. Pressure relief valves, on the other hand, are safety devices designed to open when pressure exceeds some predetermined maximum.

System Design

- ✓ Pressure loss in pipes depends on the diameter of the pipe and the flow in gallons per minute. Pressure loss is due to friction within the pipe. For the same flow rate, the smaller the diameter of the pipe, the greater the friction.
- ✓ The smallest possible pipe size is desired because cost increases with the pipe size.

Hot Water Supply

- ✓ The water in the pipes cools and must be run until fresh hot water from the heater travels the distance to the fixture.
- ✓ This problem can be solved with a two-pipe circulation system. All fixtures needing hot water are connected with a supply pipe and a return pipe. The natural convection in the system keeps the water slowly circulating; hot water rises to the uppermost fixtures and as it cools falls down to the water heater to be reheated. When a circulating system is used long, low buildings, or where natural convection may not provide enough circulation, pumps are used.
- ✓ The size of water heater is based on the total daily and peak hourly hot water demands of a building. The peak hourly demand is used because at certain times of the day it is likely that most occupants will want hot water at the same time.
- ✓ For large buildings, a separate storage tank is required to meet demand, while a smaller boiler actually heats the water.
- ✓ In addition to storage capacity, the recovery rate of a water heater is important. This is the number of gallons per hour of cold water that the heater can raise to the desired temperature.
- ✓ Water heaters are set to keep the water at any desired temperature. Generally, this setting is the highest temperature that is required at the point of use. (90 F to 180 F)
- ✓ Water heaters
 - Direct heating brings the water directly into contact with heated surfaces that are warmed with flame, hot gases, electricity, or solar radiation. This is the method used for the typical residential tank-type water heater.

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- Indirect heating uses an intermediary transfer medium to heat the water. For example, in commercial applications where central steam is available, the steam can be piped to tubes within a tank containing the domestic hot water.

Storage tank	the same tank is used to both heat the water and store it for use
Tankless	water is quickly heated as it is needed and sent to where it is needed ie. instantaneous water heater
Circulating	the water is heated in one place and stored in a separate tank until it is needed ie. solar-powered water heating system

Solar Water Heating

Direct, open-loop system	Indirect, closed-loop system
<ul style="list-style-type: none"> ■ the water used in the building is the same water that is heated in the solar collectors ■ it has the advantage of simple design and operation and high efficiency ■ subject to freezing 	<ul style="list-style-type: none"> ■ use a separate fluid for collecting heat, which is then transferred to the domestic hot water ■ easier to protect from freezing because the heat collecting fluid can contain antifreeze, and it can also operate at a lower pressure than that required for the domestic hot water. ■ Heat exchanger is required, which reduces efficiency.

- ✓ The heating fluid is circulated either passively or actively. Passive circulation relies on gravity and the thermosiphoning action of heated water. This is a simple and low-cost system, but the storage tank must be placed above the solar collectors and the points of use must be close to the storage tank.
- ✓ Active systems use pumps to circulate the heat collecting fluid. This system is much more flexible and reliable, but it adds costs for equipment and operation.
- ✓ Direct or open-loop systems must use some type of drainage system.

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✓ Common types of Solar Heating systems

<p>Batch System (a breadbox heater)</p>	<ul style="list-style-type: none"> ✓ It heats water directly in a black-painted tank inside a glazed box. This passive system is simple, but it is subject to freezing and nighttime heat loss.
<p>Themosiphon System</p>	<ul style="list-style-type: none"> ✓ A thermosiphon system relies on the natural movement of heated water to circulate the water in a passive, open-loop system. This system is also simple, but the storage tanks must be located above the collectors and the piping must me kept simple to minimize pipe friction. ✓ To address the problem of freezing, a variation of this method uses a closed-loop system with antifreeze fluid.
<p>Closed-loop active system</p>	<ul style="list-style-type: none"> ✓ This is one of the most common types of systems for both residential and commercial applications. ✓ A separate nonfreezing fluid is circulated by pumps through the solar collectors and into heat exchanger where the domestic hot water is heated. ✓ This system is flexible and provides control but suffers from some loss in efficiency because of the need for a heat exchanger.
<p>Drain-down system</p>	<ul style="list-style-type: none"> ✓ It is a direct (open-loop), active system that solves the problem of freezing by automatically draining the water from the collectors when the outside temperature is near freezing. ✓ Because water is wasted whenever the system is drained, this method is bets for climates with mild winters where the draining process would not occur frequently.
<p>Drain-back system</p>	<ul style="list-style-type: none"> ✓ It is an indirect (close-loop), active system that uses water as the heat collector fluid. ✓ The heated water is pumped to a heat exchanger where a coil of domestic hot water is heated. ✓ When the controller senses the temperature is too low, it turns off the pump and the collector water drains back into the solar storage tank.
<p>Phase Change systems</p>	<ul style="list-style-type: none"> ✓ Hot water systems can also take advantage of phase change material as the collector fluid. ✓ Phase change materials store large amounts of latent heat as well as sensible heat.

