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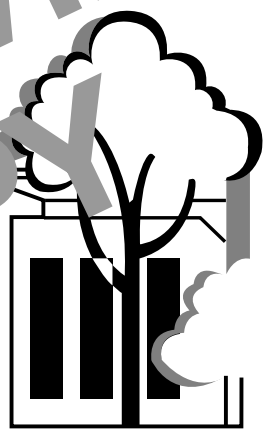
PLUMBING SYSTEMS MAINTENANCE

Lesson One

Introduction to Plumbing



TPC Training Systems

36701

Lesson

1 Introduction to Plumbing

TOPICS

Codes and Standards
Basic Plumbing System
Sanitary Drainage, Waste, and Vent System (DWV)
Drainage Line Flow
Stacks
Traps and Connection Methods
Combined Sewer System
Venting System
Plumbing Fixtures
Storm Water Drainage System
Cold Water Supply and Distribution
Water Flow
Installation and Maintenance
Hot Water Supply and Distribution
Pressure-Boosting Systems

OBJECTIVES

After studying this Lesson, you should be able to…

- Describe a basic plumbing system.
- Name the parts of a DWV system and explain their functions.
- Explain the purpose of the different elements in an industrial cold water supply and distribution system.
- Describe a basic system for industrial hot water supply and distribution.
- Describe three basic systems for boosting incoming water pressure.

KEY TECHNICAL TERMS

Stack 1.13-1.15 a vertical pipe that carries wastewater or air
Trap seal 1.19 the maximum depth of water retained in a trap
Fixture 1.26 a receptacle that receives and discharges water or wastes
Gravity tank 1.53 an elevated, non-pressurized vessel
Hydropneumatic tank 1.54 a pressurized vessel containing water and compressed air

It would be impossible for the modern industrial plant to function without plumbing systems that endure proper water distribution and drainage. The term plumbing is used to describe all sanitary and storm water removal systems, and all potable water supply systems.

For safety and health reasons, minimum requirements for the selection of materials, the methods of installation, and the operation of plumbing systems are included in plumbing codes and standards.

After studying this Lesson, you will be able to name the major standards organizations that regulate plumbing. You will be able to identify the basic plumbing systems found in an industrial plant and explain the function of each system. You also will be able to describe three pressure-boosting systems.

Codes and Standards

1.01 The words *code* and *standard* are similar but they have different meanings. Codes are laws. They usually are based on standards. Codes have requirements that must be obeyed. They form the basis for legal obligations. Standards usually are developed by voluntary committees made up of persons interested in the subject. When standards become codes, then they must be obeyed.

1.02 Plumbing codes establish the *minimum* requirements for designing, selecting materials for, building, testing, and inspecting safe plumbing systems. Revisions are made from time to time to incorporate any new developments in the field.

1.03 Plumbing codes may be adopted by a city, county, or state. Standards are issued by various plumbing organizations. Some of the major ones are:

- American National Standards Institute (ANSI)
- American Society of Mechanical Engineers (ASME)
- American Society of Testing and Materials (ASTM)
- International Association of Plumbing and Mechanical Officials (IAPMO)
- Manufacturers Standardization Society of the Valve and Fittings Industry (MSS).

Basic Plumbing System

1.04 A plumbing system includes all plumbing fixtures and traps, all drainage and vent pipes, building drains, and all supply and distribution pipes for potable (drinking) water. It also includes all joints and connections, devices, receptacles, and appliances within the property lines of the industrial plant.

1.05 A plumbing system has two main components: a *water supply and distribution system* and a *drainage system*. The water supply and distribution system consists of the water service pipe, distribution pipes within the building, all the necessary connecting pipes, fittings, valves, and all appurtenances carrying or supplying potable water in or around the building.

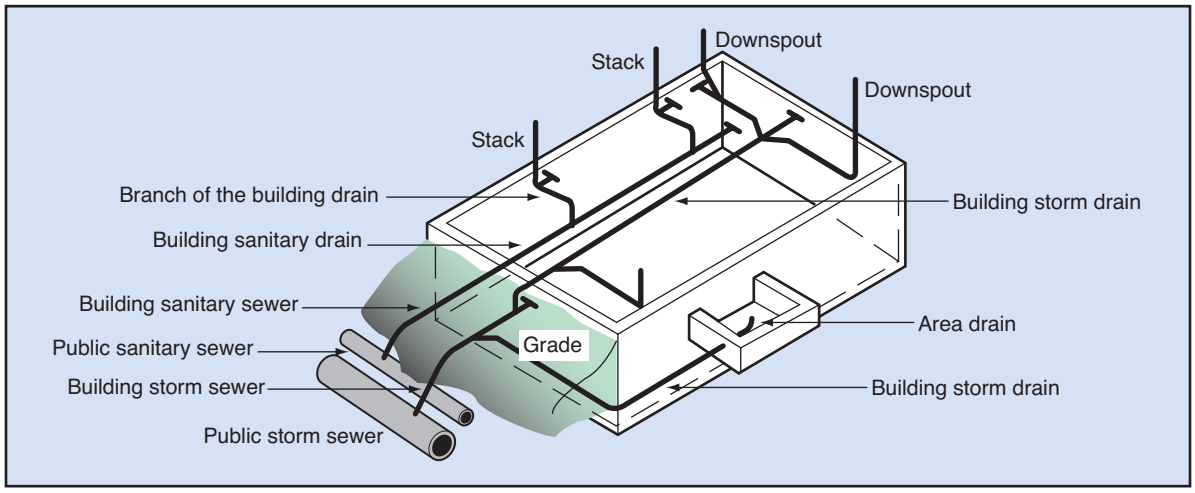
1.06 The drainage system is referred to as the sanitary *drainage, waste, and vent system (DWV)*. It consists of all drain and vent pipes and fixtures that carry waste liquids out of a building into a sewage system, as shown in Fig. 1-1 on the following page.

Sanitary Drainage, Waste, and Vent System (DWV)

1.07 The *building drain* is a horizontal line that receives the discharge from soil, waste, and other drainage pipes inside the walls of the building. The building drain carries the discharge to the building sewer, which begins outside the building walls. (See your local code for the precise point of transition from building drain to building sewer.)

