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PLUMBING AND PIPEFITTING

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PREFACE

This manual is a guide for engineer personnel who are responsible for plumbing and pipefitting. The objective of this manual is to provide information on water, waste, and heating systems and basic plumbing techniques. Use this guide to help repair fixtures, leaky pipes, and valves; to make pipe joints; to install water, waste, and heating systems; and to test and service these systems.

The plumber is a person who installs and repairs water systems, waste systems, and fixtures; cuts, reams, threads, and bends pipes; caulks, solders, and tests joints or systems for leaks.

Users of this manual should be familiar with the tools used by the construction MOS in career management field (CMF) 51. This manual provides information on utility plans and drawings to include bills of material and standard plumbing and heating symbols; plumbing materials and procedures; sewerage, water supply, and heating installation; insulation material; and pumps. The entire pattern for soldiers in CMF 51 is described in Army Regulation (AR) 611-201.

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Unless this publication states other wise, masculine nouns and pronouns do not refer exclusively to men.

CHAPTER 1
PLUMBING SYSTEMS

Plumbing is a system of piping, apparatus, and fixtures for water distribution and waste disposal within a building. This chapter covers the basic water supply and distribution system, the theater of operations water supply and distribution system, and sewerage system. Plumbing also includes installation and maintenance of these systems.

When architects design a building, they prepare a set of prints. The architect also prepares a set of specification sheets detailing the types and quality of materials to be used. Plumbers use the prints and specifications to lay out and plan the project.

Section I. Basic Water Supply and Distribution System

A water supply system receives, treats, and moves water to a water distribution system. Water may come from a stream or lake, from a deep or shallow well, or from a reservoir, which collects surface water. The water supply system purifies and pumps the water into a storage tank. After the water is purified, it is released into the distribution system. The distribution system is an arrangement of connected pipes (called a ***run)*** *that carries the water to its destination. This system usually has a means of heating some of this water.*

1-1. Plans. See Section I of Appendix A for information on construction plans, prints, and drawings and Section II for a list of symbols used on plans.

a. *Water Supply and Distribution Plans.* A plumber should be able to install a complete water supply system by using a plan together with standard and special detail drawings and a bill of material. A standard detail drawing will show the water heater and standard storage-tank connections. The plan will show the type of piping by size and fittings. See Appendix A, paragraph A-2 (page A-l).

b. *Utility and Building Waste System Plans.* See Appendix A, paragraph A-3 (page A-l).

c. *Unit Construction and Package Unit Prints.* Prints are used for structures and equipment in water supply and distribution systems. The type of print depends on whether the unit is constructed or is a package unit to be assembled in the field. See Appendix A, paragraph A-4 (page A-2).

1-2. Bills of Materials. The designer (architect) or draftsman usually prepares a bill of materials (BOM) when he prepares the original drawings. However, if no BOM accompanies field prints, the plumber must compile it. Appendix B gives instructions for preparing a BOM.

1-3. Water Supply Lines and Branches. The main water supply system provides potable cold water at the main at a pressure that meets National Plumbing Code standards. The water-service main for the plumbing installation tees (Ts) into the main water supply. The plumbing system must provide enough water for normal use at each outlet.

Fixture supply risers take water from the main supply to the fixtures on each floor level. Each fixture supply riser must have a diameter large enough to supply water to all the fixtures it connects. The size is determined by the design load for the riser. Refer to Table C-3 (page C-6) or C-4 (page C-7).

a. *Pipe Selection.* Cold-water systems may use galvanized-iron or galvanized-steel pipe, copper tubing, or plastic pipe. The material used depends on the—

- Amount of water to be supplied.
- Water pressure.
- Corrosion factor for different types of pipe in different temperatures.
- Cost.
- Availability.

b. *Pipe Size.* The size of water supply piping depends on the—

- Water pressure and friction loss through the length of the pipe.
- Number and kinds of fixtures installed (fixture demand).
- Number of fixtures in use at a given time (factor of simultaneous use).
- Type of flushing devices. (See Chapter 4, paragraph 4-2, pages 4-6 and 4-7.)

(1) *Friction Loss.* When a liquid flows through a pipe, layers move at different speeds, with the center layer moving fastest. This resistance to flow (called *friction loss)* varies with different types of pipe. Pipe friction, in turn, causes a drop in water pressure. In a small pipe, this friction loss is overcome by increasing the water pressure. If higher water pressure is not possible, increasing the pipe size can reduce friction loss. (See Appendix C for friction loss in different types of pipe.

(2) *Water Pressure.* Pressure in the main usually ranges from 45 to 60 pounds per square inch (psi). If the pressure is over 60 psi, a pressure-reducing valve must be placed in the water-service line at its entry to the building. The size of the water-service pipeline, the rate of use, the length of the line, and the outlet height in the system control the pressure available at the outlet.

(3) *Calculations for Sizing Pipe.* The minimum practical size for a water-service line is 3/4 inch. This size should be used even when calculations indicate a smaller one. Calculations for factoring loss of pressure in complex systems are beyond the range of this manual. For simple systems, use approximate figures to find the pipe size. Tables C-1 and C-2 (pages C-2 through C-5) give capacities and psi for galvanized-steel/iron pipe, copper tubing, and plastic pipe. Use these tables combined with maximum fixture demand and factor of simultaneous use to determine pipe sizes.

(a) Maximum fixture demand. The maximum fixture demand in gallons per minute (GPM) is the total amount of water needed to supply all fixtures at the same time. Estimate the maximum fixture demand by counting the number and type of fixtures in the plumbing system. Table 1-1 gives the maximum fixture demand for different fixtures.

Table 1-1. Fixture demand (in GPM)

Fixture	GPM
Water closet	45
Lavatory	7.5
Shower	15
Urinal	39.5
Slop sink	22.5
Laundry tub	15
Floor drain	7.5

EXAMPLE

What is the maximum fixture demand for a plumbing system consisting of 14 fixtures as follows: two water closets, four lavatories, two showers, three urinals, one slop sink, one laundry tub, and one floor drain? Use Table 1-1 and the following steps:

Step 1. Multiply the number of each fixture by the GPM of that type fixture (from Table l-l).

Step 2. Total these figures.

Result: A maximum fixture demand of 313.5 GPM.

Use the fixture demand (313.5 GPM) with the factor of simultaneous use to select the pipe size.

(b) Factor of simultaneous use. The factor of simultaneous use is the percentage of fixtures potentially in use at a given time (Table 1-2). It is an estimate of the total demand on a water supply system, expressed as water supply fixture units. Simultaneous use factors decrease as the number of fixtures in a building increases. Take the number of fixtures, using the higher number in the use-percentage range. For example, for five fixtures, use a probable demand of 50 percent, the higher figure in that range. The probable demand for 45 fixtures is about 25 percent. See example on page 1-4.

Table 1-2. Factor of simultaneous use

Number of Fixtures	Percent of Simultaneous Use
1-5	50-100
5-50	25-50
50 or more	10-25

If a table for the factor of simultaneous use is not available, estimate the probable demand by computing 30 percent of the maximum fixture demand in gallons.

Example

Continuing the above example, the 14 fixtures would have a simultaneous use of about 35 percent. Since the fixture demand was 313.5 GPM, the water-service line must have a capacity of 35 percent of 313,5 (110 GPM). What size pipe would you need for a 60-foot long pipeline with a pressure at the main of 45 psi?

Step 1. Read down the 60-foot column in Table C-1 (page C-3) or C-2 (page C-5) to **1 1/2-inch** diameter.

Step 2. Read across (left) to the psi column and establish the given as **45** psi.

Step 3. Read back to the 60-foot column. Table C-1 shows **150** GPM (the quantity that includes 110 GPM); Table C-2 shows **155** GPM.

Pipe Size: Either 1 l/2-inch galvanized, copper, or plastic piping would be large enough for the water-service line.

NOTE: *Remember, the minimum practical size for a water-service line is 3/4 inch. This size should be used even when calculations indicate a smaller size.*

c. *Installation.*

(1) *Main Water Supply Line.* The main water supply is a pipe, usually hung from a ceiling, with branches connected to serve the fixture risers. This supply has the same diameter as the water service from the main and is centrally located to provide short takeoffs to fixture supply risers throughout the building. To reduce friction loss, lay the main supply piping as straight as possible. The main supply pipe must not sag or trap water. It should be graded slightly, up to 1/4 inch per foot, dropping toward the meter. At the low end of the grade, place a drip cock or stop-and-waste valve for draining the pipe in winter. A drain pipe may be needed to carry the waste water from the opening in the valve to a floor drain or sump. If it is impossible to grade all the piping to one point, all parts that cannot be centrally drained should have separate drip cocks or stop-and-waste valves. The main supply pipe must be well supported to take its weight off the fittings and to prevent leaks.

(2) *Fixture Supply Risers.* Use reducing Ts to connect fixture supply risers to the main supply. Run the risers through the interior walls of the building. Tighten all joints before the partitions are finished. Pipe rests or clamps should be used to support vertical fixture supply risers at each floor level. (Fixture supply risers must not depend on the horizontal branches for support.) Horizontal fixture branches should be well supported and graded upward toward the vertical fixture supply risers.

(3) *Valves.* Install gate valves in each vertical supply riser, so that a section can be repaired without shutting off the water to other sections. Small gate valves on the supply of each fixture allow shutting off the water for faucet repairs.

d. *Testing for Leaks.* Inspecting for leaks is important. A leaky joint wastes water and causes costly damage to the building. In new construction, test the entire system for leaks before the floor and partitions are closed up. When performing this test, use the water pressure from the main that feeds the system. While the system is under pressure, inspect each joint for moisture. If a leak is detected in a joint, tighten the joint or replace it by cutting the pipe and connecting a new section with a union. When working with copper soldered joints or plastic solvent-weld joints, drain the pipe and then connect the joint. Copper compression joints can be tightened or replaced.

e. *Disinfecting the Piping System.* After installation or repair, plumbing pipes and other parts of a water-supply system carrying drinking water must be cleaned and disinfected before use. The first step is flushing the system to remove dirt, waste, and surface water. Then, each unit must be disinfected with a chemical such as a solution of hypochlorite or chlorine.

(1) *Dosage.* Under average conditions, use the dosages (in parts per million (ppm)) in Table 1-3. The chlorine dosage required to disinfect a unit depends on the—

- Contact time.
- Amount of organic chlorine-consuming material present.
- Volume of waler to be disinfectcd. Table 1-4 gives the volume of water for different sizes and lengths of pipe.

Table 1-3. Chlorine dosage

Unit	Minimum Dosage (ppm)
Pipe	50
Storage	50
Filter	100
Well	150

Table 1-4. Volume of water disinfected (by pipe size)

Pipe Diameter (in inches)	Volume Per Foot of Pipe (in gallons)
2	0.16
4	0.65
6	1.47
8	2.61
10	4.08
12	5.88
16	10.45
20	16.32

(2) *Application.* Use portable gas chlorinators to apply the liquid chlorine. Chlorine cylinders should not be connected directly to the mains because water may enter the cylinder and cause severe corrosion, resulting in dangerous leakage. A solution of hypochlorite is usually applied by measuring pumps, gravity-feed mechanisms, or portable pipe-disinfecting units. Use the following procedures:

Step 1. Flush all sections thoroughly at a velocity of at least 3 feet per second (fps) until all dirt and mud is removed.

Step 2. Stop all branches and other openings with plugs or heads properly braced to prevent blowouts.

Step 3. Insert the disinfectant into the mains through taps or hydrants at the ends of each section.

Step 4. Bleed out any air trapped in the line.

Step 5. Add the predetermined chlorine dosage as the main slowly fills with water.

Step 6. Continue feeding until the water coming from the supply end contains the desired amount of chlorine.

Step 7. Keep the chlorinated water in the unit for 24 to 48 hours.

Step 8. Flush the main until the water contains only the amount of chlorine normally in the supply.

Step 9. Analyze samples daily for bacteria until the analyses show no further need for disinfection. If the samples are unsatisfactory, dechlorinating is required.

f. *Maintenance and Repair.*

(1) *Corrosion.* Galvanic corrosion (resulting from a direct current of electricity) occurs in a plumbing system that includes two different kinds of metal pipe, such as galvanized pipe and copper pipe. See Chapter 3, paragraph 3-1 (pages 3-1 and 3-2) for reducing and repairing corrosion.

(2) *Scale.* Hard water contains a large amount of calcium and magnesium compounds, which prevent soap from lathering. This forms a scum that slows the flow of water. The scum deposits harden and form scale. See Chapter 3, paragraph 3-3 (page 3-4) for reducing and removing scale.

(3) *Frozen Pipes.* Water supply lines may freeze when exposed to temperatures below 32° Fahrenheit (F) (0° Celsius (C)). Outside pipes must be buried below the frost line. In northern zones, this is 4 feet or more. If the building temperature falls below freezing, inside pipes may also freeze, causing the pipe to break at the weakest point. See Chapter 3, paragraph 3-2 (pages 3-2 and 3-3) for the procedures for thawing frozen pipes.

1-4. Tapping the Water Main. Water mains are usually cast iron, 8 inches or more in diameter. If the main is less than 8 inches in diameter, taps should be 2 inches or smaller. Use Figure 1-1 and the following procedure to tap the water main:

Step 1. Dig to expose the pipe at the point where the tap is to be made. Dig as close to the top of the water main as possible.

Step 2. Clean all dirt and rust off the pipe at that point.

Step 3. Place the gasket of the water-main self-tapping machine on the pipe and set the saddle of the machine on the gasket.

Step 4. Wrap the chain around the pipe, and tighten it to clamp the water main self-tapping machine to the pipe.

Step 5. Remove the cap from the cylinder of the machine, and place the combination drill and tap in the boring bar.

Step 6. Reassemble the machine by putting the boring bar through the cylinder and tightening the cap.

Step 7. Open the flap valve between compartments.

Step 8. Start drilling the hole by applying pressure at the feed yoke and turning the ratchet handle until the drill enters the main.

Step 9. When the tap starts threading the hole, back off the feed yoke to prevent stripping the threads.

Step 10. Continue to turn the boring bar until the ratchet handle can no longer be turned without extra force.

Step 11. Remove the tap from the hole by reversing the ratchet. Then, back the boring bar out by turning it counterclockwise.

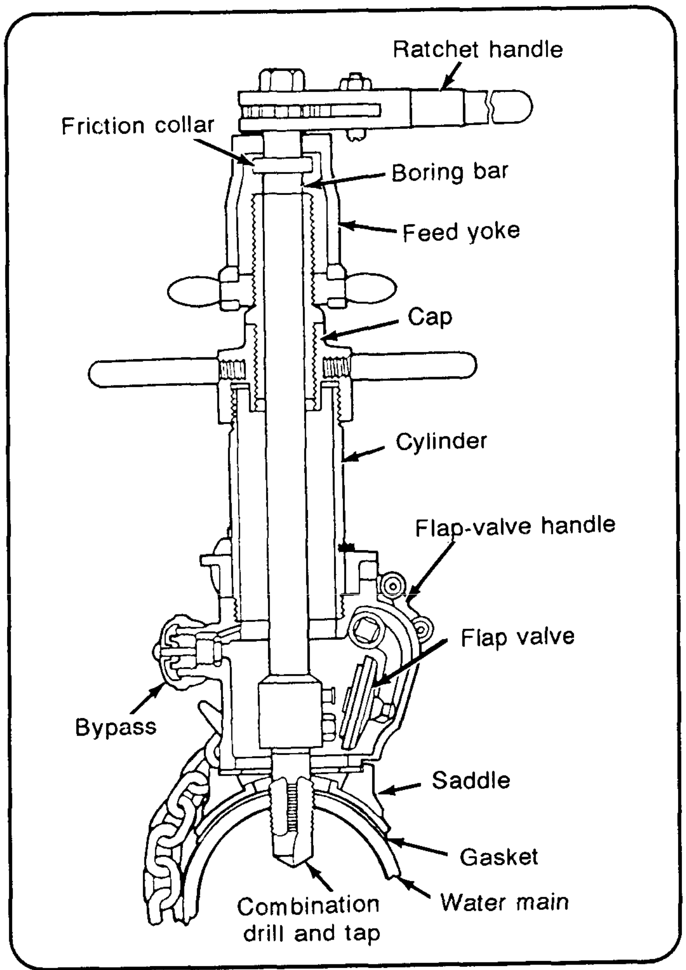


Figure 1-1. Tapping the water main

Step 12. Close the flap valve between the upper and lower compartments.

Step 13. Drain the water from the cylinder through the bypass.

Step 14. Remove the cap and drill tool, and place a corporation stop in the boring bar. The corporation stop should be closed.

Step 15. Repeat steps 6 and 7.

Step 16. Turn the ratchet handle to thread the corporation stop into the pipe.

Step 17. Repeat step 13.

Step 18. Remove the cap from the cylinder, and unbolt the boring bar from the corporation stop.

Step 19. Remove the lower chamber from the pipe.

Step 20. Inspect for leaks.

Step 21. If the corporation stop leaks, tighten it with a suitable wrench.

1-5. Installing Curb and Meter Stops. Curb and meter stops control the water entering the building. Figure 1-2 shows this installation.

a. *Curb Stop.* After tapping the water main and inserting the corporation stop, install the curb stop in a suitable position. It is usually set in a cast-iron stop box to provide easy access in the water service between the curb and the building.

The stop box has a variable telescopic length for use on different grades. When the water service is copper, join the curb stop to the service piping with a compression joint. After you install the curb stop, run the water-service line to the building and through the building wall to the inside of the basement. The water-service line may be laid in the same trench as the sewer; however, it is usually laid on a shelf of undisturbed, solid soil above the sewer line to prevent pollution of the water supply. It must be placed in the ground at a level deeper than the maximum depth of frost penetration.

b. *Meter and Meter Stop.* After running the water-service lines through the side of the building and closing the holes around the service pipe with waterproof cement, install the water meter and meter stop.

- *Meter stop.* The meter stop is a ground joint valve, which controls and shuts off the flow of water into the building. Place the meter stop as close to the service pipe entry as possible.
- *Water meter.* The water meter, installed near the meter stop, measures the amount of water used in the building.

Often the meter and stop are placed in a meter vault that replaces the stop box at the curb. In this case, you should place a stop-and-waste valve in the line where the water service enters the building.

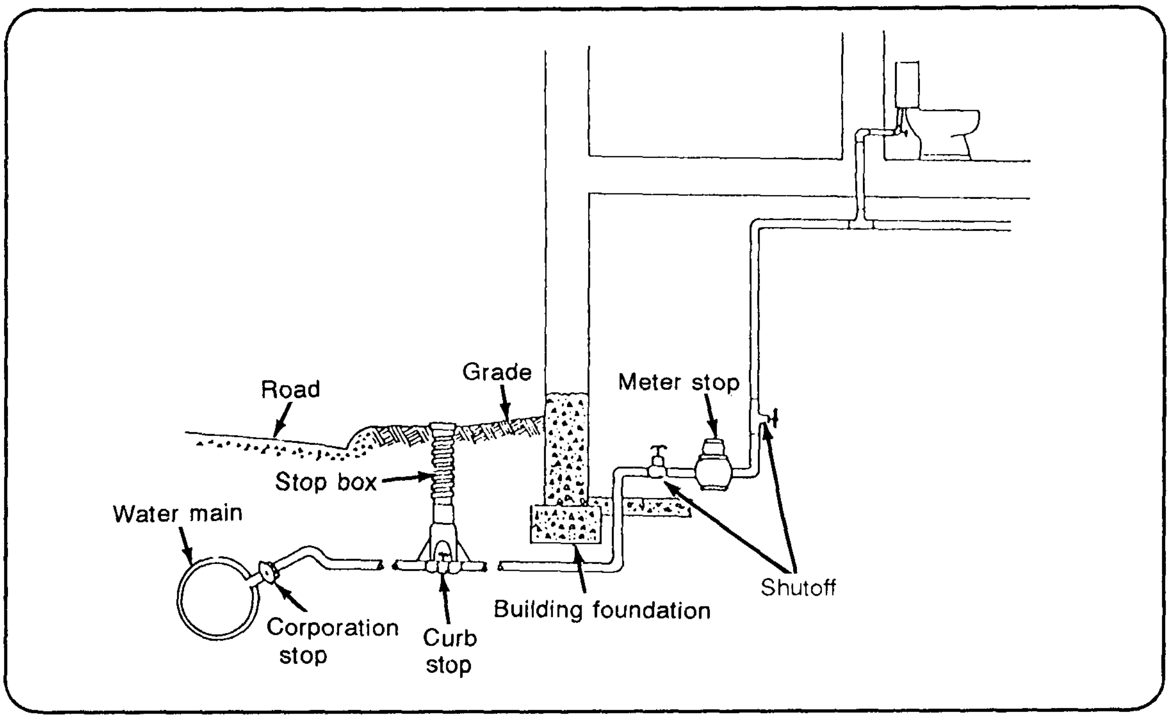


Figure 1-2. Curb and meter stops

1-6. Hot-Water Supply System. The hot-water system consists of a water heater and a piping system that runs parallel to the cold-water pipes to the plumbing fixtures (faucets) where hot waler is desired. A standard detail drawing will show the water heater and standard storage-tank connections. The water heater is fueled by gas, oil, electricity, or try the sun.

a. *Water Heaters.* Water heaters are classified into four categories: range boilers, gas, oil-burning, and electric. See Chapter 5 for water heaters.

b. *Pipe Selection.* The pipes used in hot-water systems are similar to those used in cold-water supply systems. Old hot-water systems used wrought-iron or steel pipe. Newer systems use chlorinated polyvinyl chloride (CPVC) plastic pipe, since CPVC resists corrosion.

c. *Pipe Size.* To size the hot-water main supply lines and the risers, follow the same procedure as for cold-water systems.

d. *Installation.* Installation begins with a water-heating device and the main supply line from that device. Grade the hot-water supply to a centrally located drip cock near the water heater. Water for the fixtures at various levels throughout the building is taken from the main hot-water supply by fixture supply risers. Each of the risers should have a valve.

(1) *One-Pipe System.* Buildings with a large floor area or with several floors need the supply of hot water to the fixture as soon as possible after the tap is opened. In a one-pipe system, such as that used for cold-water supply, a lag occurs from the time the hot--water lap is opened until the water travels from the water-heating device to the tap.

(2) *Two-Pipe System.* To overcome this time lag, use a two-pipe circulating water supply system (Figure 1-3). Hot water passes from the water heater through the main fixture supply risers and returns through a line to the water heater. This looped system circulates the hot water at all times. Warm water tends to rise and cold water tends to fall, creating circulation. The water within the loop is kept at a high temperature. When a tap is opened, hot water flows from the hot-water supply riser into the branch and out of the tap. The cold-water filler within the hot-water storage tank (water heater) has a siphon hole near the top of the tank. If reduced pressure occurs at point A, the siphon hole allows air to enter the cold-water filler. This breaks the vacuum and prevents back siphonage of hot water into the cold-water distribution system.

This circulating supply system (Figure 1-3) is an overhead-feed and gravity-return system and is likely to become air-locked. An air lock prevents circulation of the hot water.

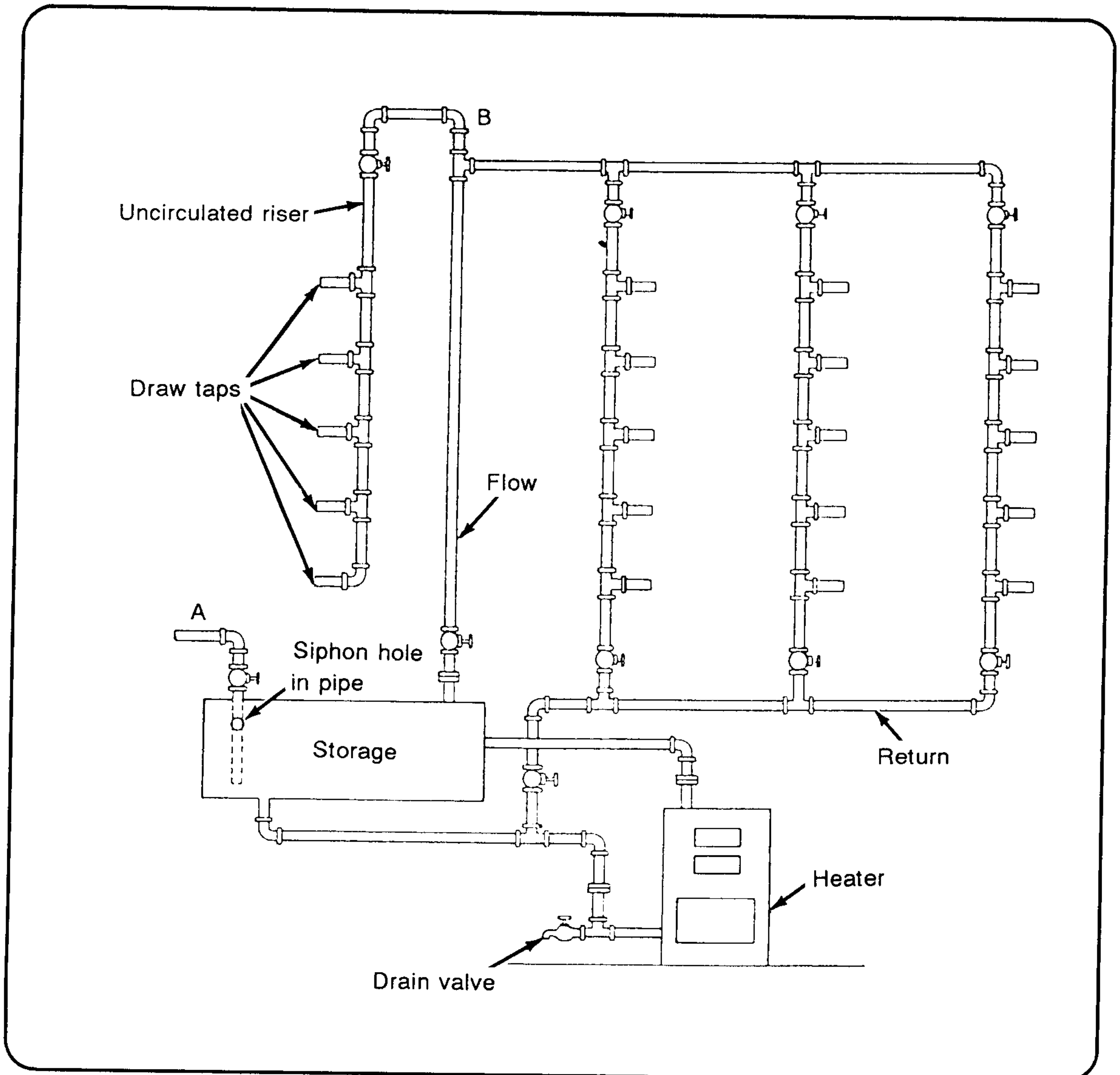


Figure 1-3. Circulating hot-water system (two-pipe)

Since air collects at the highest point (B of the distribution piping), the most practical way to relieve the air lock is to connect an uncirculated riser to the line at that point. The air lock is relieved when a fixture on the uncirculated riser is used.

c. *Maintenance and Repair.* Maintenance and repair of hot-water systems is similar to that of cold-water supply systems. Refer to paragraph 1-3f (page 1-6).

1-7. Fire-Protection Water Systems.

a. *Fire Hydrants.* Fire protection for buildings of fire-resistant construction is provided by fire hydrants. These are usually located at least 50 feet from each building or from the water distribution system within the building.

b. *Automatic Sprinkler Systems.* Automatic sprinkler systems are uscd for fire-resistant structures only when the value. the importance of the contents or activity, or the possibility of a fire hazard justifies a sprinkler system. Buildings of frame and ordinary construction that are more than two stories high and house troops will be protected by automatic sprinkler systems.

Section II. Theater of Operations Water Supply and Distribution System

In a theater of operations, there is always a chance t e Amy may have to take over the repair and operation of a municipal water system. Although most systems will be similar to those used in the United States, problems can be expected in obtaining replacement parts and operating supplies. Sizes and dimensions of basic components can be expected to differ from those in the United States and even require the use of metric tools. Also, certain nations may use differemt disinfecting methods than chlorine. Under these circumstances, the Army should consider hiring former local employees who are familiar with the equipment to operate and maintain the system.

1-8. Water Distribution Methods. After water is purified, it is released into the distribution system. The distribution of large quantities of water under tactical conditions will be by pipelines, trucks carrying bladders. and 5,000-gallon (18,900-liter) tanker trucks. Small quantities can be picked up from tank farms or storage and distribution points in 400-gallon (1,510-liter) water trailers or in refillable drums, 5-gallon (19-liter) cans, and in individual containers.

1-9. Plans and Installation. Figure A-1 (page A-3) shows a distribution system plan for a hospital area. The general location and size of the pipes are shown, together with the valves, sumps, water tank, and other fixtures. Generally, the symbols used on distribution system plans are the same as those for water plumbing. (See Appendix A (page A-10) for standard plumbing symbols.) The plumber who installs the system determines the location of pipes and other equipment to suit the climate and terrain, and according to National Plumbing Codes.

1-10. Design Procedures. See Appendix D for water distribution system design procedures used in the theater of operations.

Section III. Sewerage System

A sewerage system consists of the pipes and apparatus that carry sewage from buildings to the point of discharge or disposal. The system includes sewer pipe and conduits, manholes, flush tanks, and sometimes storm drain inlets. If it is not served by a processing plant, the system may include facilities for pumping, treating, and disposing of sewage.

1-11. Plans. Figure 1-4 shows a typical sewerage system and drain systems.

1-12. Sanitary Sewer and Drains.

a. *Building Drain.* The building drain receives the discharge of sanitary and domestic wastes (or soil and waste) from within the building.

b. *House Drain.* The house drain is located between and is connected to the building drain and the house sewer. The house drain, also called the *collection line,* receives the discharge of sanitary and domestic wastes from the building drain and carries it to the house sewer, as shown in Figure 1-4. The house drain may be underground or suspended from the basement ceiling.

c. *House Sewer.* The house sewer begins just outside the building foundation wall and ends at the main sewer in the street or at a septic tank (Figure 1-4). A house sewer carries liquid or waterborne wastes from the house drain to the main sewer lines. Sanitary sewers are not connected to the storm sewers, because the sanitary discharge must be treated before it is dumped into a stream or lake.

1-13. Storm Sewer and Drain. A storm sewer carries rain water and subsurface water. Since the discharge sewer is runoff water, treatment is not needed. The storm drain receives storm water, clear rain, or surface-water waste only (Figure 1-4).

1-14. Combination Drain. The combination system (Figure 1-4) receives the discharge of both the sanitary waste and the storm water from roofs and other exterior sources.

1-15. Industrial Drain. The industrial drain receives liquid waste from industrial operations. However, this type of drain is of little importance in theater of operations construction.

1-16. Pipes and Fittings. The pipes and fittings for sewer systems are standard to National Plumbing Codes and general usage.

a. *Pipe Selection.* Cast-iron soil pipe or plastic pipe is usually used for house sewers and drains. Bituminous-fiber pipe, when not prohibited, may be substituted for cast-iron pipe for the house sewer. Concrete or vitrified-clay pipe is found in older installations.

(1) *Vitrified-Clay or Concrete Sewer Pipe.* These pipes are connected with resilient joints, using a rubber sleeve and / or rigid joints by compressing rubber or neoprene rings. Vitrified-clay tile is highly resistant to all sewerage and industrial wastes. Concrete pipe may be manufactured with steel reinforcing; it comes in diameters of 12 inches to 108 inches.

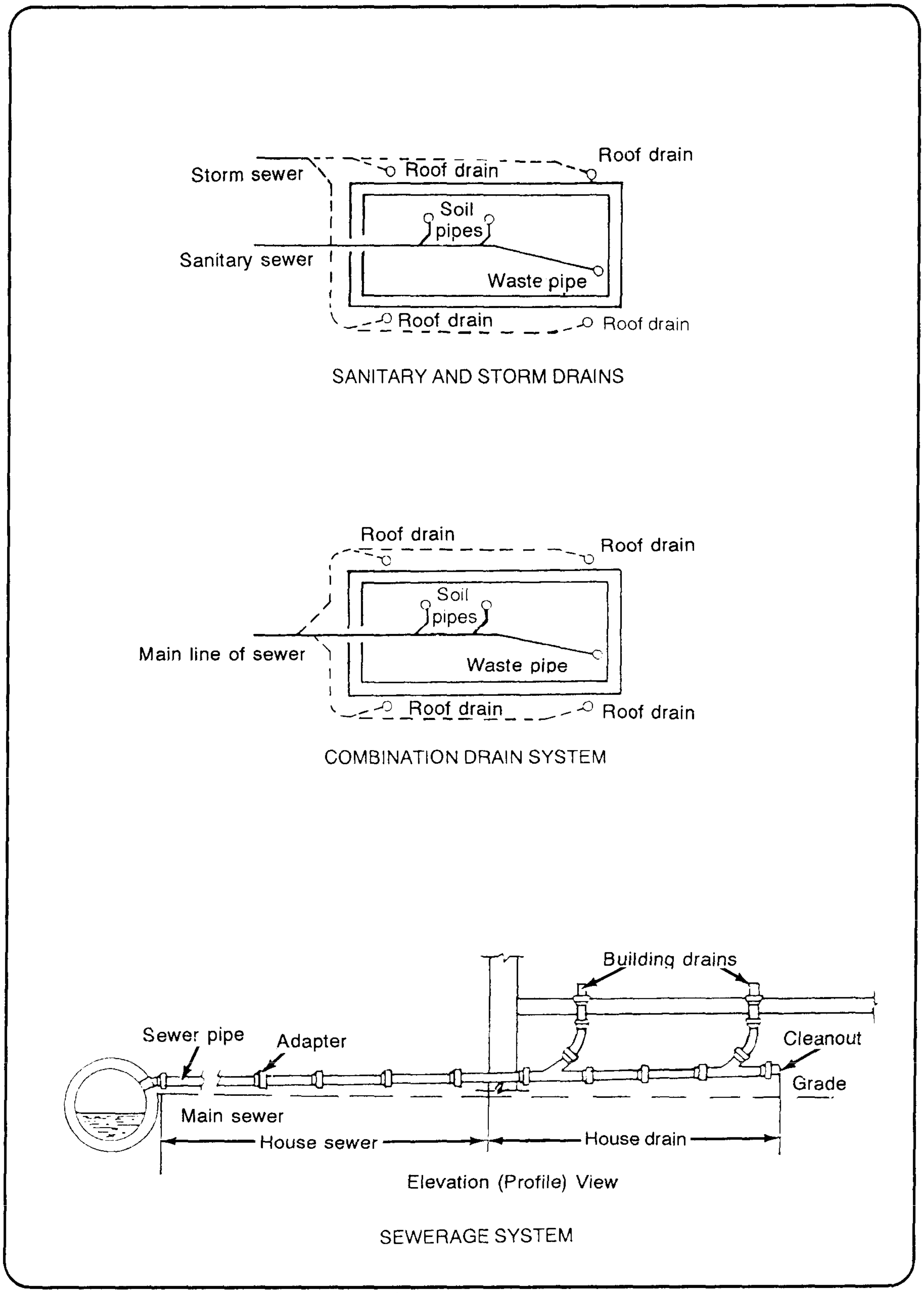


Figure 1-4. Sewer and drain systems

(2) *Cast-Iron Soil Pipe.* Cast-iron soil pipe is classified as follows:

- *Hub-(or Bell-) and-spigot.* Hub-and-spigot pipe comes in 5- and 10-foot lengths (in various diameters). It is connected with lead joints and / or mechanical compression joints.
- *Hubless.* Hubless pipe comes in 10-foot lengths (in various diameters). It is connected with a stainless steel band over a neoprene sleeve.

(3) *Plastic Pipe.* Acrylonitrile-Butadiene-Styrene (ABS) is grey or black plastic pipe used for storm or sanitary drainage, above and below ground. It is connected with solvent-cement joints. This pipe comes in 10- and 20-foot lengths in various diameters.

(4) *Cast-in-Place Concrete Conduit (Tube or Pipe).* This conduit is used when a pipe larger than 60 inches is needed to increase the capacity in a main, a trunk, or an outfall sewer. The drains arc arches or culverts reinforced concrete.

b. *Pipe Size.* Sewerage systems are usually constructed of pipe ranging in diameter from 4 to 36 inches. Both the house sewer and thc house drain must be leakproof and large enough to carry off the discharge of all plumbing fixtures. If either the sewer or the drain is too small, fixtures may overflow. The house sewer and house drain are usually the same size. Waste matter is forced through the house drain pipe by water. Therefore, the pipe must be large enough to carry out all water and waste discharged through it; but it must be small enough for the water to move rapidly, forcing the waste through to the sewer. A pipe sized to flow half full under normal use will have good scouring action, and it can carry peak loads when required.

(1) *Drainage Fixture Units.* The discharge of a plumbing fixture is figured in drainage fixture units (DFU). One DFU represents approximately 7.5 gallons of water (1 cubic foot) discharged per minute. The DFUs for standard fixtures are shown in Table 1-5.

(2) *Pipe Capacity.* Table 1-6 lists the capacity (in DFUs) of various pipe sizes for horizontal drains. This table is for cast-iron soil pipe, galvanized-steel / iron pipe, or plastic house drains, house sewers, and soil and waste branches. When using copper tubing (drain, waste, and vent (DWV) type) for above ground only, it may be one size smaller than shown on the table.

Table 1-5. Drainage fixture unit values

Fixture	Unit Value (DFUs)
Lavatory or washbasin	1
Floor drain	1
Kitchen sink	2
Bathtub	2
Laundry tub	2
Shower	2
Slop sink	3
Urinal	5
Water closet	6

To find the correct size of the pipe, plan the slope of the pipeline by counting the total number of DFUs emptying into a horizontal drain line.

c. *Pipe Support.* A base of solid, undisturbed earth provides enough support for house sewer and drain piping. This prevents future settling, which might cause the weight of the pipe sections to press too heavily on the joints. If the soil is loose, each joint should be supported on concrete, cinder block, or brick.

Table 1-6. Horizontal sanitary drain capacity (in DFUs)

Size of Pipe (in inches)	Slope (inches per foot)		
	1/8	1/4	1/2
1 1/4	1	1	1
1 1/2	2	2	3
2	5	6*	8*
3	15**	18**	21**
4	84	96	114
5	162	216	264
6	300	450	600
8	990	1,392	2,220
10	1,800	2,520	3,900
12	3,084	4,320	6,912

*No water closet will discharge into a pipe smaller than 3 inches (includes DWV-type copper tubing).
**No more than two water closets will discharge into any 3-inch, horizontal-branch house drain or house sewer.

EXAMPLE

For example, assume that a plumbing installation consists of two water closets, four lavatories, two shower heads, three urinals, one slop sink, one laundry tub, and one floor drain. Determine the discharge in DFUs from Table 1-5. Assume that the cast-iron house drain will have a slope 1/4 inch per foot.

Step 1. Multiply the number of each fixture by its DFU value from Table 1-5, for a total of 41 DFUs.

Step 2. Read down the l/4-inch column in Table 1-6. The fixture unit capacity next higher than 41 is 96.

Step 3. Read horizontally across to the left to 4 inches.

Result: The minimum pipe size required is 4 inches.

1-17. House Sewer.

a. *Installation.* Usually the first step in installing the house sewer is to connect the sewer thimble and then work back, grading up to the house drain. The hole cut in the sewer must be no larger than necessary to fit the sewer thimble. All joints must be supported. The thimble should be tapped in above the normal flow level. For example, if the street sewer is 24 inches in diameter and the normal flow is 50 percent, the tap should be at least 12 inches above the bottom of the pipe. Install the thimble with its discharge parallel to the direction of sewer flow. This prevents backflow during periods of high flow. Use the following installation procedures:

Step 1. Tap gently around the circumference of the main sewer to find the depth of flow for placing the thimble. A dull sound results from tapping below the sewer level, and a ringing sound results from tapping above the sewer level.

Step 2. Use the thimble as a pattern for marking the size of the hole with chalk.

Step 3. Make the cut on this line with a small cold chisel and an 8-ounce ballpeen hammer, as shown in Figure 1-5. Use light blows to prevent damage to the main sewer.

Step 4. Work around the cut until you reach a depth of 1/8 to 3/16 inch.

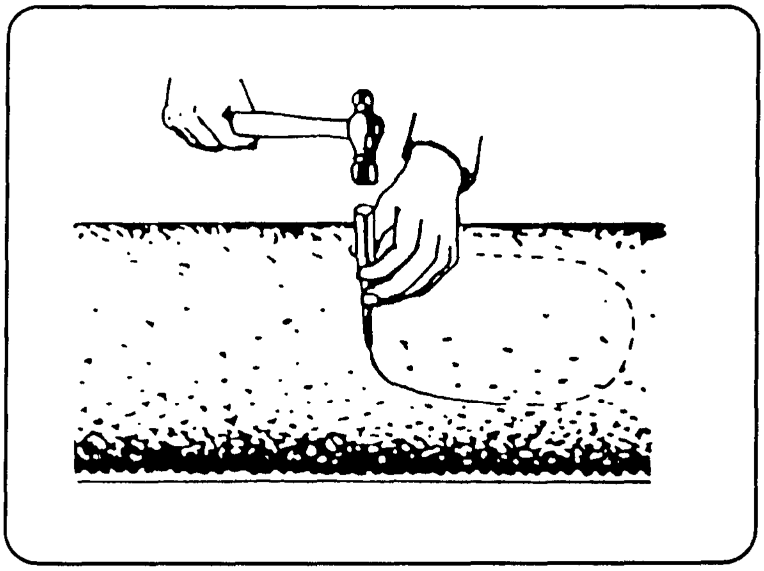


Figure 1-5. Cutting a hole in the main sewer

Step 5. Make a small hole in the center of the area to be removed. Always use light blows.

Step 6. Enlarge the hole into an oval shape as near the size of the sewer thimble as possible. Try the thimble in the opening frequently to see if it will fit without enlarging the hole.

Step 7. Place the thimble in the proper position and pack oakum around the edges of the flange.

Step 8. Complete the installation by packing a rich portland cement mortar (one part sand to one part cement) around the thimble. Use sufficient mortar under the thimble, on the bottom of the tap, and on the top and sides. Support the joint until the mortar sets.

NOTE: *The system must be tested after it is completed.*

b. *Grading.* When possible, house sewers should be graded to a slope of 1/4 inch per foot. Greater or lesser slope is permitted when necessary. Trenches for house sewers may be graded with surveying instruments or with a carpenter's level having a rising leg or a board under one end. For example, a l/4-inch-per-foot slope would be 1/2 inch for 2 feet using a 2-foot carpenter's level with a l/2-inch board under one end. If the pipe is sloped correctly, the level will read level anywhere on the pipe except the hub. The drain is graded toward the main sewer with the hub end of the pipe lying upgrade. A similar procedure uses an 8-foot board and a 4-foot level.

DANGER

All underground plumbing must be laid at least 12 inches from any underground electrical cable. Failure to do so could result in physical injury, death, and/or destruction of equipment.

1-18. Manholes. Manholes are entranceways to the sewer system (for cleaning, inspection, and repair). They are round and are constructed of cement with brick-and-mortar walls on a concrete slab. A removable heavy lid in a cast-iron ring closes the top. Figure 1-6 (page 1-18) is a section drawing of a round manhole. The base slab slopes from 10 to 9 inches. The lid is 2 1/3 feet in diameter by 3 1/4 inches thick. There are three shelves around the pipes in an opening measuring 3 feet 6 inches in diameter. (Precast concrete manholes are available, but the military plumber rarely installs this type.)

1-19. Sewage Disposal.

a. *Grease Traps.* Grease traps are placed in the flow line of the building sewer to catch grease and fats from kitchen and scullery sinks. (Solid grease usually clogs the waste pipes.) The box-type traps are made of brick, concrete, or metal, in various shapes and sizes. The grease trap should be set in the waste line as close as possible to the fixture. Figure 1-7 (page 1 -19) shows baffle walls, which control the flow. Baffle walls are placed in boxes to separate floating grease particles.

b. *Septic Tanks.* The septic tank (Figure 1-8, page 1 -20) speeds up decay of raw sewage. It may be concrete, stone, or brick, in box-section form. (Lumber is used when other materials are not available.) It should be watertight. The siphon chamber makes certain that liquid will flow from the chamber; however, the siphon chamber is not absolutely necessary. The baffle boards are usually 2-inch oak planks, which run entirely across the tank. The boards are suspended from hangers and extend several inches below the surface of the sewage. One board should be located 10 inches from the *inlet* pipe and the other about 4 inches from the *outlet* partition. They should have a manhole and cover to give access for cleaning and repair. Septic tanks must be designed to hold for 24 hours and not less than 16 hours, 70 percent of the peak water demand of that facility.