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Sanitary Drainage and Venting

- ✓ Sanitary drainage: any drainage that may include human waste
- ✓ Storm drainage: only runoff from roof drains, landscaped areas, and the like.
- ✓ The two types of drainage are separated because storm drainage does not have to be treated. It can also easily overload the lines of a sanitary sewage disposal system and cause sewage to back up into a building.
- ✓ Black water is sewage including human waste, and grey water is sewage not including human waste, such as from kitchen sinks, dishwashers, and lavatories.

Drainage Systems

- ✓ A drainage system consists of a number of components designed to safely carry away sewage to a private or municipal disposal system.
- ✓ Trap: Traps are located at every fixture and are designed to catch and hold a quantity of water to provide a seal that prevents gases from the sewage system from entering the building. Traps are connected to the actual drainage piping, but they must also be connected to vents.
- ✓ Vents: Vents are pipes connected to the drainage system in various ways, vented to outside air, and designed to serve two primary purposes. First, they allow built-up sewage gases to escape instead of bubbling through the water in the traps. Second, they allow pressure in the system to equalize so that discharging waste does not create a siphon that would drain the water out of the traps.
- ✓ Air gaps: They are used as a safety feature in sanitary drainage systems. If the potable water outlet was below the highest level of the overflow of a sink or tub, contaminated water in the sink could be siphoned back into the potable water supply lines. To prevent this, faucets are always mounted with their outlet at least 2 inches above the highest possible level of waste water.
- ✓ From the trap, sewage travels in fixture branch lines to a vertical stack. If the stack carries human waste from toilets, it is called a soil stack. If the stack carries wastes other than human waste, it is known as a waste stack.
- ✓ Vents from individual fixtures are connected above the fixtures in two ways. If a vent connects to a soil or waste stack above the highest fixture in the system, the portion of the stack above this point is known as a stack vent. The stack vent extends through the roof. In multistory buildings there is a separate pipe used for venting. This is called a vent stack and either extends through the roof or connects with the stack vent above the highest fixture.
- ✓ The stacks connect at the bottom of the building to a horizontal drain. Within the building and to a point 3 feet outside the building this is the house drain (also known as a building drain). From a point 3 feet outside the building to the main sewer line or private disposal system, the

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horizontal pipe is the house sewer (building sewer).

- ✓ Cleanouts are provided at the intersections of the stacks and house drain to allow for maintenance of the drain.

Components and Materials

- ✓ Piping for drainage systems may be DWV (drainage, waste, vent) copper, cast iron, or plastic.
- ✓ Plastic has become popular because it is less expensive and less labor intensive to install than other types.
- ✓ PVC and ABS plastic are suitable for DWV systems.
- ✓ Cast-iron piping can be connected with hub and spigot joints or with hubless joints.
Cast-iron piping is required for the house sewer.
- ✓ Copper and plastic piping is joined just as supply water piping.
- ✓ Backflow preventors or backwater valves prevent sewage from upper stories or from the building sewer from reversing flow and backing up into fixtures set at a lower elevation.
- ✓ When plumbing fixtures must be below the level of the house drain and house sewer, a sump pit is installed. This device collects the sewage and pumps it to a higher level where it can flow by gravity into the sewer.
- ✓ Floor drains collect water in shower rooms or in places where overflow is likely.
- ✓ Interceptors are devices that collect foreign matter at the source instead of allowing it to get into the sewer system.

Ch. 11 Plumbing Systems-Fire Protection

- ✓ Three major objectives for fire protection and life safety in buildings:
 1. the protection of life
 2. the protection of property
 3. the restoration and continued use of the building after the fire
- ✓ Fire prevention includes limiting the products of combustion and other hazardous situations that could lead to starting a fire.
- ✓ Fire containment is provided with building materials, compartmentation, and smoke control.
- ✓ Fire suppression is provided by sprinkler systems, standpipes, and other methods.

Compartmentation

- ✓ It is a critical concept in fire and life safety. The basic idea is to contain a fire and limit its spread, both to allow building occupants to escape and to protect other parts of the building that are not initially subject to the fire.
- ✓ Compartmentation can provide places of refuge where occupants can wait until the fire is extinguished or until they can exit safely. Compartmentation provides time for fire suppression, either by automatic sprinklers or by fire fighting personnel.
- ✓ Separation is required both vertically with fire resistive floor-ceiling assemblies, and horizontally with fire rated walls.