1.08 The building drain shown in Fig. 1-1 pitches at a slope of ⅛ inch per foot or ¼ inch per foot (in/ft)

Fig. 1-1 Typical sanitary and storm system

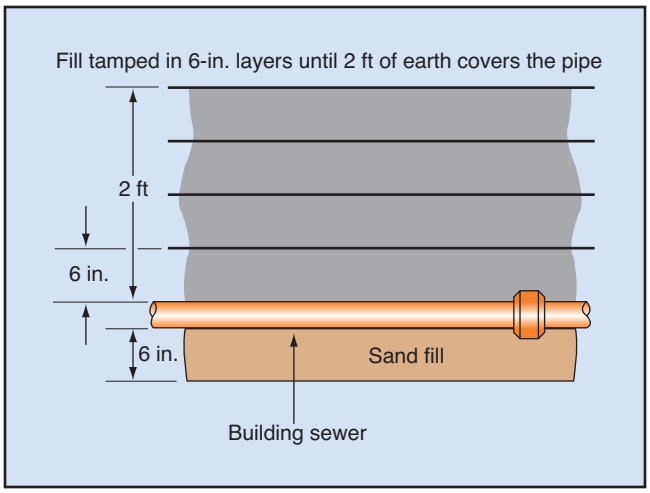


toward the building sewer. The slope provides for gravity flow of the water waste. The building drain must be installed at an elevation higher than the public sewer in order to provide for the flow of sewage to the public sewer.

1.09 *Slope* is the fall (or pitch) of a line of pipe in reference to a horizontal plane. It is expressed as the fall in a fraction of an inch per foot length of pipe. *Backflow* is the reversal of flow in the drainage system.

1.10 The *building sewer* is a buried horizontal line that connects the building drain and the public sewer, as shown in Fig. 1-1. It receives the discharge of the building drain and carries it to a public sewer, private sewer, individual sewage disposal system, or other point of disposal. The pipe normally is buried at a minimum depth of two feet (this may vary from region to region—see your local code), as shown in Fig. 1-2. It pitches toward the public sewer at a slope of ⅛ or ¼ in/ft.

Fig. 1-2. Buried building sewer



Drainage Line Flow

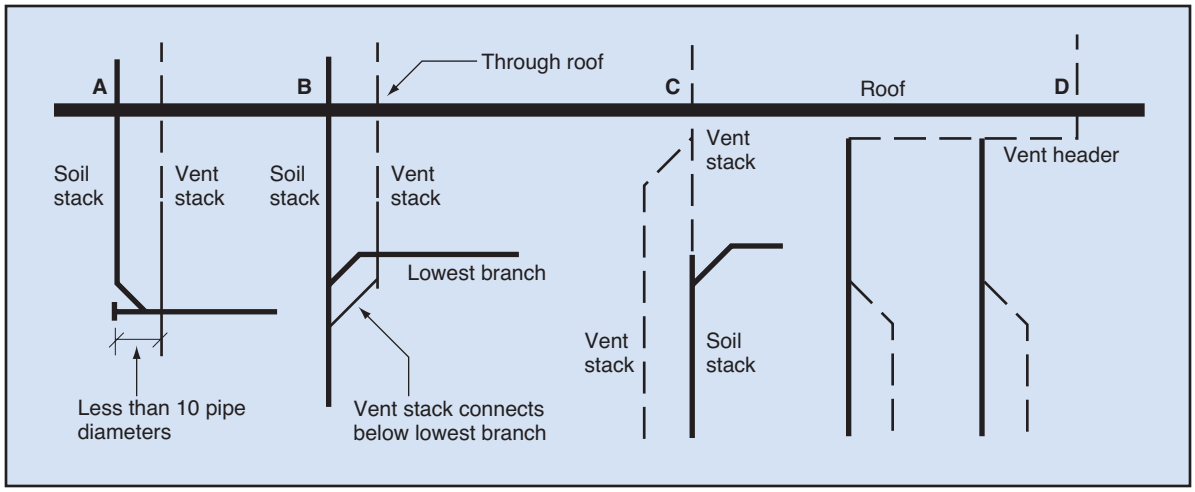
1.11 When there is flow in a sloping horizontal drainage line, the pipe is not full under design condi-tions of flow. If the pipe were to flow full, there would be excessive changes in hydraulic and pneumatic pressure—changes that could cause the loss of seal of traps and the release of sewer gases into the building.

1.12 Flow in a horizontal drainage line does not depend upon a pressure applied to the water. Flow takes place because of gravity, and is affected by the slope of the drain line and the depth of the water in that drain line.

Stacks

1.13 There are three types of stacks: soil stacks, waste stacks, and vent stacks. *Soil stacks* are vertical pipes that extend from the building drain up through the roof. They are connected to branch piping to carry the discharge of water closets and urinals to the building drain. Discharge from other fixtures may or may not be included. Figure 1-3 shows the location of soil stacks.

Fig. 1-3. Soil and vent stack connections



1.14 *Waste stacks* are also vertical pipes that extend from the building drain up through the roof. They carry the discharge of all fixtures, appliances, and appurtenances, other than water closets and urinals, to the building drain.

1.15 *Vent stacks* extend vertically from the base of soil and waste stacks up through the roof They may reconnect with the soil or waste stack above the highest branch connection before extending through the roof. Branch vents are connected to the vent stacks to provide ventilation throughout the entire DWV system. Figure 1-3 shows the location of vent stacks.

1.16 Water flowing in a stack does not completely fill the cross-sectional area of the pipe. Stacks are sized so that the water takes no more than a third of the cross-sectional area of the pipe when the stack is flowing at its design capacity. The water travels down the walls of the stack with a core of air in the center. Proper stack design keeps hydraulic and pneumatic pressure changes within safe limits for the protection of trap seals.

Traps and Connection Methods

1.17 Tank overflows, tank-emptying lines, relief valve discharges, steam expansion tank drains and overflows, boiler blowoffs, and condensate and cooling tower drains should not connect directly to the drainage system. An *indirect connection* is used to avoid the danger of contaminating the water supply system, should backflow take place in the drainage system. The discharges must be through an air gap into a trap, an acceptable receptacle, a floor drain, or onto a roof.