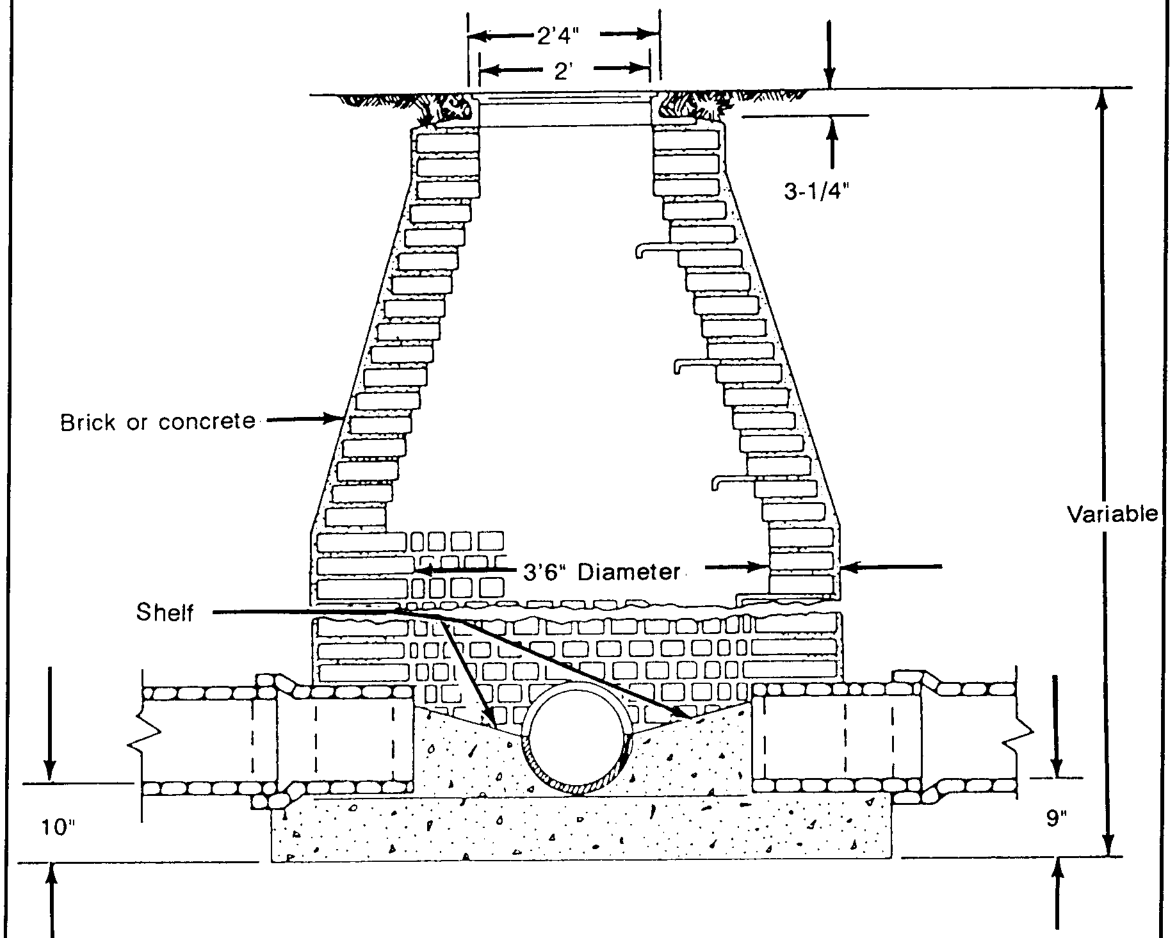


Figure 1-6. Round-manhole construction

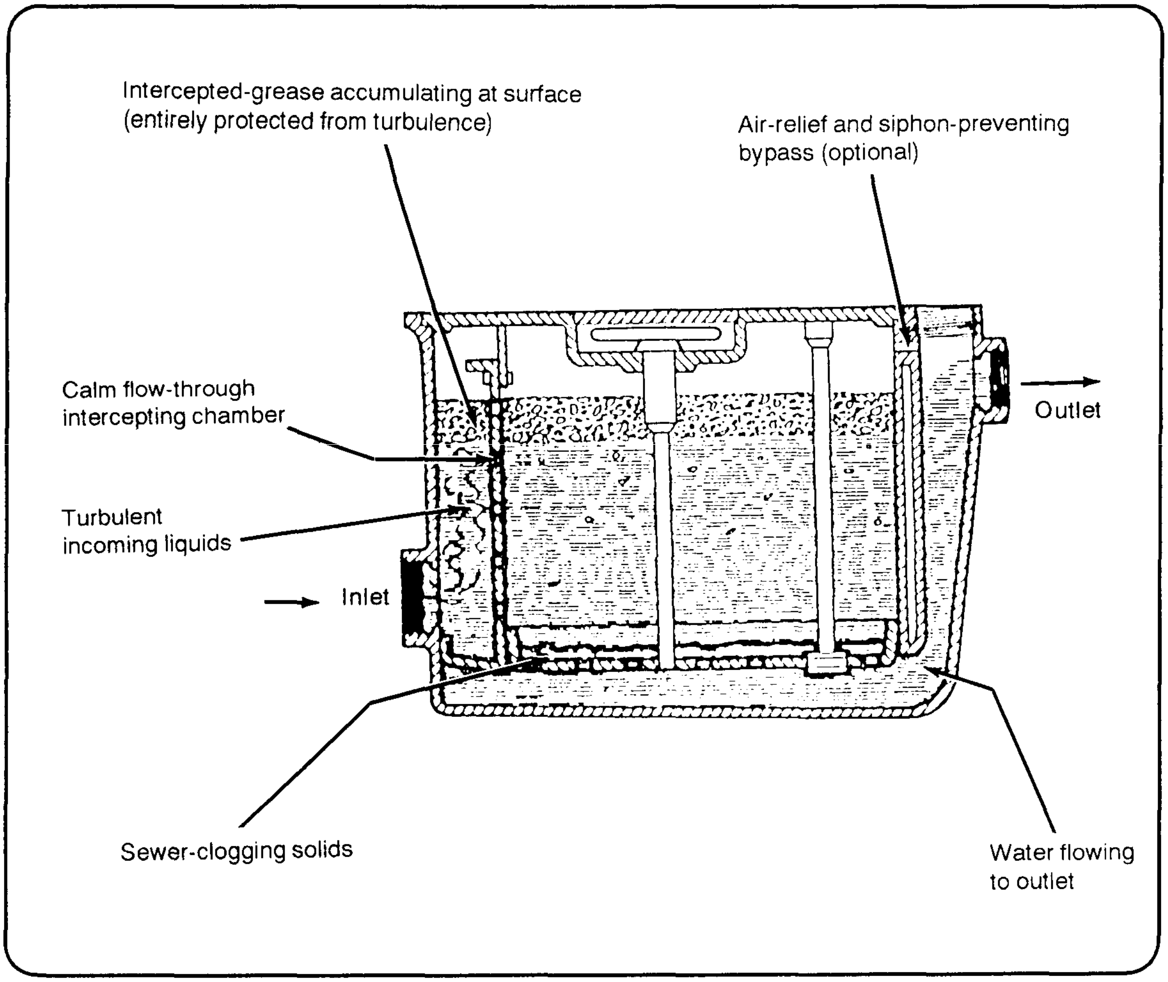
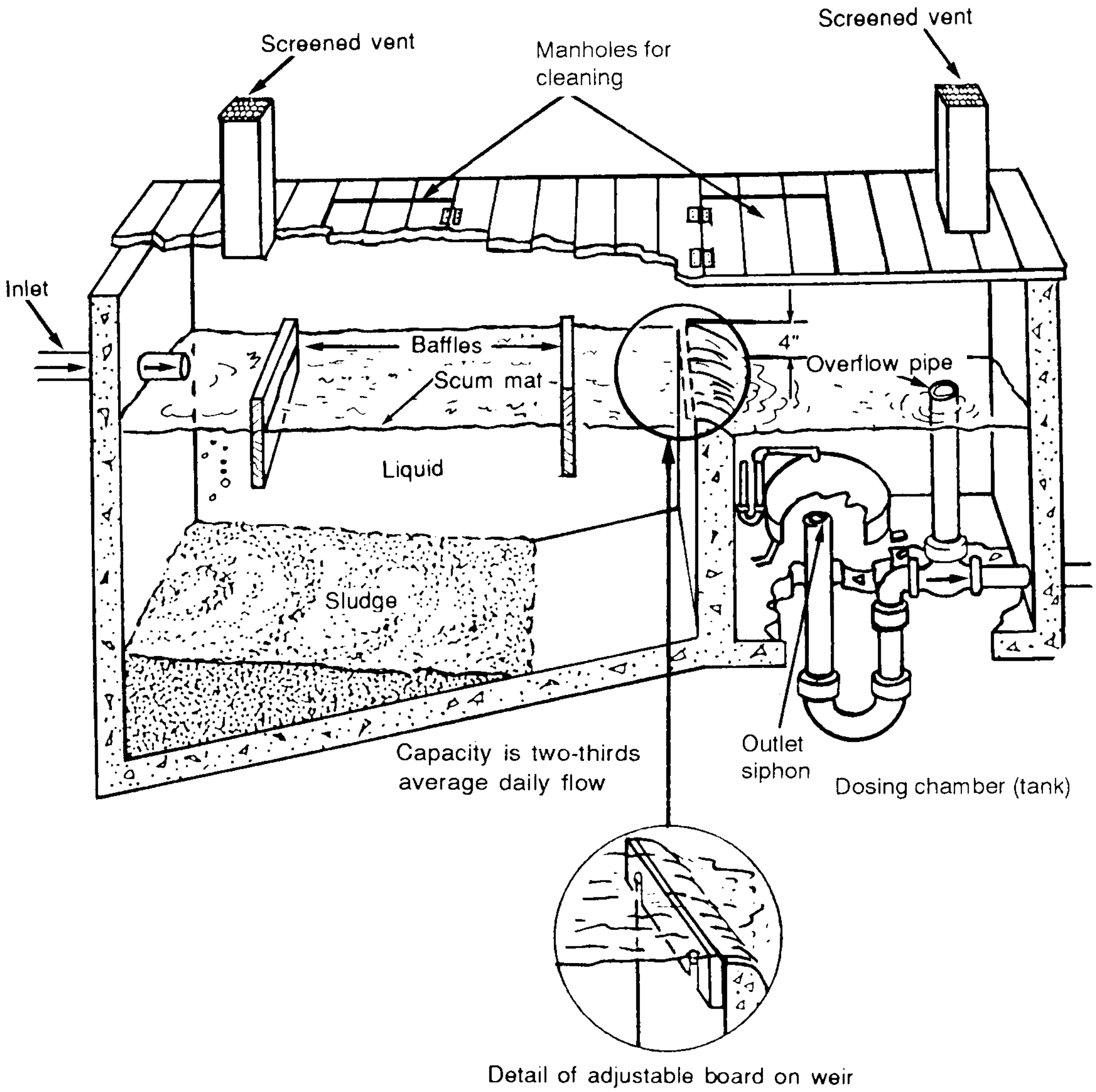


Figure 1-7. Grease trap

Figure 1-9 (page 1-21) shows a small sewerage system, which includes the septic tank. The distribution box, which permits equal flow to all lines of the disposal field, can be either wood, concrete, or brick. The diversion gate is usually wood with a handle slot, so it can be moved to change the sewage flow.

The system shown in Figure 1-9 (page 1-21) uses both a septic tank and a subsurface sand filter to dispose of sewage. A plumber needs both a plan and a profile (elevation) view of the system.

c. *Imhoff Tank.* If a septic tank cannot handle the load, an Imhoff tank may be used. Figure 1-10 (page 1-22) shows typical construction details. When a treatment plant is required, plans for a specific site should be prepared, taking into account soil conditions and features of the land surface. (The Imhoff tank is described in FM 5-163.)



NOTES:

1. *Use the board cover only to retain heat in cold climate or to control fly nuisance.*
2. *When not required for dosing tile drain system, the dosing chamber and siphon are omitted.*

Figure 1-8. Septic tank

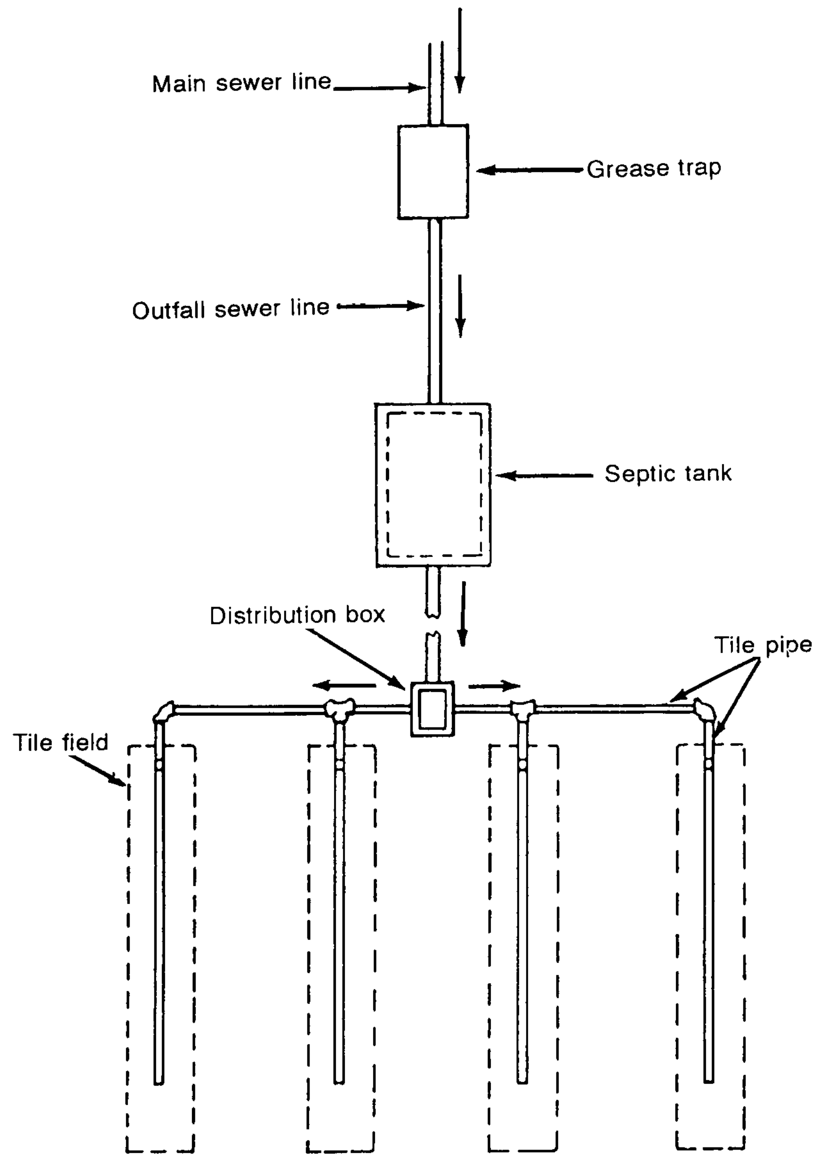


Figure 1-9. Small sewerage system plan

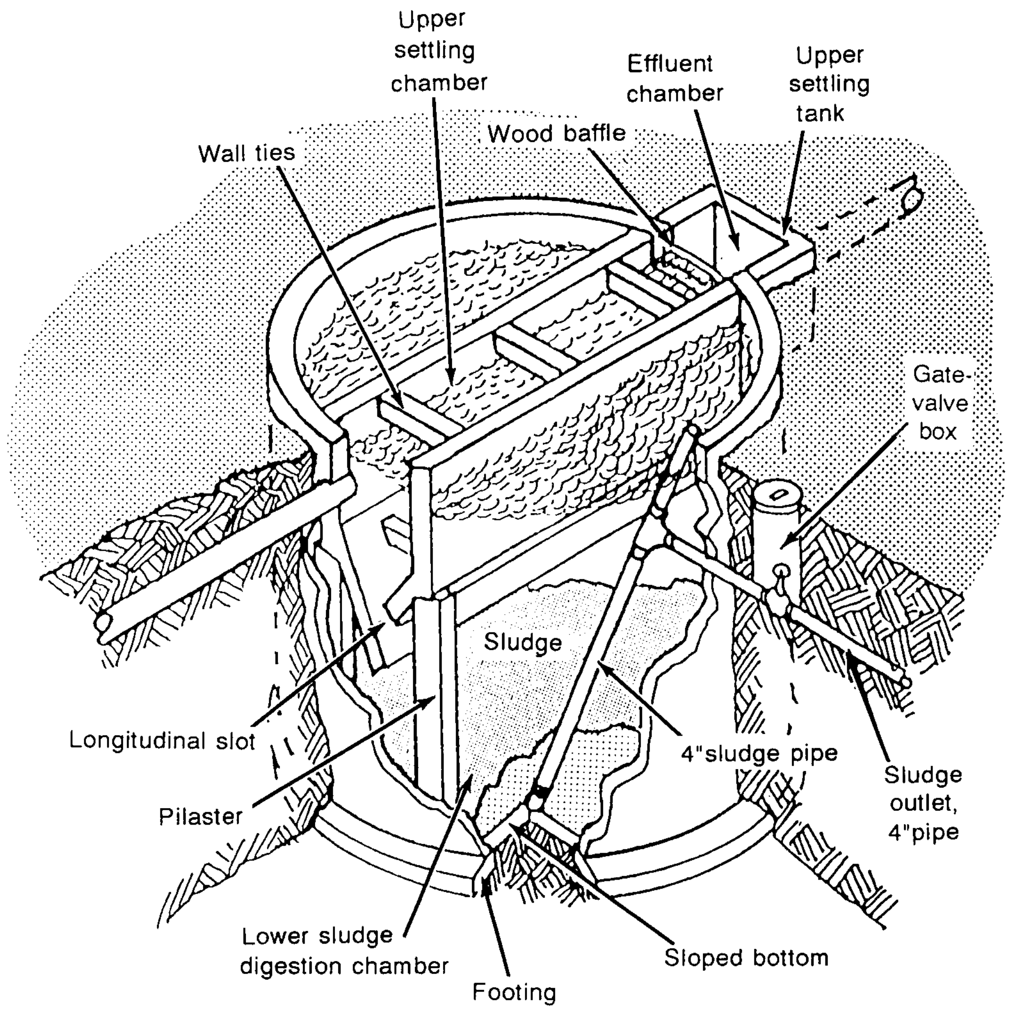


Figure 1-10. Cross sections of an Imhoff tank

1-20. Sewage Disposal Facilities.

a. *Drainage Bed.* The subsurface system is the most common type of drainage bed. A subsurface system is used where space and soil permit or where there is no stream or pond nearby. The following factors must be considered when laying the piping for a drainage bed:

- Lay of the land (topography).
- Depth of the potable water supply.
- Location of surface lakes and streams.
- Type of soil.

EXAMPLE

A subsurface irrigation system must handle 2,000 gallons per day (GPD), and the average time noted in the soil absorption test is 10 minutes. From Table 1-7, this corresponds to 1.7 GPD per square foot (sq ft).

The length of piping in a subsurface drainage bed depends on the type of soil and the volume of liquid to be treated. This is determined by a soil percolation test. Use the procedures in Figure 1-11 (page 1-24). To compute the length of the drainage lines, an average percolation rate is used. Table 1-7 gives soil absorption rates of the drainage lines.

$$\frac{2{,}000\ GPD}{1.7\ GPD/sq\ ft} = 1{,}180\ sq\ ft$$

If trenches are 18 inches wide (1.5 feet)—

$$\frac{1{,}180\ sq\ ft}{1.5\ sq\ ft} = 790\ ft\ of\ trench\ and\ pipe$$

Table 1-7. Soil absorption rates of drainage lines

Absorption (gallons per day)		
Time Required for Water Level to Fall 1 Inch (in minutes)	**Per Square Foot of Trench Bottom in the Field**	**Per Square Foot of Percolating Area in a Leaching Tank**
1	4.0	5.3
2	3.2	4.3
5	2.4	3.2
10	1.7	2.3
30	0.8	1.1
60	0.6	0.8

Soil Percolation Test

Step 1. Dig at least six test holes, 1-foot square, to a depth equal to that of the planned drainage bed.

Step 2. Place a layer of gravel in the bottom of the holes and fill the holes with water.

Step 3. If the soil is tight or has a heavy clay content, the test holes should stand overnight. If the soil is sandy and the water disappears rapidly, no soaking period is needed. Pour water into the holes to a depth of 6 inches above the gravel. The batter board acts as a reference line, and a ruler should be used to record the level of water in the hole below the batter board.

Step 4. Measure the water every 10 minutes over a 30-minute period. The drop in water level during the final 10 minutes is used to find the percolation rate of the soil.

- Soil that takes 30 minutes to absorb 1 inch of water needs 4 feet of drainage for each gallon of liquid.
- If a test hole needs more than 30 minutes to absorb 1 inch of water, the soil is not suitable for a subsurface drainage system.

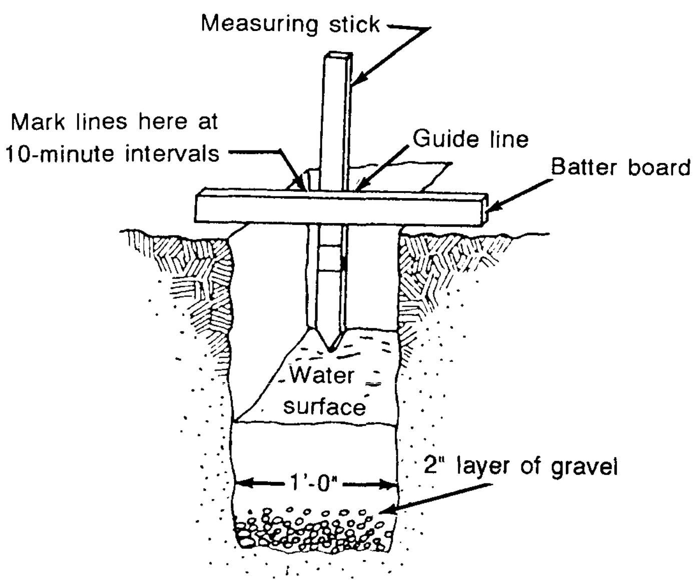


Figure 1-11. Soil percolation test

b. *Leaching Tanks.* Leaching tanks, cesspools, receive raw sewage or septic tank overflow. They can be made of 4- x 4-inch lumber or 5-inch round timber. Dry masonry may be used for wall construction when time and materials permit. Figure 1-12 shows the design for a small leaching tank.

c. *Sand-Filter Fields.* Piping of surface irrigation and subsurface sand-filter disposal systems is installed using plans and profiles. The plans and profiles are based on the area topography and a soil percolation test. The small sewerage system shown in Figure 1-9 (page 1-21) shows a sand-filter field. (Refer to FM 5-163 for a complete description of sand-filter fields.)

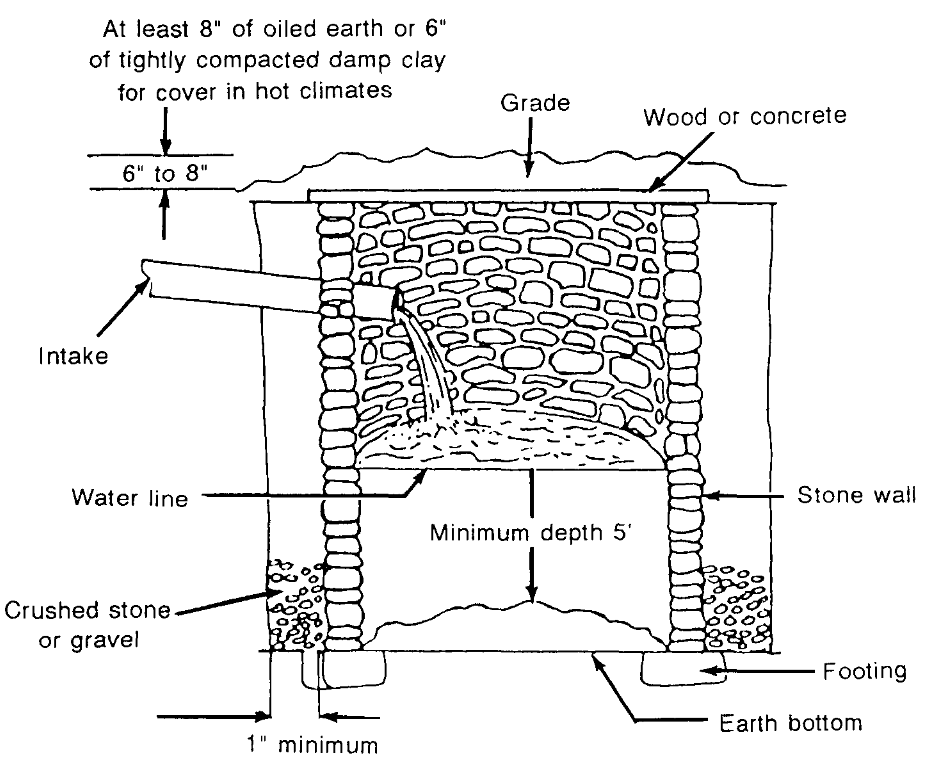


Figure 1-12. Design for a leaching tank

CHAPTER 2
HEATING SYSTEMS

A heating system carries heat from the point of production to the place of use. Heating system designs are complex with many variations. They are classified by the medium used to carry the heat from the source to the point of use. Steam, hot-water, and forced-air systems are the most common. Hot-water heating is used extensively. Forced-air heating is used in most semipermanent constructions and in most barracks. Appendix A explains plumbing plans and includes a list of heating symbols used on heating system plans.

2-1. Hot-Water Heating Systems. A hot-water heating system is made up of a heating unit, pipes, and radiators or connectors. Water is heated at a central source, circulated through the system, and returned to the heating unit. Usually a pump (rather than a gravity system) is used to keep the water circulating. The two types of hot-water systems are the one-pipe and the two-pipe.

a. *Plans.* A hot-water heating system may have a separate plan or may be combined with the hot- and cold-water and sewer lines on the plumbing plan. A hot-water system plan shows the layout of units, pipes, accessories, and connections. Figure 2-1 shows a typical system. This figure also shows the location of the boiler, circulating pump, and compression tank. A one-pipe system is shown; however, the hot water will flow in two directions (or loops), each loop containing two radiators. The second radiator in each loop is larger than the first. (Appendix A gives heating symbols that are used on architect's plans.)

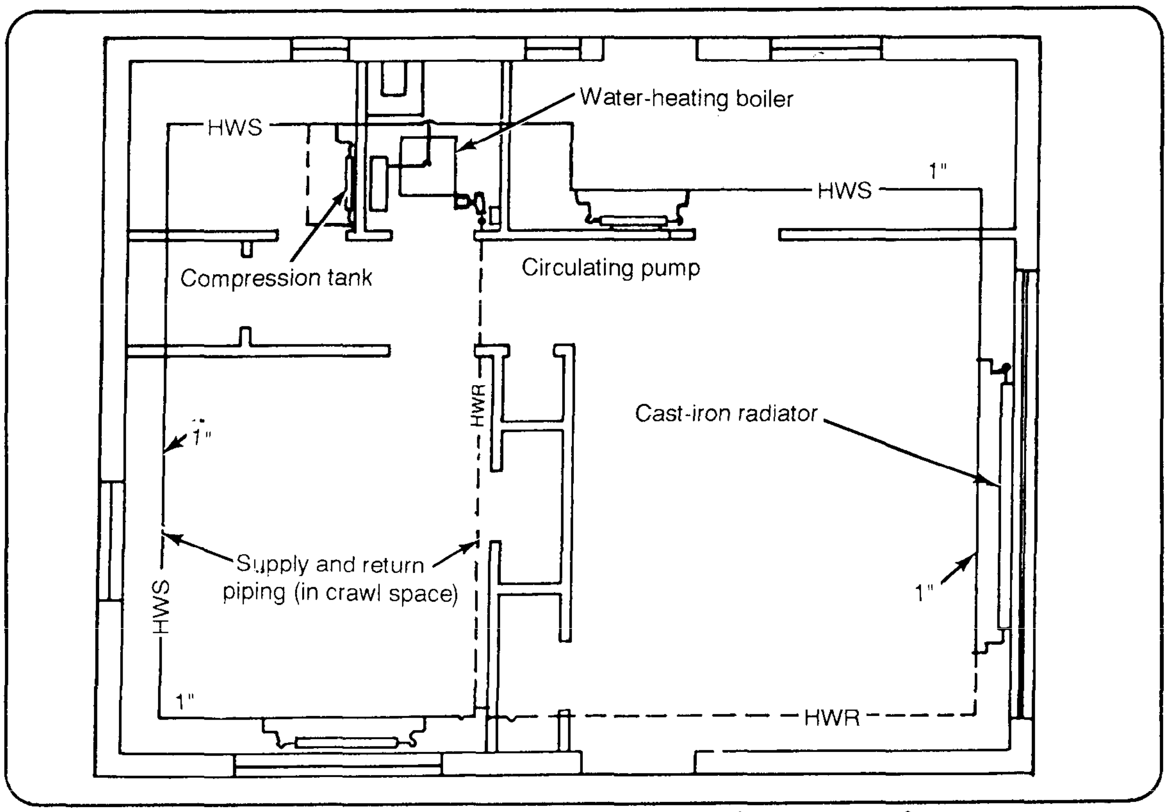


Figure 2-1. Hot-water (one-pipe) heating system plan

b. *One-Pipe System.* A one-pipe system (Figure 2-2) is the simplest type of hot-water system and is adequate for very small installations. Hot water circulates through one set of pipes through each radiator. As a result, the water reaching the last radiator is cooler than the water in the first radiator. To obtain the same amount of heat from all radiators, each radiator must be larger than the one before.

c. *Two-Pipe System.* In a two-pipe system (Figure 2-3), the hot water goes from the heating unit to each radiator by way of the main, connected by Ts and elbows. The cooler water leaving the radiators returns to the heater through separate return piping.

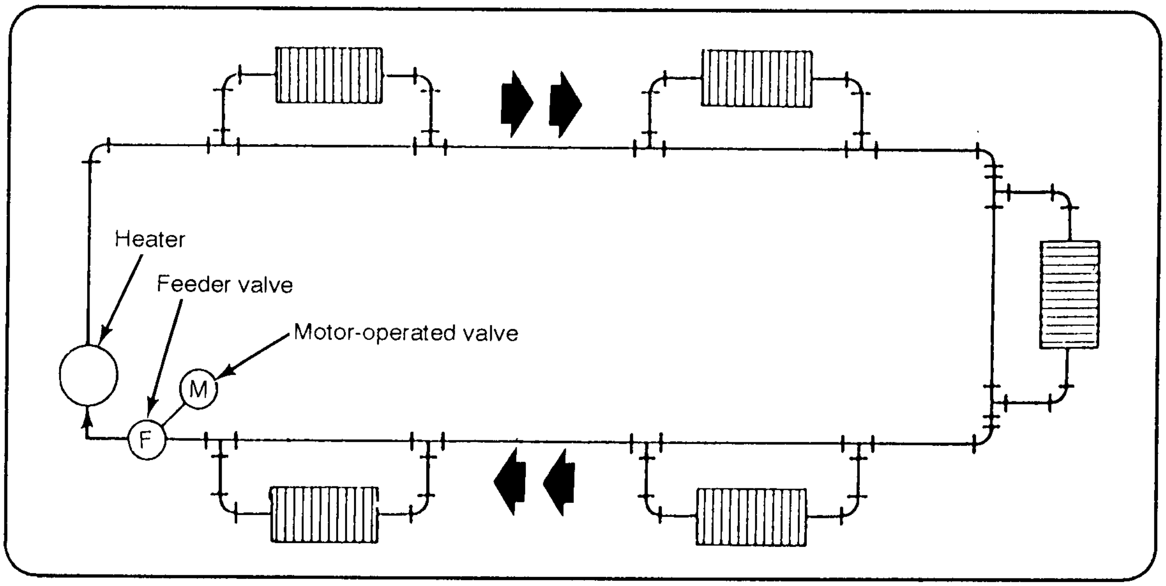


Figure 2-2. One-pipe hot-water heating system

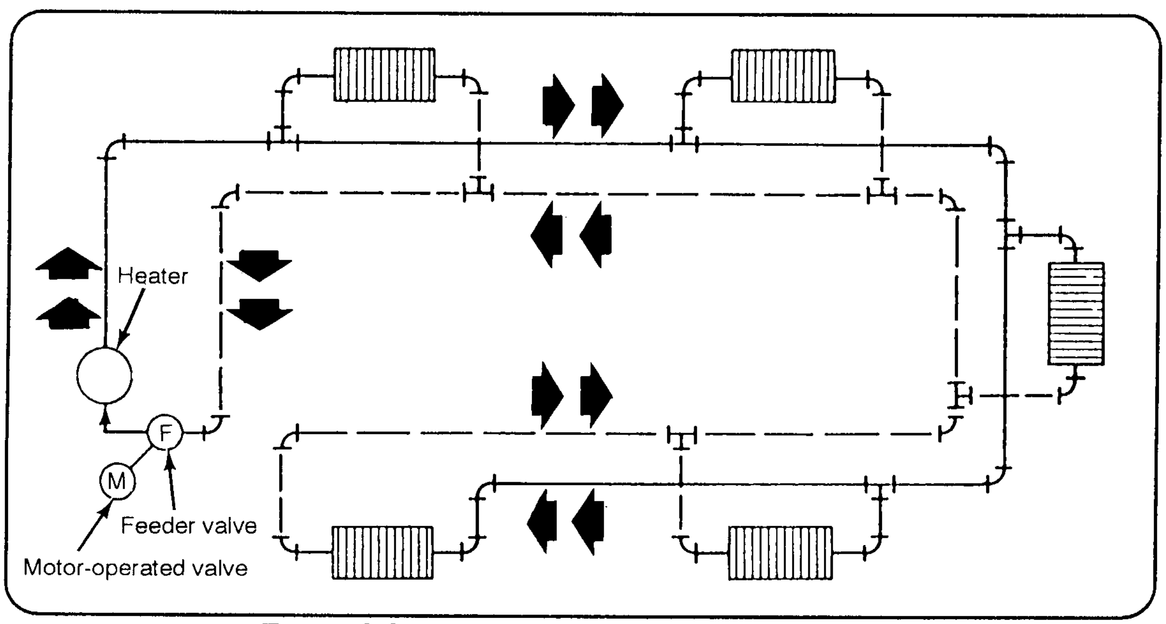


Figure 2-3. Two-pipe hot-water heating system

2-2. Steam Heating Systems. A steam heating system consists of a boiler that heats the water, producing the steam; radiators in which the steam turns hack to water (condenses), giving heat; and connecting pipes that carry the steam from the boiler to the radiators and return the water to the boiler. This system includes either an air valve or other means of removing air from the system. The two types of steam heating systems are the one-pipe and the two-pipe, which are classified as—

- *High-pressure.* A high-pressure system operates above 15 psi gauge.
- *Low-pressure.* A low-pressure system operates from 0 to 15 psi gauge.
- *Vapor.* A vapor system operates under both low-pressure and vacuum conditions.
- *Vacuum.* A vacuum system operates under low pressure and vacuum conditions with a vacuum pump.

a. *One-Pipe System.* The one-pipe system uses a single main and riser to carry steam to radiators or other heating units and to return condensed steam (condensate) to the unit. This system is best for small installations where low cost and easy operation are important. Each radiator or other heating unit is equipped with an air valve, controlled by heat (thermostatic), as shown in Figure 2-4. Larger air valves are installed at the end of steam mains. These valves should be the vacuum-type with a small check valve to keep air from flowing back into the system when heat input is reduced. The connection to the unit may have shutoff (angle) valves. Since the restricted opening causes a repeated banging sound (water hammer), these valves cannot be partly closed for heat input control.

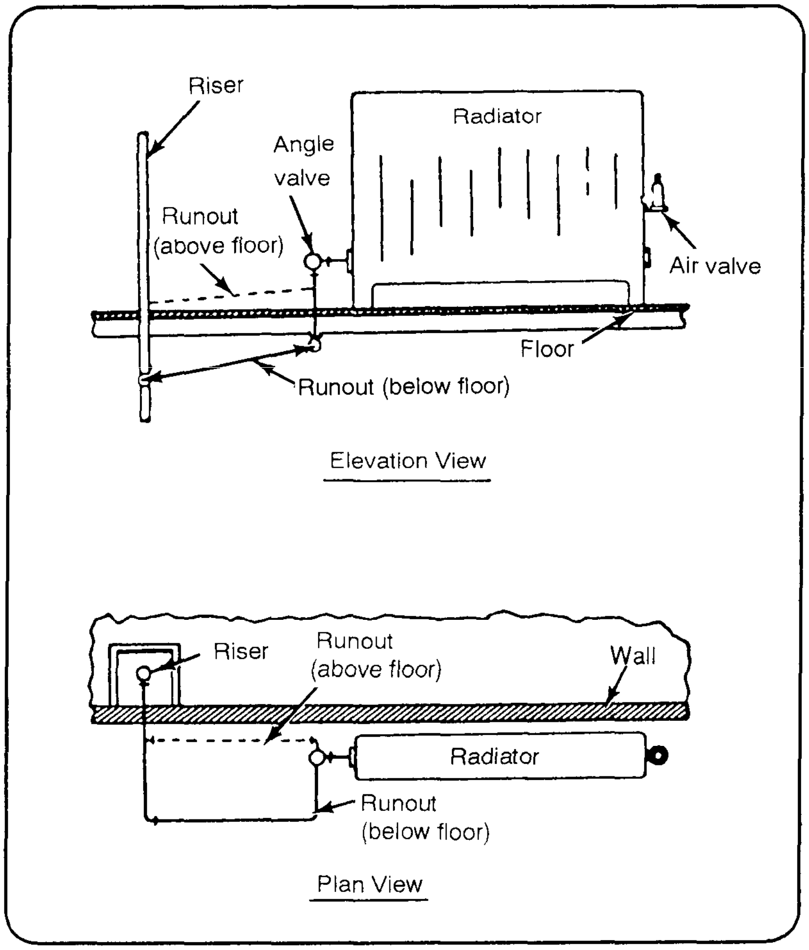


Figure 2-4. Radiator connections for a one-pipe steam system

h. Two-Pipe System. The two-pipe system has two sets of mains and risers: one set distributes steam to the heating unit and the other returns condensate to the boiler. Figure 2-5 shows a two-pipe steam system. This system may operate under high- or low-pressure, vapor, or vacuum conditions, and with either upflow or downflow distribution. This system allows adjustment of steam flow to individual heating units. It uses smaller pipes than the one-pipe system. A lwo-pipe *upflow vapor* system, which can operate over a range of pressures, is shown in Figure 2-6.

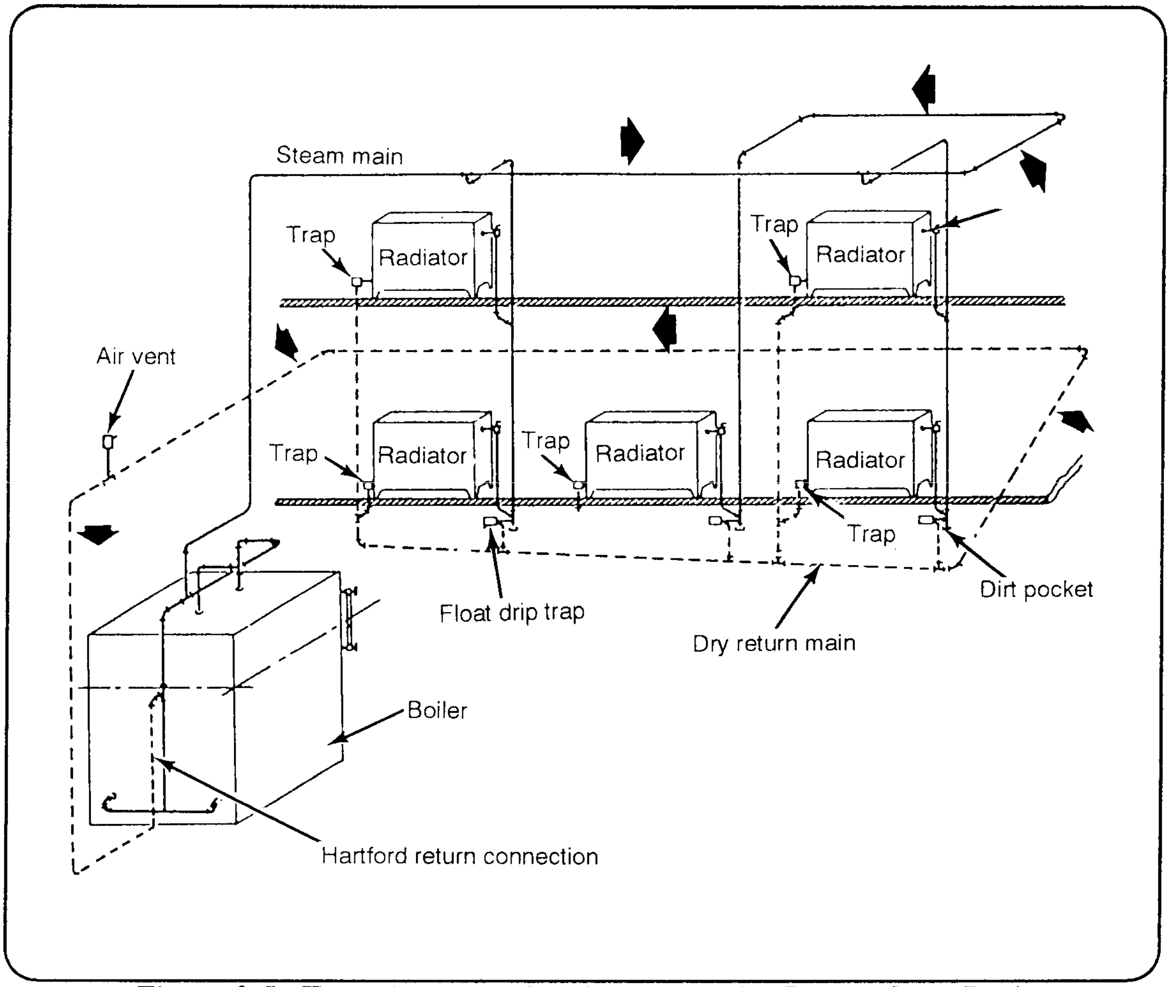
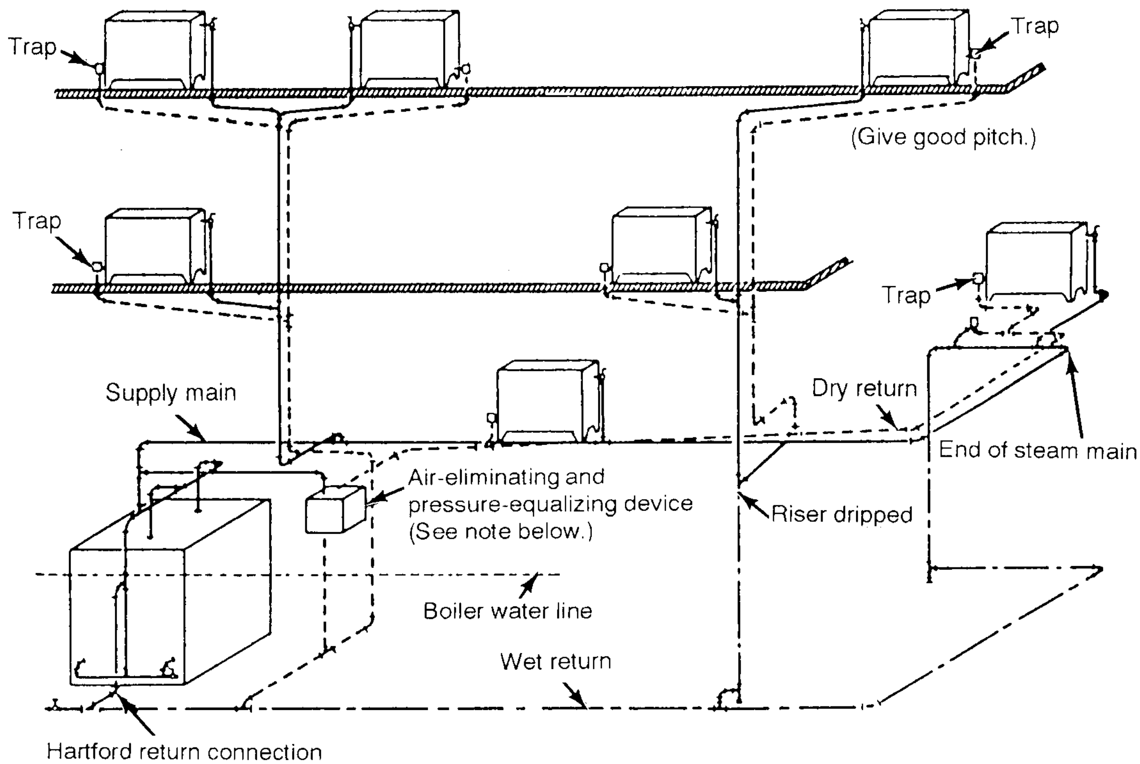


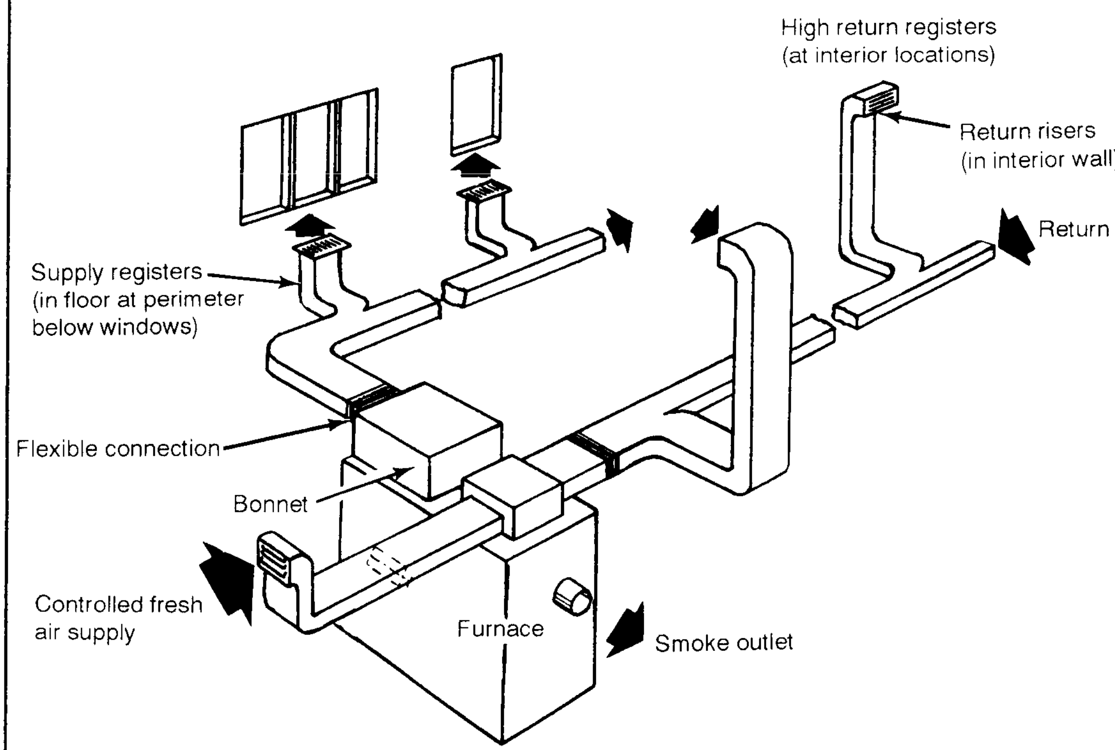
Figure 2-5. Two-pipe steam heating system (upflow or downflow)



NOTE: *Proper piping connections, with special appliances for pressure equalizing and air elimination, are essential. Condensate may be dripped from the end of stream main through the trap into the dry return.*

Figure 2-6. Two-pipe upflow vapor system

2-3. Forced-Air Heating Systems. A forced-air *upflow* heating system (Figure 2-7) distributes heated air through a duct system. The air is usually heated by a gas-fired or oil-fired furnace. This system consists of a furnace, a bonnet, warm-air supply ducts and registers, return cold-air registers and ducts, and a fan or blower forced-air circulation. Figure 2-8 shows a *downflow* furnace with a crawl-space duct system and a crawl-space plenum system.



NOTE: *The furnace and ducts are located in the basement of this basement-and-one-story house. In two-story houses, supply and return registers should be in the same relative positions in each story.*

Figure 2-7. Forced-air upflow system

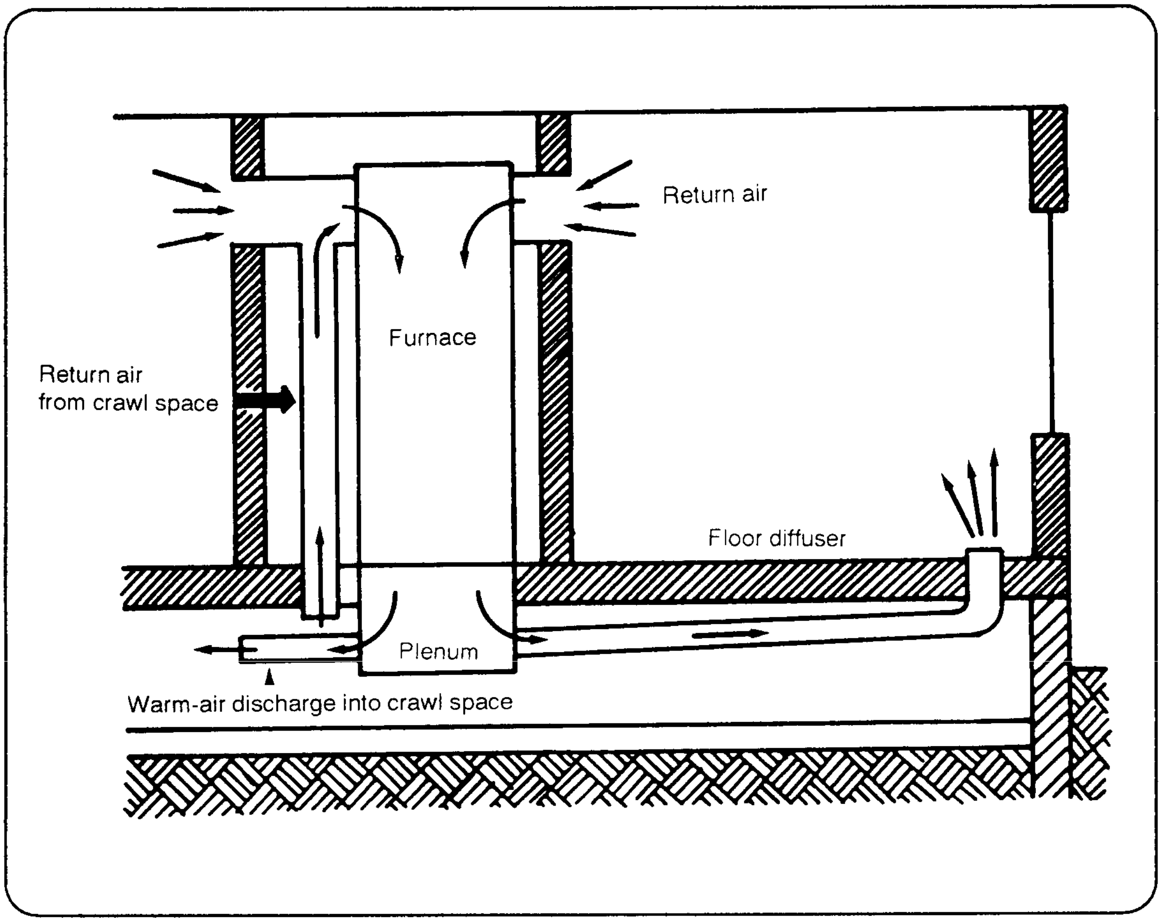


Figure 2-8. Forced-air downflow system

a. *Plans.* In a forced-air heating-system plan (Figure 2-9, page 2-8), warm-air ducts are indicated by solid lines; cold-air return ducts by dashed lines. (Appendix A gives the most common heating symbols used on plans.) All duct sizes give the horizontal or width dimensions first. (Depth, the second dimension, is not shown on a plan drawing.) You can use the plan to determine the location and sizes of warm-air registers needed. When ceiling registers (diffusers) are used, the neck dimensions are given. When wall or baseboard registers are used, face dimensions are given. Look in the notes on a plan for the height of wall registers above the finished floor line. Return (cold-air) registers are shown recessed into the wall. The face dimensions of the return registers are noted adjacent to the register symbol.

b. *Installation and Operation.* The bonnet above the heat plant (furnace) collects the heated air for distribution to various rooms. The warm air is distributed from the bonnet through rectangular-shaped supply ducts and registers (warm-air) into the rooms. The warm-air registers are installed in the ceiling. The air, after circulating through the rooms and losing heat, is returned to the furnace by the return (cold-air) registers and ducts. The return registers are placed in the wall, just below the opening; the return air ducts are installed in the crawl space. The warm-air distribution by branch ducts is the same as the examples shown in Figure 2-9 (page 2-8).