Smoke Control

- ✓ Smoke control is one of the most important aspects of fire protection. Smoke is particularly troublesome because many factors cause it to move rapidly through a building, well beyond the location of the fire.
- ✓ Smoke moves by the natural convection forces caused by differential air pressure between cool and warm air.
- ✓ There are several elements to smoke control. These include containment, exhaust, and, to a lesser degree, dilution. Devices such as fire dampers, gaskets on fire doors, and automatic closing fire doors seal openings in fire walls.
- ✓ A passive smoke control system is one with a system of smoke barriers arranged to limit the migration of smoke. It can be partitions, doors with smoke seals, or curtain board.
- ✓ A curtain board is a piece of construction suspended a minimum of 6 feet from the ceiling that restricts the passage of smoke and flame during a fire's initial stages.
- ✓ An active smoke control system is an engineered system that uses mechanical fans to produce pressure differentials across smoke barriers or to establish airflows to limit and direct smoke movement.

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Sprinkler Systems

- ✓ Wet-pipe systems are the most common. They are constantly filled with water and respond immediately to a rise in temperature at any sprinkler head of from 135 F to 170 F. In most wet-pipe systems, flow detectors are placed on each zone of sprinkler piping. When a sprinkler head opens, the detector senses movement of water and sends a signal to an annunciator panel or fire control center so that fire fighting personnel know where the fire is.
- ✓ Dry-pipe systems are used in areas subject to freezing. The pipes are filled with compressed air or nitrogen until one or more heads are activated, allowing water to flow. Alternately, a dry-pipe system can be activated by a valve connected to a fire alarm.
- ✓ Preaction systems are similar to dry-pipe systems except that water is allowed into the system before any sprinkler head has opened. At the same time an alarm is activated. This system is used where damage from water might result. The early alarm allows the fire to be put out before any sprinkler head opens.
- ✓ Deluge systems activate all the sprinkler heads in an area at once, regardless of where the fire is. All the sprinkler heads are open and the pipes empty. Upon activation of an alarm, valves automatically open, flooding the space. Deluge systems are used in high hazardous areas where fire is likely to spread rapidly.
- ✓ Siamese connections are provided on the exterior of the building so the fire department can connect hose pumps to the sprinkler system.

Standpipes

- ✓ Standpipes are pipes that run the height of a building and provide water outlets at each floor to which fire fighting hoses can be connected. They are located within the stairway or in the case of pressurized enclosures, within the vestibule.
- ✓ Three classes of standpipes:

Class I	<ul style="list-style-type: none">✓ a dry-standpipe system without a directly connected water supply and equipped with 2 1/2 inch outlets for use by fire department personnel✓ Automatic wet or manual wet standpipes must be used where any portion of the building' s interior area is more than 200 feet of travel, vertically or horizontally, from the nearest point of fire department vehicles access.✓ They must be located at every level of a building within stairway enclosures or within the vestibule if the exit enclosures are pressurized.
Class II	<ul style="list-style-type: none">✓ a wet-standpipe system directly connected to a water supply and equipped with 1 1/2 inch outlets and hoses intended for use by building occupants
Class III	<ul style="list-style-type: none">✓ a combination system directly connected to a water supply and equipped

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	<p>with both 1 1/2 inch and 2 1/2 inch outlets</p> <p>✓ it must be installed in buildings where the floor level of the highest story is more than 30 feet above the lowest level of fire department vehicle access, or where the floor level of the lowest story is located more than 30 feet below the highest level of fire department access.</p>
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- ✓ Water is supplied in two ways: from storage tanks and through Siamese connections at ground level for connection with fire department groups
- ✓ Like a sprinkler system, the standpipes can be either dry or set.
- ✓ In a wet system, the standpipes are constantly filled with water and are connected to a tank of water at the top of the building that provides a supply of water for immediate use.
- ✓ In a dry system, there is no water standing in the pipe. In the event of fire, water must be charge with pumps in the building or by the fire department through Siamese connections.

Other extinguishing agents

- ✓ Extinguishers are classified according to what type of fire they are suitable for:

Type A	<ul style="list-style-type: none"> ✓ ordinary combustibles of paper, wood, and cloth ✓ Fire extinguishers for these fires contain water or water-based agents
Type B	<ul style="list-style-type: none"> ✓ Flammable liquids such as gasoline, solvents, and paints ✓ Fire extinguishers for these fires contain smothering types of chemicals like carbon dioxide, foam, and <u>halogenated agents</u>
Type C	<ul style="list-style-type: none"> ✓ Electrical equipment and the corresponding extinguisher contains nonconductive agents.
Type D	<ul style="list-style-type: none"> ✓ Involve combustible metals, and each type of extinguisher must be matched with the fire they might be used on.

- ✓ Halogenated agents: commonly referred to as halon, are used where water might damage the contents of the room, like computer installations.
- ✓ Foam is commonly used where flammable liquid fires might occur, for example, in industrial plants or aircraft hangars.
- ✓ Intumescent materials respond to fire by expanding rapidly, insulating the surface they protect or filling gaps to prevent the passage of fire, heat, and smoke. They are available in the form of strips, calks, paint, and spreadable putty.