1.18 *An indirect connection* is a pipe that does not connect directly with the drainage system. An *air gap* is the unobstructed vertical distance through the free atmosphere between the outlet of waste pipe and the flood level rim of the receptor into which it discharges. Figure 1-4 shows an indirect connection with an air gap.

1.19 A *trap* is a fitting or device that provides a liquid seal to prevent the passage of air without materially affecting the flow of sewage or wastewater through it. *Trap seal* is the maximum vertical depth of liquid

Fig. 1-4. Indirect connection to drainage system

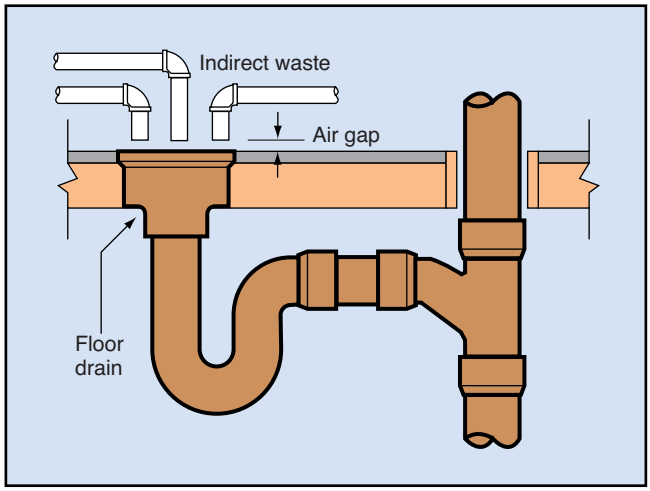
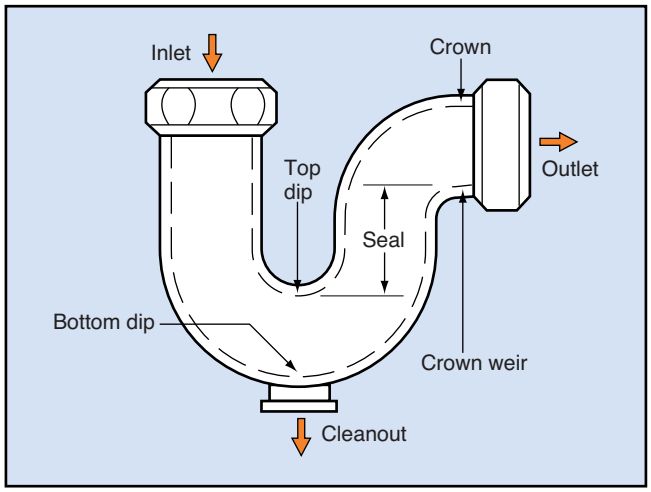


Fig. 1-5. Typical fixture trap



that a trap will keep. It is measured between the crown weir and the top dip of the trap. Figure 1-5 shows a trap and trap seal.

1.20 *Branches* are horizontal lines that carry the discharge from fixtures to the stacks or building drain. They generally are installed at a slope of ¼ in/ft. Figure 1-6 shows a drainage branch.

Combined Sewer System

1.21 A combined plumbing and drainage system (combined sewer) is one which carries both sanitary sewage and storm water in the same piping. Sanitary and storm water drainage systems within a building should be independent of each other, unless they discharge into a combined public sewer. If there is only a combined public sewer, the storm water system can be connected to the sanitary drainage system within the building at the most convenient locations.

1.22 When separate public sanitary and storm water sewers are available, the sanitary drainage and storm water systems in the building must be kept separate, with no interconnections. The building sanitary sewer must discharge into the public sanitary sewer and the building storm sewer must discharge into the public storm sewer, as shown in Fig. 1-1. Soil, waste, or vent stacks must *never* be used to carry storm water. Downspouts must *never* be used as soil, waste, or vent stacks.

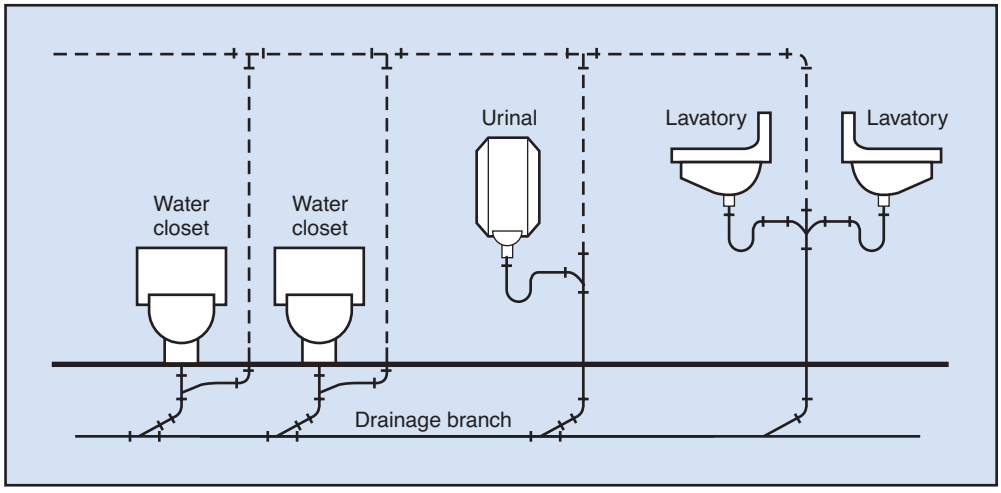
Venting System

1.23 A venting system is necessary in a sanitary drainage system in order to:

- prevent excessive hydraulic and pneumatic pressures, thus protecting the water seals of all fixture traps against siphonage or blowout
- provide the circulation of air that will prevent a buildup of foul air and the growth of slime and fungus within the piping system.

1.24 Air circulation in the system is caused by the difference in pressure between the outdoor air and the air in the piping system, and by the flow of water in the drainage piping.