Forced-air systems are laid out so that the warm air from the registers is directed at the cold exterior walls. In some systems, the warm-air registers are located in exterior walls below windows. The registers for cold-air return are normally installed at baseboard height. Cold air moves to the floor where it is collected by the cold-air registers and returned through ducts to the furnace for reheating and recirculation. Furnace location is important for proper forced-air heating. This design (Figure 2-9) equalizes duct lengths by locating the furnace room centrally.

(l) *Comfort Zone Design.* The comfort zone is a horizontal area between the top of the average person's head and knees. Air blowing from the supply is uncomfortable. To avoid this, registers are placed either above or below the comfort zone-high on the wall or in the baseboard.

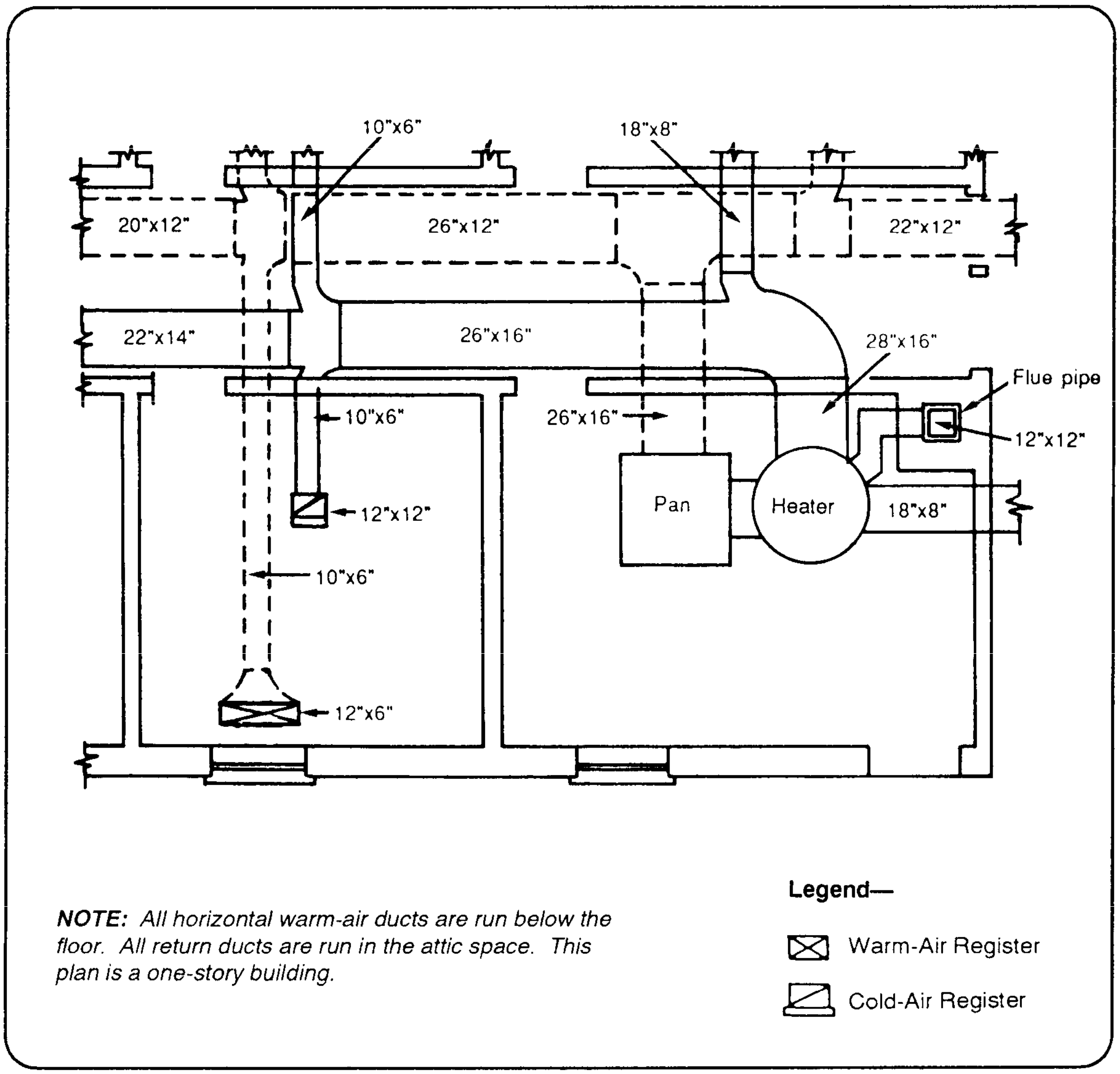


Figure 2-9. Forced-air heating-system plan

(2) *Duct Connections.* The main trunk should run above a central corridor to equalize branch duct lengths to individual rooms. Figure 2-10 shows common rectangular duct connections.

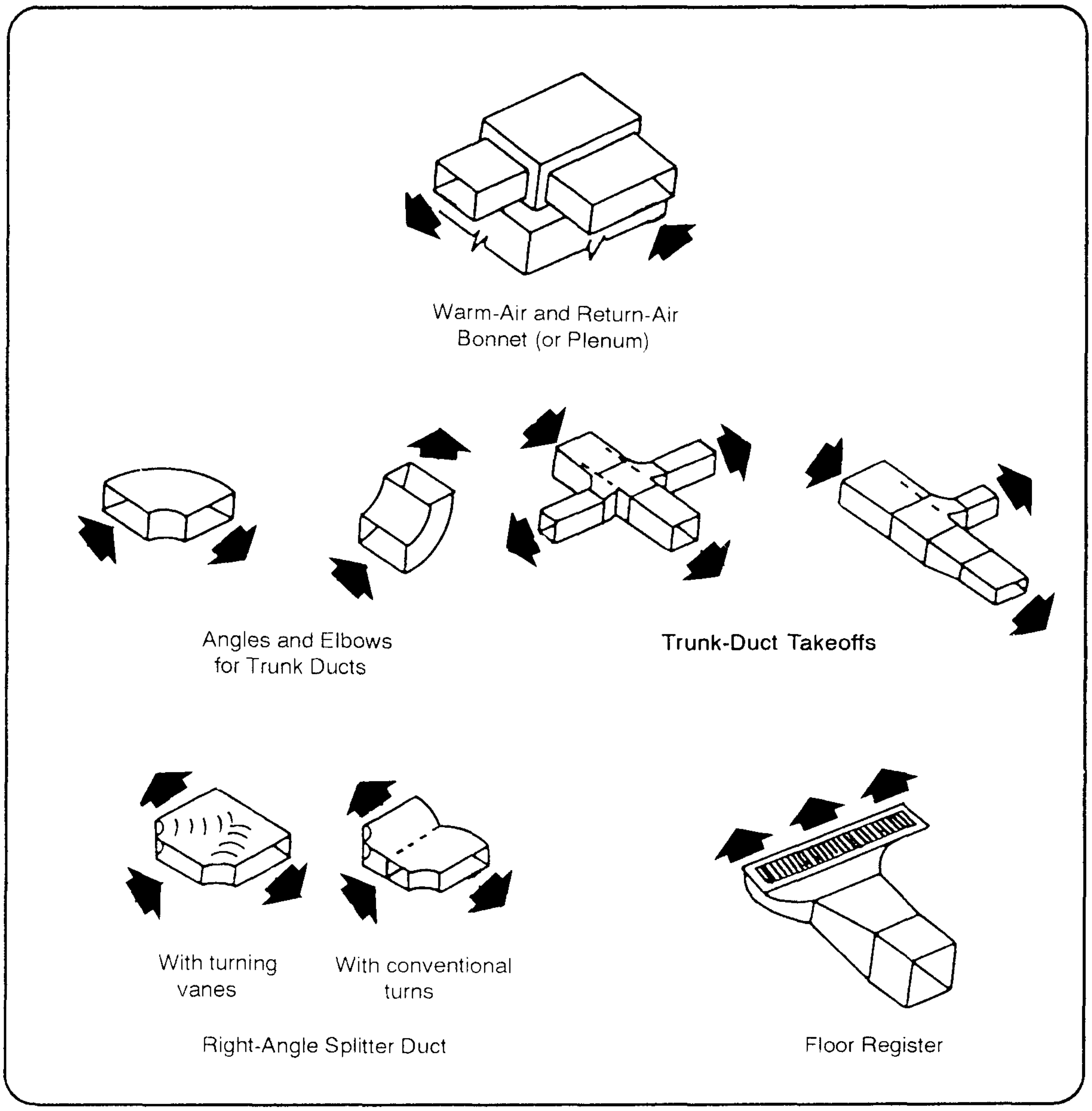


Figure 2-10. Rectangular duct connections

Figure 2-10 also shows a typical warm-air bonnet with two main supply ducts. It shows two possible elbow connections and two duct Ts. The split T is used to direct the flow of air on the warm side of the system. The straight T may be used on the cold-air return. Trunk takeoffs are shown. In the double-branch connection, less air is present in the main duct after some of it has been channeled into branch ducts. The size of the main duct can then be reduced on the far side of the connection point. The single-branch connection shows two methods of reduction. First, reduction in the duct is made at the connection. Secondly, a reduction in duct depth is made on the far side of the connection. In both double- and single-branch takeoffs, the branch connections form a natural air scoop to encourage airflow in the desired direction.

A boot is one method to change the shape of a duct without changing the equivalent cross section area or constricting the flow of air. A boot fitting from branch to stack, with the stack terminating at a warm-air register, is shown in Figure 2-11. Table 2-1 gives the equivalent lengths of gravity duct fittings.

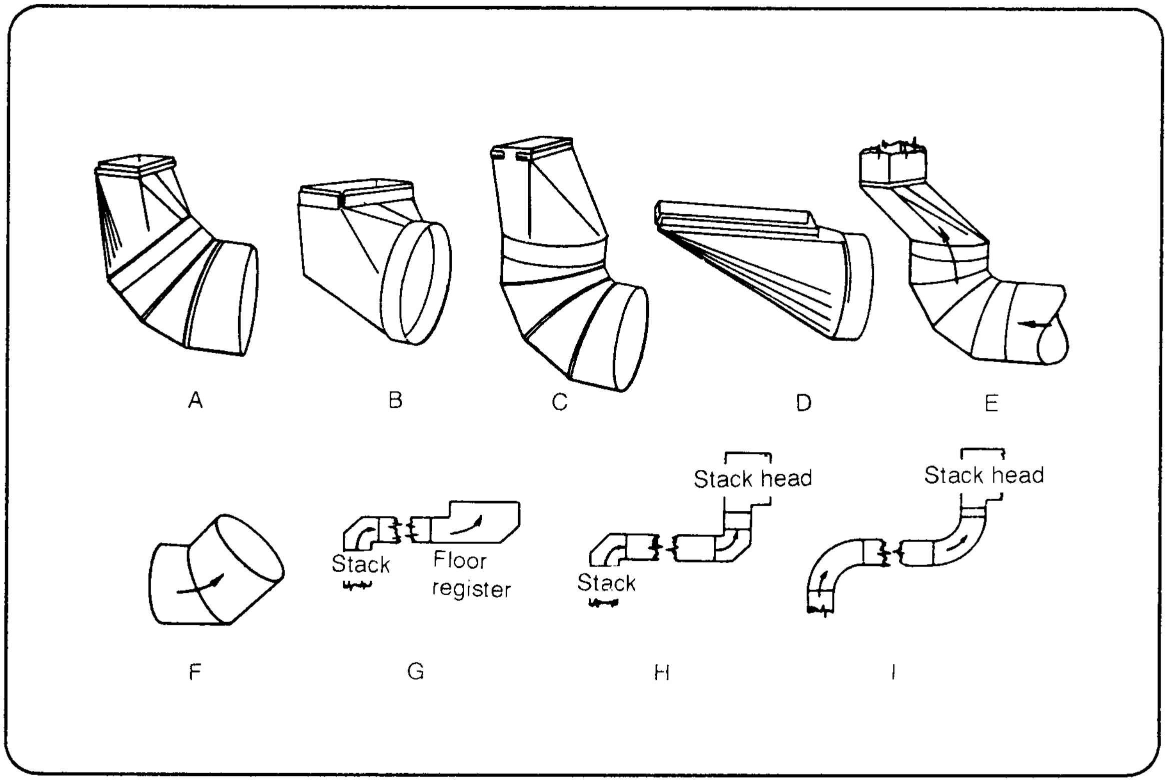


Figure 2-11. Duct (boot) fittings

Table 2-1. Equivalent lengths of gravity duct fittings

Warm Air Boot	Name of Combination	Equivalent No. of 90° Elbows
A	45° angle boot and 45° elbow	1
B	90° angle boot	1
C	Universal boot and 90° elbow	1
D	End boot	2
E	Offset boot	2½
F	45° angle	½
G	Floor register, second story	3
H	Offset	3
I	Offset	2½

CHAPTER 3
BASIC PLUMBING REPAIRS AND MAINTENANCE

This chapter covers step-by-step repair procedures for leaky pipes, frozen pipes, and fixture and drain-line stoppages. (Repairing leaky valves and faucets is covered in Chapter 7.) Preventive maintenance, covered in this chapter, can help reduce corrosion and scale, which can cause leaky pipes and a sharply reduced water flow, respectively.

3-1. Leaks.

a. *Pipe Corrosion.* Corrosion is the thinning of the wall of a metal pipe, caused by electrolysis (chemical breakdown by electric current), rust, or acidity of the water. Galvanic corrosion (resulting from a direct current of electricity) occurs in a plumbing installation system that includes two different kinds of metal pipe, such as galvanized pipe and copper pipe.

The first sign of corrosion may be a leak in the system occurring within the walls or floors of the building. Water may show up several levels below the leak. To help locate the leak, use a strip of wood as a resonator to detect and magnify the sound of the leak. Place one end of the wood against your car and other end against the pipe and trace the sound. Sound will increase as you get closer to the leak.

(1) *Repairing Corrosion.* After locating the leak, cut out and replace the corroded pipe as follows:

REPAIRING CORRODED PIPE

- **Galvanized pipe.**

  Step 1. Shut off the water at the nearest valve below the leak, and drain the pipe.

  Step 2. Where the fittings on each side of the leak are not readily available, cut out the leaking section. One plumber should hold the pipe with a wrench to prevent its turning in the adjoining fitting, while another plumber cuts a thread on it.

  Step 3. Replace the cutout section with a coupling, a pipe section of the required length, and a union.

- **Copper pipe.** Copper pipe resists corrosion, except when attacked by acids. If a leak occurs in copper pipe—

  Step 1. Shut off the water at the nearest valve below the leak, and drain the pipe.

  Step 2. Cut out the corroded section.

  Step 3. Replace it with either soldered or compression joints. (These methods are described in Chapter 6, paragraph 6-6 (pages 6-27 through 6-31).)

NOTE: *Make sure to allow for the fittings required to install the replacement pipe.*

(2) *Reducing Corrosion.* The two ways to reduce corrosion in in plumbing systems are—

- *Dielectric unions.* Dielectric unions placed in the cold-and hot-water takeoffs from the tank can control gallvanic corrosion of water tanks. A dielectric union has a fiber washer, which insulates the tank from the rest of the plumbing installations, preventing the flow of current from the tank to the system.
- *Magnesium rods.* Magnesium rods are used in some water healers, such as the gas-operated type, to protect against rust and corrosion. They act as elctrolytic cells in which the magnesium particles go into solution, flow through the water, and are deposited on the metal to be protected. The electrolytic action (electrolysis) dissolves the rods. Eighteen months is considered the maximum life of the rods; then they must be replaced.

b. *Valve Repair.* All valves should be checked regularly for leaks. Most leaks are from leaky washers or bonnets. Refer to Chapter 7, paragraph 7-2 (pages 7-3 through 7-6) for repairs.

c. *Faucet Repair.* Refer to Chapter 7, paragraph 7-5 (pages 7-9 through 7-15) for faucet repairs.

d. *Temporary Repairs for Small Leaks.* Small leaks in a system require temporary or emergency repairs. Before making any repairs, shut off the water and relieve the pressure from the system. Pipes can be temporarily repaired with one of the following methods:

EMERGENCY REPAIRS

- ***Rubber hose or plastic tubing.*** Cut the pipe on either side of the leak with a hacksaw or pipe cutter. Remove the damaged pipe section and replace it with a length of rubber hose or plastic tubing. To do this, slip the ends over the pipe and fasten them with hose clamps. The inside diameter of the hose must fit the outside diameter of the pipe.
- ***Sheet rubber.*** Wrap the leaking area with sheet rubber. Place two sheet-metal clamps on the pipe (one on each side). Then, fasten the clamps with nuts and bolts.
- ***Electrician's friction tape.*** Wrap several layers of friction tape around the hole or crack, extending the tape about 2 inches above and below the leak.
- ***Wood plugs.*** Small holes can be filled with wood plugs. Drive a wooden plug into the hole after it is drilled or reamed. The plug will swell as it absorbs water, preventing it from being blown out by water pressure.

NOTE: *A permanent repair should be made as soon as possible to replace the weak or defective part. Replace them with units (and insulation if used) that are the same size and quality as the original installation.*

3-2. Frozen Pipes. Water supply lines may freeze when exposed to temperatures below 32° F (0°C). Outside pipes must be buried below the frost line. In northern zones, this is 4 feet or more. If building temperature falls below freezing, inside pipes may also freeze, causing the pipe to break at the weakest point. Use the procedures in Figure 3-1 for thawing above- and below-ground pipes.

ABOVE-GROUND PIPES

- A blowtorch is the best method, but there is a risk of fire. The blowtorch method is—

  Step 1. Open the faucets in the line.

  Step 2. Apply heat from the blowtorch at one end of the pipe and work along the entire length of the pipe.

  Step 3. Continue to heat the pipe until the water flows freely.

- Pipes can also be thawed by wrapping them with burlap or other cloth and pouring boiling water over the wrappings, thus transmitting heat to the frozen pipe.
- When internal freezing is due to failure in the heating plant, the heating plant must be repaired; a high temperature should be maintained in the building until pipes thaw.

UNDERGROUND PIPES

Step 1. Remove the pipe fittings.

Step 2. Place a small thaw pipe or tube into the frozen pipe as shown below.

Step 3. Add an elbow and a piece of vertical pipe to the outer end of the thaw pipe.

Step 4. Place a bucket under the opening to the frozen pipe.

Step 5. Insert a funnel into the open end of the vertical pipe.

Step 6. Pour boiling water into the funnel and, as the ice melts, push the thaw pipe forward.

Step 7. After the flow starts, withdraw the pipe quickly. Allow the flow to continue until the thaw pipe is completely withdrawn and cleared of ice.

NOTE: A small pump may be used to clear a piece of pipe. However, excessive pump pressure can cause a backup; therefore, this procedure must be carefully monitored.

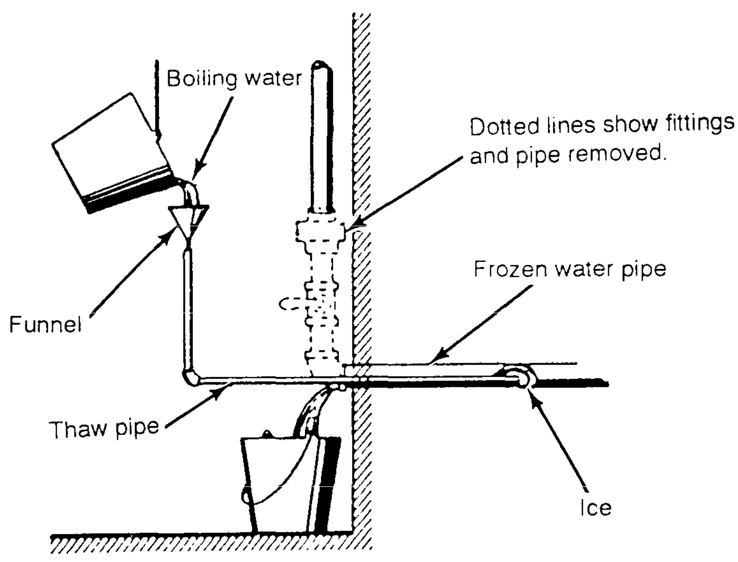


Figure 3-1. Thawing frozen pipe

3-3. Scale. Scale can sharply reduce the flow of water to fixtures. Scale is a result of hard water. Hard water contains a large amount of calcium and magnesium compounds which prevent soap from lathering. This forms a scum, which slows down the flow of water. The scum deposits harden and from scale.

a. *Reducing Scale.* In localities where the water is unusually hard, a water softner is used to reduce the hardness. The softner normally contains zeolite, which must be recharged regularly. The recharge is done by adding sodium chloride (table salt) to the waler. Water softners are programmed to recharge at a set time each day. The softened water is then piped into the distribution system.

b. Removing Scale. To remove scum that has formed on the inside of a pipe, do one of the following—

- Flush with hot water.
- Use lye or lye mixed with a small quantity of aluminum shavings. Only cold water should be used with lye.
- For a sharp reduction of water flow, you may have to replace the entire pipe.

NOTE: *Chemical cleaners should not be used in pipes that are completely stopped up because the cleaners must contact the stoppage directly.*

3-4. Waste-System Stoppages. A common problem in waste systems is a stoppage. A stoppage can occur in a fixture drain, floor drain, branch line, or main line. The cause can be hair, grease, or other foreign matter that holds back the flow of waste disposal. Use the proper clearing tool to clear the stoppage. These tools (Figure 3-2) are designed to clear stoppages in different areas of the waste system. These areas are—

a. *Water Closets.* Use the procedures in Figure 3-3.

b. *Lavatories and Sinks.* Use the procedures in Figure 3-4 (pages 3-6 and 3-7).

c. *Urinals.* A stoppage in a urinal with an exposed P-trap is cleared the same as a lavatory (using a plunger and a 1/4- to l/2-inch snake). A urinal with a waler seal is cleared the same as a water closed (using a plunger and a 1/4- to l/2-inch snake).

d. *Bathtubs.* Use the procedures in Figure 3-5 (pages 3-8 and 3-9).

e. *Shower Drains.* Use the procedures in Figure 3-6 (page 3-10).

f. *Branch and Main Waste Lines.* Stoppages that occur in a branch or main waste line in a building are cleared through a cleanout. Use the procedures in Figure 3-7 (page 3-11).

g. Grease Traps. All work is done on the principle that grease is lighter than water and will rise to the top of the water. To clear a grease-trap stoppage—

Step 1. Remove the top cover and dip out the grease with a ladle.

Step 2. After the grease is scooped out, scrape the walls and bottom.

Step 3. Flush with clear water.

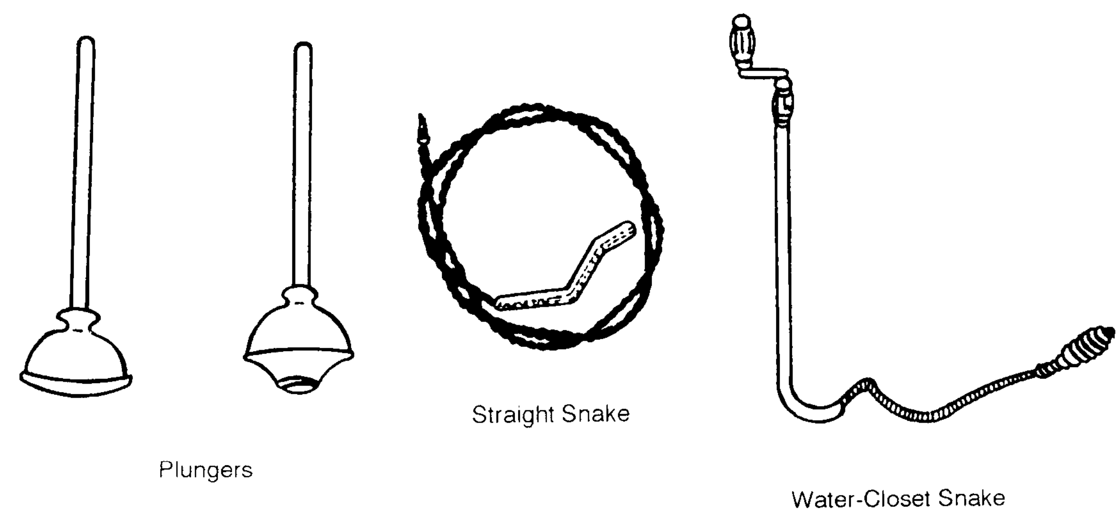


Figure 3-2. Stoppage clearing tools

WATER CLOSET

- Plunger.

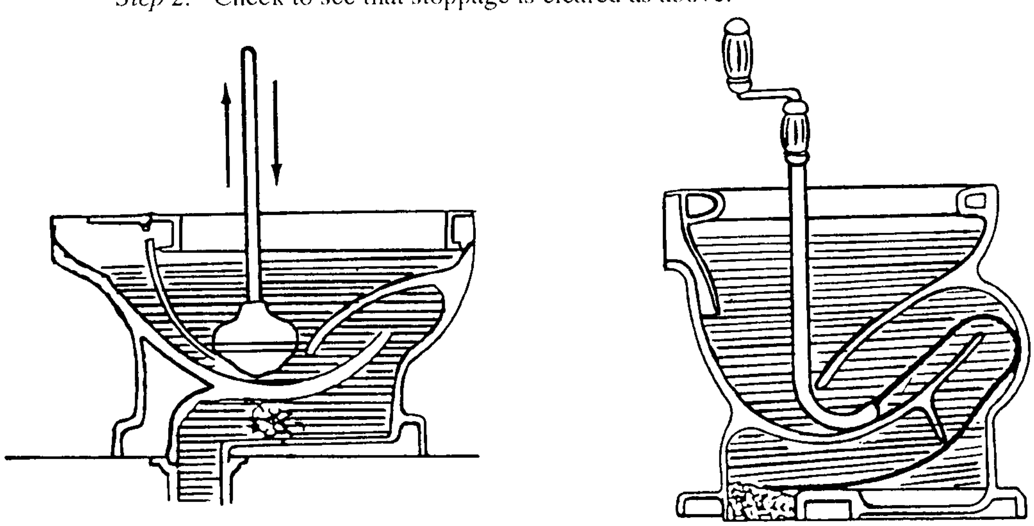
  Step 1. Pump the plunger up and down until the water level drops.

  Step 2. Place toilet paper in the bowl and flush the water closet to check if the stoppage is cleared.

- Water-Closet Snake.

  Step 1. Push the snake into the bowl and turn the handle clockwise with a push-pull action until the water level drops.

  Step 2. Check to see that stoppage is cleared as above.



Clearing with a cane-shaped plunger

Clearing with a water-closet snake

Figure 3-3. Clearing water-closet stoppages

LAVATORY AND SINK P-TRAP

P-Trap Stoppage.

- *Plunger.*

  Step 1. Place a wet rag in the bowl's overflow opening.

  Step 2. If the lavatory has a pop-up plug, remove the plug.

  Step 3. Set a plain plunger over the waste outlet and push it up and down until the water completely drains out of the bowl.

  Step 4. Remove the rag from the overflow opening and replace the pop-up plug, if necessary.

- *Snake (1/4- to 1/2-inch).*

  Step 1. If the lavatory has a pop-up plug, remove the plug.

  Step 2. Push the snake down into the waste outlet as far as it will go.

  Step 3. Use a push-pull and turning action until the water completely drains out of the bowl.

  Step 4. Remove the snake and replace the pop-up plug, if applicable.

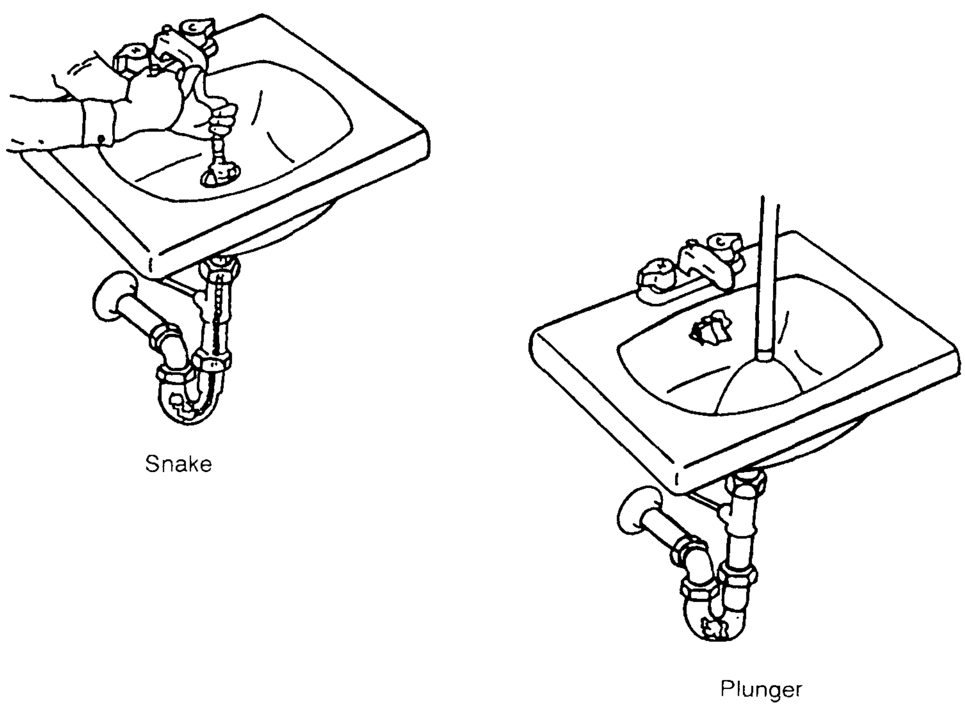


Figure 3-4. Clearing lavatory and sink stoppages

LAVATORY AND SINK DRAIN-LINE

Drain-Line Stoppage.

Step 1. Turn off the water service at the shutoff valves.

Step 2. Place a container under the P-trap to catch the water spillage, then disassemble the P-trap.

Step 3. Push the snake into the drain line, turning it with a push-pull action until it moves freely.

Step 4. Remove the snake and replace the P-trap, then turn on the water service.

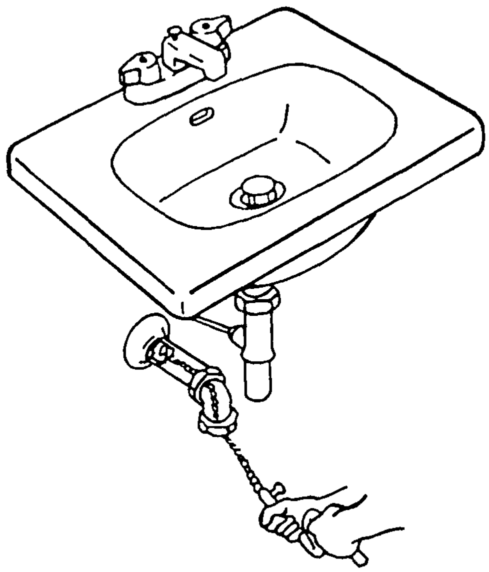


Figure 3-4. Clearing lavatory and sink stoppages (continued)

BATHTUB P-TRAP

P-Trap Stoppage.

Step 1. Remove the stopper linkage and the overflow cover.

Step 2. Push a 1/4- to 1/2-inch drain snake into the overflow opening until it meets some resistance.

Step 3. Turn the snake using a push-pull motion until it turns freely.

Step 4. Remove the snake and turn on the water supply to check if the stoppage is cleared.

Step 5. Replace the overflow cover and linkage.

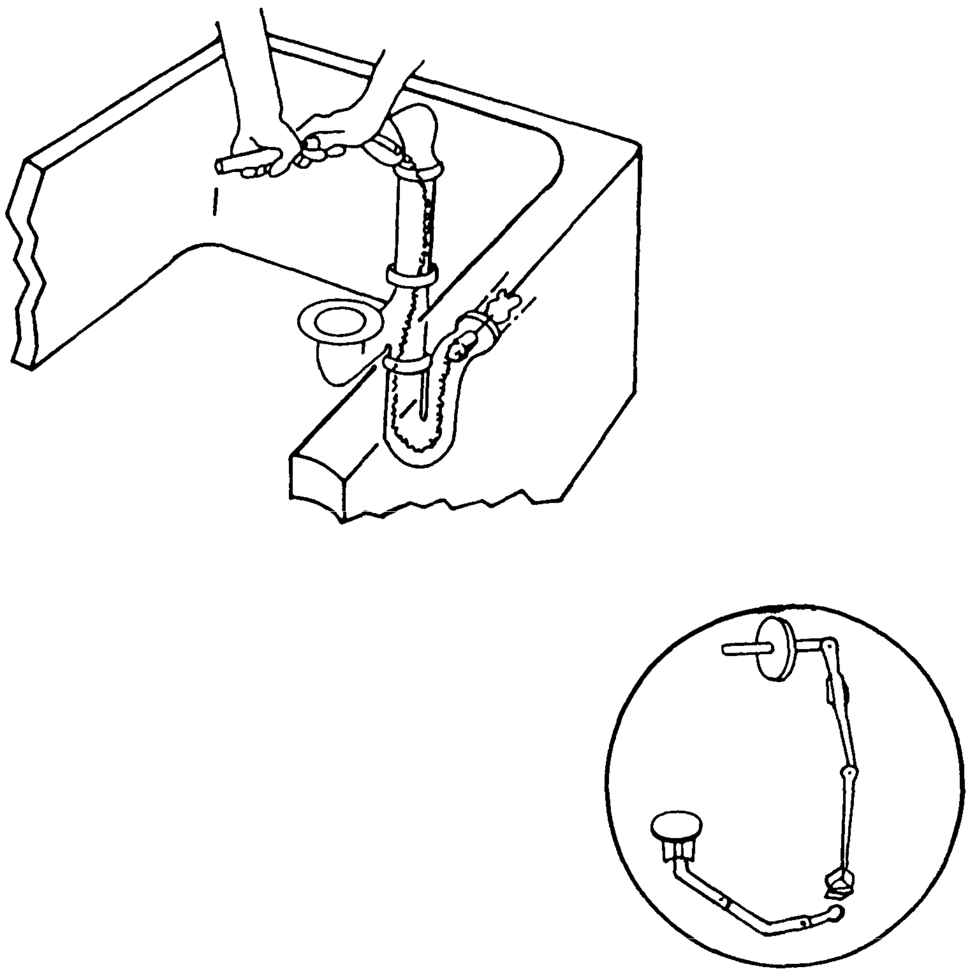


Figure 3-5. Clearing bathtub stoppages

BATHTUB DRUM TRAP

Drum-Trap Stoppage.

Step 1. Remove the drum-top cover and gasket and push a 1/4- to 1/2-inch snake into the trap's lower line to search for stoppage.

Step 2. If a stoppage exists, clear it.

Step 3. If there is no stoppage in the lower line, remove the snake and push it into the upper line.

Step 4. Turn the snake with a push-pull action to remove the stoppage and replace the gasket and cover.

Step 5. Turn on water service to see if the stoppage is cleared.

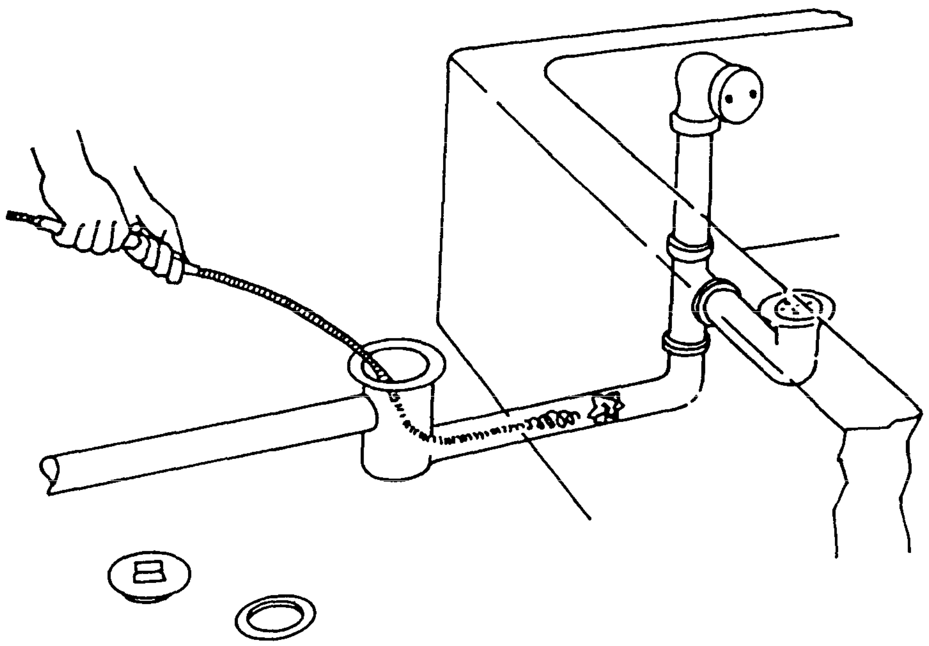


Figure 3-5. Clearing bathtub stoppages (continued)

SHOWER DRAINS

Shower Drain Stoppage.

• *Hose.*

Step 1. Remove the strainer from the drain.

Step 2. Hook up the water hose to a source of water and place the other end of the hose into the drain.

Step 3. Stuff rags around the hose to form a tight seal.

Step 4. Turn the water on full force, off, and then on again. The surge of water (pressure) will clear the stoppage.

Step 5. Replace the strainer.

• *Snake (1/4- to 1/2-inch).*

Step 1. Remove the strainer from the drain.

Step 2. Push the snake into the drain and turn the snake with a push-pull action until it moves freely.

Step 3. Remove the snake and replace the strainer.

Floor Drain Stoppage. Floor drain stoppages are cleared the same as shower drains. A floor drain may have the strainer cemented to the floor; if so, remove it by chipping the cement around the strainer. Once the stoppage is cleared, cement the strainer back in place.

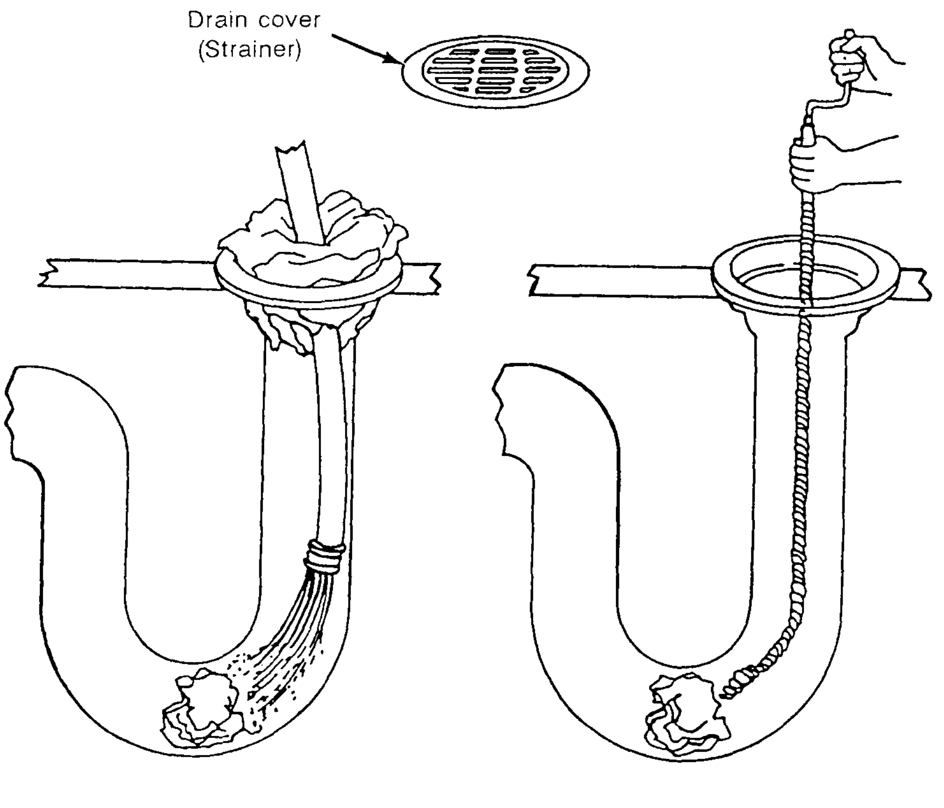


Figure 3-6. Clearing shower drain stoppages

WASTE-LINE STOPPAGES

Branch Line.

Step 1. Remove the closest cleanout plug.

Step 2. Clear the stoppage with a snake.

Step 3. Replace cleanout plug.

Main Line. See below.

Step 1. Remove the closest cleanout plug.

Step 2. Clear the stoppage with a 3/4- to 1-inch heavy-duty snake.

Step 3. Replace cleanout plug.

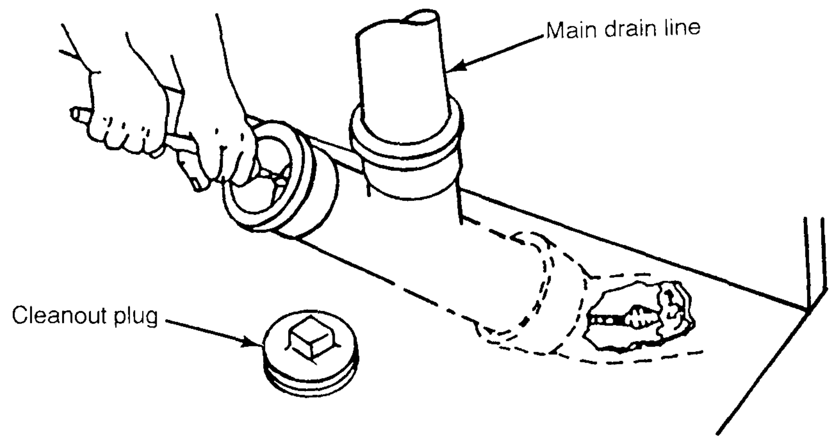


Figure 3-7. Clearing waste-line stoppages

CHAPTER 4
PLUMBING FIXTURES

A plumbing fixture receives water and discharges its waste into a sanitary drainage system. Plumbing fixtures include water closets, lavatories, sinks, urinals, showers, bathtubs, laundry tubs, and drinking fountains. This chapter covers the installation and repair procedures for these fixtures.

4-1. Water Supply and Piping Requirement. A plumbing fixture must be supplied with a water flow rate that will fill it in a reasonable time. The pipe size required to supply each fixture depends on the psi pressure on the water main, length of piping in the building, number of fixtures, and, for water closets, the types of flushing devices. Table 4-1 shows the pipe diameter for various fixtures. (See Chapter 6 also for pipes and fittings.)

Table 4-1. Pipe diameters for plumbing fixtures

Fixture	Pipe Diameter (inches)
Lavatory	1/2
Shower	1/2
Bathtub	1/2
Kitchen sink	1/2
Slop sink	1/2
Scullery sink	3/4
Laundry tub	1/2
Drinking fountain	1/2
Water-closet tank	1/2
Urinal with diaphragm-type flushometer	1/2

4-2. Water Closets. A water closet is a fixture used to carry organic body wastes to the sewer system. Water closets are made of vitreous china. They can be installed on a floor or suspended from a wall. They are available with various types of flushing action: washdown bowl, washdown bowl with jet, reverse-trap bowl, and siphon-jet bowl (Figure 4-1, page 4-2).

a. *Bowls.*

(1) *Types.* Each type has a built-in trap containing a water seal based on the same atmospheric pressure on both sides of the trap.

(a) Common washdown bowl. This bowl is the least expensive and the simplest type of water closet. The trap is at the front of the bowl, and the bowl is flushed by small streams of water running down from the rim.

(b) Washdown bowl with jet. This bowl is similar to the washdown bowl but is flushed differently. The unit has a small hole in the bottom which delivers a direct jet as the unit is flushed. The jet, directed into the upper arm of the trap, starts a siphoning action.

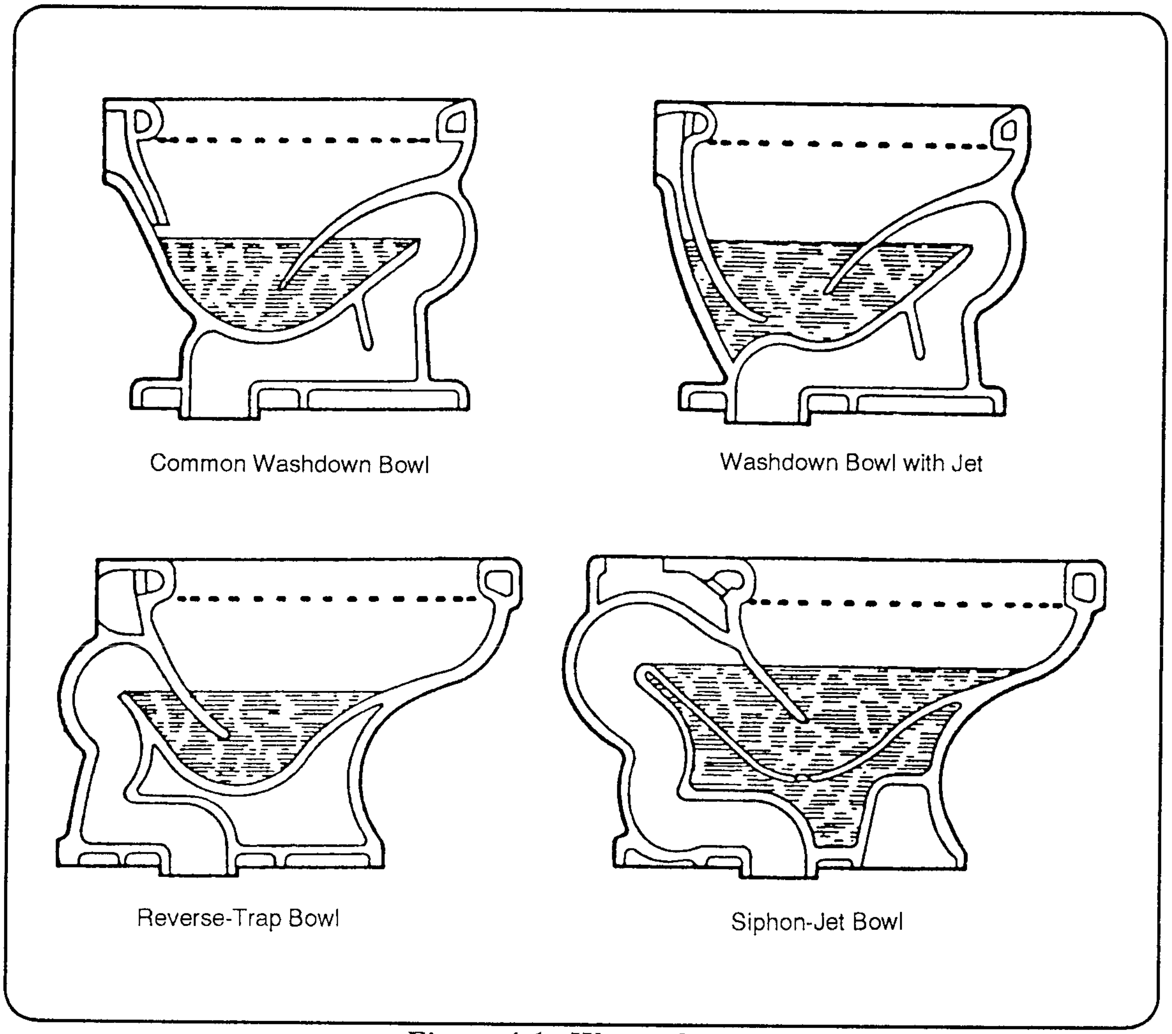


Figure 4-1. Water closets

(c) Reverse-trap bowl. This bowl is similar to the washdown bowl, except that the trap is at the rear of the bowl, making the bowl longer. This bowl holds more water than the washdown bowl and is quieter in operation.

(d) Siphon-jet bowl. This bowl is the most efficient, the quietest, and the most expensive water closet. It looks like the reverse-trap bowl but holds more water. It is almost completely filled with water.

(2) *Installation.* Water-closet bowls are either floor-mounted or wall-hung.

NOTE: *The method of installing water--closet bowls is the same regardless of the flushing action.*

(a) Floor-mounted. To install a floor-mounted water-closet bowl, you will need the following items and materials: floor flange, water-closet bowl, level, wrench, and a wax or rubber gasket. When installing a water closet, use the following procedure and Figure 4-2:

Step 1. Place the floor flange over the closet bend until the flange rests on the finished floor, then make a joint for the type of piping being used.

Step 2. Put two bowl bolts with their threaded ends up into the flange slots. If the bowl needs four bolts, place the bowl properly on the flange and mark the spots for the two additional bolts. Set these bolts into the positions marked. For a wood floor, use bolts with wood threads at one end and machine threads at the other end. For tile or concrete floors, set heads of machined bolts in holes and fill with cement to floor level.

Step 3. Turn the bowl upside down on protective waste newspaper or wooden strips to avoid scratching. Set a wax gasket over the horn.

Step 4. Turn the bowl right side up and set it on the flange with the bolts through the holes of the bowl.

Step 5. Place a washer and nut on each bolt, tightening each alternately until the bowl is set.

Step 6. Check that the bowl is in a level position. If it is not level, use thin metal shims to make it level.

Step 7. Place a nut cap on each nut and tighten down. Do not overstress.

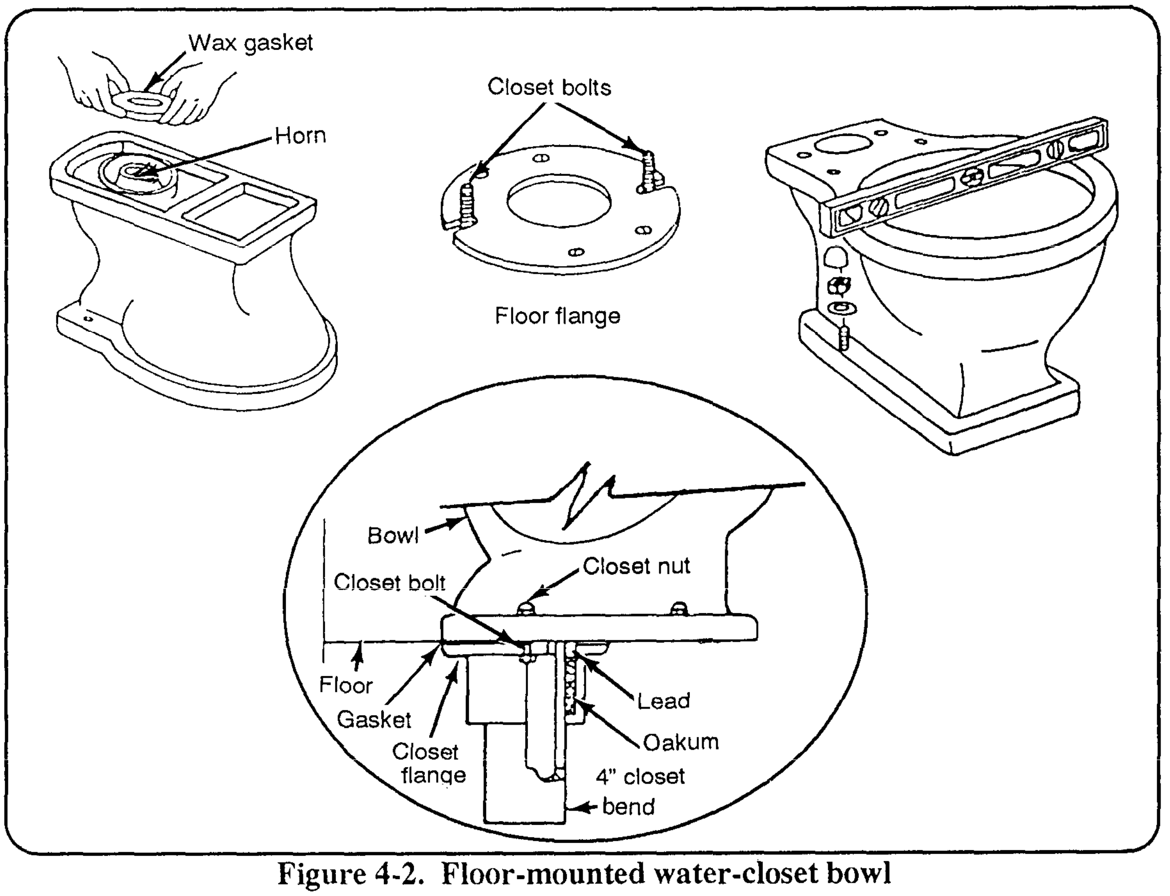


Figure 4-2. Floor-mounted water-closet bowl

(b) Wall-hung. Install the bowl after the finished wall is up. A wall-hung, water-closet bowl is installed on a carrier mounted between the wall studs. This type of water closet is used mainly in commercial buildings, but may also be found in residential buildings. Use the following procedure and Figure 4-3:

Step 1. Install a carrier using the manufacturer's instructions.

Step 2. Connect the carrier's outlet to rough-in waste pipe.

Step 3. Place a sealing gasket in the rear opening of the bowl.

Step 4. Place the bowl against the wall with the carrier's bolts passing through the bowl's holes.

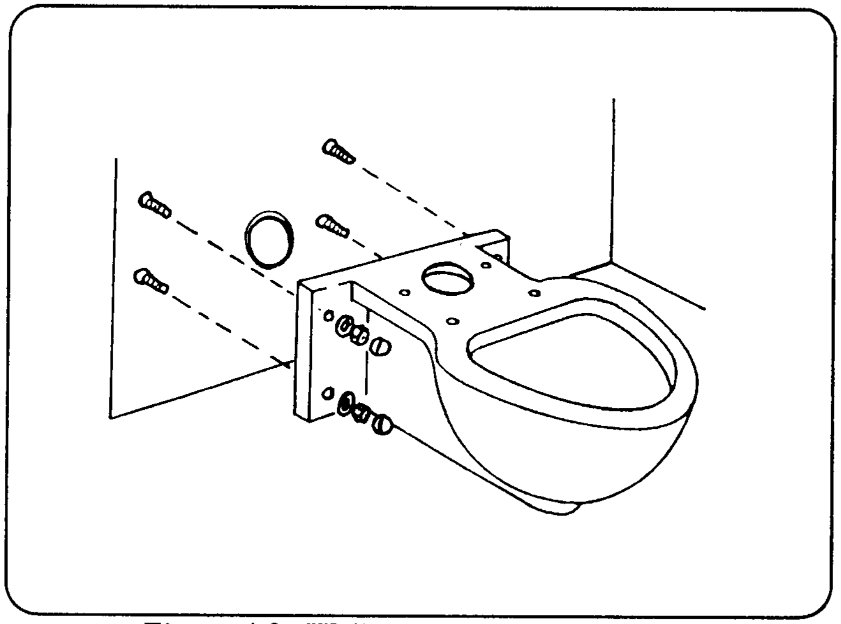


Figure 4-3. Wall-hung water-closet bowl

Step 5. Place a washer and nut on each bolt.

Step 6. Tighten nuts alternately, keeping the bowl level.

Step 7. Place beauty caps over the bolts.

b. *Tanks.* Tanks are classified as close-coupled (floor-mounted) or wall-hung. A close-coupled tank is attached to a floor-mounted bowl. A wall-hung tank is attached to the wall above the bowl, using fittings for the bowl connection. The flushing mechanism is the same for both types.

(1) *Close-Coupled (Floor-Mounted).* To mount a floor-mounted tank, use the following procedure and Figure 4-4:

Step 1. Push the cone-shaped gasket over the tank's flush outlet. If a cushion gasket is included, place it on the bowl, lining up the holes.

Step 2. Place the tank on the bowl with bolt holes lined up.

Step 3. Slide a rubber washer on each bolt and, from inside the tank, push bolts through the holes.

Step 4. Slide a washer over each bolt under the back lip of the bowl and tighten the nuts hand-tight.

Step 5. Tighten the nuts alternately to seat the cone gasket and tank on the bowl.

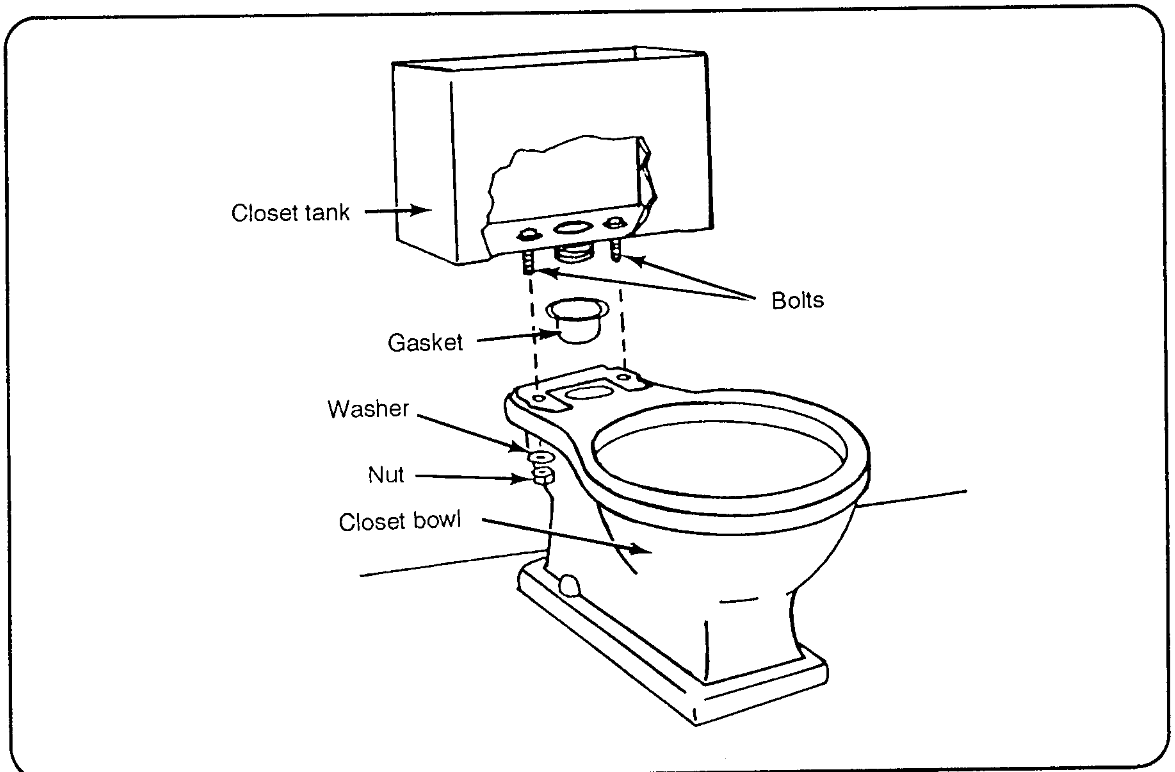


Figure 4-4. Floor-mounted tank

(2) *Wall-Hung.* To mount a wall-hung tank, use the following procedure and Figure 4-5 (page 4-6):

Step 1. Install a 2 - x 4-inch mounting board by notching the wall studs at the height recommended by the manufacturer.

Step 2. Install the elbow and spud connection (flange) to the rear of the bowl.

Step 3. Slide the slip nut, ring, and washer (in that order) onto the other end of the elbow.

Step 4. Attach the tank to the wall's mounting board with screw bolts. Make sure the elbow is in the tank's outlet and the tank is level.

Step 5. Connect elbow to tank outlet hand-tight.

Step 6. Check elbow alignment and tighten slip-joint nuts.

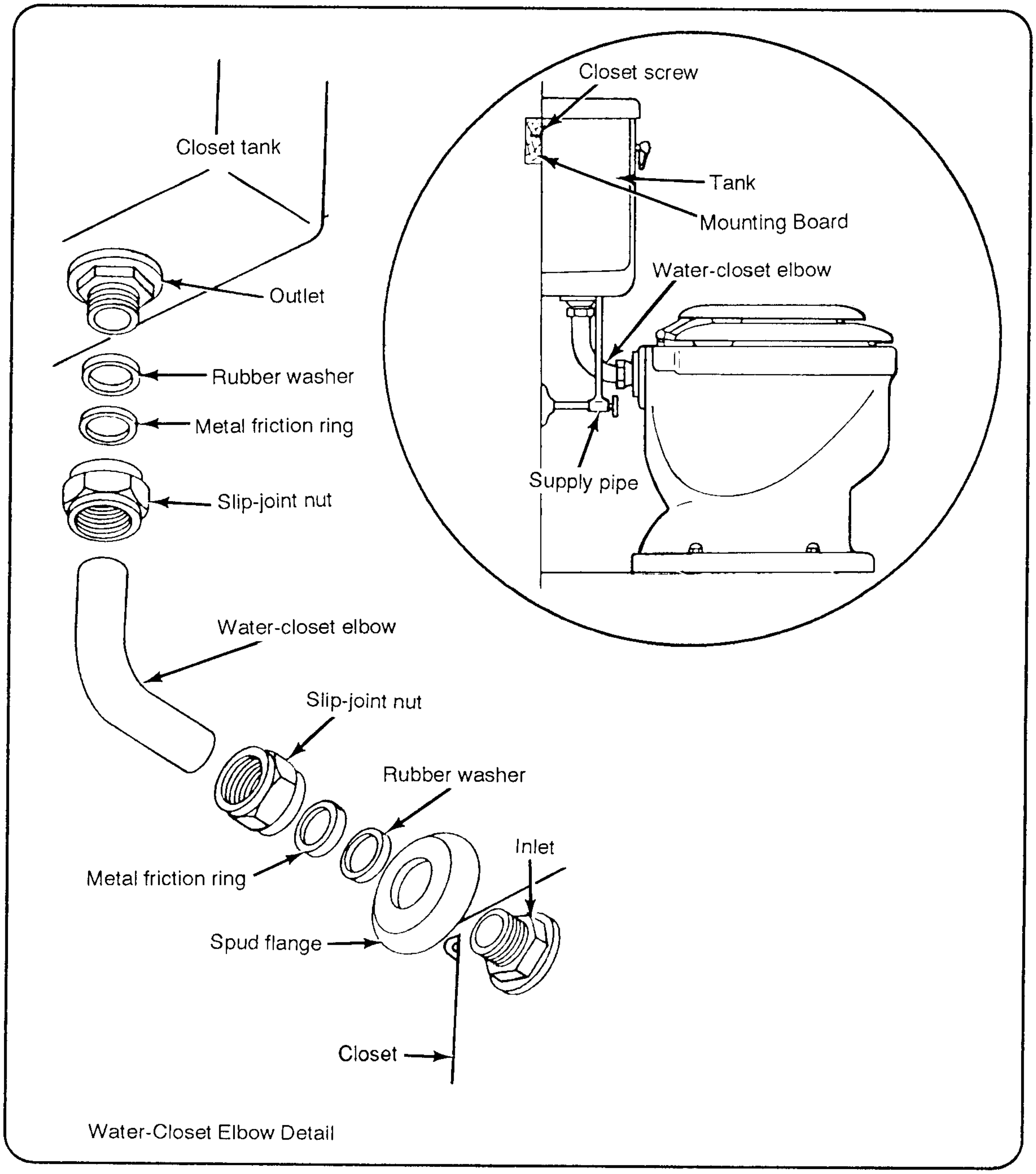


Figure 4-5. Wall-hung tank

c. *Flushing Mechanisms.* Figure 4-6 shows tank mechanisms and flushometers.

(1) *Tank Flushing Mechanisms.* A tank's flushing mechanism is mechanically operated to flush the water closet. The two most common mechanisms are the ball cock and float cup (Figure 4-6). Follow manufacturer's instructions to install a flushing mechanism in a tank. After installation, connect the water supply service, check the flushing mechanism operation, and adjust it to maintain the proper water level in the tank.

(2) *Flushometers.* The flushometer valve delivers (under pressure) a preset amount of water directly into a water closet for flushing. The flushing action is quick and shuts off automatically. Always follow the manufacturer's instructions to install a flushometer. After installation, turn on the water supply and operate the flushometer several times, checking for leaks and proper operation. The most common type of flushometers valves are the diaphragm and piston (Figure 4-6).

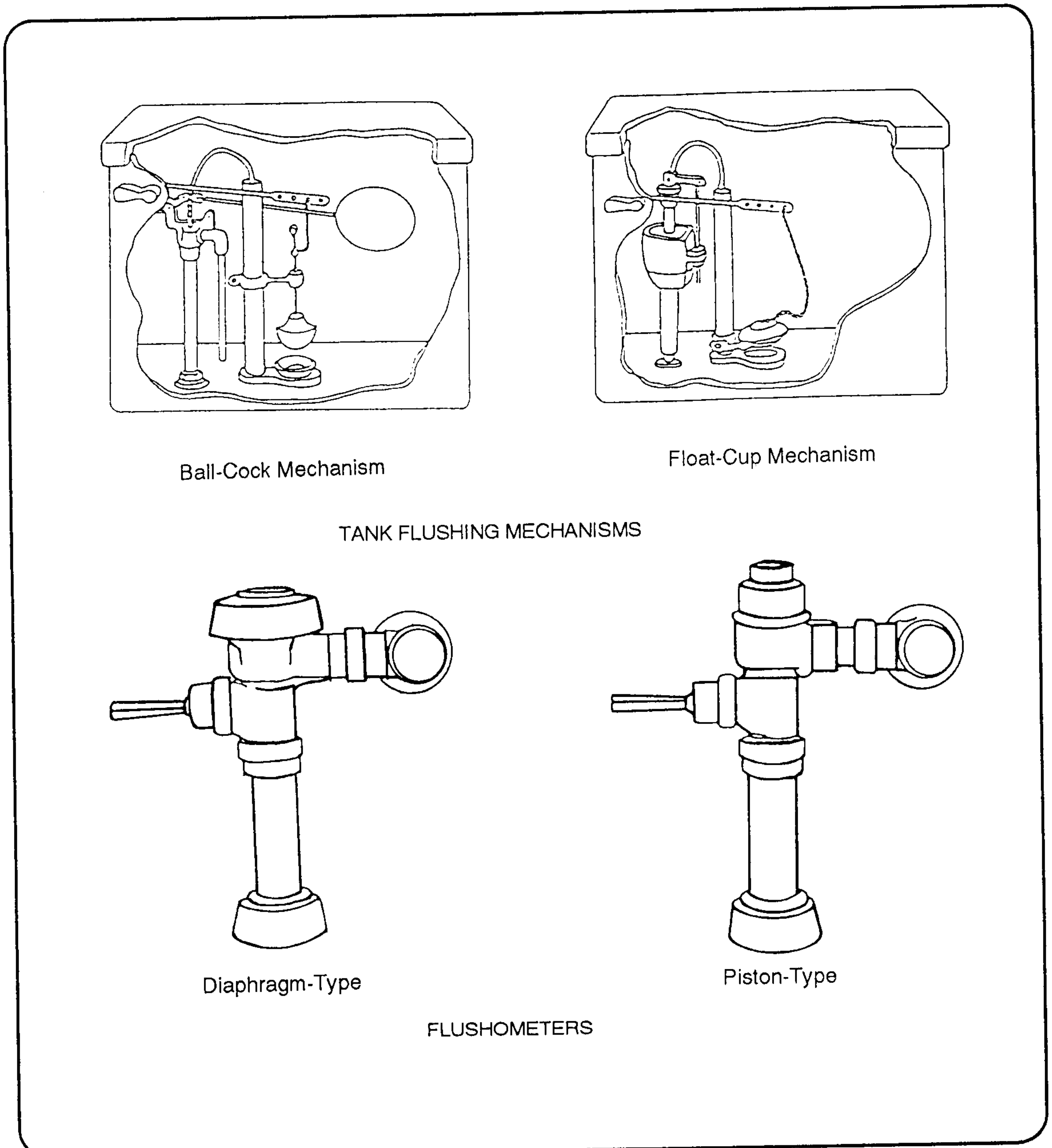


Figure 4-6. Flushing mechanisms

d. *Tank Water Supply Connection.* A close-coupled tank water supply is connected from the rough-in plumbing to a shutoff valve and from the valve to the inlet at the bottom of the tank. Use Figure 4-7 and the following procedure:

Step 1. Slide the chrome cover on the pipe projecting out from the wall and push it against the wall.

Step 2. Coat the threads with joint compound or teflon tape and screw the shutoff valve onto the pipe. Tighten the valve so that its othcr opening is straight.

Step 3. Bend the flexible tube with a spring bendeer to get a proper fit.

Step 4. Slide the inlet coupling nut on with tubing thrcads up, and attach it to the tank's inlet and tighten hand-tight.

Step 5. Slide the coupling nut threads and compression ring down onto tubing. Screw the coupling nut onto the valve hand-tight.

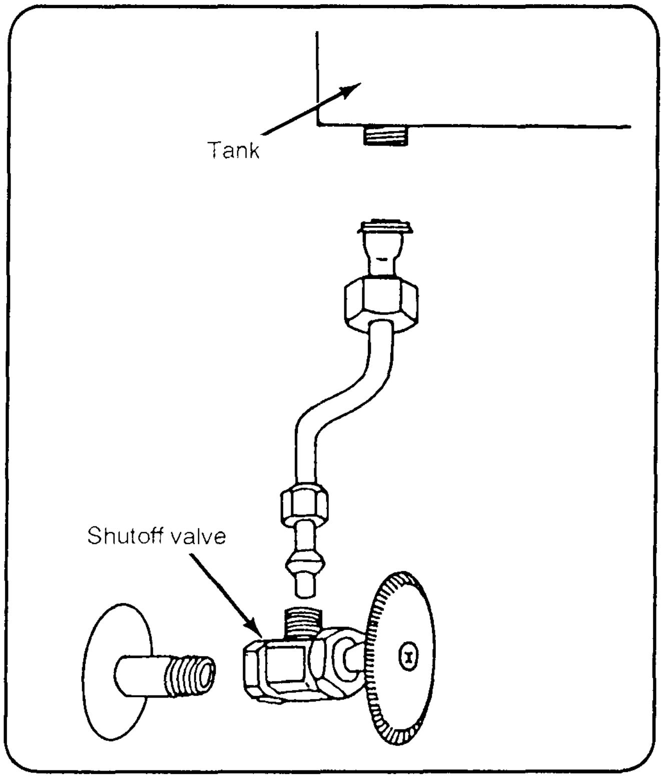


Figure 4-7. Tank water-supply connection

Step 6. Tighten the inlet-coupling nut and valve-coupling nut.

Step 7. Open the shutoff valve for the water supply and check for leaks.

Step 8. Adjust to get a proper water level of 1 inch below the top of the overflow tube. If an adjustment is made, check the operation.

Step 9. Place the tank cover on the tank and install the water-closet scat.

e. *Repairs and Maintenance.* See Chapter 3 for water-closet stoppages.

(1) *Flushometers.* Use the repair procedures and illustration in Figure 4-8 when the valve is not flushing or will not stop flushing. Use Figure 4-9 (page 4-10) for handle repairs.

(2) *Tank Flushing Mechanisms.* Fixture control devices are used for flushing water closets, holding water in a lavatory bowl, and draining waste. These devices get much usage and wear. Use the illustrations and repair procedures in Figure 4-10 (pages 4-11 and 4-12) for ball cock and float cup repairs.

Diaphragm-Type

Step 1. Turn off water supply and remove outer cover.

Step 2. Remove inner cover. If cover will not remove easily, pry it off with a screwdriver.

Step 3. Remove relief valve.

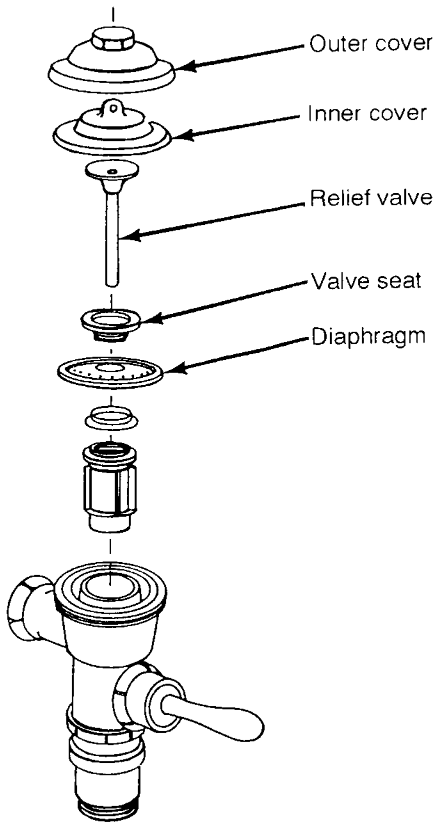
Step 4. Remove valve seat.

Step 5. Remove clogged or worn diaphragm.

Step 6. Install new diaphragm.

Step 7. Reassemble the valve.

Step 8. Turn on water supply and check valve operation.



Piston-Type

Step 1. Turn off water supply and remove outer cover and gasket.

Step 2. Remove inner cover and gasket.

Step 3. Remove brass screws and retaining plate.

Step 4. Remove clogged or worn rubber cup.

Step 5. Install new rubber cup.

Step 6. Reassemble the valve.

Step 7. Turn on water supply and check valve operation.

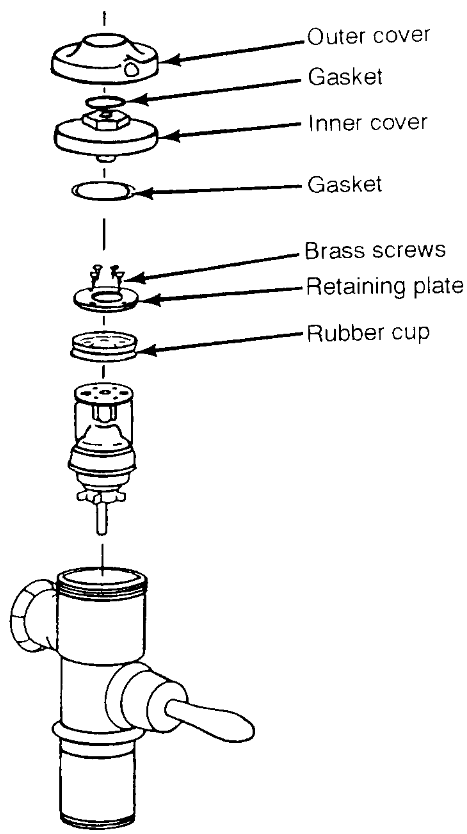


Figure 4-8. Flushometer repairs

REPAIR PROCEDURES

Water leak at handle.

Step 1. Turn off water supply and unscrew retaining nut.

Step 2. Pull out the handle body, which contains all parts up to the packing nut.

Step 3. Grip the handle body with a wrench and unscrew the packing nut with another wrench.

Step 4. Remove the worn packing washer; install new packing washer.

Step 5. Reassemble all parts.

Step 6. Turn on water supply and check handle for leaks and for proper operation.

Loose and wobbly handle.

Step 1. Turn off water supply and unscrew retaining nut.

Step 2. Pull out handle body, which contains all parts up to the packing nut.

Step 3. Grip the handle body with a wrench and unscrew the packing nut with another wrench.

Step 4. Grip the handle body with a wrench and unscrew the bushing with lock grip pliers.

Step 5. Remove worn bushing spring or plunger and replace worn part(s) with new ones.

Step 6. Reassemble all parts.

Step 7. Turn on water supply and check handle for leaks and for proper operation.

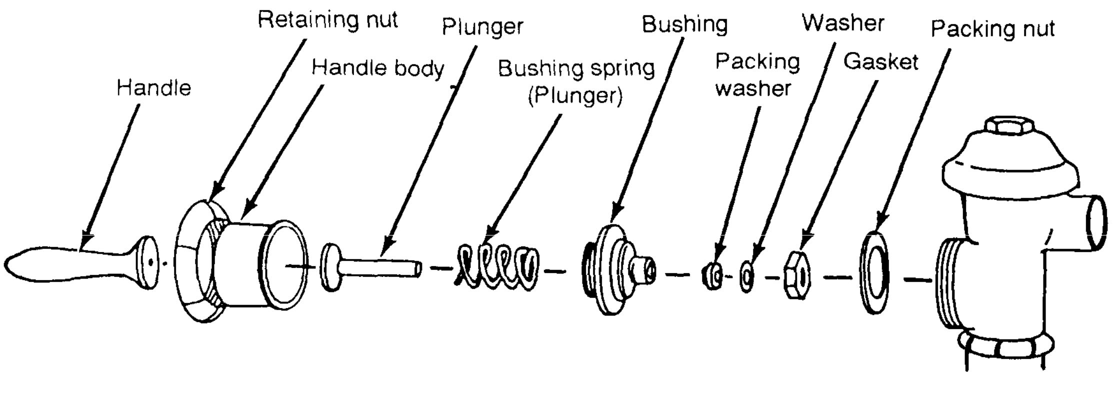


Figure 4-9. Flushometer handle repair

BALL COCK REPAIRS

Water level running into top of overflow pipe.

Step 1. Remove tank top and unscrew the float ball from the float rod.

Step 2. Shake the float ball to find out if water is in the ball. If water is inside the ball, replace the ball. If no water is in the ball, the float ball is functional.

Step 3. Screw the float ball back onto the rod.

Step 4. Place both hands on the middle of the float rod and carefully bend the ball side of the rod down about 1/2 inch.

Step 5. Flush water closet to see that the water level is about one inch below the top of the overflow pipe, then replace tank top.

Running water closet.

Step 1. Remove the tank top and turn off water supply at the shutoff valve.

Step 2. Flush the water closet to empty tank.

Step 3. Unscrew the flush (tank) ball from lift wire.

Step 4. Check bottom of flush ball for damage or wear.

Step 5. If damaged or worn, replace the flush ball with a new one.

Step 6. Clean the flush outlet valve with emery cloth or steel wool.

Step 7. Operate the handle to see that the flush ball sits evenly in the flush outlet valve.

Step 8. Turn on water supply and flush water closet to check repair, then replace tank top.

Faulty ball cock operation.

Step 1. Remove the tank top and turn off the water supply.

Step 2. Flush the water closet to empty the tank.

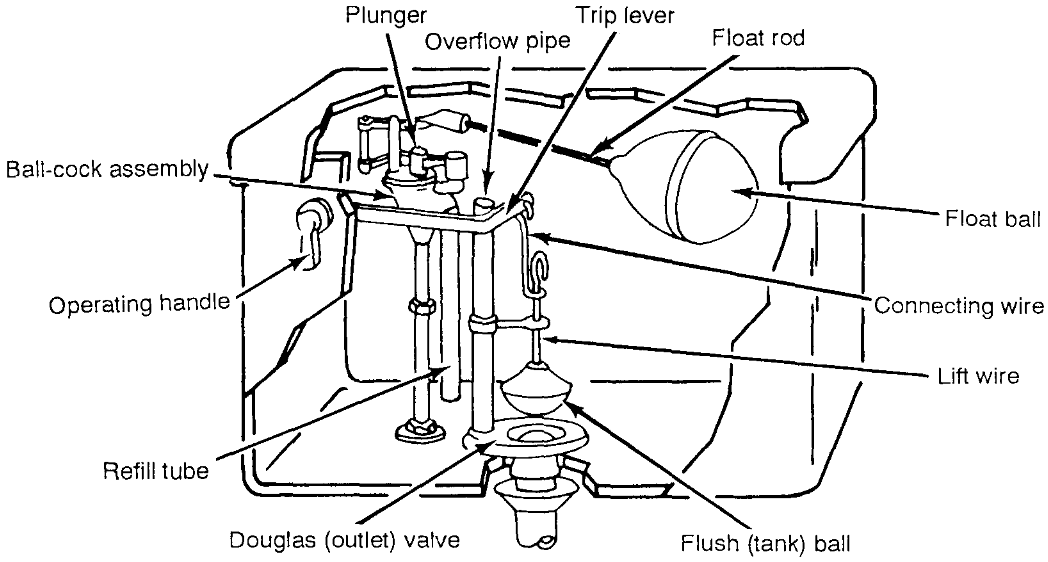


Figure 4-10. Tank mechanism repairs

BALL COCK REPAIRS (continued)

Step 3. Remove the float rod with the float ball attached.

Step 4. Remove screws or pins at the top of the ball cock assembly.

Step 5. Lift the plunger out of the assembly.

Step 6. Remove both washers and replace them.

Step 7. Reassemble ball cock assembly float rod with the float ball attached.

Step 8. Turn on water supply and check ball cock.

FLOAT CUP REPAIRS

Water level running into top of overflow pipe.

Step 1. Remove tank top. Then squeeze the top and bottom of the adjustment clip and move it down on the pull rod to lower the float cup.

Step 2. Flush the tank, then check incoming water level. Level should be about one inch below top of overflow pipe.

Step 3. Replace tank top if level is correct. If level is not correct, repeat steps 1 and 2 until it is correct.

Step 4. Replace tank top.

Running water closet.

Step 1. Remove tank top. Turn off water supply at shutoff valve and flush water closet to empty tank.

Step 2. Lift up the flapper ball and check bottom for damage or wear. If the flapper ball is damaged or worn, replace it.

Step 3. Clean outlet valve with emery cloth or steel wool.

Step 4. Operate handle to check that flapper ball sits evenly in the outlet valve.

Step 5. Turn on water supply and flush the water closet to check repair. Replace tank top.

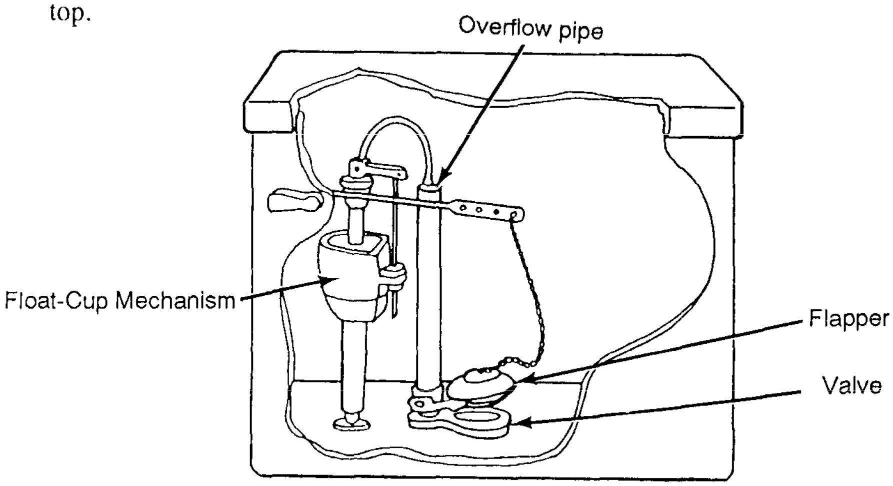


Figure 4-10. Tank mechanism repairs (continued)

4-3. Lavatories. A lavatory is designed for washing one's hands and face. Lavatories come in a variety of shapes, sizes, and colors. They are made of vitreous china, enameled cast iron, stainless steel, and plastic. Hot and cold water is supplied through the supply system and the waste drains into the sanitary sewer.

a. *Types.* Figure 4-11 shows examples of wall-hung, vanity, pedestal, and trough lavatories.

(1) *Wall-Hung.* This lavatory hangs on a bracket attached to the wall. It may or may not have legs for added support.

(2) *Vanity.* Vanities are installed on a cabinet or counter top with a stainless steel rim.

(3) *Pedestal.* This lavatory's weight rests on the floor and does not require support.

(4) *Trough.* This lavatory is mostly used in commercial plants and certain military facilities.

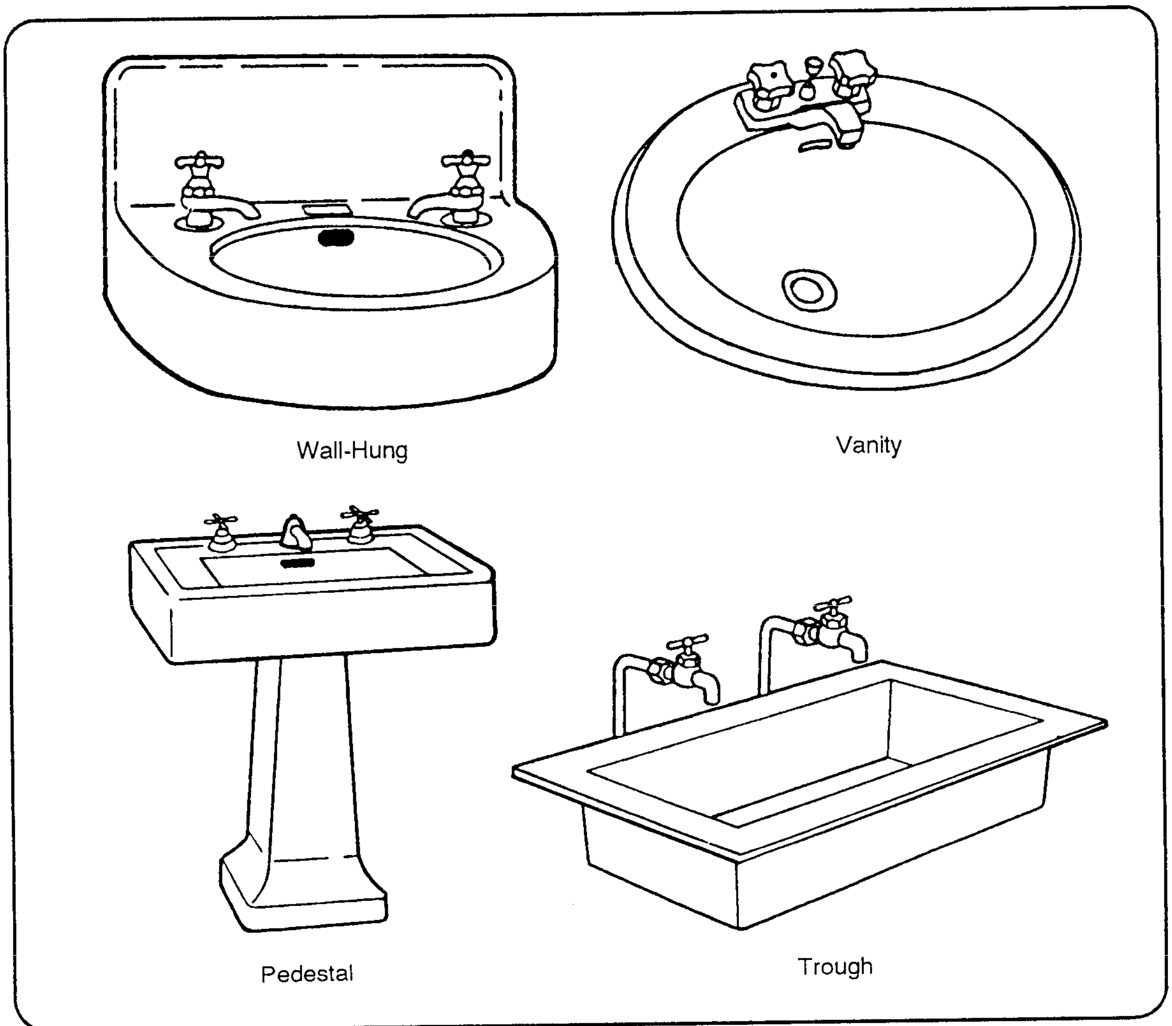


Figure 4-11. Lavatories

b. *Installation.*

(1) *Wall-Hung.* Use the following procedure and Figure 4-12 to install a wall-hung lavatory:

Step 1. Install mounting board between studs at the proper height, using the same method as for a wall-hung flush tank (page 4-5).

Step 2. Attach hanger bracket(s) on the finished wall using proper length wood screws at the recommended height. The metal bracket(s) must be level.

Step 3. Place the lavatory on bracket(s) and push down. Make sure the lavatory is level.

(2) *Faucets.* See Chapter 7, paragraphs 7-4 and 7-5 (pages 7-8 through 7-15) for faucet installation and repairs.

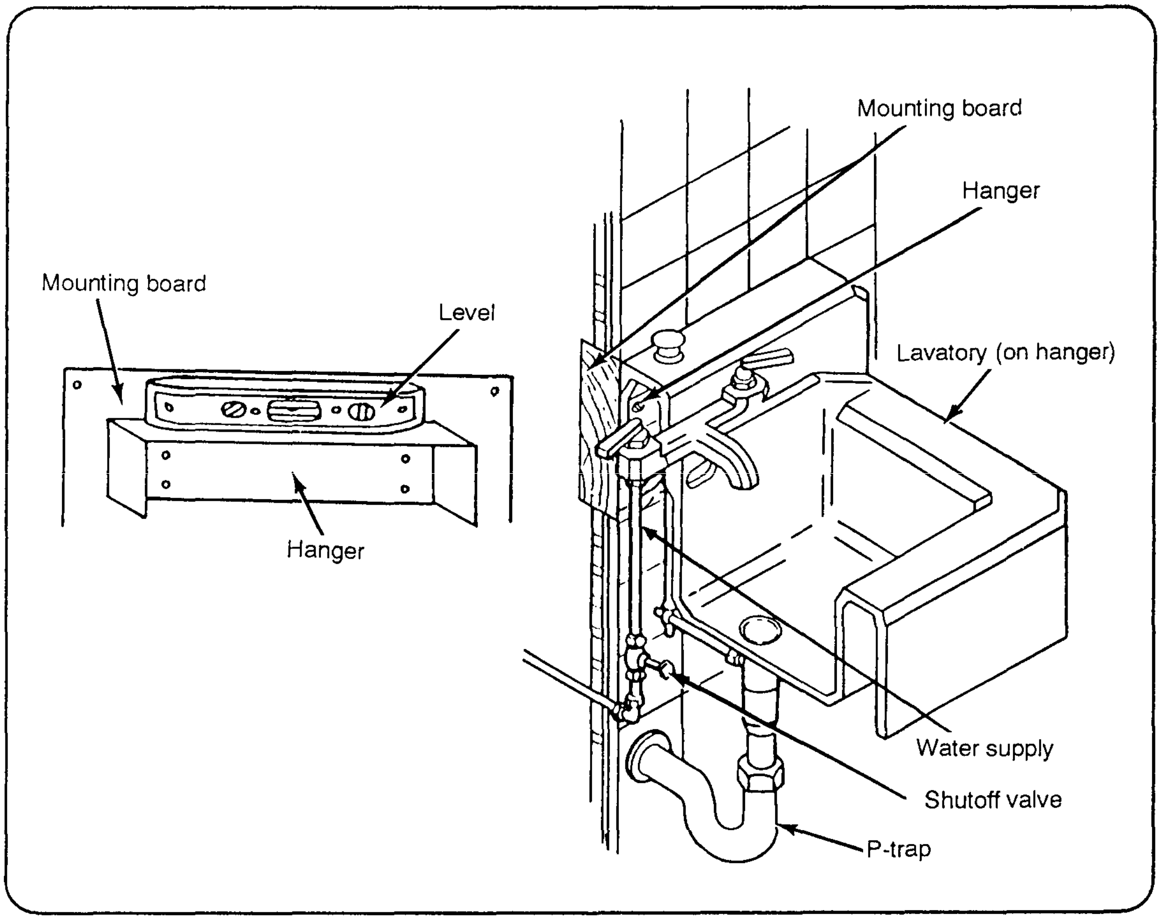


Figure 4-12. Wall-hung lavatory installation

(3) *Drain Assembly*. The waste from the lavatory maybe released by either a pull-out plug or pop-up plug (Figure 4-13). Installation of the flange is the same for both types. (Follow manufacturer's instructions to install the pop-up plug mechanism to attach the tailpiece.) To install a flange—

Step 1. Apply a ring of plumber's putty around the drain outlet and set the flange firmly into the outlet.

Step 2. Connect the flange to the bowl with the washer and locknut.

Step 3. Coat the flangc threads with pipe-joint compound and screw on the tailpiece.

Step 4. Connect the P-trap between the rough-in waste outlet and the tailpiece (Figure 4-14, page 4-16). All connections should be made with washers and slipnuts to form leakproof joints.

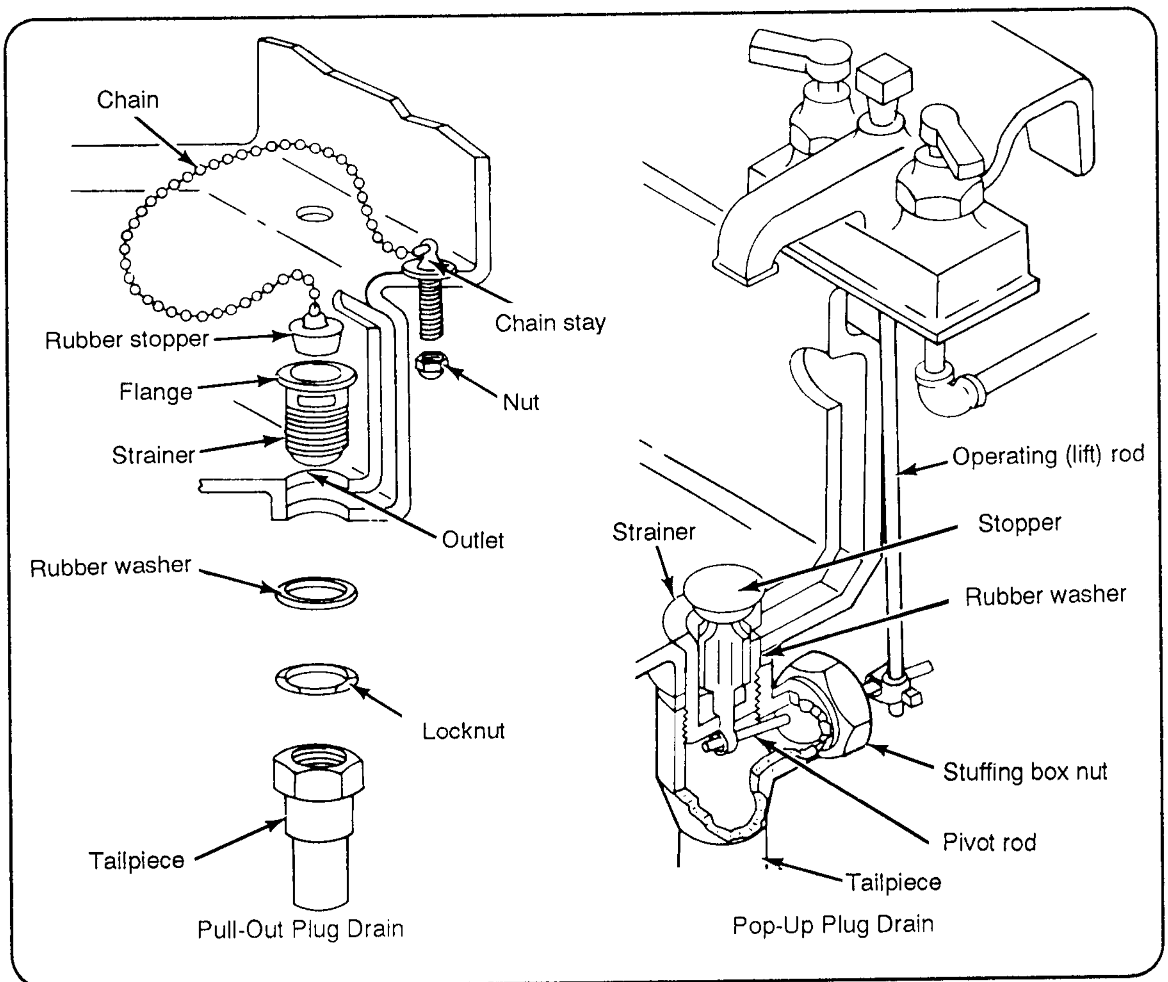


Figure 4-13. Drain-plug assembly

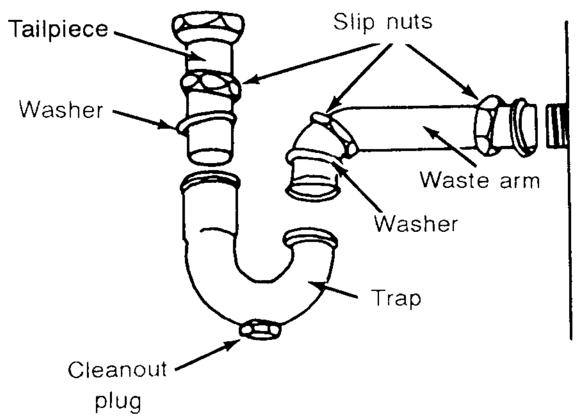


Figure 4-14. P-trap connection

(4) *Water-Supply Connection.* Figure 4-15 shows how to connect water services (hot and cold) for a lavatory. After installation, turn on the water supply to check for leaks.

c. *Pop-Up Plug Repairs.* Use the repair procedures in Figure 4-16 when the pop-up plug (stopper) fails to keep water in the bowl.

4-4. Sinks. Sinks are available for different uses and come in several sizes and shapes, as shown in Figure 4-17 (page 4-18). They are made of enameled cast iron, enameled prcxscd-steel, galvanized steel, and stainless steel. (See Chapter 7, paragraph 7-4, pages 7-8 and 7-9, for faucet installation.)

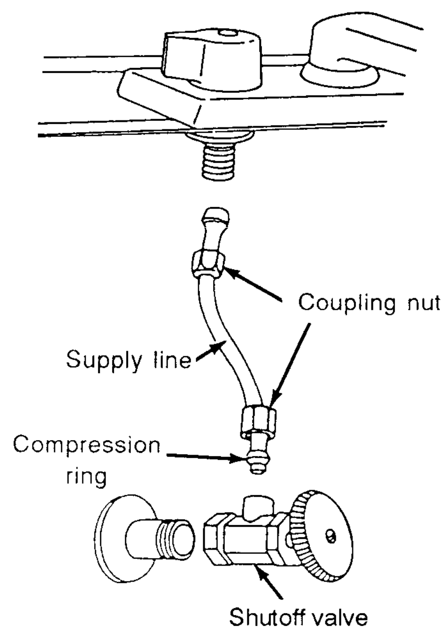


Figure 4-15. Water-supply connection

a. *Scullery Sink.* Scullery sinks are large, deep sinks used in mess-hall type facilities. Scullery sinks need only installation of faucets and connection 10 waste- and water-supply lines.

b. *Slop Sink.* Slop sinks are used for buckets and mops.

c. *Kitchen Sink.* Kitchen sinks can be either single- or double-compartment and can be wall-hung or set in a counter top. Kitchen sinks have a strainer to prevent food waste from entering the waste system (Figure 4-18, page 4-18). Connect the water service the same as for a lavatory (see Figure 4-15).