Fig. 1-6. Drainage branch



1.25 The components of a venting system are vent stacks, vent headers, vent branches, individual vents, and vent terminals. There are several methods for the venting of a fixture trap to prevent the loss of its water seal. Some codes require an individual vent for every fixture trap. Other codes allow methods such as wet venting, circuit and loop venting, and combination waste and vent venting.

Plumbing Fixtures

1.26 *Plumbing fixtures* are receptacles, devices, or appliances which are supplied with water or which receive liquid or liquid-borne wastes and discharge such wastes into the drainage system. These fixtures may be directly or indirectly connected to a drainage system. Plumbing fixtures found in a typical industrial plant include:

- water closets
- lavatories
- showers
- drinking fountains
- area drains.
- urinals
- sinks
- eye washes
- floor drains

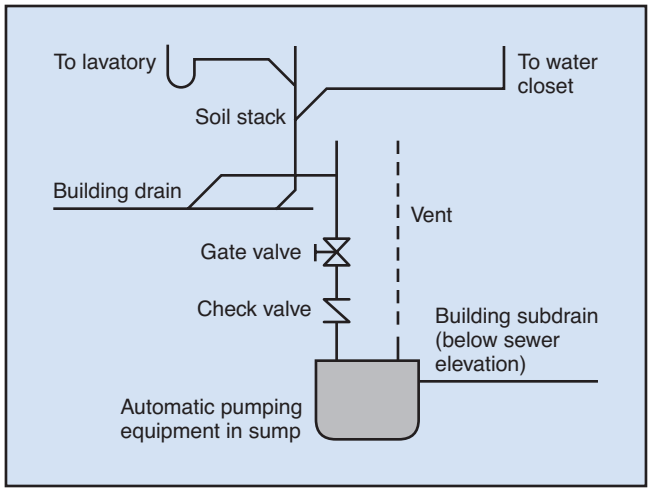
1.27 Industrial tanks, vats, and similar processing equipment are not plumbing fixtures. However, they may be connected to, or discharge into, approved traps or plumbing fixtures, as provided for in the plumbing code.

1.28 A *building subdrain* is a horizontal line located below the level of the public sewer, as shown in Fig. 1-7. It carries the discharge from plumbing fixtures to a receiver. The contents of the receiver are pumped up into the house drain.

Storm Water Drainage System

1.29 Storm water consists of rainwater, surface runoff, ground water, subsurface water, or similar clear water wastes. A storm water drainage system is provided to drain water from roofs, paved areas, courts, and yards. It has the following five basic components:

Fig. 1-7. Building subdrain



1. building storm sewer
2. building storm drain
3. downspouts
4. roof drains
5. subsoil drain.

1.30 The *building storm sewer* is a buried horizontal line which carries the discharge of the build-

Fig. 1-8. Connecting the roof drain to the storm water drainage system

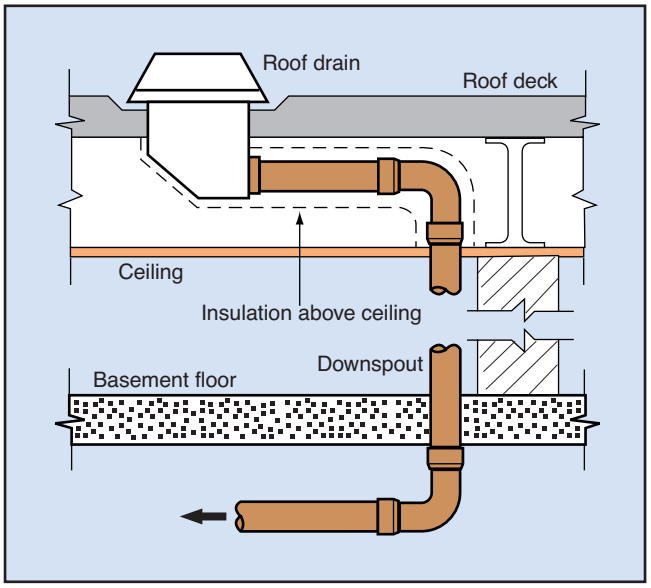
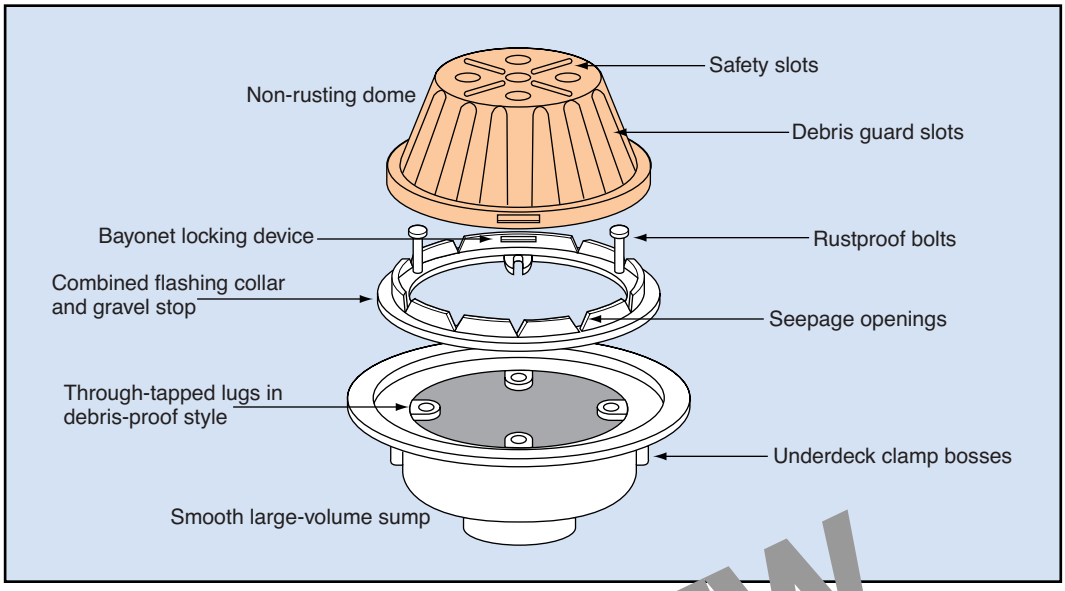