POP-UP PLUG

Step 1. Loosen the clevis screw with pliers.

Step 2. Push the pop-up plug (stopper) down so that it sits snugly on the flange.

Step 3. Tighten the clevis screw. Check that it fits snugly on the flange.

Step 4. Squeeze the spring clip and pull out the pivot rod from the clevis hole. The stopper then should operate easily. Place the pivot rod through the next higher or lower hole in the clevis.

Step 5. Close the stopper and fill the bowl with water.

Step 6. Check the water level to be sure the stopper holds water in the bowl.

NOTE: If steps 1-6 do not fix the problem, continue on using the following steps:

Step 7. Tighten the pivot-ball retaining nut. If the leak continues, remove the nut with pliers.

Step 8. Squeeze the spring clip, sliding the pivot rod out of the clevis hole.

Step 9. Slide the pivot-ball retaining nut and worn washers off the pivot rod.

Step 10. Slide new washers (plastic or rubber) and the ball nut onto the pivot rod and tighten the pivot ball.

Step 11. Reassemble the pivot rod into the clevis hole.

Step 12. Run water into the lavatory and check the connection for leaks.

NOTE: Check the pop-up stopper's ability to hold water after repairing the pivot-ball connection.

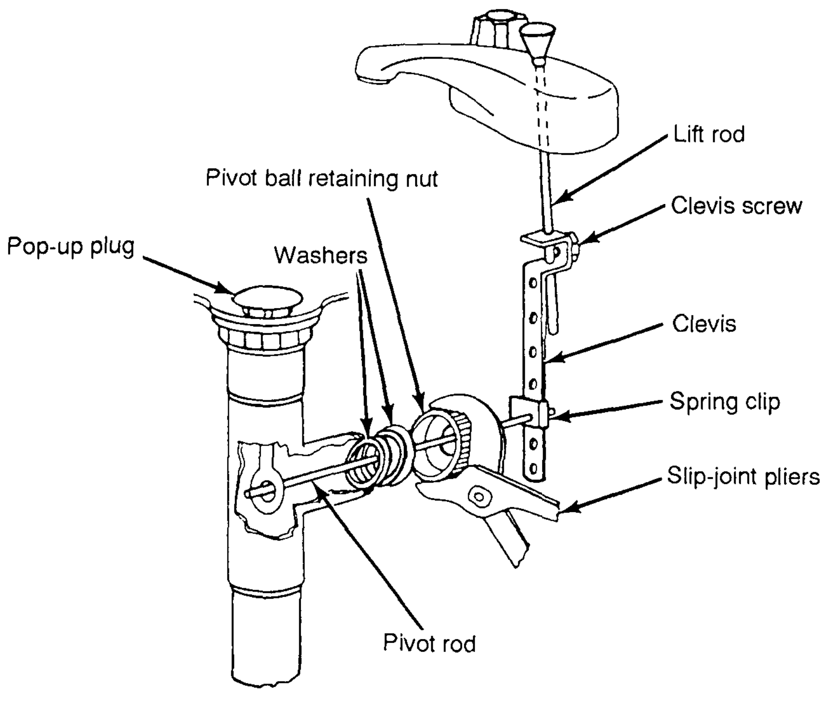


Figure 4-16. Pop-up plug repairs

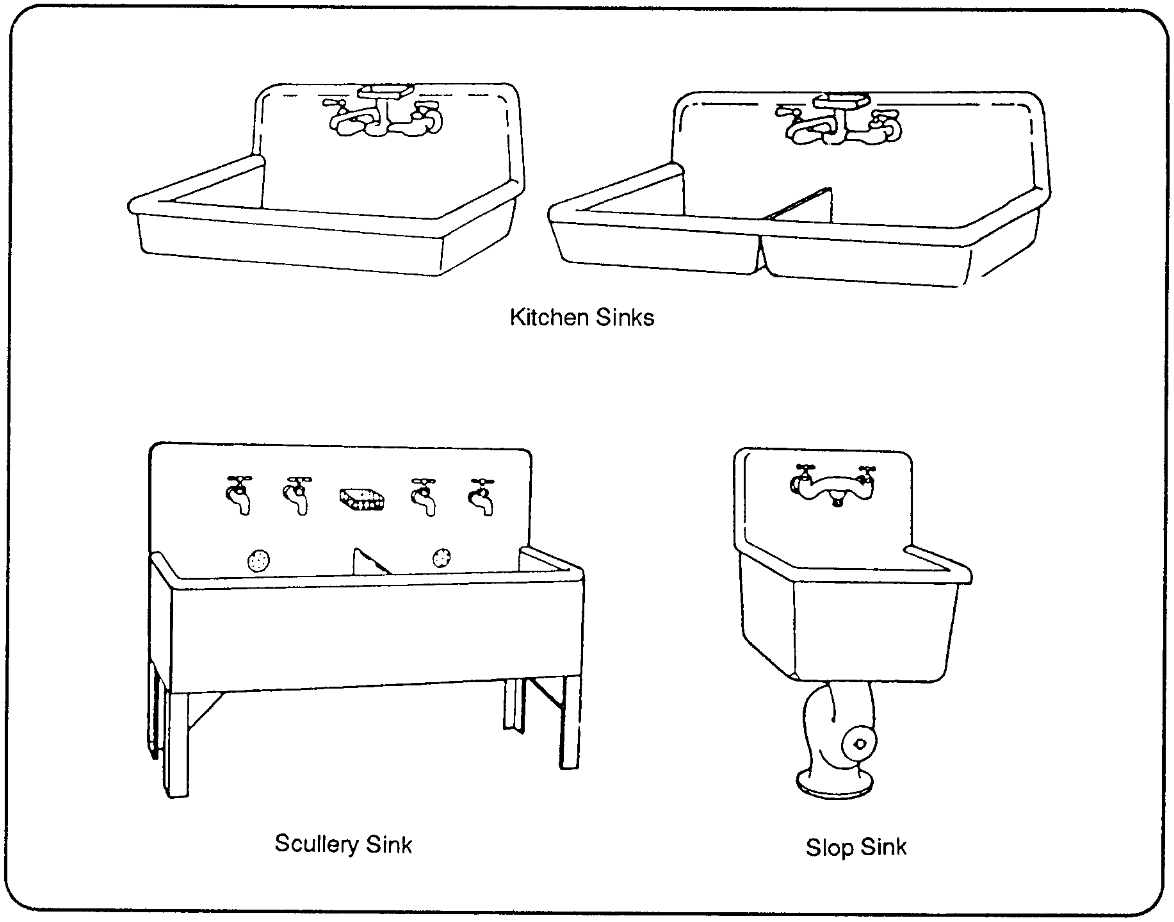


Figure 4-17. Sinks

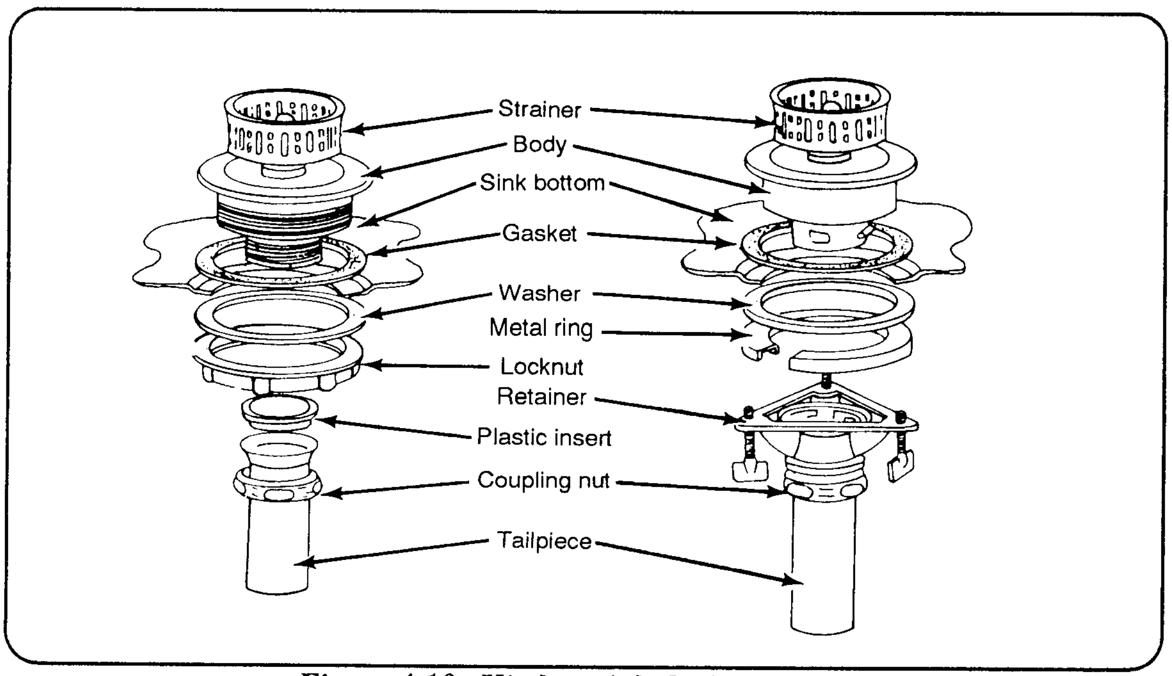


Figure 4-18. Kitchen sink drain assembly

4-5. Urinals. A urinal is a fixture that carries human liquid waste to the sewer. It is made of vitreous china or enameled cast-iron.

a. *Types.* Urinal types are wall-hung, stall, and trough (Figure 4-19, page 4-20).

(1) *Wall-Hung.* This urinal can have a built-in water-seal trap or a P-trap with a washdown or siphon-jet flushing action. The hushing device for a wall-hung urinal is a flushometer valve.

(2) *Stall.* The stall urinal is set into the floor. A beehive strainer covers the waste outlet, which is caulked to a P-trap below floor level. The flushing action is the washdown-type produced by a flushometer valve.

(3) *Trough.* A trough urinal is wall-hung with a flush tank. The urinal has perforated pipe across the rear, which allows water to flow down the back of the trough when flushed.

b. *Installation.*

(1) *Wall-Hung.* (See also manufacturer's instructions.)

Step 1. Install the mounting board and bracket.

Step 2. Install the urinal on the bracket.

Step 3. Make the waste connection to rough-in piping.

Step 4. Make the water connection to rough-in piping to include the flushometer valve.

Step 5. Turn on main water supply and flush urinal several times, checking for leaks.

(2) *Trough.* (See manufacturer's instructions or military construction drawing.)

Step 1. Install the mounting board for the trough and tank.

Step 2. Attach the tank to the wall and install the flushing mechanism.

Step 3. Install the hanger for the trough bowl.

Step 4. Attach the bowl to the wall.

Step 5. Install the waste connection to rough-in piping.

Step 6. Install the piping from the tank to the trough bowl.

Step 7. Install a water line between the tank and the rough-in piping.

Step 8. Turn on the main water supply and flush the urinal several times, checking for leaks.

(3) *Flushometers.* Refer to paragraph 4-1c(2) (page 4-7) for flushometers.

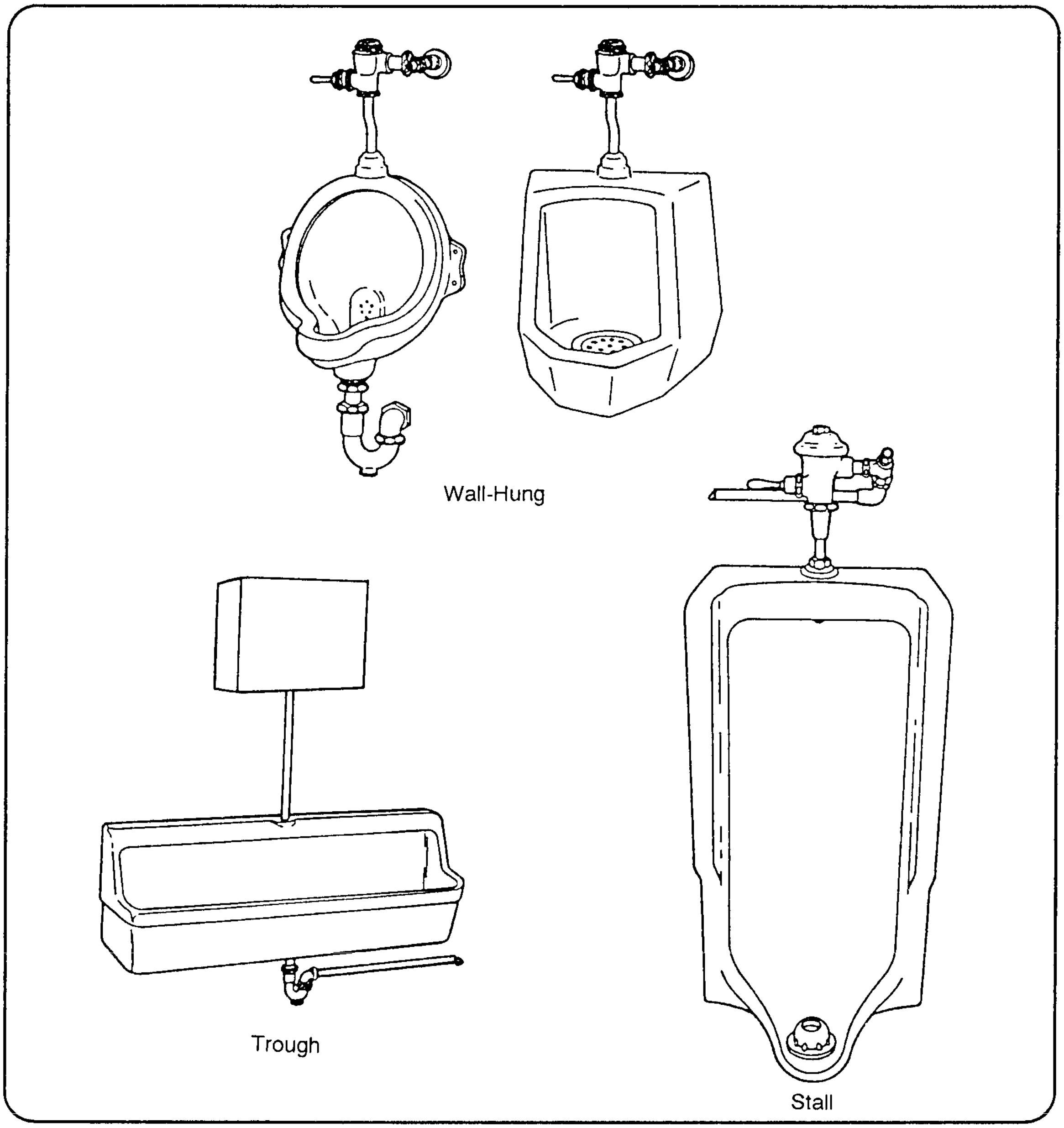


Figure 4-19. Urinals

4-6. Showers. A shower has many advantages over a bathtub: (1) the small amount of space required for installation, (2) the small amount of water used compared with bathtub use, and (3) sanitation. Figure 4-20 shows the types of shower heads. The two types of individual shower installations are: tiled and the steel-stall. (Group showers are usually tile or concrete.)

a. *Types.*

(1) *Tile.* The tile shower has tile or marble walls on three sides with a waterproof shower curtain or door, which can be closed while the shower is in use. The tiled floor

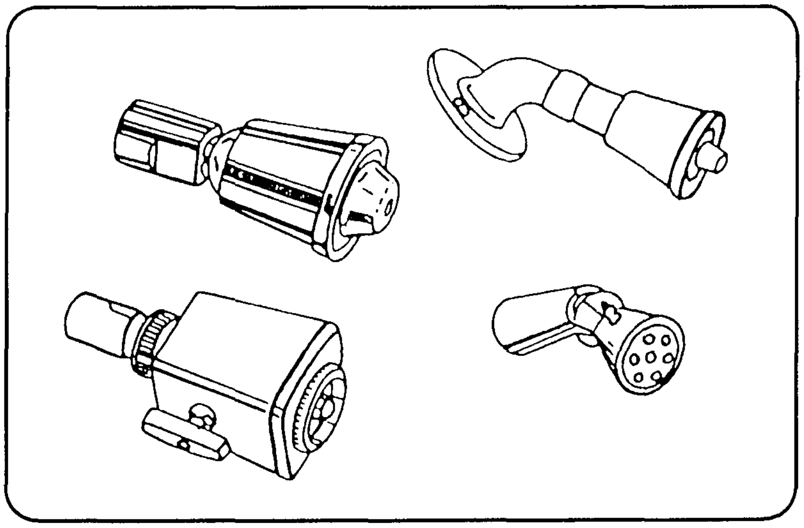


Figure 4-20. Shower heads

slopes to the center (or rear) where a drain is placed. The wall should be waterproofed by setting the tile in waterproof cement. The floor is generally laid upon a lead shower pan, which forms a waterproof base on which to lay the tile, as shown in Figure 4-21 (page 4-22).

(2) *Stall.* The stall shower is a prefabricated unit with three sides and a base, fitted together. The sides are thin sheets of grooved steel, fitted together with a watertight joint. The base is usually precast concrete. Spray from the shower head causes considerable noise as it hits the thin steel, and the metal sides tend to rust rapidly.

b. *Installation.* Complete waterproofing is the most important requirement of shower installation. Tile installed with good quality waterproof cement provides a waterproofed wall. For the floor, a waterproof base (shower pan) under the shower is necessary, since water standing on the tile surface can seep through and cause leaks. (See Chapter 7, paragraph 7-4, pages 7-8 and 7-9, for faucet assembly and installation.

(1) *Lead Shower Pan.* Before installing the lead shower pan, a carpenter must rough in the general outline of the stall and lay a solid base of subflooring or plywood. Without a solid base, the shower pan is soft and flexible. If not supported properly, the pan will sag and Ieak under the weight of the tile. Inspect the rough-in of the trap underneath the flooring to ensure the outlet is correctly placed.

Many types of shower drains are available. The one in Figure 4-21 (page 4-22) has the proper length nipple for placing the seepage flange at a level with the lead pan threaded into the nipple. The lead pan is made by using a solid sheet of lead 6 to 8 inches larger than the size of the shower floor and bending up the edges at right angles to the desired height. Use Figure 4-21 (page 4-22) and the following procedure to install a lead shower pan:

Step 1. Cut a hole where the drain is located and lower the shower pan into place. The pan should rest firmly on the seepage flange of the shower drain.

Step 2. Coat the inside of the shower pan with asphalt.

Step 3. Paint with pipe-joint compound and putty under the top of the flange.

Step 4. Place the upper flange on top of the lower flange and attach them together to form a watertight joint between the shower waste and the shower pan.

Step 5. Thread the strainer down into the flanges to the desired level of the tile.

Step 6. Complete the installation by laying cement in the shower pan and tiling the floor.

(2) *Concrete Shower Pan.* Concrete shower pans with prefabricated, steel shower stalls are easy to install. They are often set up after the original construction. In this case, the cement base is laid directly on top of the floor.

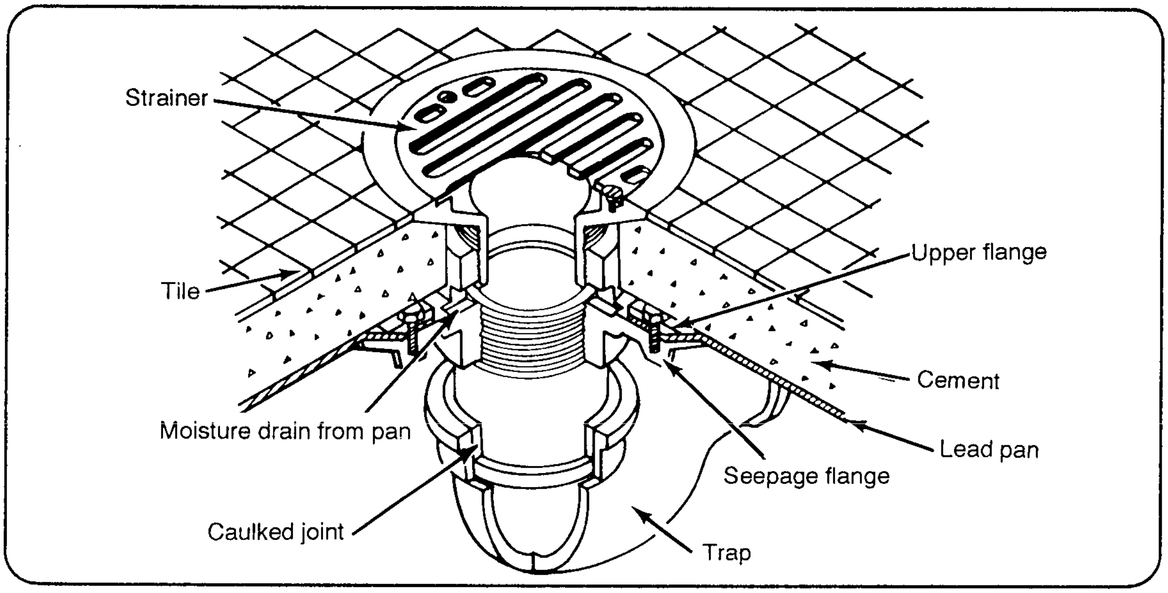


Figure 4-21. Shower pan installation

c. *Water-Supply Connection.* The water supply for a shower may be hidden in the wall or exposed. Figure 4-22 shows exposed hot- and cold-water lines tied into a single water line ending in a shower head. The cold-water line is brought in on the right side while the hot-water line is brought in on the left. A variety of faucet and valve combinations is available on unexposed installations (Figure 4-23, page 4-24). The compression valve provides a tempered water line of chromium-plated tubing, ending in a gooseneck and shower head. In the single-handle mixing valve, the hot and cold water are mixed in a cast-brass mixing chamber. The handle controls a piston-like valve. By turning the valve handle clockwise, warmer water is supplied to the shower head. A greater variety of shower heads than valves is available (see Figure 4-20, page 4-21).

4-7. Bathtubs.

a. *Types.* A variety of built-in bathtubs is available. They are designed to be recessed for corner installation of square, rectangular, and angled tubs and tubs with one or more ledge seats. Tubs are made of enameled cast iron/steel, or fiberglass.

b. *Installation.* Modern cast-iron tubs are designed to rest on the floor and fit against the wall framing (studs). They need no wall support, except that steel tubs have flanges supported by l-inch x 4-inch boards, nailed to the studs. Use a waterproofing cement to caulk the joint between the finished wall surface and the tub. The over-rim tub filling, with or without a shower diverter, is mounted on the wall at one end of the tub. The drain may be the pull-out or pop-up type. A removable service panel in the wall behind the tub provides access to the trap and the water-supply valve.

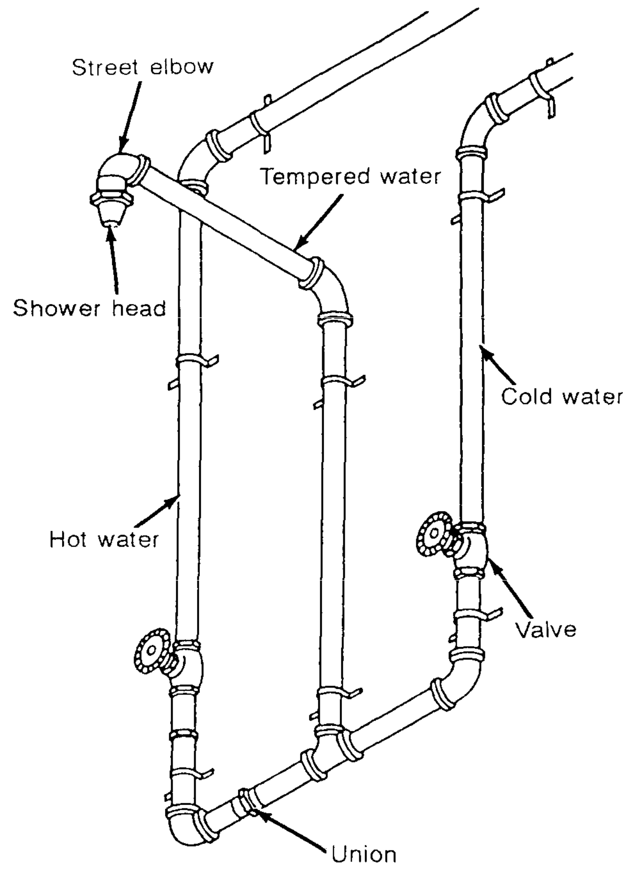


Figure 4-22. Shower with exposed piping

4-8. Laundry Tubs. Laundry tubs are usually placed in the basement or utility room.

a. *Types.* The most common type is concrete with a metal rim, although enameled cast-iron/steel and plastic units are also available. They come in single - and double-compartment styles (Figure 4-24, page 4-24).

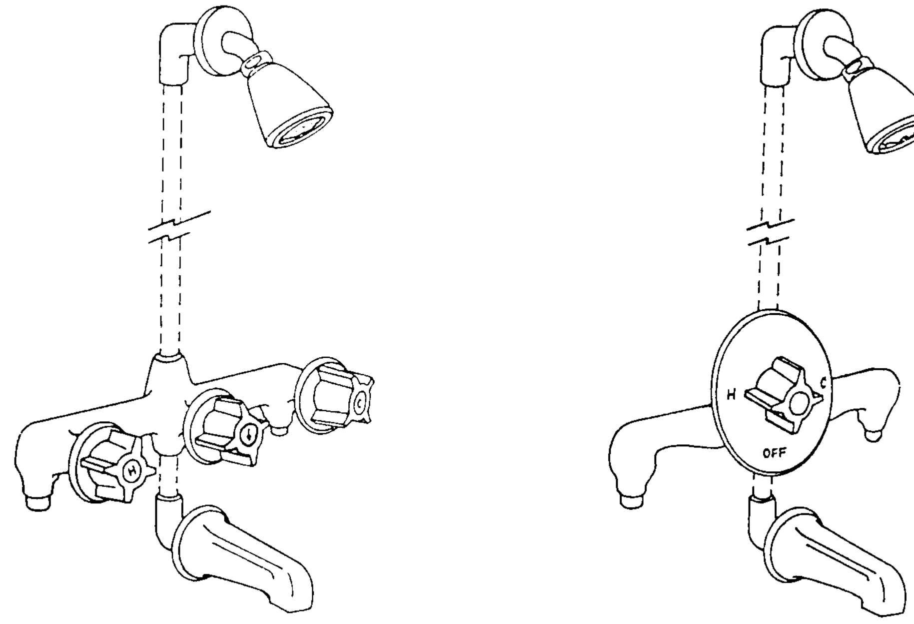
b. *Installation.* Use Figure 4-25 (page 4-25) and the following procedure: (See Chapter 7, paragraph 7-4, pages 7-8 and 7-9, for faucet installation.)

Step 1. Assemble the metal stand by bolting its sections together.

Step 2. Place the stand in a convenient place in front of the rough-in piping and carefully set the tub on the stand.

Step 3. Connect the P-trap to the tub, as shown in Figure 4-25 (page 4-25).

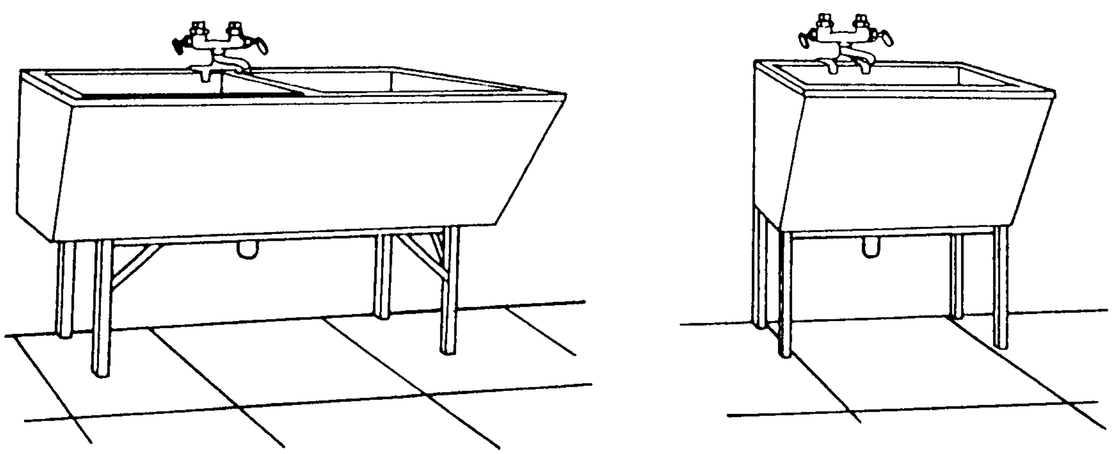
Step 4. Connect a swing-combination faucet to the hot- and cold-watct supply lines. Usually, the faucet is furnished with a hose bibb for attaching a hose.



Combination Compression Faucet
(with or without shower)

Single-Knob Noncompression Faucet
(with or without shower)

Figure 4-23. Showers with unexposed piping



Double

Single

Figure 4-24. Laundry tubs

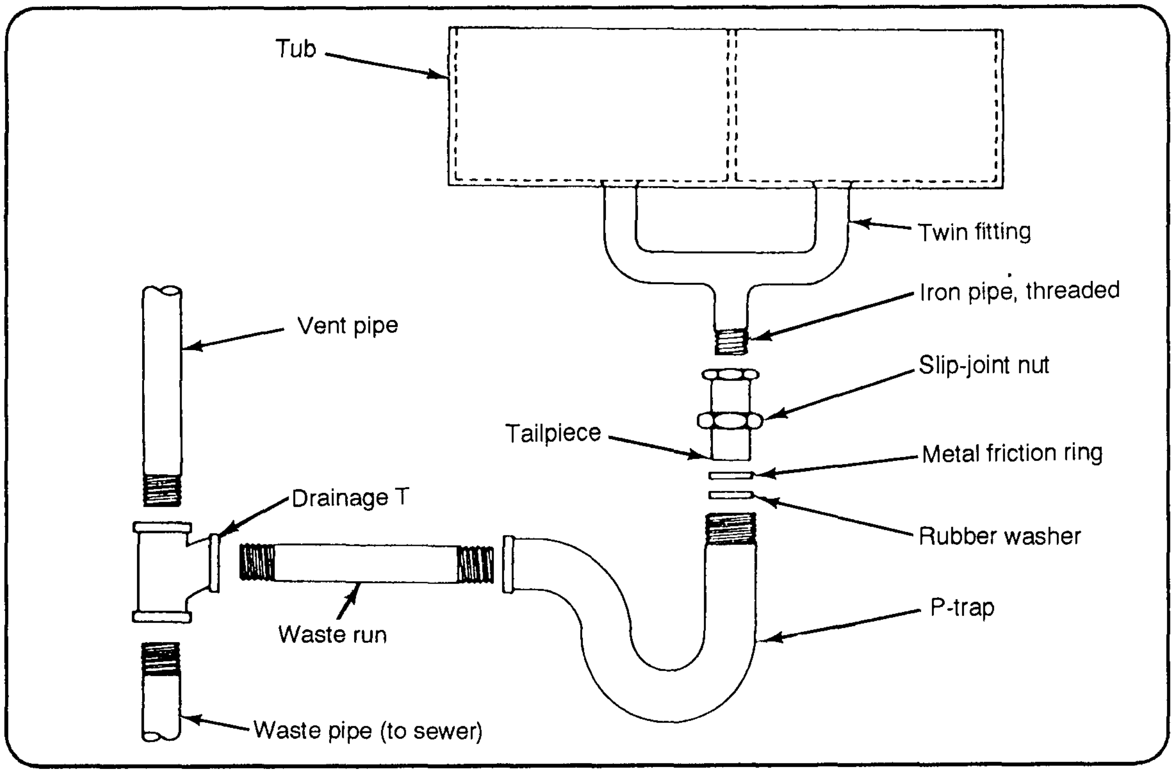


Figure 4-25. Laundry tub installation

4-9. Drinking Fountains. Drinking fountains, shown in Figure 4-26 (page 4-26), are made of porcelain enameled steel, cast iron, or stainless steel.

a. *Types.* The three types of drinking fountains are—

(1) *Pedestal.* The pedestal fountain needs no wall support.

(2) *Wall-Hung.* The wall-hung fountain is bolted to a mounting board on the wall.

(3) *Electrically Cooled.* The electrically cooled fountain has a refrigerating unit in which the water passes over refrigerating coils to be cooled before being supplied to the drinking outlet.

b. *Installation.* Sanitation is an extremely important consideration when installing drinking fountains. Water from the drinking outlet should not fall back on the bubbler head. The bubbler head should project at least 3/4 inch above the rim of the fountain and be located so that a person's mouth cannot touch it. The fountain drain should have a good strainer to keep chewing gum and other objects from entering the drain line.

Fountains should be installed with the bubbler head at a height designed for the average user. The mounting must be sturdy to support considerable weight in addition to that of the fixture. Install a 1 1/4-inch P-trap below the waste pipe. The electrically cooled fountain requires a nearby electrical outlet. Follow the manufacturer's instructions when installing a water fountain.

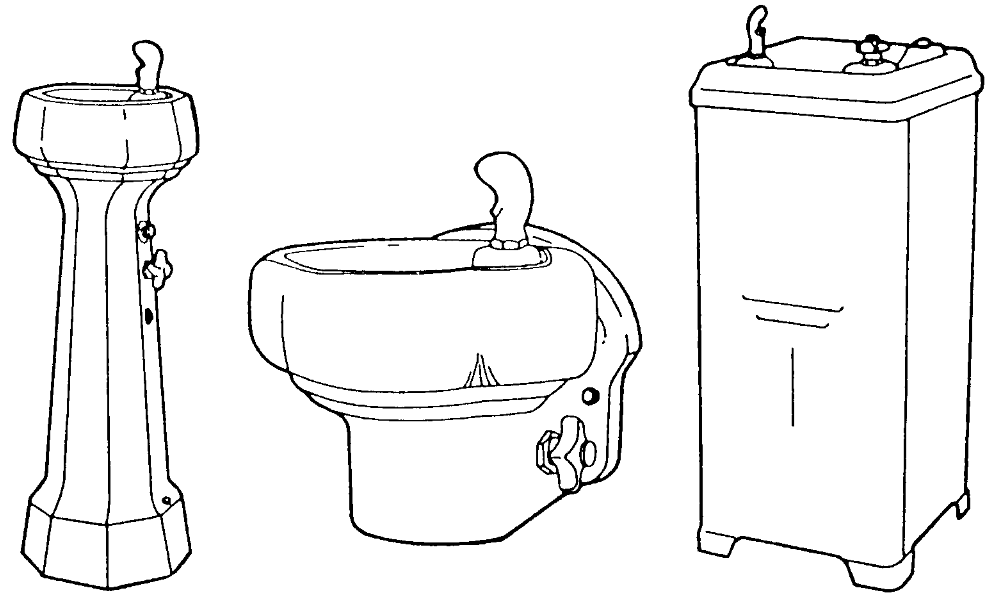


Figure 4-26. Water fountains

CHAPTER 5
WATER HEATERS

Water heaters are classified into four categories: range boilers, gas, oil-burning, and electric storage heaters. Each type should have a temperature- and pressure-relief valve and a sediment drain at the lowest part of the tank. Relief valves are set to allow water to blow into a drain line when the pressure exceeds 210°F (81°C), or when the pressure exceeds 125 psi.

5-1. Types.

a. *Range Boilers.* The range boiler is a hot-water storage tank, varying from 1 to 5 feet in diameter and from 6 to 15 feet in length. It has a furnace coil, an exterior device to heat the water, or a combination of the two.

(1) *Range Boiler and Furnace Coil.* In the range boiler and furnace-coil arrangement shown in Figure 5-1, the range boiler is usually mounted upright on a stand. A drain is placed at the bottom to remove sediment, and a temperature- and pressure-relief valve is placed at the top for safety. The furnace coil is located in the furnace firebox, which supplies heat to the building. This type of installation is of value only when the furnace is heating the building; it is impractical in the summer months.

(2) *Range Boiler and Heater.* In the range boiler and heater installation (Figure 5-2, page 5-2) , the boiler is usually installed horizontally on a stand. The heater may be fired by coal, gas, or oil.

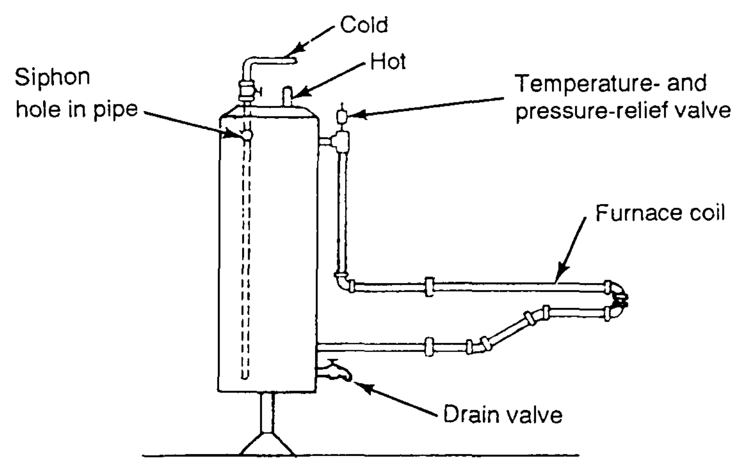


Figure 5-1. Range boiler and furnace-coil installation

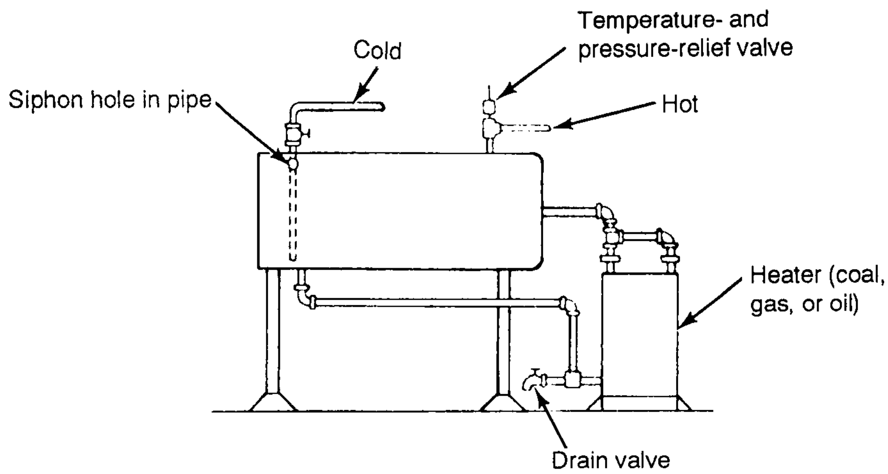


Figure 5-2. Range boiler and heater installation

b. *Gas Heaters.*

(1) *Side-Arm Gas Heater.* The side-arm gas heater (Figure 5-3) (usually in older installations) is used mostly during the summer months to support furnace-oil water heaters.

(2) *Gas Storage Heater.* The gas storage heater (Figure 5-4) is a galvanized-iron, copper, or porcelain-lined (gas-lined) steel tank enclosed in an insulating jacket. A gas burner provides the heat. The temperature of the water in the insulated tank is controlled by the thermostat. Its operation is automatic and will keep water at any temperature from 110° to 165°F (43° to 60°C), according to the setting on the thermostat. When gas is available, the gas storage heater provides an efficient and inexpensive way to supply hot water at all times.

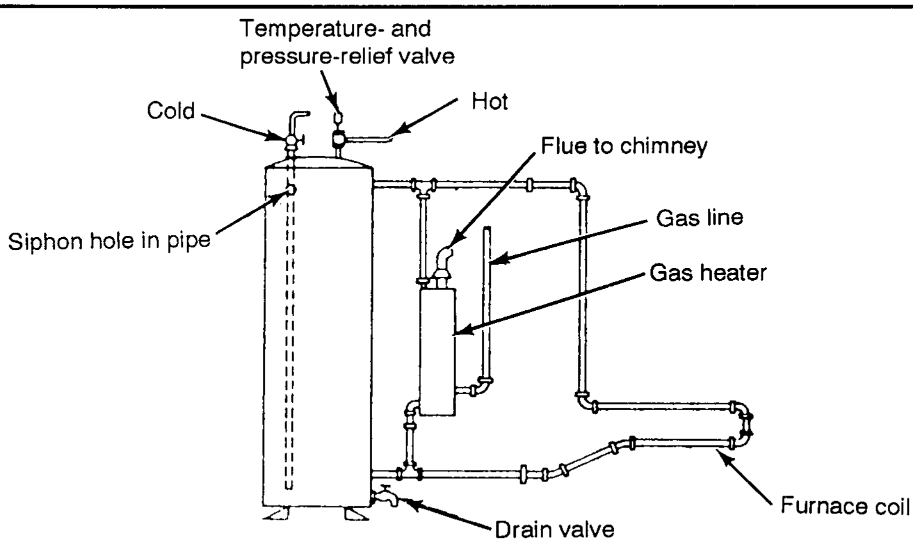


Figure 5-3. Side-arm gas heater

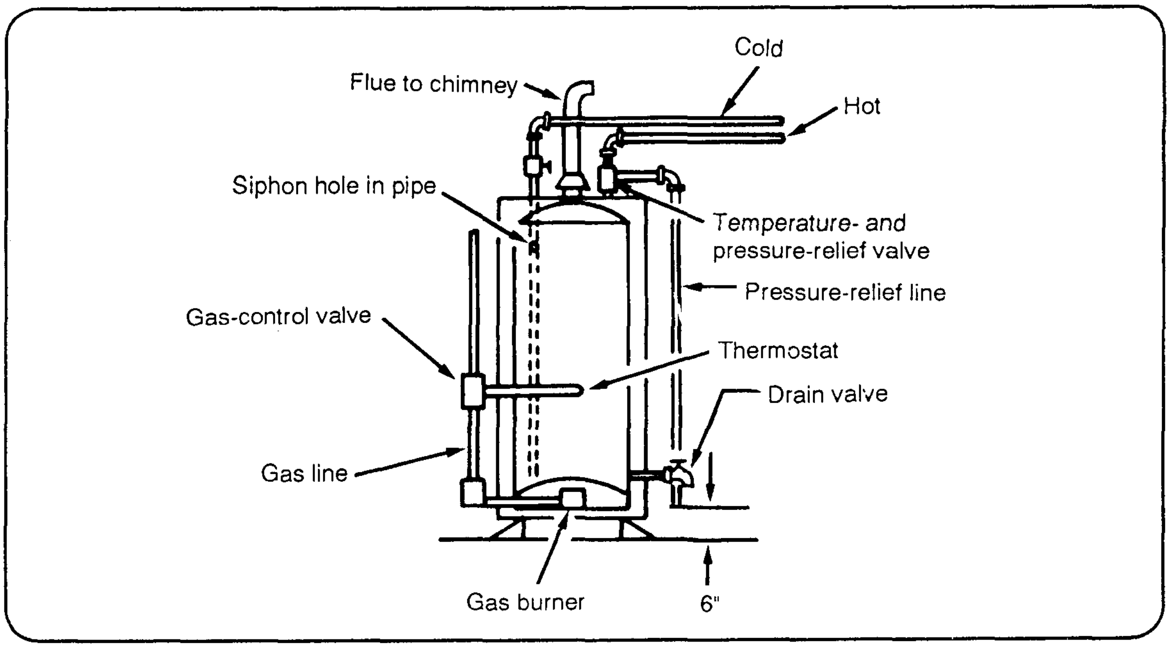


Figure 5-4. Gas storage heater

DANGER

Whenever gasoline or oil heaters are used, there is danger of carbon monoxide poisoning, lead poisoning, or serious illness or death from explosions. Only experienced personnel should be allowed to operate them. (See paragraph 5-3, page 5-6.)

c. *Oil-Fired Storage Heater.* The oil-fired storage heater is similar to the gas storage heater, except that heat is supplied by a vaporizing or a pressure oil burner.

d. *Electric Storage Heater.* The electric storage heater (Figure 5-5) normally has two immersion-type healing elements. The upper heater usually has higher wattage than the lower. Thermostats control these elements to ensure the operation is automatic. The heater does not need a flue or smoke pipe, since there are no burning products. The electric storage heater may be located away from the chimney; in a closet, for example.

e. *Field Water-Heating Devices.* Under field conditions, water-heating devices are desirahle to maintain the health, cleanliness, and morale of the troops. In some climates, heat from the sun will take the chill from shower water. (More heat from the sun can be absorbed by painting water containers black.) When a device is needed to heat water, it can be assembled by using available materials. Two devices for mess-kit washing and showers arc the vapor burner and the oil-water flash burner, which is assembled from a kit.

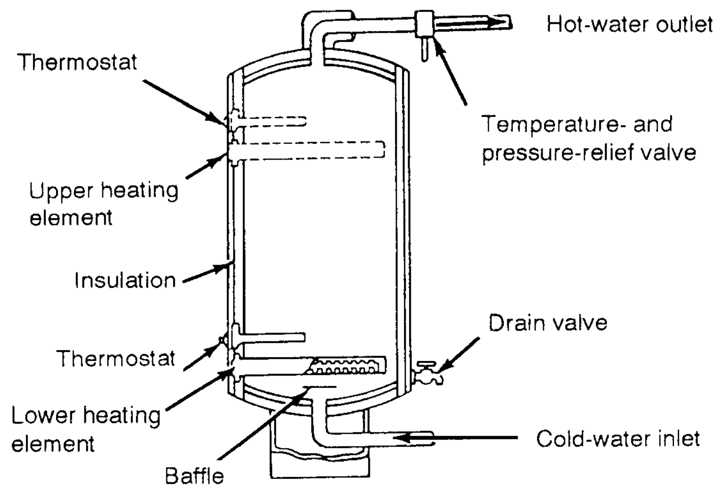


Figure 5-5. Electric storage heater

(1) *Vapor Burner.* Fuels such as diesel oil, kerosene, gasoline, or a combination arc used. In cold climates, gasoline may be added to thin the oil before use. To construct the burner, several sections of pipe, a valve, pipe fittings, and a fuel reservoir are needed. The burner operates by preheating the fuel to form a vapor before burning. Figure 5-6 shows a vapor burner for a mess-kit washing setup, as described in the following procedures:

Step 1. Assemble the pipe so that it doubles under itself. The best pipe size to use is 1/2- or l/4-inch.

Step 2. Drill small holes (1/16 inch or less) in the top of the lower pipe, where the water containers will be placed.

Step 3. Cap the end of the pipe so that fuel can only escape from the drilled holes.

Step 4. Burn the fuel from the lower pipe to heat the fuel in the upper pipe, causing the fuel to vaporize. The vapor causes pressure in the lower pipe and forces the fuel out through the holes as a spray, making a better flame.

Step 5. Place the pipes in a fire trench for more efficient operation. The trench should be about 1 foot wide and 15 inches deep.

Step 6. Coil iron wire around the lower pipe near the holes and around the upper pipe just above the holes to serve as an automatic relighting device. The wires become red hot after the burner has been operating for a few minutes. If the flame goes out, the heat from the wires relights the fuel, preventing an explosion of gas collected in the trench.

Step 7. Before lighting the burner, open the control valve to allow a small amount of fuel to run through the lower pipe.

Step 8. Ignite the fuel by heating the upper pipe and starting the fuel-heat-gas pressure cycle.