Fig. 1-9. Typical roof drain



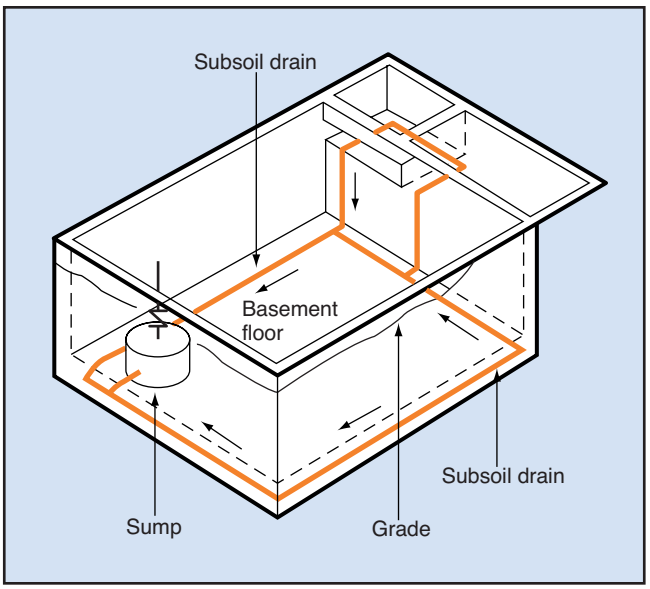
ing storm drain to a point of disposal, as shown in Fig. 1-1. It may discharge into the public sewer, into an existing stream, or into a system of dry wells. A dry well is a pit or receptor with porous walls that allow the liquid contents to seep into the ground.

1.31 The *building storm drain* is a horizontal line which takes the storm water from downspouts and area drains and carries it to the building storm sewer, as shown in Fig. 1-1. It is installed at a slope of ⅛ or ¼ in/ft.

1.32 *Downspouts* are vertical pipes that carry storm water from roof drains to the building storm drain. They also are called *leaders, conductors,* or *downcomers*. Figures 1-1 and 1-8 on the previous page show the location of downspouts.

1.33 *Roof drains* are receptacles which collect the storm water on the roof and discharge it into the downspouts. Figure 1-8 shows the location of a roof drain on the roof deck. Figure 1-9 shows a typical roof drain.

Fig. 1-10. Subsoil drain



1.34 *Subsoil drain lines* are installed under the basement floor and/or around the building. They collect subsoil water which might cause damage to the building structure. The water is carried to a sump and pumped up to the building storm drain or sewer. Figure 1-10 shows a subsoil drain with a sump.

The Programmed Exercises on the next page will tell you how well you understand the material you have just read. Before starting the exercises, remove the REVEAL KEY from the back of your Book. Read the instructions printed on the Reveal Key. Follow these instructions as you work through the Programmed Exercises.

1-1. Must the requirements of a plumbing code be obeyed?	1-1. YES Ref: 1.01
1-2. Name at least one organization that issues plumbing codes or material standards.	1-2. ANSI, ASME, ASTM, IAPMO, MSS Ref: 1.03
1-3. The building drain is installed at a slope of _____.	1-3. ⅛ OR ¼ IN/FT Ref: 1.08
1-4. The building sewer connects the _____ and the_____.	1-4. BUILDING DRAIN; PUBLIC SEWER Ref: 1.10, Fig. 1-1
1-5. What types of stacks extend vertically through the roof and carry water and waste discharges?	1-5. SOIL STACKS; WASTE STACKS Ref: 1.13, 1.14, Fig. 1-3
1-6. The depth of a trap seal is measured between the _____ and the _____ of the trap.	1-6. CROWN WEIR; TOP DIP Ref: 1.19, Fig. 1-5
1-7. Is a building subdrain located above or below the level of the public sewer?	1-7. BELOW Ref: 128, Fig. 1-7
1-8. Subsoil drains frequently are installed under the _____.	1-8. BASEMENT FLOOR Ref: 1.34

Cold Water Supply and Distribution

1.35 A cold water supply and distribution system is provided in an industrial plant to ensure an adequate supply of water at an adequate pressure to all fixtures and equipment at all times. The basic elements of a cold water supply system include:

- water service
- water main
- water meter
- riser runouts
- water risers
- branches.

Figures 1-11 and 1-12 show some of these elements.

1.36 The *water service* is a buried horizontal pipe that carries water from the water main (or wells, reservoirs, waterways) to the building. It should always be buried below the frost level of the ground to prevent freeze-ups and disruption of the supply of water to the building. Figure 1-11 shows a typical arrangement of a water service.

1.37 The cold *water main* in Fig. 1-12 is a principal line in the building that carries water from the water service to all other water piping in the building. A *water meter* is installed in the water main as close as possible to the point of entry of the water service. It measures the quantity of water used.

1.38 *Riser runouts* are pipes that connect the water main to the water risers. *Water risers* are water supply pipes which extend vertically two or more stories to carry water to all the branch lines and fixtures. Figure 1-12 shows the location of riser runouts and water risers. A *branch* is the pipe that carries water from a riser to the fixtures. The piping to a fixture or piece of equipment is always called a *branch*.

Water Flow

1.39 Flow in the water distribution piping depends on an applied pressure. The pressure required by the industrial plant may come from the public water main, or it may be supplied by a pressure-boosting system. When there is no flow in the water distribution system, the pressure at any point in the system is due to the height of the water above that point. The pressure is expressed as *feet of head* or *pounds per square inch* (psi). It is called *static head* or *static pressure*.