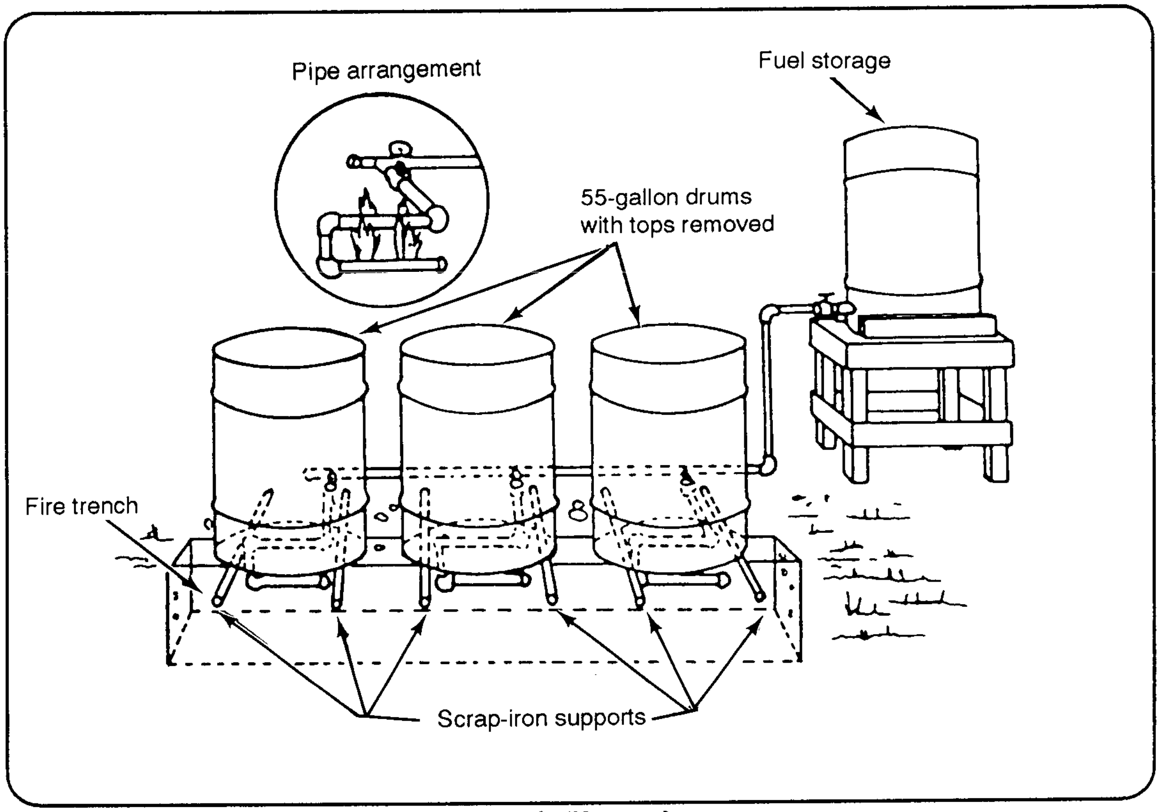


Figure 5-6. Vapor burner

(2) *Oil-Water Flash Burner.* This burner can be assembled and installed from a kit, following manufacturer's instructions. A properly operated burner produces a blue flame. If a blue flame blows itself out, insufficient fuel is getting through the holes. Opening the valve slightly or enlarging the holes will correct this situation. A yellow flame indicates incomplete burning caused by too much fuel escaping from the holes. Closing the valve slightly or decreasing the size of the holes may correct this condition.

5-2. Sizes. The maximum load and the working load determine the amount of hot water needed per hour. A heater with a storage capacity and recovery rate supplying that amount should be installed.

a. *Maximum load.* The maximum load of a water heater is the maximum amount of water used daily per person per hour. (The amount of daily water used is spread over several hours.) The amount of water varies with style of living and type of building. To determine the size of the hot water heater for a building, consider the maximum hourly use and number of users. Generally, the maximum hourly use of hot water per person would be—

Schools.. 2 or 3 gallons.

Offices................................ 4 or 5 gallons.

Living quarters and barracks.........8 to 10 gallons.

b. *Working Load.* The working load of a water heater is the percentage of maximum load expected under normal conditions in any given hour. Approximate working loads are—

School or office buildings ....25 percent.

Residential buildings ....35 percent.

Barracks buildings .... 40 percent.

EXAMPLE

The capacity of a water heater for a barracks that houses 50 soldiers can be determined as follows:

50 users x 8 gallons per hour (GPH) each = 400 gallons

400 gallons x 40 percent working load = 160 gallons

A heater with a 100-gallon storage capacity and a 60-GPH recovery rate (100°F rise) could be installed.

***5-3.* Operation Hazards.** Operation hazards and methods of reducing them areas follows:

- *Carbon monoxide poisoning.* Carbon monoxide is a colorless, odorless gas given off when burning is incomplete. The hazard may be removed by proper operation and adequate ventilation.
- *Lead poisoning.* Lead poisoning results from using leaded fuel such as ethyl gasoline. Breathing the vapors is very dangerous. Adequate ventilation is absolutely necessary.
- *Explosion.* A serious explosion can occur when a burner is not built or operated properly. If the flame of a burner goes out and the fuel is not turned off or relighted immediately, gas may build up. An explosion can result if the gas is ignited. The vapor burner is more dangerous than the oil-water flash burner, but the vapor burner's automatic relighting device reduces the chance of an explosion.

CHAPTER 6

PIPES AND FITTINGS

Pipes and fittings for plumbing systems are classified into four basic groups: (1) cast-iron soil pipe and fittings, (2) galvanized-steel/iron pipe and fittings, (3) copper tubing and fittings, and (4) plastic pipe. Other pipes are also covered in this chapter.

6-1. Pipe Selection. Table 6-1 gives the characteristics and use of pipes and fittings in a plumbing system. Appendix C covers pipe capacities and allowance for friction loss in pipes.

Table 6-1. Pipe characteristics and uses

Type of Pipe	Rigid	Flexible	System	
			Water	Waste
Cast-iron soil pipe				
Hub and spigot	•			•
Double hub	•			•
Hubless	•			•
Galvanized-steel/iron pipe	•		•	•
Copper tubing				
K - thick wall	•	•	•	
L - medium wall	•	•	•	
M - thin wall	•		•	
DWV - drain waste vent	•			•
Plastic pipe				
PB - polybutylene		•	•	
PE - polyetylene		•	•	
PVC - polyvinyl chloride	•		•	•
*CPVC - chlorinated polyvinyl chloride	•		•	
ABS - acrylonitrile-butadiene-styrene	•			•

* CPVC is used for cold- and hot-water systems.

6-2. Pipe Assembly Materials.

a. *Joint Materials.* All joints must be watertight and gas tight. To do this. a specific material is used with each kind of pipe. Refer to the following and to definitions in the back of this manual:

(1) *Oakum.* Oakum is hemp or jute fibers soaked with a bituminous compound. It is loosely twisted or spun into a rope or yarn. It is used with lead or other materials to make caulked joints in hub-and-spigot cast-iron pipe and in vitrified-clay tile or concrete pipe.

(2) *Lead.* Lead is melted and poured into the joint. Alternatively, lead wool or shredded lead, packed cold, may be used on top of the oakum in caulked joints.

(3) *Pipe-Joint Compound* Thread and pipe joints are made by using one of several compounds, referred to as *dope,* for protecting the threads and for easy maintenance.

(4) *Solder.* Solder is used with solder fittings to join copper tubing and brass and copper pipe. A nonacid flux (a substance, such as rosin, applied to promote union of materials) must be used. A 50-50 solder (50 percent tin and 50 percent lead) is used for copper tubing.

(5) *Solvent Cement.* Solvent cement is used with plastic fittings to join rigid plastic pipe. This cement comes in several types for each different plastic pipe and fitting.

(6) *Bitumen.* Bituminous compounds, such as asphalt and tar pitch, are used to make joints in vitrified-clay tile and concrete pipe.

(7) *Gaskets.* Flange joints need gaskets of rubber, cork, composition, sheet metal, or other material.

b. *Other Materials.* In addition to the following, some materials are named under the different types of pipes in this chapter.

(1) *Sheet Metal, Aluminum, Lead Copper, and Galvanized-Iron. These* materials are used for flashing around stacks and for shower pans.

(2) *Pipe Hangers.* Many types of hangers for supporting pipe are available (Figure 6-l). Among the most common are the perforated iron strap furnished in rolls and cut to length, U-shaped wire hangers, and iron-ring hangers.

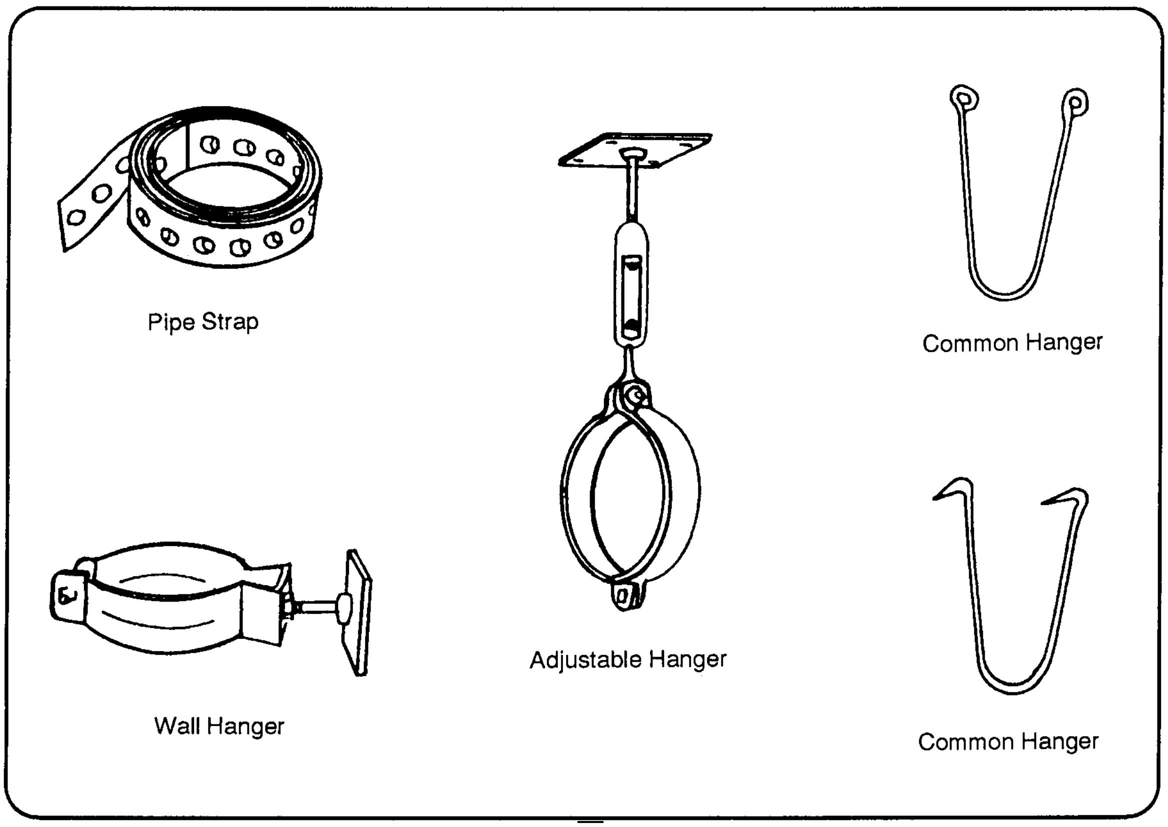


Figure 6-1. Pipe hangers

(3) *Oil.* Cutting oil or lard oil is used as a lubricant when cutting threads on pipe.

(4) *Insulation.* See Chapter 12 for pipe insulation.

6-3. Pipe Measurements. Fittings are part of a pipe-run length. The total length measurement must include the distance (engagement) a pipe goes into a fitting and the fitting's dimensions. This section describes determinations and definitions of pipe runs and plumbing measurements.

a. *Definitions.*

(1) *Pipe Engagement.* The distance the pipe goes into a fitting. The distance the pipe goes into a fitting is determined by its nominal size diameter (Figure 6-2).

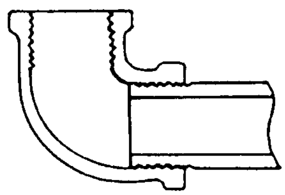
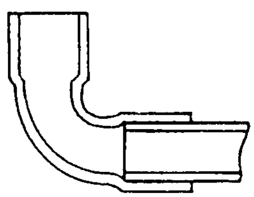
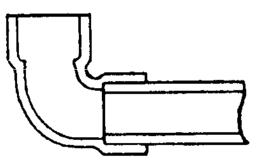
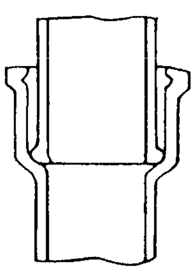
Type of Fitting Material	Nominal Size Diameter (in inches)	Approximate Pipe Engagement (in inches)
Steel, Threaded (Pipe-joint compound) 	1/8 1/4 3/8 1/2 3/4 1 1 1/4 1 1/2 2 3	1/4 3/8 3/8 1/2 9/16 11/16 11/16 11/16 3/4 1
Copper (Solder) 	1/4 3/8 1/2 3/4 1 1 1/4 1 1/2	5/16 3/8 1/2 3/4 15/16 1 1/18
Plastic (Solvent cement) 	1/2 3/4 1 1 1/4 1 1/2 2 3 4	1/2 5/8 3/4 11/16 11/16 3/4 1 1/2 1 3/4
Cast-iron (Oakum and lead) 	2 3 4 5 6	2 1/2 2 3/4 3 3 3

Figure 6-2. Pipe engagements into fittings

(2) *Fitting Dimension.* A fitting's dimension is from the center of a fitting to the end of the fitting, as shown in Figure 6-3. Use this dimension when the fitting is part of the pipe-run length.

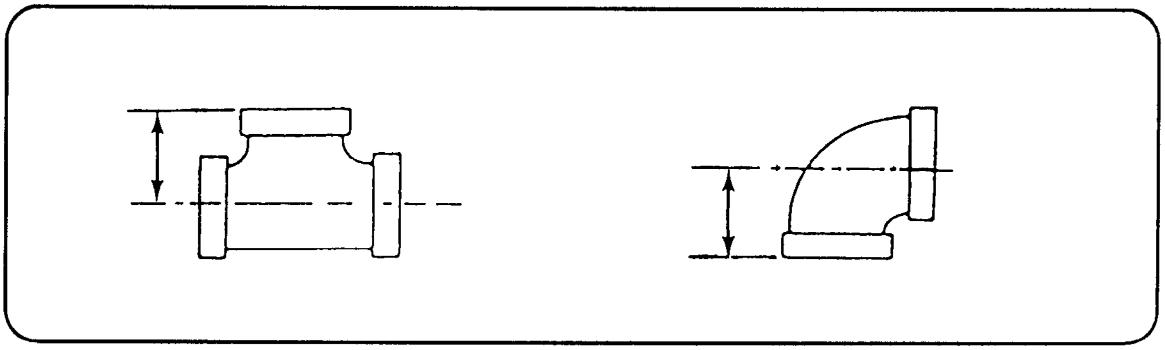


Figure 6-3. Fitting dimension

b. *Types of Measurements.* Of the several methods of measuring pipe lengths, the ones most commonly used are the face-to-face and the center-to-center methods, as shown in Figure 6-4.

(1) *Face-to-Face.* A face-to-face measure is the distance between the face of each fitting. To determine the pipe length needed, add the pipe engagement into each fitting to the face-to-face measurement.

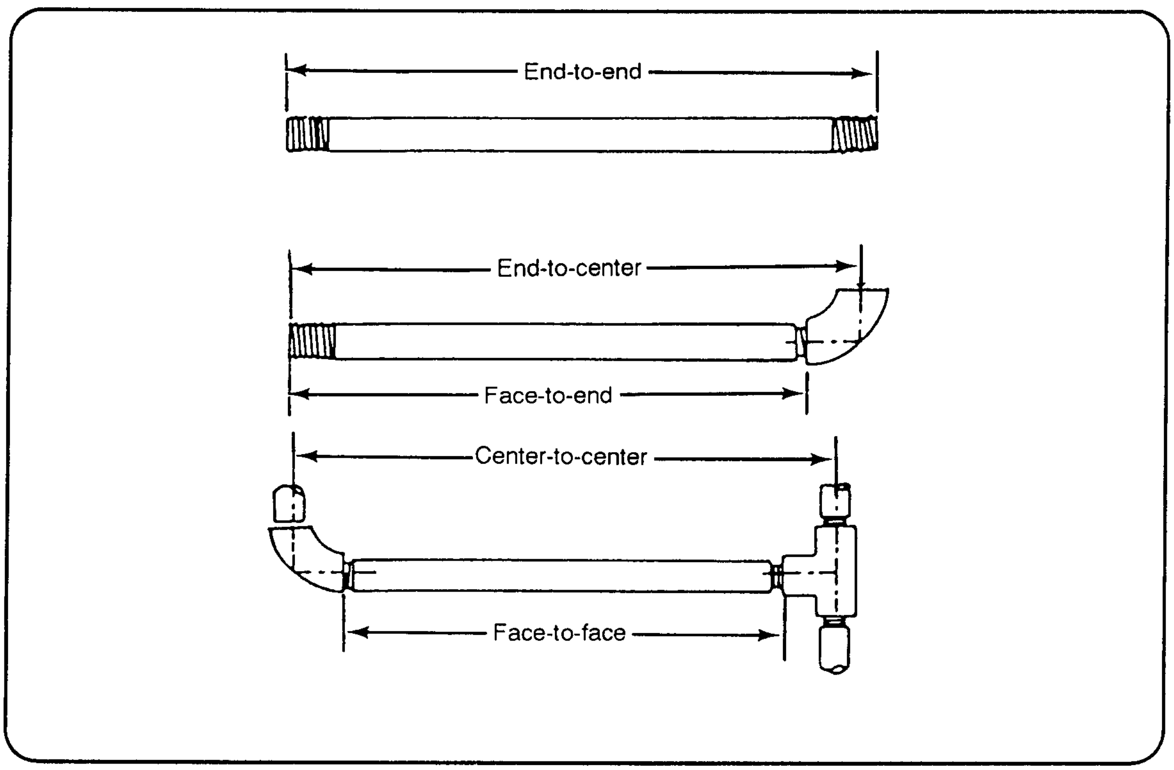


Figure 6-4. Types of measurements

(2) *Center-to-Center.* A center-to-center measure is used when pipe fittings are on each end. To determine the pipe length needed, subtract the sum of both fitting dimensions and then add the sum of both pipe engagements.

(3) *End-to-End.* End-to-end measure is the full length of pipe, including both threads.

(4) *Offset.* An offset measurement is used to install a pipeline run around an obstacle (Figure 6-5). The following procedure explains how to run an offset using 3-inch, steel-threaded pipe; 45-degree elbows with a fitting dimension of 4 5/8 inches; and a l-inch, threaded-pipe engagement:

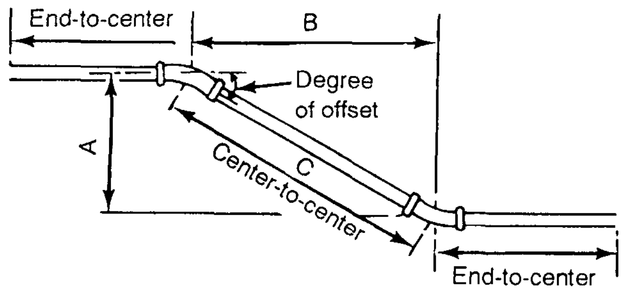


Figure 6-5. Offset measurement

EXAMPLE

Step 1. Determine the vertical distance "A" from center of pipe to center of pipe. In this example, the distance is 40 inches.

Step 2. Refer to Table 6-2 (page 6-6) for the 45-degree offset constant, which is 1.4142.

Step 3. Multiply 1.4142 inches by 40.

1.4142 x40= 56.5680 = 56.57= 56 9/16 *inches of pipe*

Step 4. Since two elbows are needed, subtract the sum of both elbow fitting dimensions from 56 9/16 inches. A 3-inch, 45-degree elbow fitting dimension is 4 5/8 inches.

45/8 + 4 5/8= 8 10/8= 9 2/8= 9 1/4 (or 9 4/16)

56 9/16 -9 4/16= 47 5/16

Step 5. Add the sum of l-inch pipe engagement for each fitting to 47 5/16 inches.

47 5/16 + 2 = Total pipe length needed for "C"

Table 6-2. Offset degree constants

Degree of Offset	When A = 1, B =	When B = 1, A =	When A = 1, C =
60°	0.5773	1.7320	1.1547
45°	1.0000	1.0000	1.4142
30°	1.7320	0.5773	2.0000
22 1/2°	2.4140	0.4142	2.6131
11 1/4°	5.0270	0.1989	5.1258
5 3/8°	10.1680	0.0983	10.2170

6-4. Cast-Iron Soil Pipe and Fittings. Cast iron is available in two different wall thicknesses or weights, service weight (SW) and extra heavy weight (XH).

a. *Use.* Cast-iron soil pipe is used for sewers, drains, stacks, and vents in a waste system. SW is used in households and is adequate for most military construction; XH is used where liquids may corrode the pipe or where greater strength is needed for tall stacks or under roadways.

b. *Types and Sizes.* This pipe is manufactured in three different types (Figure 6-6):

(1) *Hub and Spigot.* Hub-and-spigot pipe comes in 5-foot lengths ranging in diameter from 2 to 15 inches.

(2) *Double Hub.* Double-hub pipe comes in lengths ranging in diameter from 2 to 15 inches.

(3) *Hubless.* Hub less pipe comes in 10-foot lengths ranging in diameter from 1 1/2 to 8 inches.

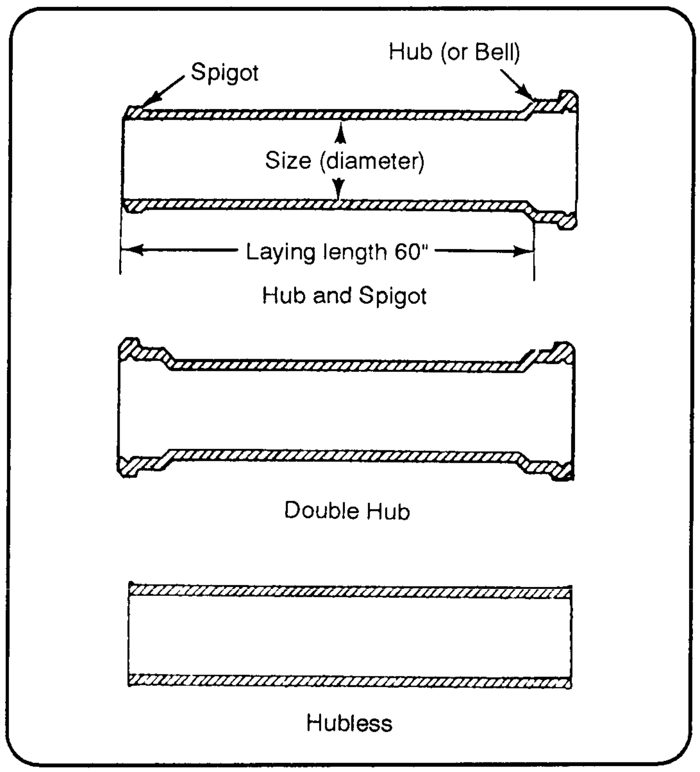


Figure 6-6. Cast-iron pipes

c. Handling and Storage. This pipe is heavy and brittle; therefore, it must be stored and handled with care to prevent cracks or breakage.

d. *Fittings.* The major types of fittings used for cast-iron pipe are Ts, Y-branches, bends, and traps. (Less commonly used fittings are listed in paragraph 6-4d(6), pages 6-8 and 6-9.) These fittings are used for connecting hub-and-spigot or hubless cast-iron pipes.

(1) *Ts.* The Ts are *sanitary* if designed to carry drainage and *straight* when used for vent lines (Figure 6-7). Use a tapped T, either sanitary or straight, to connect threaded-pipe branch drains or vent lines. Use a test T for testing a newly installed waste system for leaks. A T's size is always given first by the through section (run) and then by the takeoff (outlet).

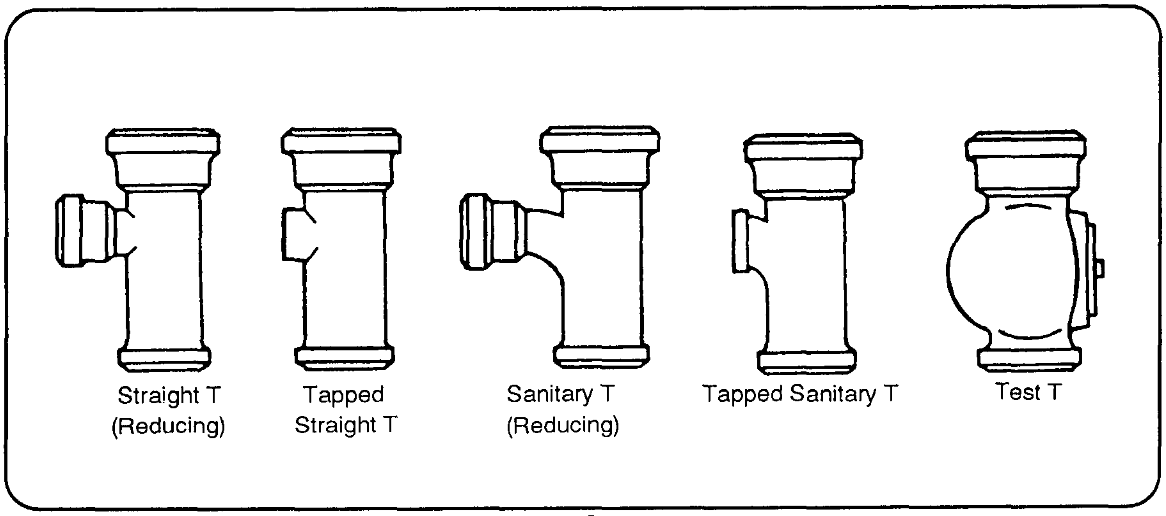


Figure 6-7. Cast-iron Ts

(2) Y-Branches. Y-branches are used to join one or more sanitary sewer branches or to connect a branch to a main line. This design allows a smoother change in flow direction. The most common Y-branches are the 45- and 90-degree types (Figure 6-8, page 6-8).

- *45-Degree.* A 45-degree Y-branch has a side takeoff entering the through section at a 75-degree angle. The side takeoff may be the same diameter or of smaller diameter. If the take off is smaller, it is a reducing Y-branch. Other types of 45-degree branches are inverted, tapped, and tapped inverted.
- *90-Degree.* The 90-degree Y-branch, also called a combination Y and 1/8 bend or T-Y, is made in several shapes. The double 90-degree Y-branch is used extensively in a unit vent installation. The box 90-degree Y-branch with a side takeoff on each side is used to install a stack in a room corner. The 90-degree Y-branches also have tapped side takeoffs.

(3) *Bends.* Bends are used to change the direction of a cast-iron pipeline. The degree of direction change is given as a common math fraction. Bends are designated in fractions of 1/16, 1/8, 1/6, 1/5, 1/4, and 1/2 as they change the direction of 22 1/2, 45, 60, 72, 90, and 180 degrees, respectively. These bends can be regular, short sweep, or long sweep (Figure 6-9, page 6-9).

(4) *Closet bends.* A closet bend is a special fitting to connect a soil-waste branch line for a water closet (toilet). It can be plain or tapped for waste or venting. Closet bends are made to fit different types of floor flanges (rims for attachment). One type may have a spigot end for caulking, which is marked for cutting to a desired length. Another type has a hub end, which connects to the floor flange with a sleeve as shown in Figure 6-9 (page 6-9).

(5) *Traps.* A trap provides a water seal, which keeps sewer gases from entering a building through a waste outlet. The most common type is a P-trap. The P-trap is used in a partition to connect a drain to a waste branch, A running trap is used in a building's drain line when the local plumbing codes require that the building drain be trapped. Figure 6-10 (page 6-10) shows four general types of cast-iron soil pipe traps. (See Chapter 9 for further information on traps and trap seal loss.)

(6) *Other Fittings.* The following fittings (except the tucker coupling) may be used on all types of pipe.

- *Offset.* An offset (Figure 6-11, page 6-10) carries soil or waste line past an obstruction in a building. Offsets are either regular or 1/8 bend. The 1/8 bend gives smoother transition than the regular one.
- *Increaser. An* increaser (Figure 6-11, page 6-10) increases the diameter of a straight-through pipeline. It is usually used at the top of a stack.

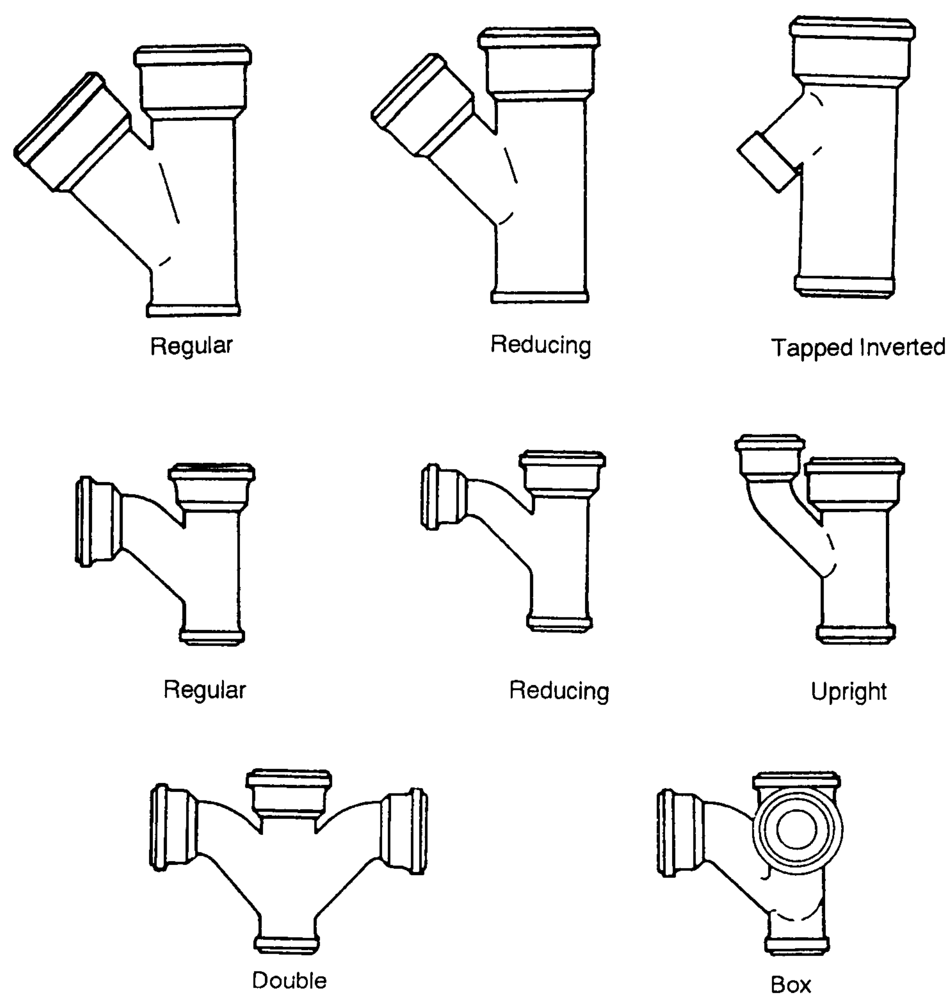


Figure 6-8. Cast-iron 45- and 90-degree Y-branches

- *Cleanout.* The cleanout (Figure 6-ll, page 6-10) is a removable threaded plug placed in drainage lines for cleaning or removing stoppages.
- *Tucker coupling.* The tucker coupling fitting (Figure 6-11, page 6-10) connects a hub-and-spigot pipe section to a threaded pipe section. This fitting has a hub on one end and female threads at the other end.
- *Sewer thimble.* The sewer thimble (Figure 6-11, page 6-10) is a special fitting, which connects the building sewer line to the main sewer line.

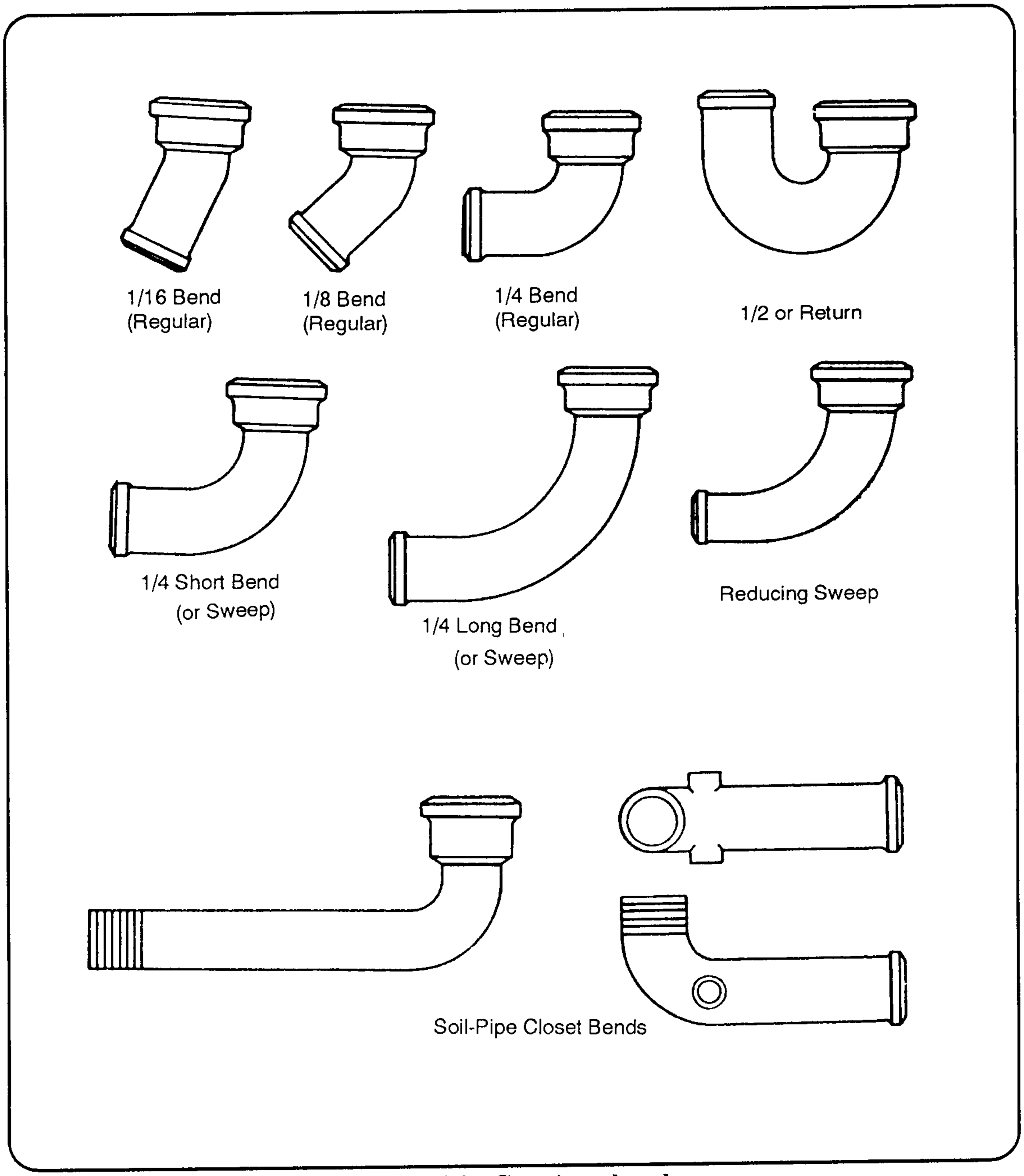


Figure 6-9. Cast-iron bends

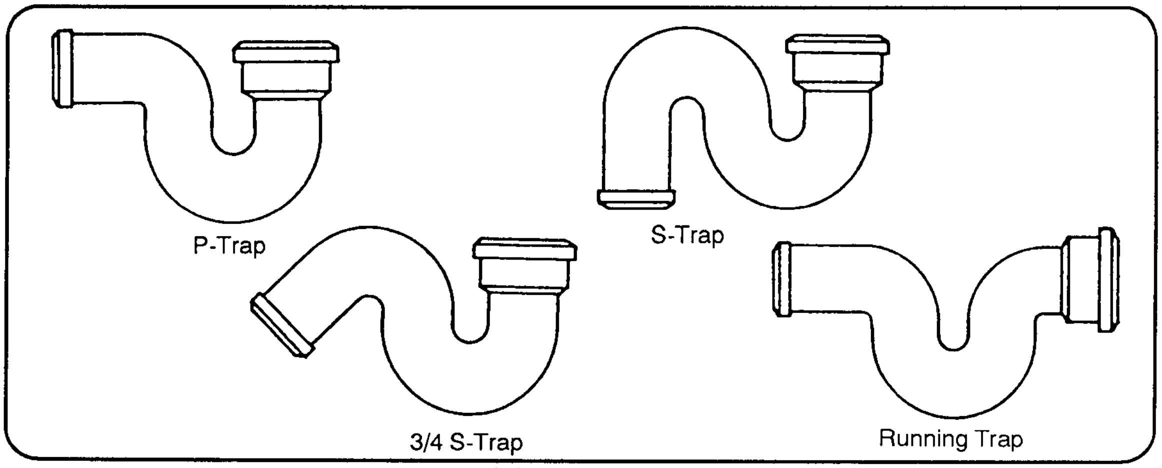


Figure 6-10. Cast-iron traps

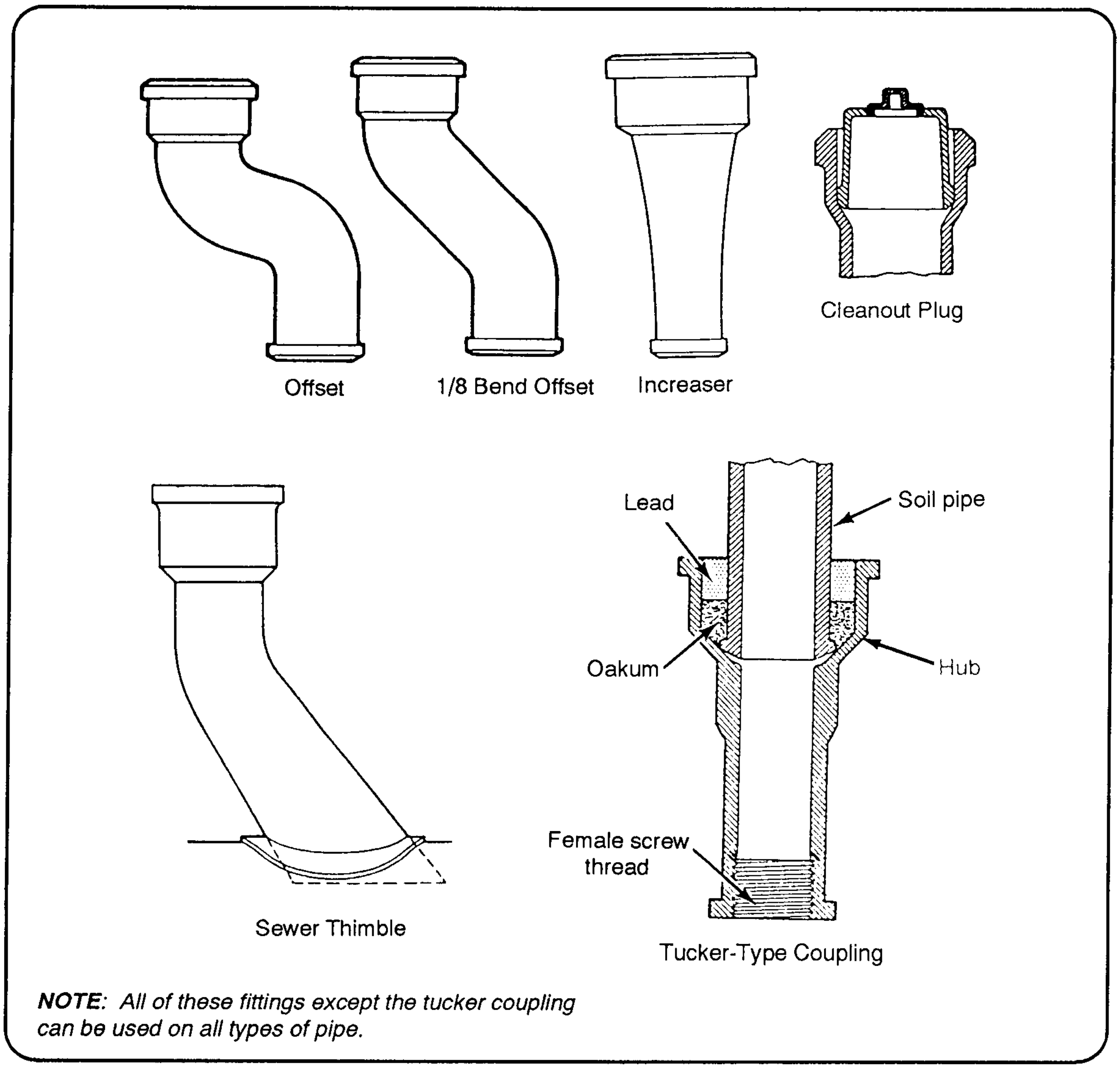


Figure 6-11. Cast-iron fittings

e. *Measuring.* Measure cast-iron soil pipe using one of the methods in paragraph 6-3b (pages 6-4 and 6-5).

f. *Cutting.* The pipe can be cut by scoring with a hammer and cold chisel or by cutting with a soil-pipe cutter (Figure 6-12). Use the following procedure:

Step 1. Make a chalk or crayon mark completely around the pipe where it will be cut.

Step 2. Cut the pipe with a soil-pipe cutter or by using a hammer and cold chisel.

- *Soil-pipe cutter.* Set the pipe in a vise and position the cutting wheels on the mark by turning the adjusting knob. Apply pressure on the handle until the pipe is cut. Use the adjusting knob to keep a good bite on the pipe (Figure 6-13).
- *Hammer and cold chisel.* Place the pipe on a board or mound of dirt at the point to be cut. Then place the chisel's cutting edge on the mark and hit it lightly with the hammer while rotating completely around the pipe. Continue scoring around the pipe using harder blows until the pipe is cut (Figure 6-13).

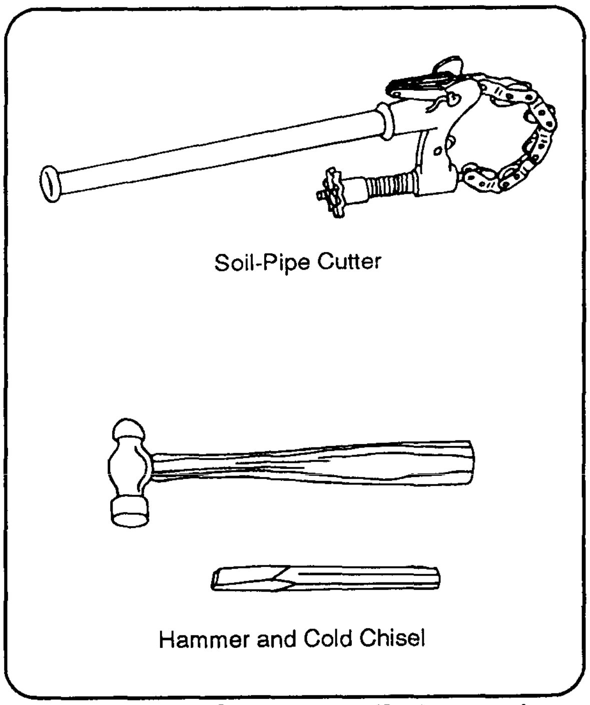


Figure 6-12. Cast-iron soil-pipe cutting tools

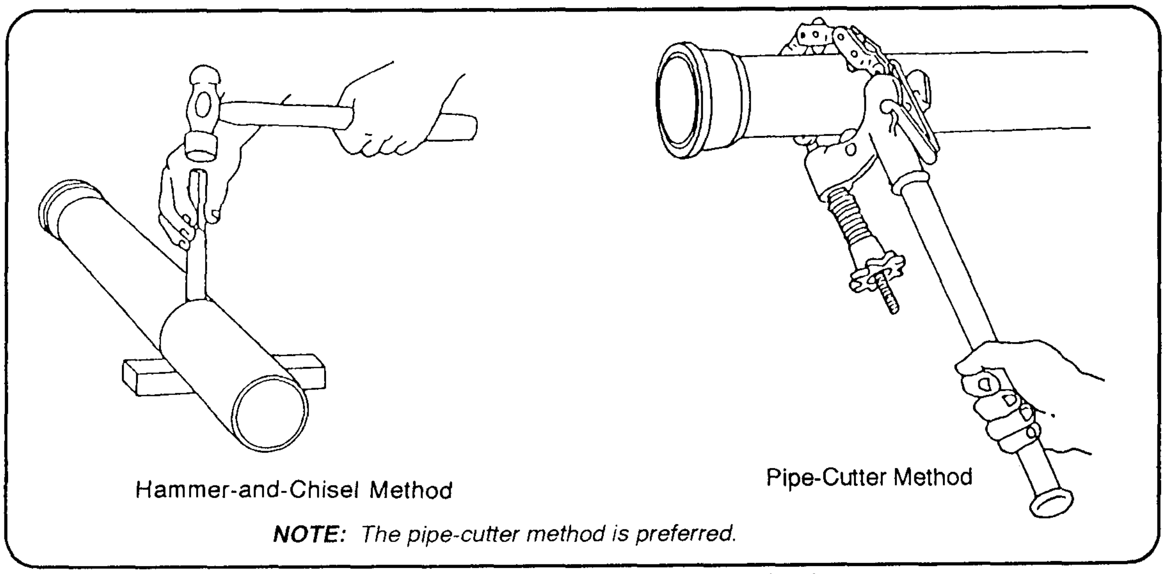


Figure 6-13. Cutting cast-iron soil pipe

g. *Joining.* Determine the amount of oakum and lead for a lead joint by the pipe size being connected (Table 6-3). Other types of joint materials-compression gaskets and neoprene sleeves with stainless steel clamps—are manufactured for different pipe sizes.

(1) *Hub-and-Spigot Joint.* Hub-and-spigot pipe joint is made with oakum and lead and/or a rubber compression gasket. A lead joint can be either vertical or horizontal. Figure 6-14 shows the tools and materials required. Figure 6-15 shows one type of lead-melting furnace. Several types of melting furnaces are available. Follow the manufacturer's instructions and safety precautions.

Table 6-3. Joint-material requirements

Pipe Size (inches)	Oakum (feet)	Lead (pounds)
2	3	1 ½
3	4 ½	2 ¼
4	5	3
5	6 ½	3 ¾
6	7 ½	4 ½

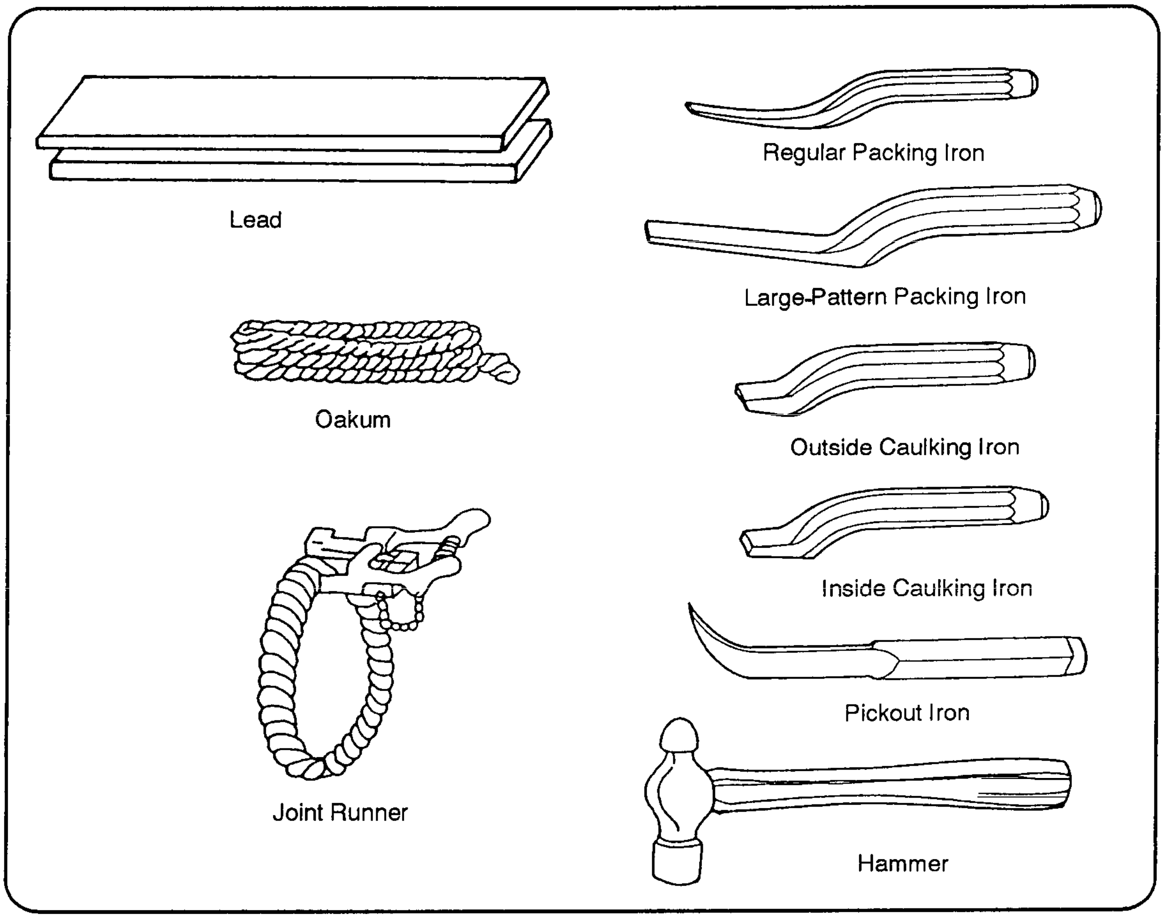


Figure 6-14. Tools and materials for lead joints

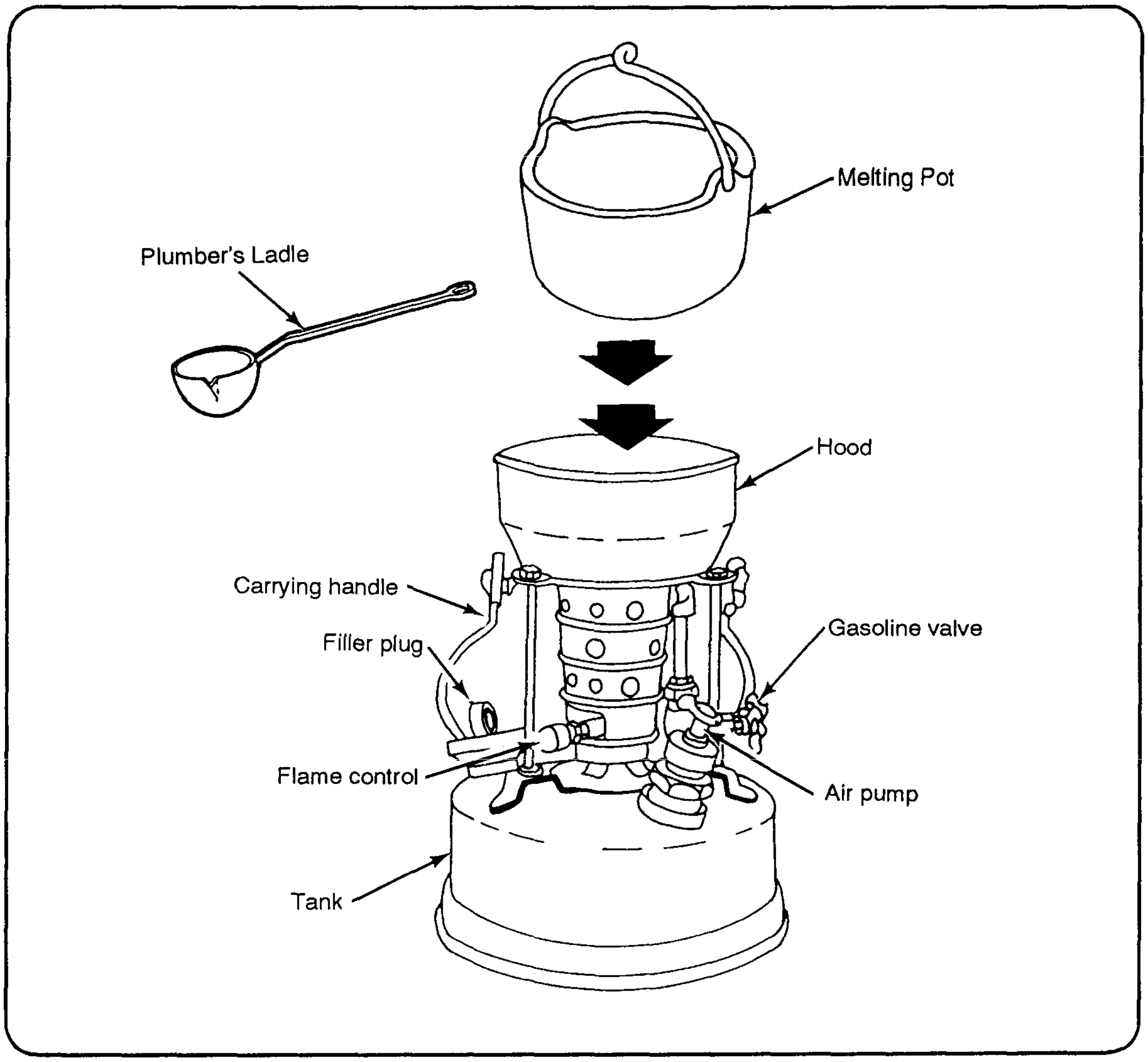


Figure 6-15. Lead-melting furnace

(a) Horizontal lead joint. Use Figure 6-16 page 6-14) and the following procedure:

Step 1. Clean pipe end and / or fitting end in the same manner as a vertical joint.

Step 2. Center the spigot or cut end into the hub of another pipe or fitting.

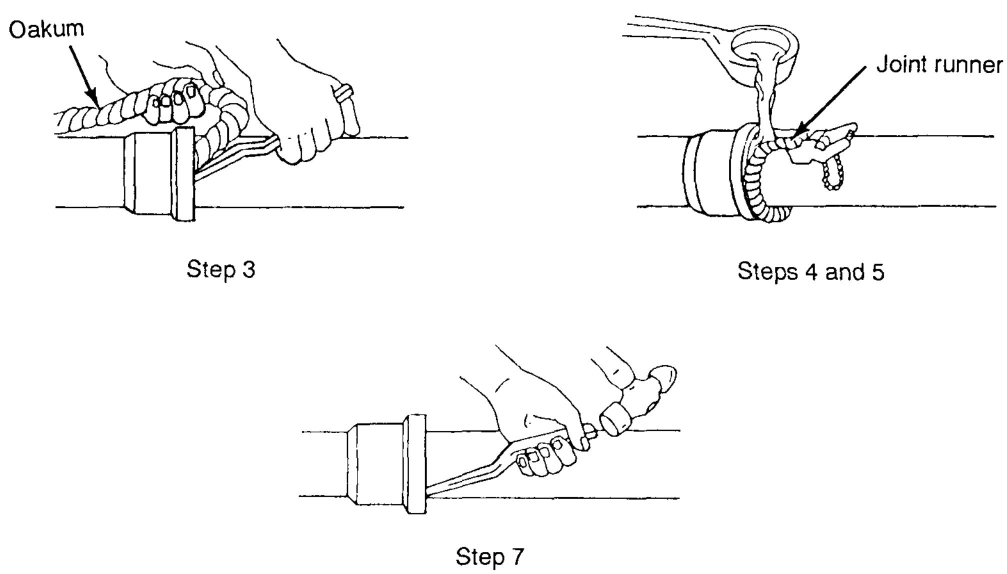
Step 3. Pack strands of oakum into the hub completely around the pipe or fitting with a packing iron to within 1 inch of the hub's end (Figure 6-16).

Step 4. Clamp the joint runner around the pipe or fitting (Figure 6-16).

Step 5. Pour the molten lead into the hub in one pour, using a plumber's ladle (see warning in Figure 6-16).

Step 6. When the lead hardens, remove the joint runner.

Step 7. Caulk the lead in the same manner as in a vertical joint (Figure 6-16).



WARNING
Always wear protective clothing, protective gloves, and goggles when working with molten lead. Severe personal injury and permanent disability may result from accidents.

Figure 6-16. Horizontal lead joint

(b) Vertical lead joint. Use Figure 6-17 and the following procedure:

Step 1. Wipe the hub and spigot or cut end to remove moisture and foreign matter.

Step 2. Center the spigot or cut end into the hub of the pipe or fitting.

Step 3. Pack strands of oakum into the hub completely around the pipe or fitting with a packing iron to within 1 inch of the hub's end (Figure 6-17).

Step 4. Pour hot molten lead carefully into the hub in one pour, using a plumber's ladle (Figure 6-17). (See warning in Figure 6-17.)

Step 5. Allow the lead to cool one minute or more to harden.

Step 6. Caulk the lead against the pipe with the inside caulking iron and then against the hub with the outside caulking iron, as shown in Figure 6-17, The joint is then complete and leakproof.

NOTE: *If hot molten lead cannot be used make a cold caulk joint using lead wool or shredded lead. Roll the lead wool or shredded lead into several strands about 1/2 inch in diameter and 1 to 2 feet long. Force the strands into the hub and caulk. For best results, arrange the ends of the strands alternately.*

WARNING

Always wear protective clothing, protective gloves, and goggles when working with molten lead. Severe personal injury and permanent disability may result from accidents.

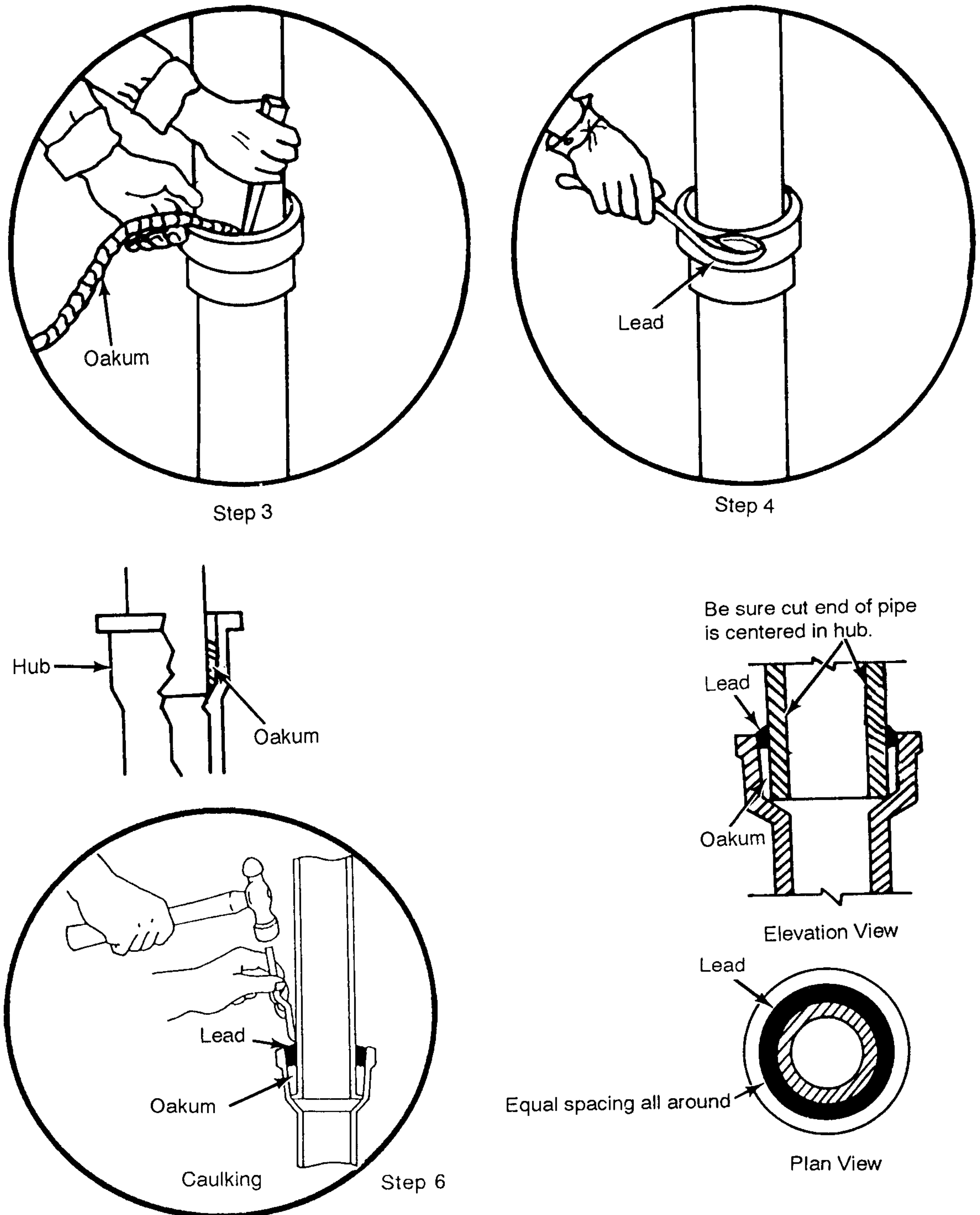


Figure 6-17. Vertical lead joint

(2) *Hubless Joint.* A hubless joint is made with a neoprene sleeve and a stainless steel clamp. To make a hubless joint use Figure 6-18 and the following steps:

Step 1. Remove the neoprene sleeve from the stainless-steel clamp.

Step 2. Slide the sleeve on the end of one pipe or fitting until it is firmly against the collar inside the sleeve.

Step 3. Slide the clamp on the other pipe.

Step 4. Slide that pipe end into the sleeve until it is firmly against the collar inside the sleeve.

Step 5. Center the clamp over the sleeve and tighten with a screwdriver or wrench.

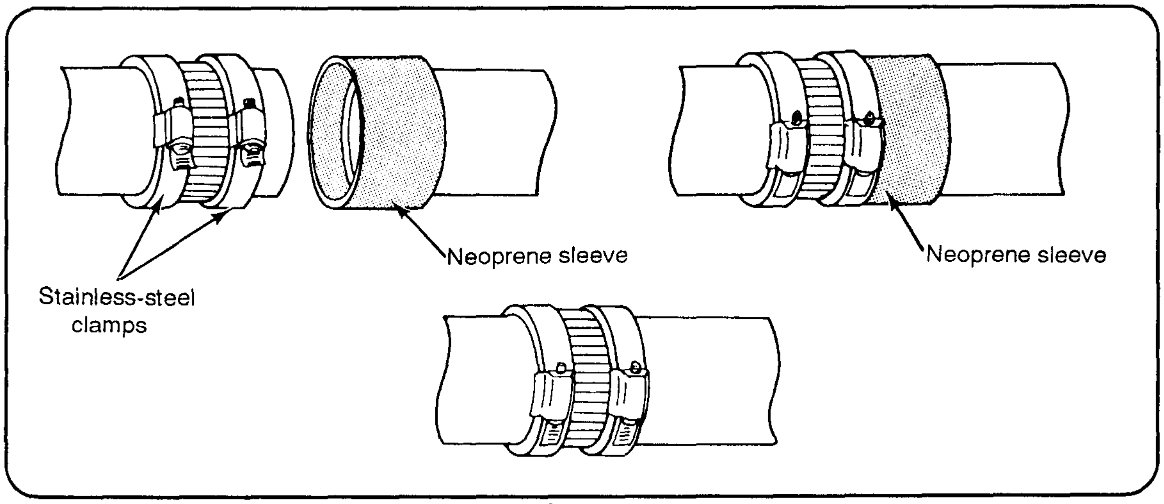


Figure 6-18. Hubless joint

h. *Supporting Pipe Joints.* To prevent strain on the joints, cast-iron pipe should be supported at various points along pipe runs and fittings. This pipe must be supported (vertically and horizontally) to maintain alignment and proper drainage slope.

6-5. Galvanized-Steel/Iron Pipe and Fittings

a. *Use.* Galvanized-steel/iron pipe can be used for hot- and cold-water supply distribution, certain drainage applications, and vent installations.

b. *Types and Sizes.* This pipe comes in three strengths: (1) standard, (2) extra strong, and (3) double extra strong. The definitions *Schedule 40* and Schedule 80 also describe pipe strengths. Schedule 40 standard is most commonly used in plumbing. Pipe diameter sizes (nominal pipe sizes) are 1/8 inch to 12 inches, also referred to as iron-pipe size. The pipe comes in 21-foot lengths, threaded or unthreaded (Figure 6-19).

c. *Handling and Storage.* Galvanized pipe should be stored in a dry place. If the pipe ends are threaded, they must be protected from damage.

d. *Fittings.* Fittings for this pipe are classified as either ordinary (standard) or drainage (recessed) (Figure 6-20).

- *Ordinary (standard).* Ordinary fittings are used for water service and venting. They range in size from 3/8 inch to 6 inches.
- *Drainage (recessed).* Drainage fittings are used in the waste system. They have threads at a slight angle so that horizontal drainage pipe will slope about 1/4 inch per foot (Figure 6-20). They range in size from 1 1/4 to 12 inches.

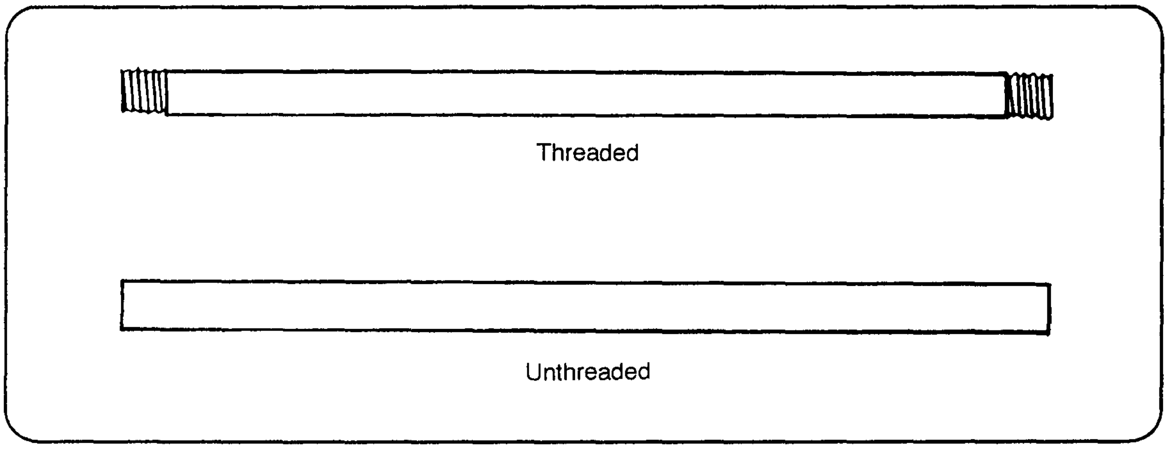


Figure 6-19. Galvanized-steel/iron pipe

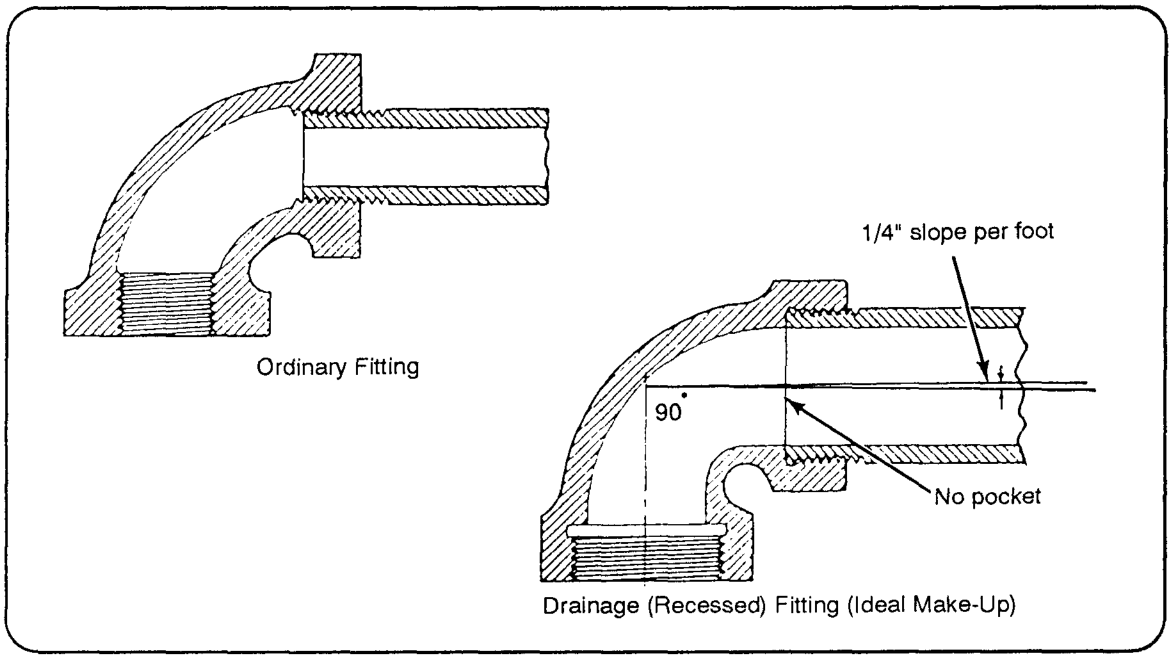


Figure 6-20. Ordinary and drainage pipe fittings

(1) *Ts.* Ts (Figure 6-21) are used when a pipe run branches at a 90-degree angle. T size is specified by the through section (run) and then the outlet.

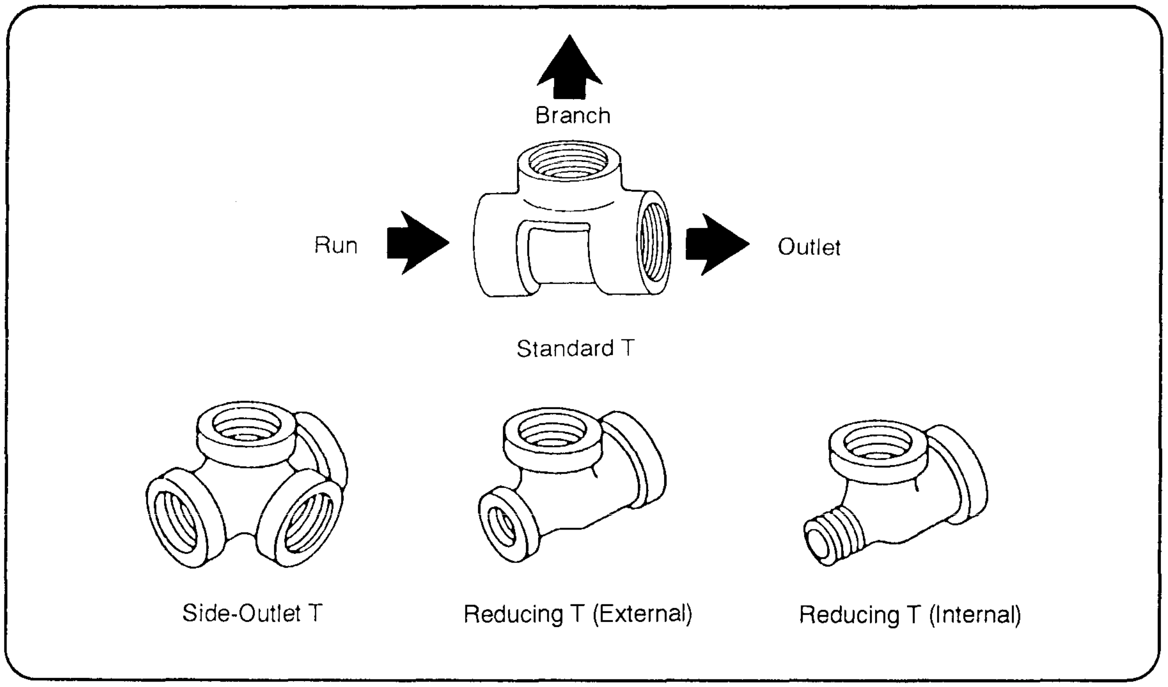


Figure 6-21. Ts

(2) *Elbows (Ls).* Elbows (Figure 6-22) are used to change the direction of a pipeline. They come in a variety of sizes and patterns. Most common are 90- and 45-degree angles. Either type can be a standard or a reducing L. The size of an L is given first by the larger opening and then by the smaller opening.

(3) *Couplings.* Couplings (Figure 6-23) are used to connect two lengths of pipe.

- *Standard coupling.* An ordinary coupling connects pipes of the same size.
- *Reducing coupling.* A reducing coupling connects pipes of different sizes.
- *Eccentric coupling.* An eccentric reducing coupling connects pipes of different size, off-center.

(4) *Unions.* Unions (Figure 6-24, page 6-20) are used to join the ends of two pipes that can be turned or disconnected.

- *Ground.* A ground union has three distinct parts: the shoulder piece with female threads; a thread piece with female and male threads; and a ring (or collar) with an inside flange, which matches the shoulder of the shoulder piece, and a female thread, which matches the male thread of the thread piece. The pipes are screwed to the thread and shoulder pieces. They are drawn together by the collar, making a gastight and watertight joint.
- *Flange.* The flange union has two parts, each with a female thread, which is screwed to the pipes to be joined. Nuts and bolts pull the flanges together. A

gasket between the flanges makes a gastight and watertight joint. Plain-faced flanges are shown in Figure 6-24 (page 6-20). They may have male and female faces or tongue and groove faces.

- *Dielectric.* Dielectric unions are used to connect dissimilar-metal, water-supply pipes to prevent electrolysis (corrosion). Always used when connecting galvanized-steel/iron pipe to copper pipe.

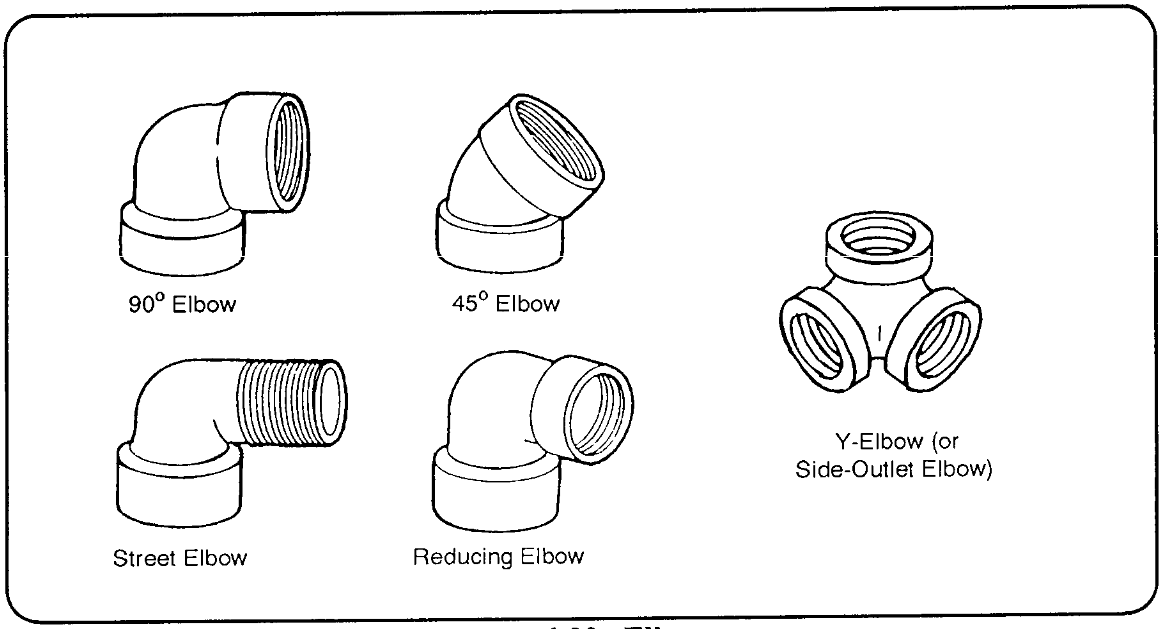


Figure 6-22. Elbows

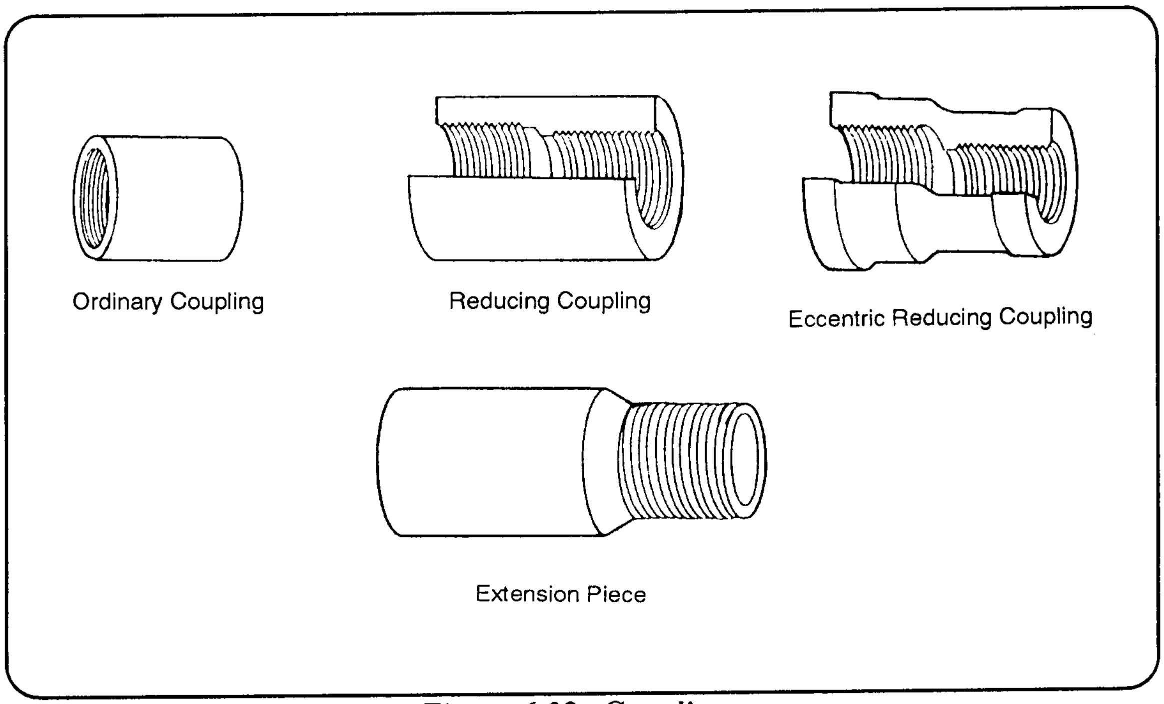


Figure 6-23. Couplings

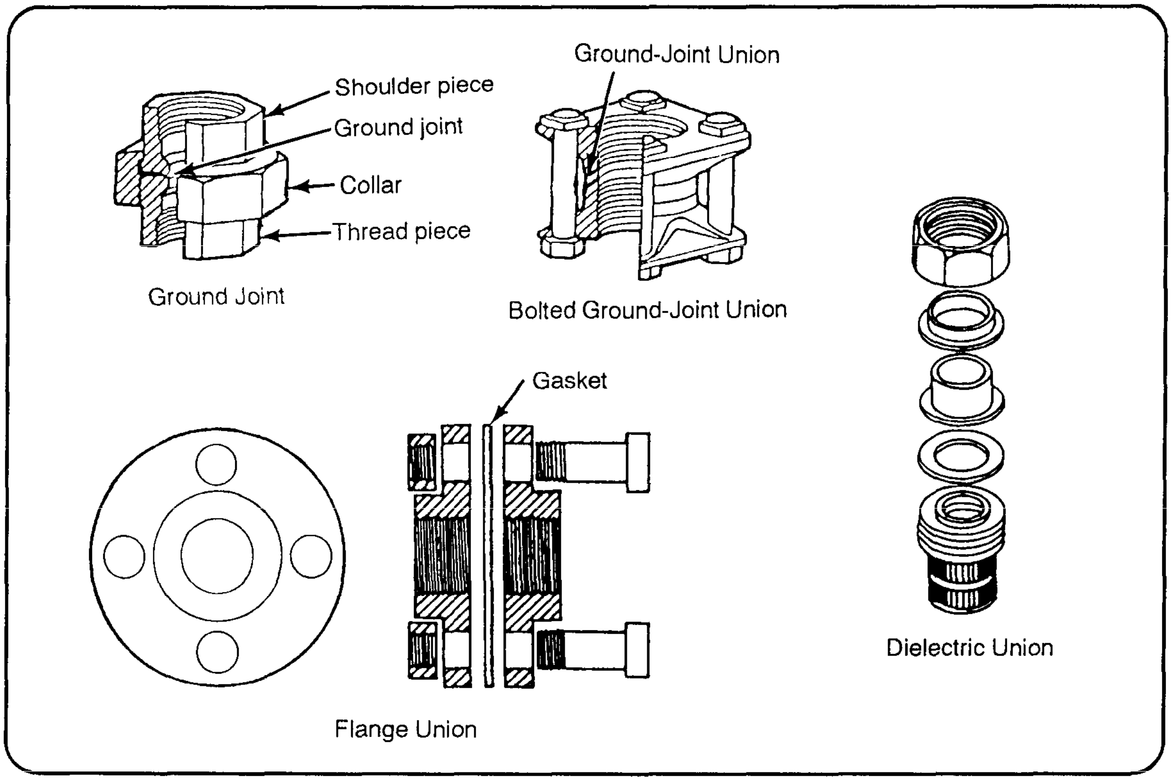


Figure 6-24. Unions

(5) *Nipples.* A nipple is used to make an extension from a fitting or to join two fittings, Nipples are pieces of pipe 12 inches or less in length, threaded on each end. They are close, shoulder, and long nipples (Figure 6-25).

(6) *Plugs and Caps.* Plugs and caps are used to seal off openings in other fittings or pipe ends (Figure 6-25). These fittings seal off a water system for testing. This rough-in system is in place until fixtures are installed.

(7) *Crosses.* A cross joins two different pipelines in the same plane, making them perpendicular to each other (Figure 6-25). Crosses can also be side-outlet and reducing.

(8) *Bushings.* A bushing is used to reduce a fitting outlet or to connect a pipe to a larger outlet. A bushing can be a pipe bushing and / or a face bushing (Figure 6-25).

e. *Cutting and Reaming.* Steel pipe is cut and reamed using a vise, pipe cutter, and reamer (Figure 6-26, page 6-22). To avoid pipe waste, use Figure 6-27 (page 6-22) and the following procedure:

Step 1. Determine the length of pipe and mark the spot for the cut.

Step 2. Lock the pipe tightly in the vise with the cutting mark about 8 inches from the vise.

Step 3. Open the jaws of the cutter, using the single-wheel cutter, by turning the handle counterclockwise.

Step 4. Place the cutter around the pipe with the cutting wheel exactly on the mark. The rollers will ensure a straight cut (Figure 6-27, page 6-22). If you are using a three-wheel cutter, place the cutting wheel of the movable jaw on the mark; make sure that all three wheels are at right angles to the centerline of the pipe.

Step 5. Close the vise jaws lightly against the pipe by turning the handle clockwise.

Step 6. Give the handle a quarter turn clockwise when the cutting wheel and rollers have made contact with the pipe.

Step 7. Apply cutting oil and rotate the cutter completely around the pipe, making a quarter turn on the handle for each complete revolution around the pipe. Continue the action until the pipe is cut.

Step 8. Push the reamer into the pipe. Turn the reamer clockwise in short, even strokes, while keeping steady pressure against the pipe (Figure 6-27, page 6-22) until the inside burrs are removed.

Step 9. If you used a three-wheel cutter, remove the outside burrs with a file.

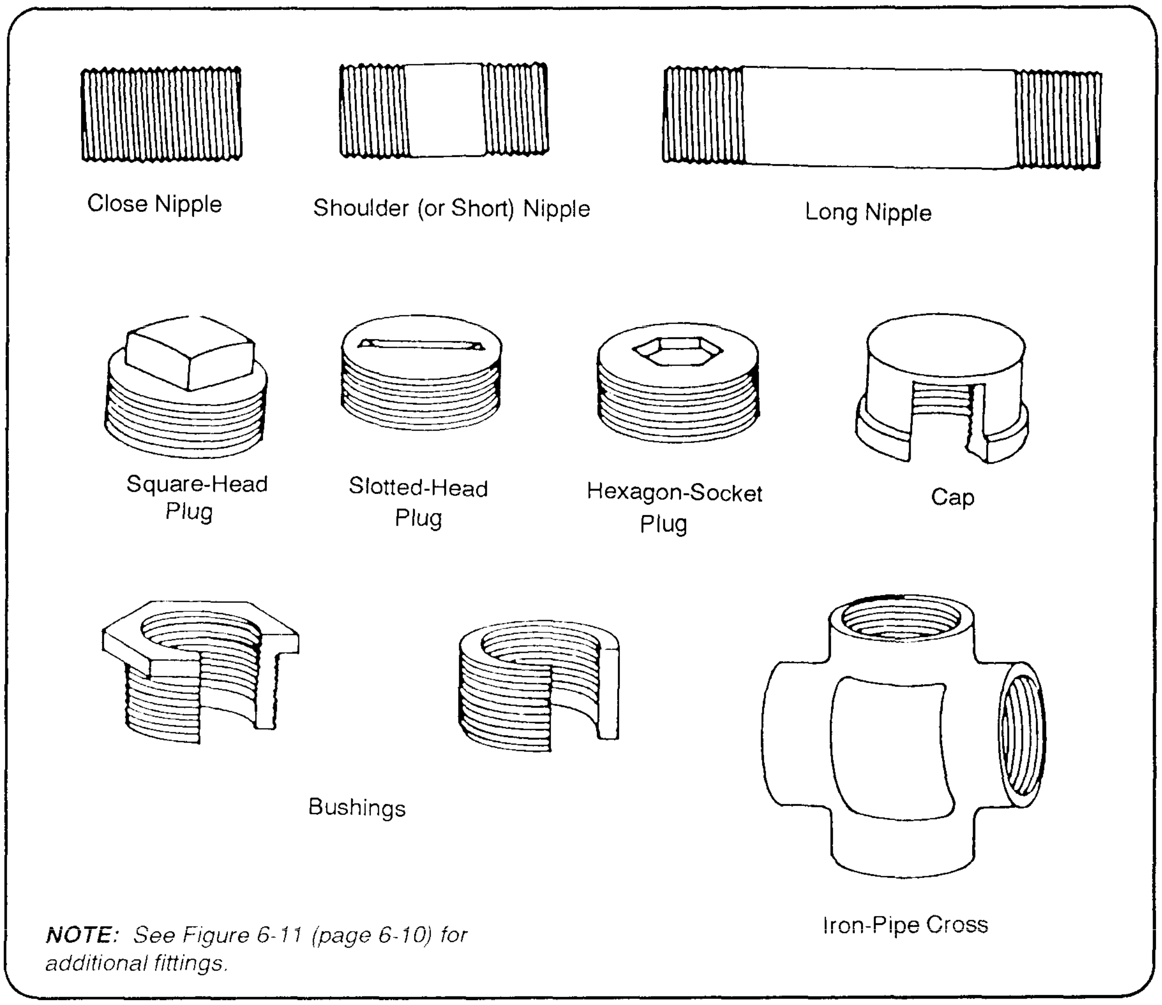


Figure 6-25. Nipples, plugs, caps, bushings, and cross

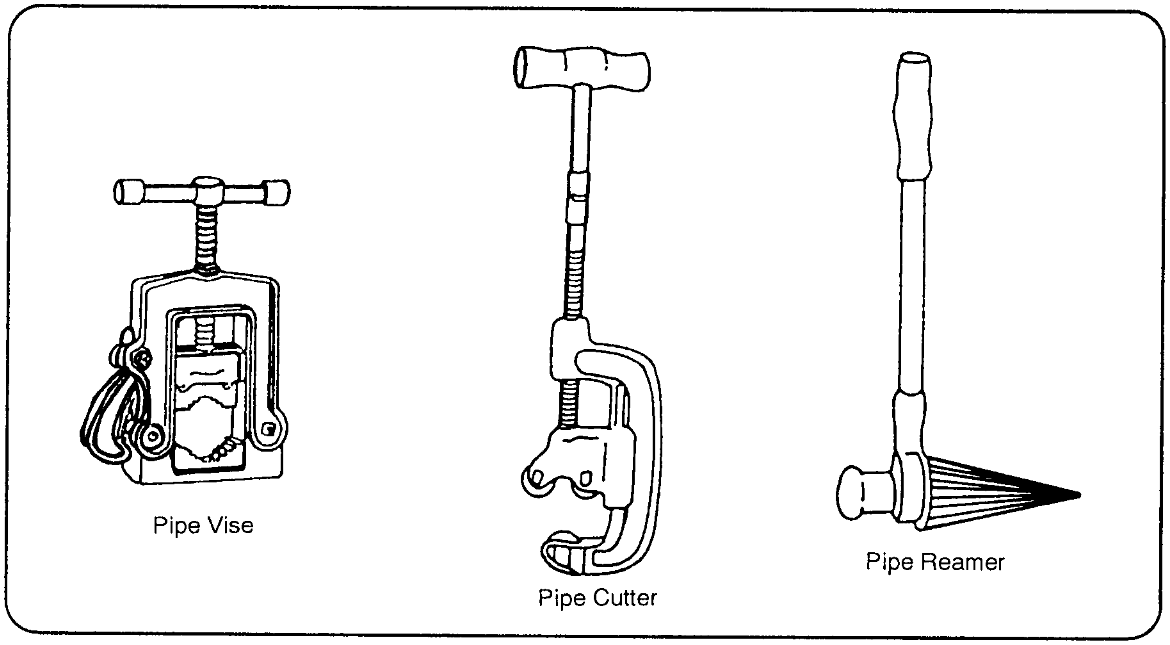


Figure 6-26. Steel-pipe tools

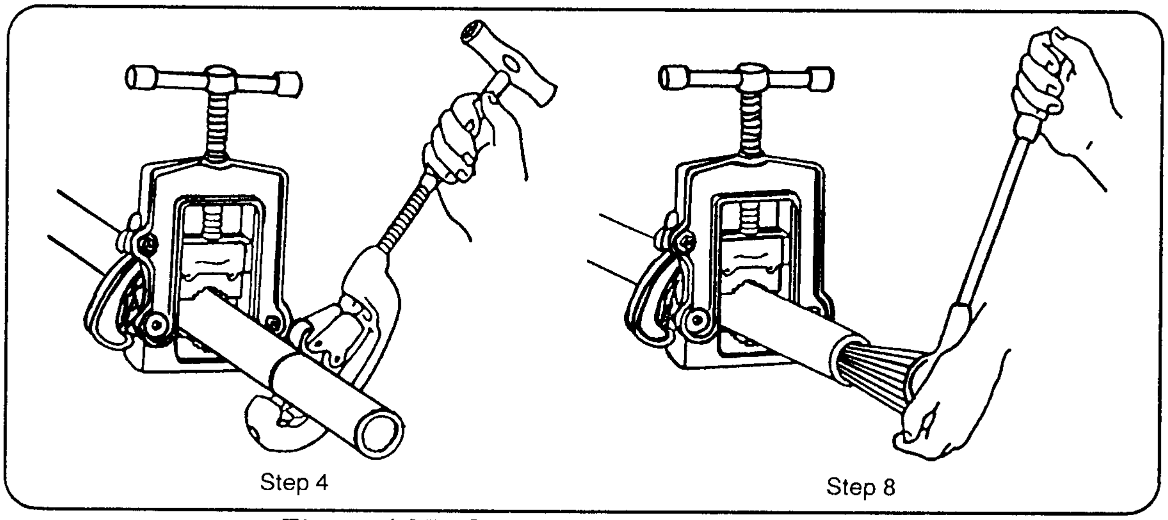


Figure 6-27. Cutting and reaming steel pipe

f. *Threading.* Many types of pipe-threading sets are in use. A common set is one with a rachet, nonadjustable stock with solid dies, and individual guides (Figure 6-28). A die and guide must be the same size to fit the pipe size being threaded. When using a threading set, use manufacturer's, or accompanying instructions with the following procedure:

Step 1. Lock the pipe securely in the vise with enough pipe projecting for threading.

Step 2. Slide the die stock over the end of the pipe with the guide on the inside. Push the die against the pipe with one hand (Figure 6-29).

Step 3. Make three or four short, slow, clockwise strokes until the die is firmly started on the pipe. Apply a generous amount of cutting oil on the die.

Step 4. Give the stock a complete clockwise turn, then turn it counterclockwise a quarter turn. This will clear cut metal from the die and burrs from the new threads.

Step 5. Continue Step 4 until 1/2 to 1/4 inch extends from the die stock.

Step 6. Carefully turn the die stock counterclockwise until the die is free of the cut threads.

Step 7. Use a heavy rag to wipe away excess oil and a wire brush to remove any chips. The pipe is now ready to be joined.

Too much pipe thread is as undesirable as too little. A good rule is to cut threads until the pipe extends about 1/4 inch from the base of the dies. Table 6-4 gives information to determine thread length.

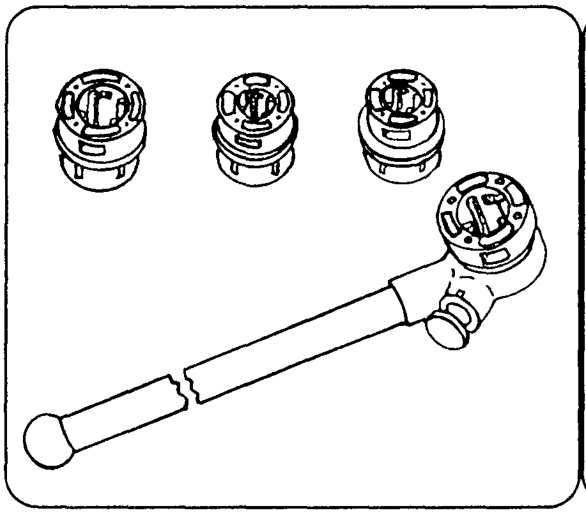


Figure 6-28. Stock and die set

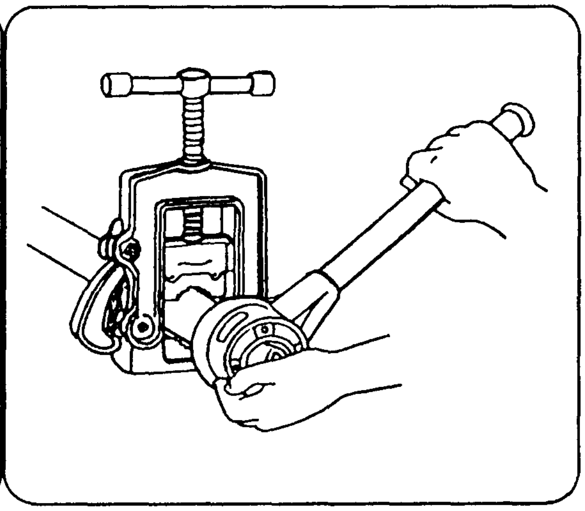


Figure 6-29. Threading pipe

Table 6-4. Thread length data

Nominal Pipe Size (in inches)	Threads per inch	Length of Thread (in inches) approximate	Number of Threads to be Cut approximate	Total Thread Makeup Engagement (in inches) approximate
1/4	18	5/8	11	3/8
3/8	18	5/8	11	3/8
1/2	14	3/4	10	7/16
3/4	14	3/4	10	1/2
1	11 1/2	7/8	10	9/16
1 1/4	11 1/2	1	11	9/16
1 1/2	11 1/2	1	11	9/16
2	11 1/2	1	11	5/8
2 1/2	8	1 1/2	12	7/8
3	8	1 1/2	12	1
3 1/2	8	1 5/8	13	11/16
4	8	1 5/8	13	11/16
5	8	1 3/4	14	13/16
6	8	1 3/4	14	13/16

g. *Joining.* Fittings are normally screwed to the pipe after it is threaded, while the pipe is still in the vise. This ensures a good fit. The assembled pipe and fittings should then be screwed into the proper place in the installation. Use Figure 6-30 and the following joining procedure:

Step 1. Check the fitting threads for cleanliness and damage. If necessary, clean with wire brush or replace.

Step 2. Repeat Step 1 for the pipe threads.

Step 3. Apply pipe-joint compound or teflon tape to the *pipe* threads only (Figure 6-30).

Step 4. Screw fitting on, hand-tight (Figure 6-30).

Step 5. Tighten fitting using two pipe wrenches, one on the fitting and the other on the pipe (Figure 6-30), provided no vise is available.