1.40 It is important to keep the flow in water piping below a speed of ten feet per second (10 ft/s).

Fig. 1-11. Water service

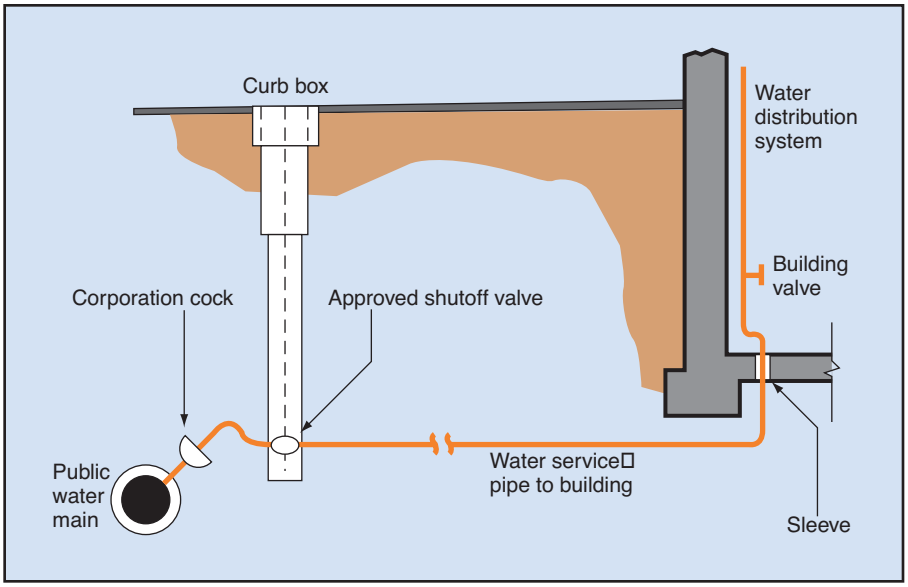


Fig. 1-12. Cold water distribution system

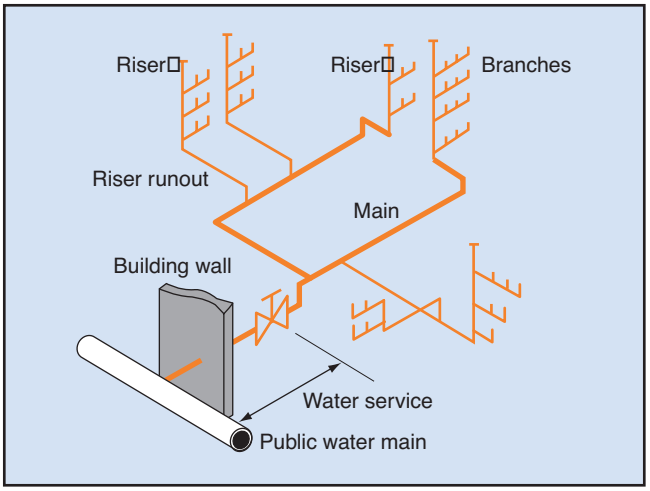
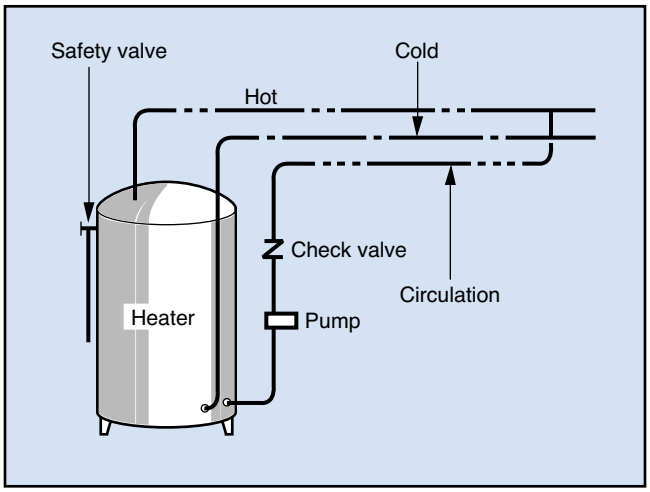


Fig. 1-13. Typical arrangement of cold, hot, and circulation mains



Installation and Maintenance

1.41 The way in which the water distribution system is installed and maintained is important for a number of reasons. The most important is the health and safety of the users. Inadequate or improper pipe sizes can cause decreases in the pressure in parts of the system. A decrease in pressure can cause failure of fixtures to operate properly, and/or the inability to deliver water to some parts of the system.

1.42 It is essential to maintain the required *pressure* or the system will not work properly. A proper *flow* must be maintained so that enough water is delivered to fixtures and equipment. An undersized pipe can cause failure of the water *supply* due to corrosion or scale buildup. Water flow of more than 10 ft/s will cause excessive noise.

Hot Water Supply and Distribution

1.43 A hot water supply and distribution system is provided in an industrial plant to ensure an adequate supply of water at the required temperature to all fixtures at all times. Figures 1-13 and 1-14 show a typical arrangement of a hot water system. The basic elements of a hot water system are:

- water heaters
- supply and circulation piping
- circulation pump
- safety valves.

1.44 Cold water is heated to a temperature of 140°F (60°C) by means of *water heaters*. The fuel for heating may be steam, boiler hot water, gas, or electricity. There are three types of water heaters that can be used in an industrial plant:

- instantaneous
- semi-instantaneous
- storage

1.45 The *instantaneous water heater* in Fig. 1-15 on the following page is used when the demand for hot water is level and constant. It also is used as a

Fig. 1-14. Typical arrangement of hot water and circulation risers

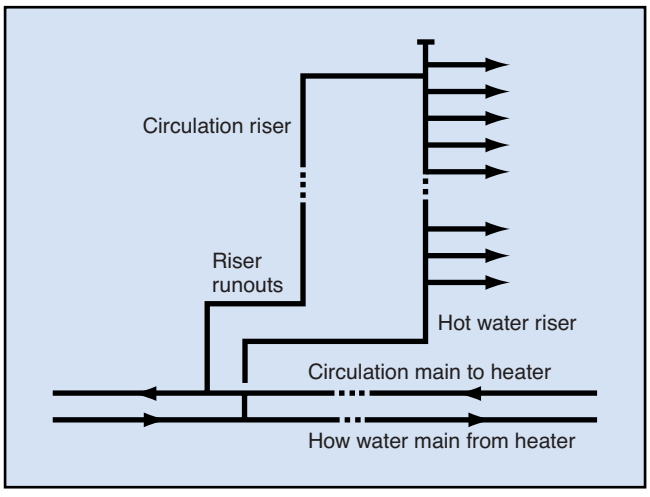
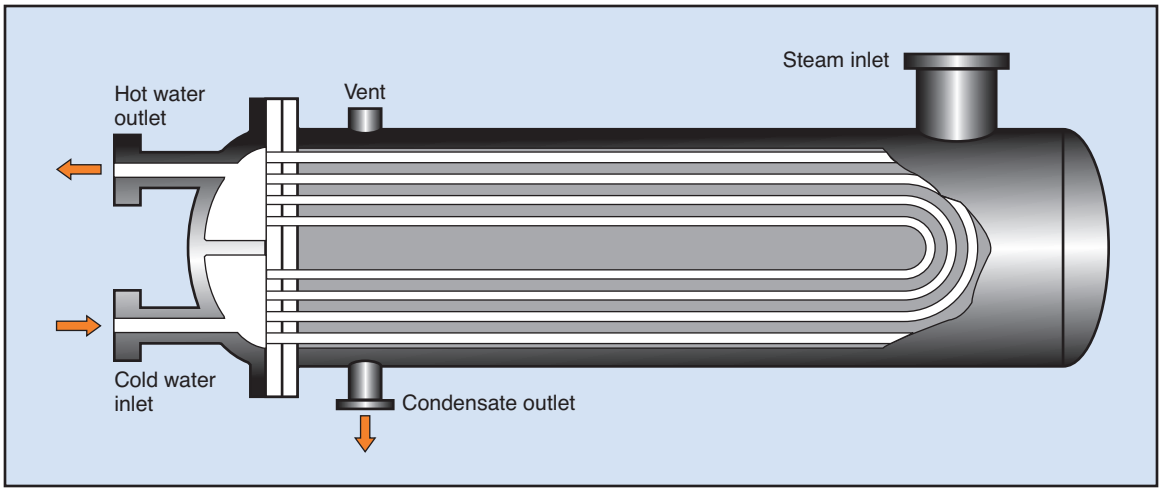


Fig. 1-15. Instantaneous water heater

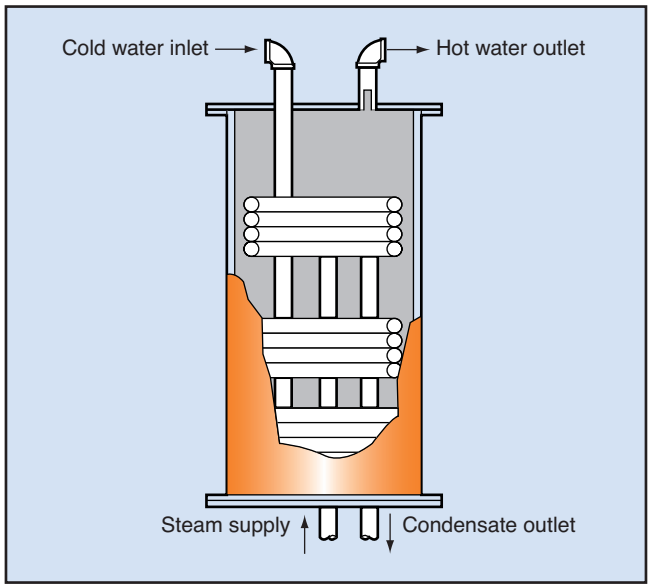


booster heater at the point of usage where a temperature higher than 140°F (60°C) is needed for a particular piece of equipment. This kind of water heater also is called a *heat exchanger*.

1.46 The *semi-instantaneous heater* in Fig. 1-16 is similar to the instantaneous type. It has a small amount of storage so that it can react to sudden changes in demand and maintain the outlet temperature within a range of plus or minus 5°F.

1.47 Figure 1-17 shows a *storage heater*. It is used where there are large volume changes in the demand for hot water. It smooths out the peak demand on the water heating equipment.

Fig. 1-16. Semi-instantaneous water heater



1.48 *Piping* (main, riser, and branch) for the hot water system is similar to the corresponding cold water system components. Figure 1-13 shows how a connection is made to the cold water main to supply water to the heaters. The hot water from the heaters is piped to all fixtures that require hot water.

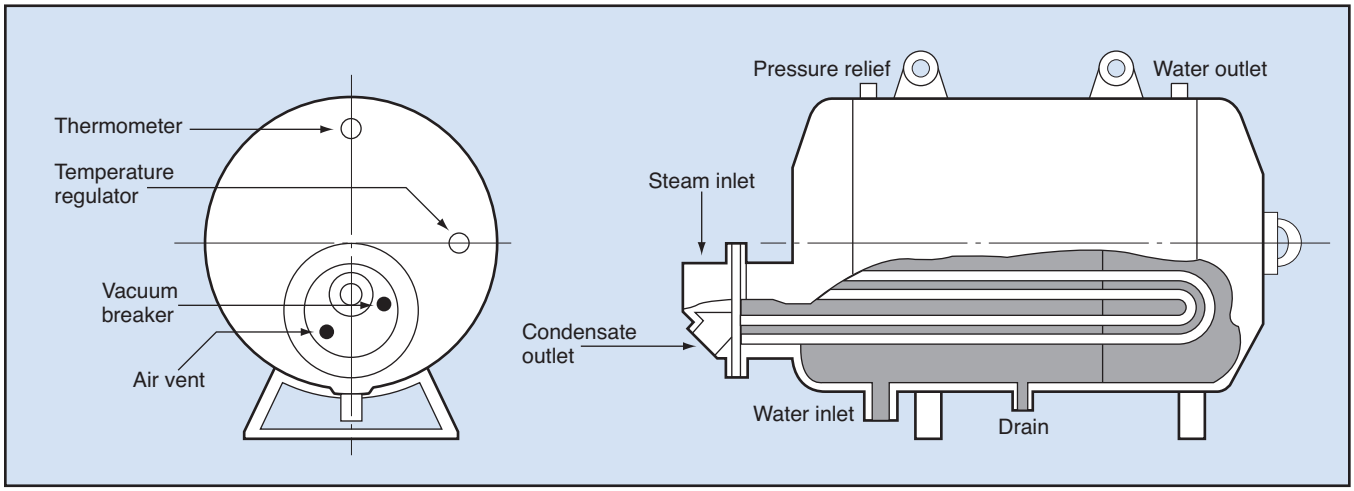
1.49 Figures 1-13 and 1-14 show a hot water *circulation system*. It is installed to ensure that hot water is delivered at the required temperature as soon as possible after the faucet is opened at any fixture. The *pump* in Fig. 1-13 is provided to circulate the water in the hot water supply and circulation piping.

1.50 Safety must be built into any hot water system and the safety features (*safety valves*) must operate automatically. The two important dangers to guard against are *excessive pressures* and *excessive temperatures*. An excessive temperature or pressure is one that produces unsafe conditions. Exploding water heaters and scalding water at fixtures are real and substantial dangers.

1.51 The cost-effective operation and maintenance of any hot water system depend on the following:

- choice of the proper type of water heater
- adequate insulation on heaters and piping
- location of piping (avoid cold, unheated areas)
- easy access to valves.

Fig. 1-17. Storage water heater



Pressure-Boosting Systems

1.52 Sometimes the pressure of the water supplied from the public main or other source is less than that required for proper plant operation. When this happens, some method must be provided to increase the pressure to an adequate level. Three basic systems for boosting the incoming water pressures are:

- gravity tanks
- hydropneumatic tanks
- booster pumps.

1.53 A *gravity tank* system is composed of an elevated, non-pressurized tank of adequate capacity and pumps to raise the water for filling the tank. Water held in the tank flows by gravity to all outlets in the building.

1.54 The *hydropneumatic tank* is simply a pressurized version of the gravity tank. The system uses pumps to pump water into a closed tank supplied with compressed air. The water is delivered from the tank to the distribution system within a preset pressure range.

1.55 The *booster pump* system is a tankless system. It has two or more pumps which deliver the water directly to the distribution system at the required capacity and pressure.

1-9. The water service is a pipe that extends from the _____ to the building.	1-9. WATER MAIN Ref: 1.36
1-10. In a water distribution system, what connects the water main to the water risers?	1-10. RISER RUNOUTS Ref: 1.38, Fig. 1-12
1-11. Water pressure is expressed as _____ or _____.	1-11. FEET OF HEAD POUNDS PER SQUARE INCH Ref: 1.39
1-12. Cold water is heated to a temperature of _____ to supply hot water to fixtures.	1-12. 140°F Ref: 1.44
1-13. Name three types of water heaters	1-13. INSTANTANEOUS, SEMI-INSTANTANEOUS, STORAGE Ref: 1.44-1.47
1-14. Instantaneous heaters also are called _____.	1-14. HEAT EXCHANGERS Ref: 1.45
1-15. Two dangers to guard against in a hot water system are excessive _____ and excessive _____.	1-15. PRESSURE; TEMPERATURE Ref: 1.50
1-16. What are the three systems used for boosting water pressure?	1-16. GRAVITY TANK, HYDROPNEUMATIC TANK, BOOSTER PUMP Ref: 1.52-1.55

Answer the following questions by marking an "X" in the box next to the best answer.

1-1. Plumbing codes establish _____ requirements.

- ☐ a. maximum
- ☐ b. minimum
- ☐ c. national
- ☐ d. permanent

1-2. ANSI, ASTM, and MSS are

- ☐ a. plumbing codes
- ☐ b. drainage systems
- ☐ c. standards organizations
- ☐ d. plumbing standards

1-3. The building drain usually is installed at a slope of _____ in/ft.

- ☐ a. 1/16
- ☐ b 1/8
- ☐ c. 3/4
- ☐ d. 1

1-4. The building sewer usually is buried at a minimum depth of

- ☐ a. 1 ft
- ☐ b. 2 ft
- ☐ c. 3 ft
- ☐ d. 4 ft

1-5. Soil and waste stacks carry the discharge from all of the following EXCEPT

- ☐ a. water closets
- ☐ b. sinks
- ☐ c. floor drains
- ☐ d. roof drains

1-6. Which of the following is a plumbing fixture?

- ☐ a. Roof drain
- ☐ b. Gravity tank
- ☐ c. Booster pump
- ☐ d. Floor drain

1-7. Another name for a downspout is a

- ☐ a. stack
- ☐ b. leader
- ☐ c. riser
- ☐ d. runout

1-8. Subsoil water is collected and carried to a

- ☐ a. sump
- ☐ b. storm sewer
- ☐ c. sanitary sewer
- ☐ d. river

1-9. Hot water is supplied to the system at a temperature of

- ☐ a. 110°F
- ☐ b. 140°F
- ☐ c 180°F
- ☐ d. 212°F

1-10. A storage heater is used when the demand

- ☐ a. is level
- ☐ b. is constant
- ☐ c. has small volume changes
- ☐ d. has large volume changes

SUMMARY

Water supply and drainage systems are the basic components of plumbing systems which must be installed in industrial plants following the requirements of local plumbing codes.

A sanitary DWV system consists of a building drain and sewer, soil, waste, and vent stacks, and branches. A storm water drainage system consists of a building drain and sewer, downspouts, roof drains, and a subsoil drain.

A water supply and distribution system consists of water service, water main, water meter, riser runouts, water risers, and branches. Basic elements of a hot water system include water heaters, supply piping, circulation piping, a pump, and safety valves.

The flow of wastewater in drainage pipes is by gravity. Horizontal piping is installed at a slope of ⅛ or ¼ inch per foot. Water in the water distribution system flows under pressure from the public water main or, if necessary, from a pressure-boosting system.

Answers to Self-Check Quiz

1-1. b. Minimum. Ref: 1.02

1-2. c. Standards organizations. Ref: 1 .03

1-3. b. ⅛. Ref: 1.08

1-4. b. 2 ft. Ref: 1.10

1-5. d. Roof drains. Ref: 1.13, 1.14, 1.33

1-6. d. Floor drain. Ref: 1.26

1-7. b. Leader. Ref: 1.32

1-8. a. Sump. Ref: 1.34

1-9. b. 140°F. Ref: 1.44

1-10. d. Has large volume changes. Ref: 1.47