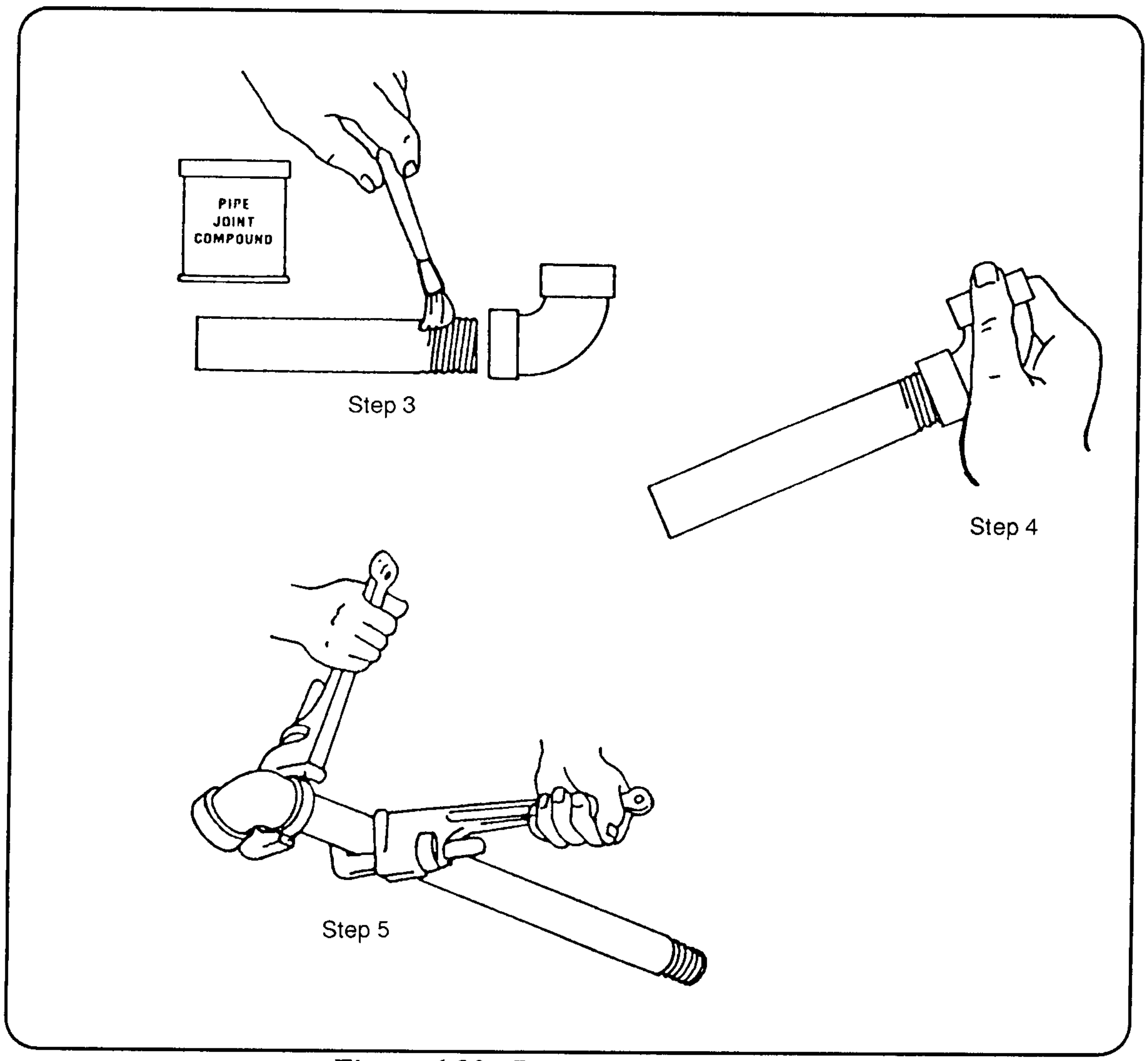


Figure 6-30. Joining threaded pipe

6-6. Copper Tubing and Fittings. Copper tubing is lightweight, easily joined, and corrosion-resistant. It can be rigid or flexible, and it is classified by its wall thickness (Figure 6-31).

a. *Use.* Copper tubing is used for hot- and cold-water supply systems, certain drainage applications, and venting.

b. *Types and Sizes.*

(1) *K.* K is a thick-walled, rigid or flexible copper tubing available in 20-foot lengths or 100-foot coils. Diameter sizes range from 1/4 inch to 12 inches.

(2) *L.* L is a medium-walled, rigid or flexible copper tubing available in 20-foot lengths or 100-foot coils. Diameter sizes are the same as K.

(3) *M.* M is a thin-walled, rigid copper tubing available in 20-foot lengths. Diameter sizes are the same as K and L.

(4) *DWV.* Drain waste vent is available in 20-foot lengths. Diameter sizes range from 1 1/4 to 8 inches.

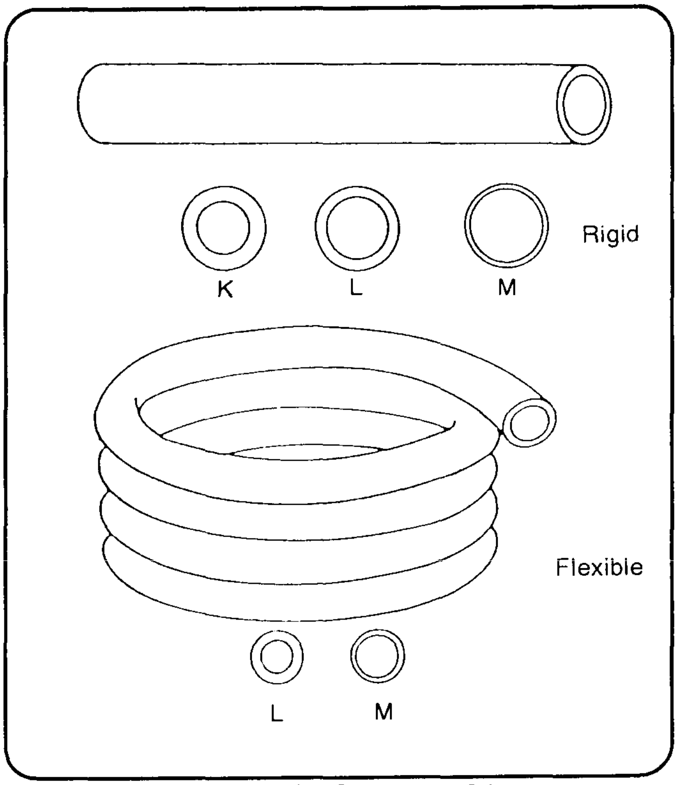


Figure 6-31. Copper tubing

c. *Fittings.* Fittings for copper tubing can be solder, flared, or compression types (Figure 6-32, page 6-26).

(1) *Solder.* Solder fittings can be used with either rigid or flexible copper tubing. The fitting sizes are similar to galvanized-steel/iron fittings. Sizes are identified in the same manner.

(2) *Flared.* Flared fittings are used with flexible copper tubing whose ends have been flared. Fitting sizes range from 3/8 inch to 3 inches in diameter.

(3) *DWV.* DWV fittings are similar to cast-iron fittings of the solder type.

d. *Measuring.* Measure copper tubing using one of the methods described in paragraph 6-3b (pages 6-4 and 6-5).

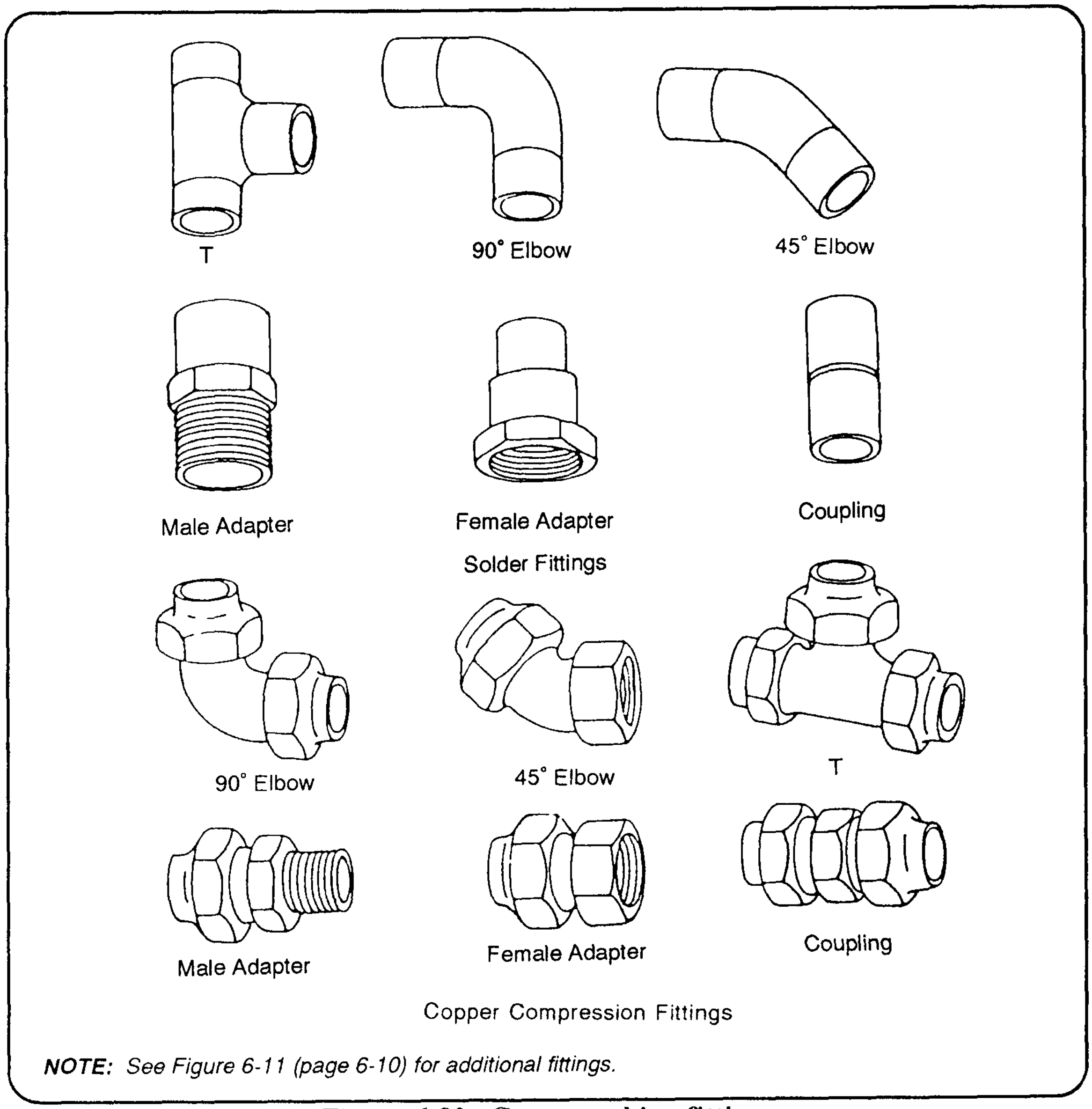


Figure 6-32. Copper-tubing fittings

e. *Cutting and Reaming.* Copper tubing can be cut with a tubing cutter or a fine-tooth hacksaw (32 teeth per inch), as shown in Figure 6-33. Use the following procedure:

Step 1. Determine the length of tubing and mark the spot for the cut.

Step 2. Set the cutting wheel on mark and turn cutter knob clockwise to get a bite on the tubing.

Step 3. Hold the tubing firmly with one hand and use the other hand to turn the cutter clockwise around the tubing until the tubing is cut. If you use a hacksaw, place the tubing in a miter box or a jig made of lumber to make a square cut.

Step 4. Ream the tubing's cut end with the reamer attached to the tubing cutter. If the cutter does not have a reamer, use a fine metal file.

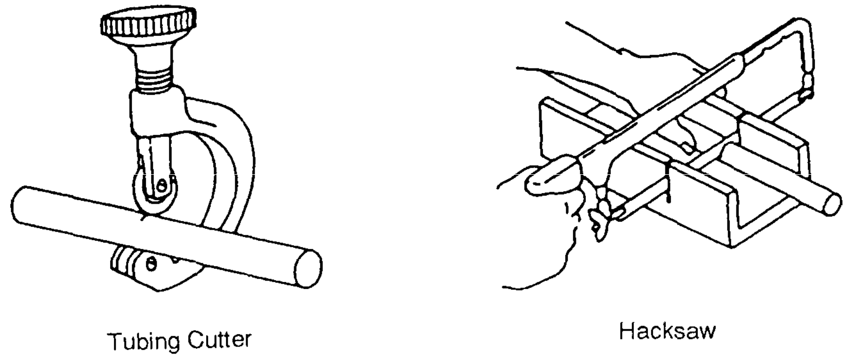


Figure 6-33. Cutting copper tubing

f. *Joining.*

(1) *Soldered Joint.* Soldered joints are used to connect rigid copper tubing. You will need the following tools and materials: a heating torch, 50-50 nonacid solder, soldering flux, and emery cloth or steel wool (Figure 6-34, page 6-28). Use Figure 6-35 (page 6-28) and the following procedure to make a soldered joint:

Step 1. Inspect the end of the tubing to be sure it is round, free of burrs, and cut square.

Step 2. Clean the end of the tubing and the inside of the fitting to a bright shine with emery cloth or fine steel wool.

Step 3. Apply a thin coat of flux to the shined end of the tubing and fitting (Figure 6-35).

Step 4. Push the fitting onto the tubing and give it a quarter turn to spread the flux evenly (Figure 6-35).

Step 5. Heat the connection with a torch, applying the flame on the fitting (Figure 6-35).

Step 6. When the flux is bubbling, apply the solder to the joint. The solder will flow into and completely around the joint.

Step 7. Clean the joint using a clean rag.

CAUTION

Precautions must be taken when soldering. When the joint is close to wood or other combustible material, place an insulation sheet or sheet metal between the fitting and the combustible material before applying the torch flame. To form a leakproof joint, you must keep the joint connection motionless while the solder is cooling.

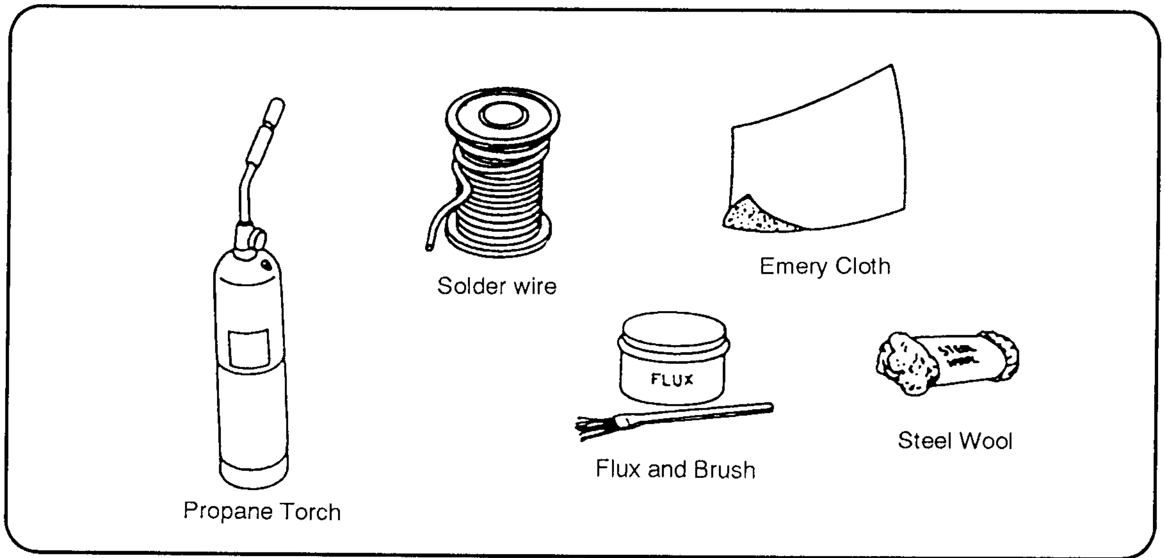


Figure 6-34. Soldering tools and materials

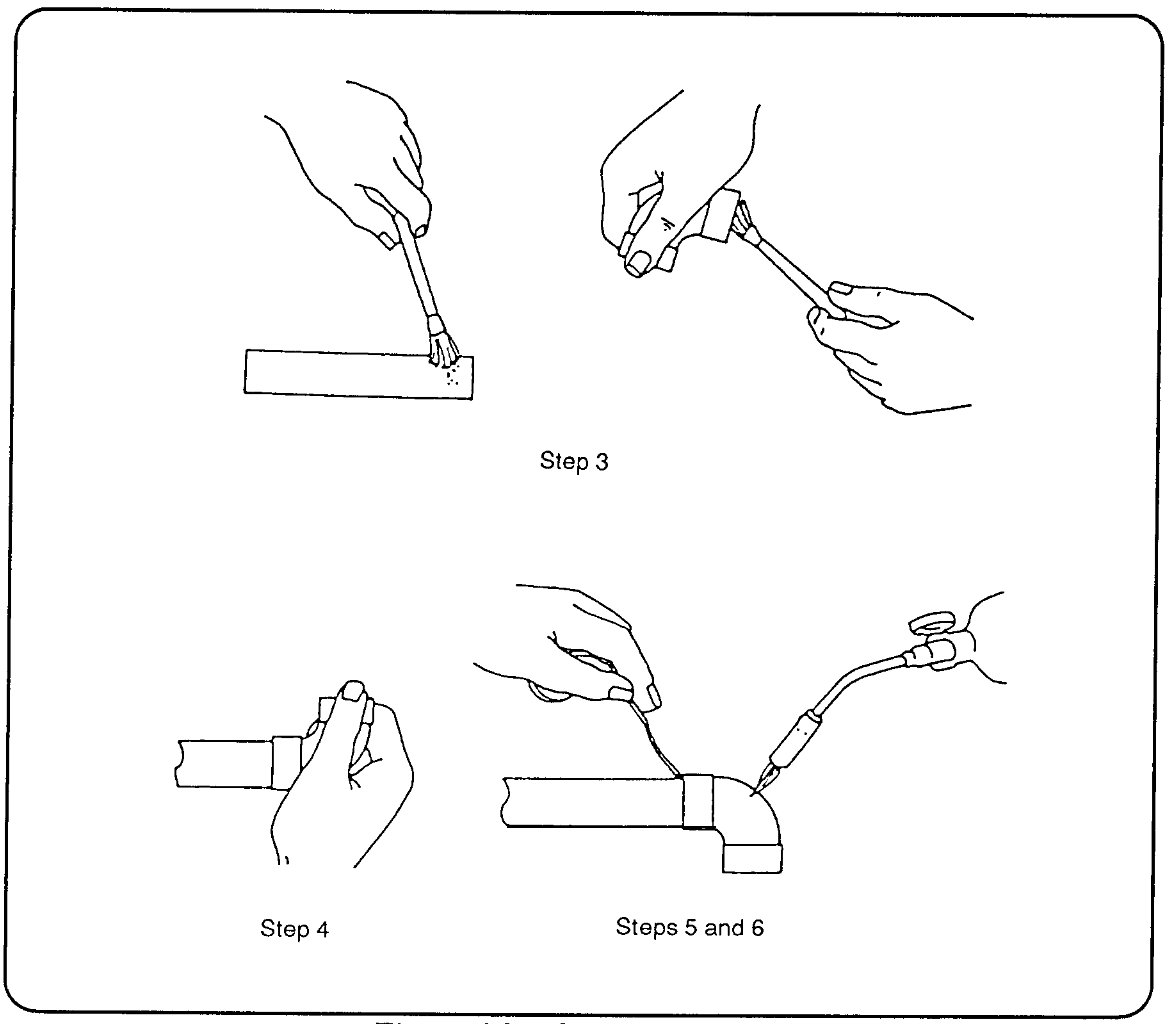


Figure 6-35. Soldering a joint

(2) *Flared Joint.* A flared joint is used with flexible copper tubing. The flare on the end of the tubing can be made with a flaring tool or a flanging tool (Figure 6-36). Use the following procedure and Figure 6-37 (page 6-30) for flaring and flanging flexible copper tubing:

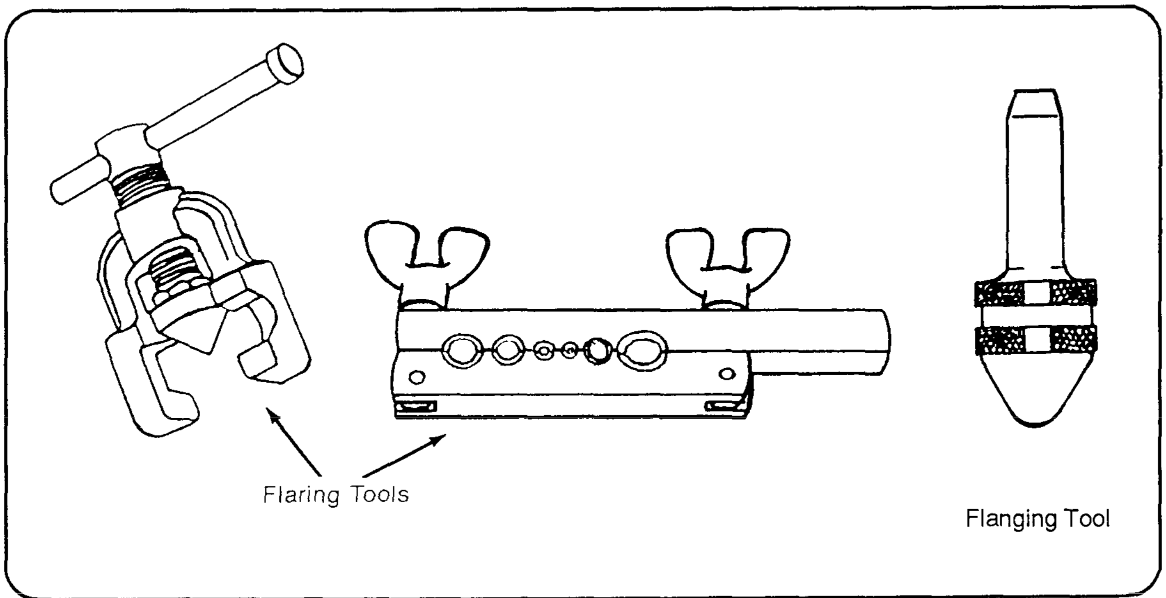


Figure 6-36. Flaring and flanging tools

Step 1. Inspect the end of the tubing to ensure it is free of burrs and is cut square.

Step 2. Remove flange nut from the fitting and slide its unthreaded end onto the tubing first.

Step 3. Flare the end of the tubing with either a flaring tool or a flanging tool.

- For the *flaring* tool method, loosen the wing nuts with a flaring tool, and place the tubing in the correct size hole. Make the tubing's end even with the tool's surface. Then tighten the wing nuts. Finally, turn the yoke cone down into the tubing until the flare fills the beveled pad of the hole.
- For the *flanging* tool method, hold the flanging tool on the end of the tubing so that it is centered and straight. Then, using a hammer, tap the flanging tool until the flare fills the recess in the flanging nut.

Step 4. Slide the flanging nut up to the flared end and screw it on the fitting hand-tight, then tighten flange nut (Figure 6-38, page 6-30).

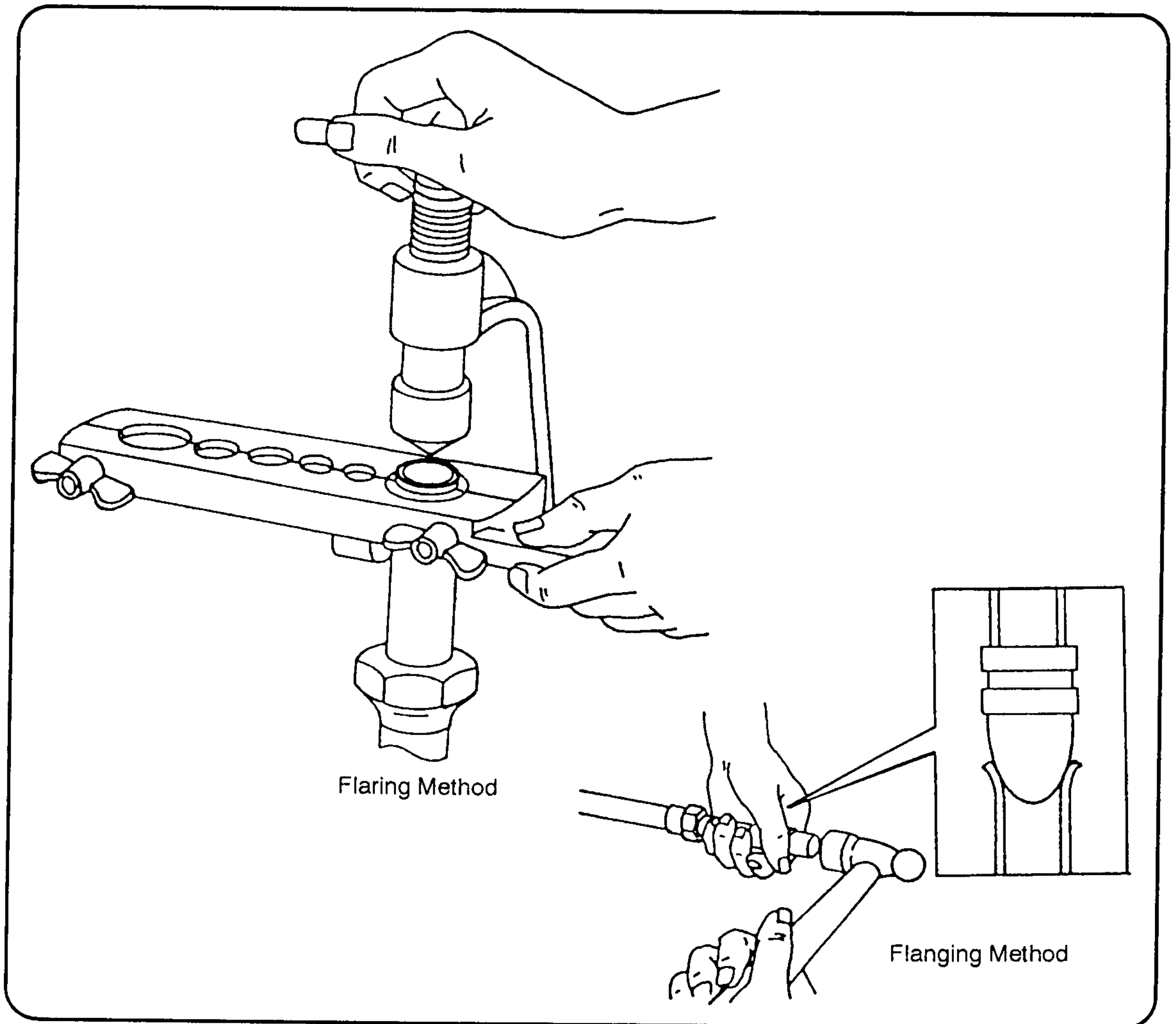


Figure 6-37. Flaring and flanging flexible copper tubing

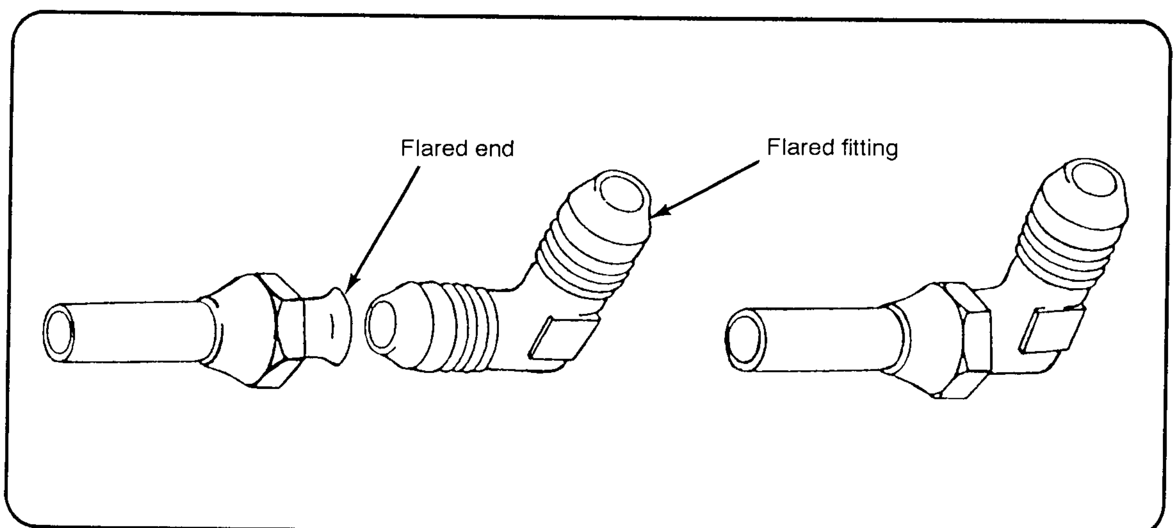


Figure 6-38. Flared joint

(3) *Mechanical-Compression Joint.* A mechanical-compression joint is used to connect a fixture's water supply tubing to shutoff valves (Figure 6-39).

Step 1. Cut or bend tubing to required length.

Step 2. Slide compression nut onto tubing.

Step 3. Slide Compression ring onto tubing.

Step 4. Screw compression nut onto fitting by hand.

Step 5. Tighten the nut. The ring is compressed to form a scaled leakproof joint.

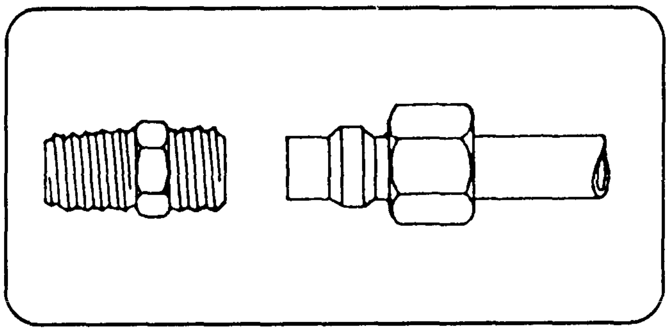


Figure 6-39. Mechanical-compression joint

(4) *Swaged Joint.* Swaging is used to join two sections of thin-walled copper tubing without the use of a fitting. The connection is soldered to form a leakproof joint. The tools required are a swaging-tool set and a ballpeen hammer (Figure 6-40). Use Figure 6-41 (page 6-32) and the following procedure for swaging copper tubing:

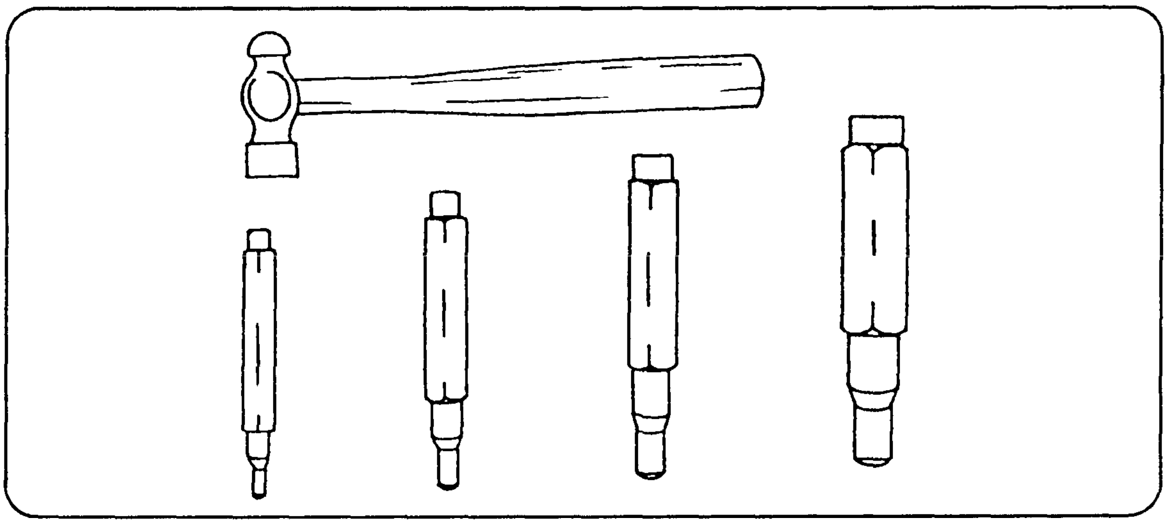


Figure 6-40. Swaging tools

Step 1. Inspect the tubing end to make sure it is free of burn and is cut square.

Step 2. Place the correct size swaging tool into the tubing (with one hand), centered and straight.

Step 3. Tap the swaging tool firmly with the ballpeen hammer to enlarge the tubing's end.

Step 4. Connect the two sections to tubing and solder the joint.

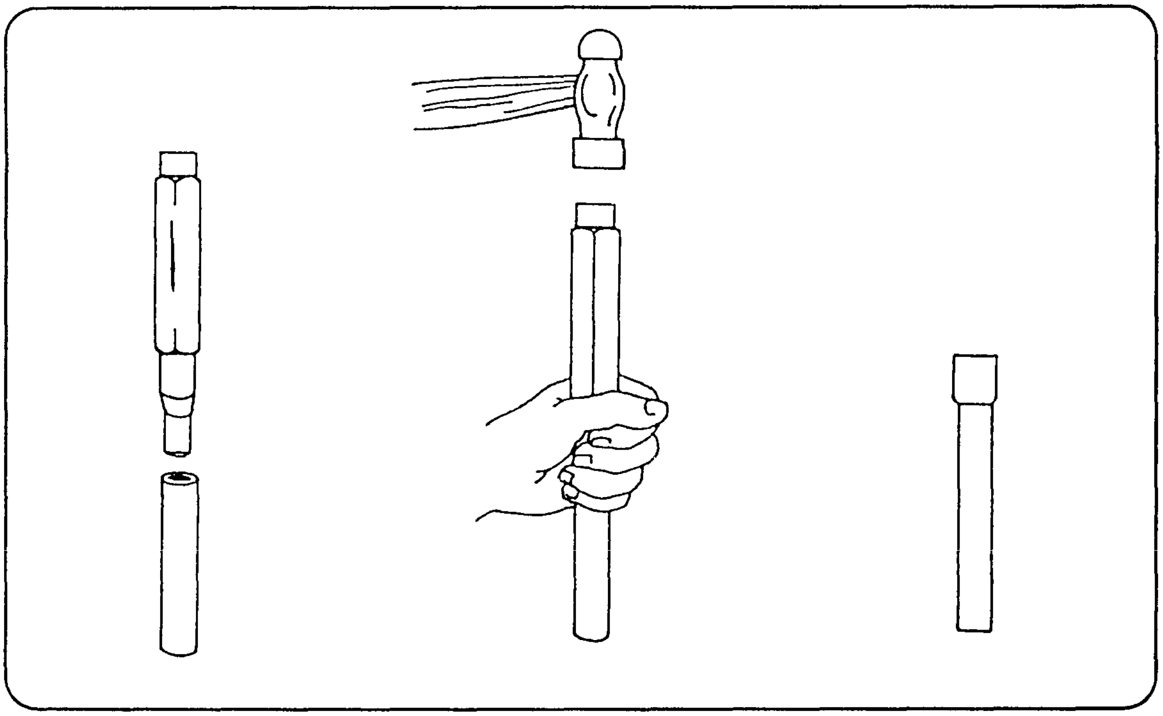


Figure 6-41. Swaging copper tubing

g. *Bending.* Spring benders are used to bend flexible copper tubing having 1/4- to 7/8-inch outside diameters. Slide the correct size spring bender over the tubing to the area of the bend. Bend the spring and tubing together (Figure 6-42).

h. *Supporting Pipe Joints.* Copper tubing should be supported horizontally and vertically at appropriate points. The method of support depends on the size of the tubing and location of all fittings.

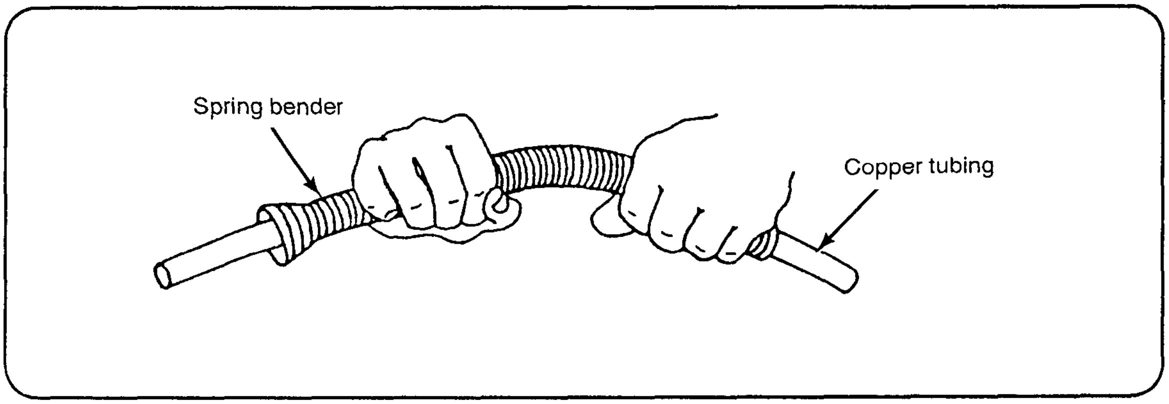


Figure 6-42. Bending flexible copper tubing

6-7. Plastic Pipe and Fittings. Plastic piping is lightweight and is rigid or flexible (similar to copper tubing shown in Figure 6-31 (page 6-25)). This type of pipe is easily joined and is corrosion-resistant.

a. *Use.* Plastic pipe can be used for water or waste systems. It is used for hot- or cold-water piping and for drain, waste, and vent piping.

b. *Types and Sizes.* Plastic pipe is classified by the acronym for the type of material from which it is made.

(1) *Polyvinyl Chloride (PVC).* PVC pipe is cream or white and is used only for cold-water pipelines, sanitary drainage, and venting. The pipe comes in 10- and 20-foot lengths. Diameter sizes range from 1/2 inch to 6 inches.

(2) *Chlorinated Polyvinyl Chloride (CPVC).* CPVC pipe is light or cream and is used for hot-water pipelines. It can also be used for cold-water lines. It comes in 10-foot lengths. Diameter sizes are 1/2 inch and 3/4 inch.

(3) *Acrylonitrile Butadiene Styrene (ABS).* ABS pipe is black or gray and is used for above- and below-ground sanitary drainage and venting. It comes in 10- and 20-foot lengths. Diameter sizes range from 1 1/4 to 6 inches.

(4) *Polybutylene (PB).* PB pipe is black or dark gray and is used for cold-water lines. It is available in coils of 100 feet or more. Diameter sizes range from 3/4 inch to 2 inches. It is costly, requires special fittings, and is not widely used.

(5) *Polyetylene (PE).* PE pipe is black and is used for cold-water lines and sprinkler systems. It comes in coils of 100 feet. Diameter sizes range from 3/4 to 2 inches.

c. *Fittings.* Fitting sizes for PVC and CPVC piping are similar to steel and copper fittings; however, joining is usually made by epoxy or plastic sealants, rather than threading or soldering. Checks should be made before performing a project. Plastic pipe fittings are shown in Figure 6-43, page 6-34.

(1) *PVC.* These fittings are used for water and waste piping.

(2) CPVC. These fittings are used only for CPVC hot- and cold-water system piping.

(3) ABS. These fittings are used only for ABS piping in waste and vent systems.

(4) *PE.* These fittings are the insertable type used for cold-water and sprinkler-system piping.

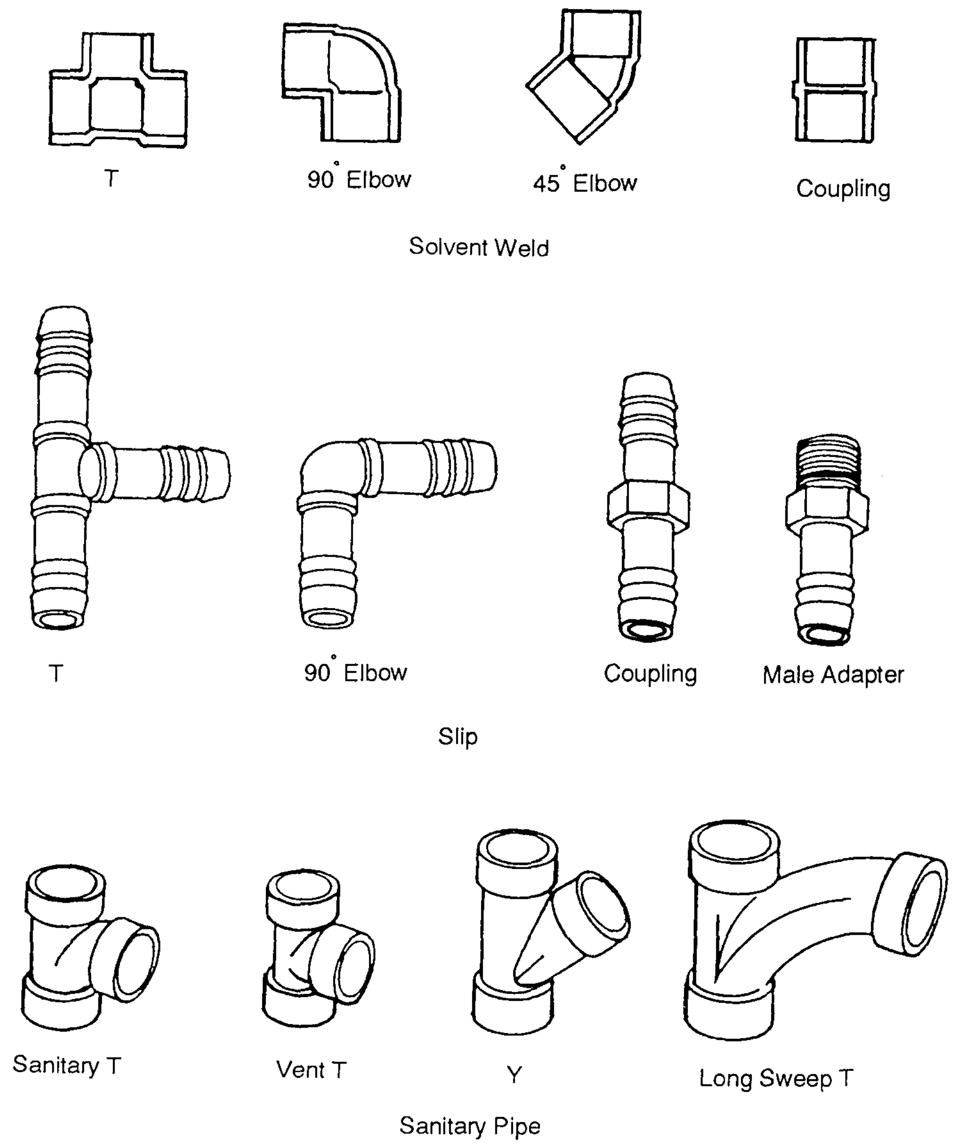
d. *Measuring.* Measure plastic pipe, rigid or flexible, as described in paragraph 6-3b (pages 6-4 and 6-5).

e. *Cutting.* Use Figure 6-44 (page 6-35) and the following steps to cut plastic pipe:

Step 1. Determine the length of pipe and mark the spot for the cut.

Step 2. Place the pipe in a miter box or jig and cut the pipe with a hacksaw or a fine-tooth handsaw. The pipe should be placed in a miter box to get a square cut.

Step 3. Remove burrs from both inside and outside of the pipe with a pocket knife. If a pocket knife is not available, use sandpaper.



NOTE: *See Figure 6-11 (page 6-10) for additional fittings.*

Figure 6-43. Plastic pipe fittings

f. *Joining.*

(1) *Solvent-Cement Weld Joint.* This joint is made by using a cleaning primer and solvent cement on the pipe and fitting. Solvent cement consists of a plastic filler (same material for each type of plastic pipe) dissolved in a mixture of solvents. You should use the appropriate solvent cement for the type of pipe being used. The solvent cement melts the plastic of the pipe and fitting to weld them together. Since solvent cement sets fast, a plastic pipe joint is completed quickly (Figure 6-45). Use the following steps to join plastic pipe with solvent cement:

Step 1. Inspect the pipe end for burrs and the fitting for cracks.

Step 2. Clean the pipe and inside of the fitting with an authorized cleaning primer, using a clean rag.

Step 3. Coat the outside of pipe end and the inside of the fitting with solvent cement.

Step 4. Push the pipe as quickly as possible into the fitting as far as it will go. A small bead of cement will be visible.

Step 5. Give the fitting a quarter turn to spread the solvent cement evenly.

Step 6. Hold the joint connection for about 30 seconds to be sure it is solidly set.

Step 7. Wipe off all excess cement.

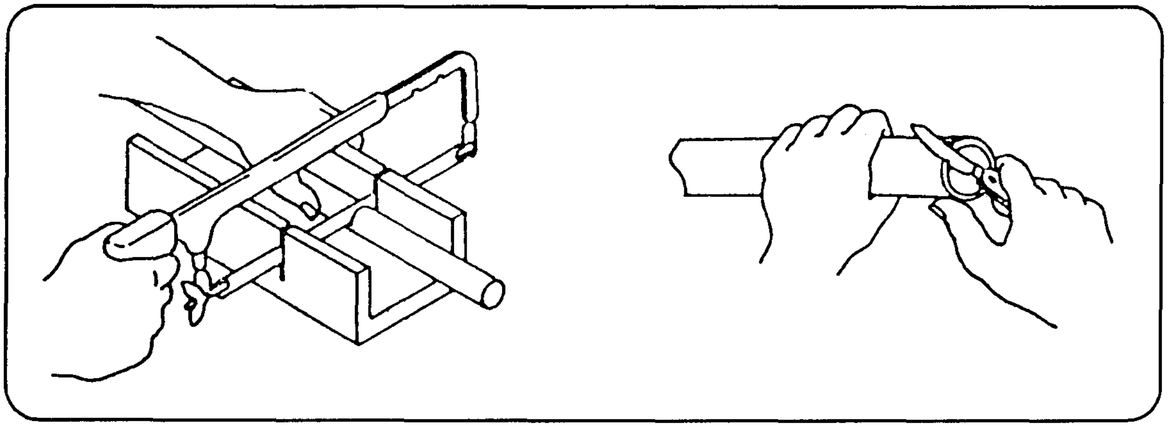


Figure 6-44. Cutting and removing burrs from plastic pipe

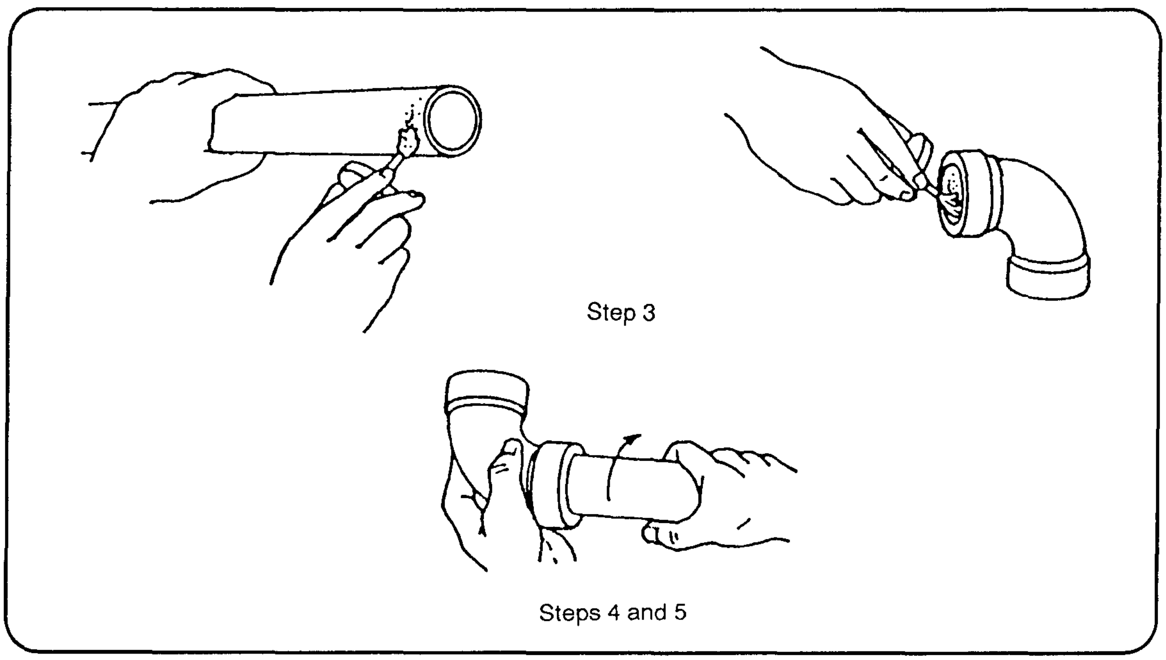


Figure 6-45. Rigid plastic pipe joint

(2) *Insert Fitting Joint.* This joint is made by sliding and clamping flexible plastic pipe onto an insert fitting (Figure 6-46), as follows:

Step 1. Slide a clamp over the flexible pipe.

Step 2. Push pipe onto insert fitting to last serration.

Step 3. Slide clamp over pipe and tighten clamp with a screwdriver.

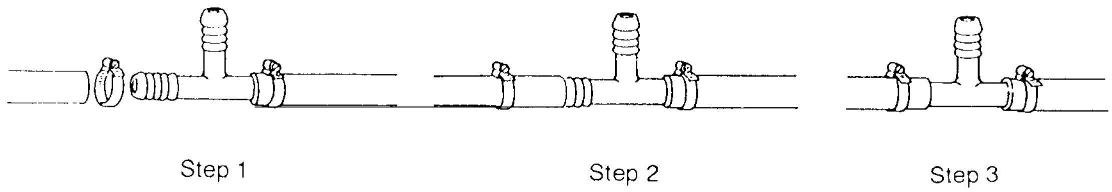


Figure 6-46. Flexible plastic pipe joint

g. *Supporting Pipe Joints.* Plastic pipe is not as stiff as metal pipe; therefore, the pipe runs (both horizontal and vertical) should be supported more often. Support joint connections in the same manner as metal pipe.

6-8. Other Types of Pipes and Fittings.

a. *Bituminous-Fiber Pipe and Fittings.*

(1) *Use.* Bituminous-fiber pipe is used underground to install house to sewer and house to septic-tank waste lines and storm drainage lines to dry wells. Perforated pipe is used for septic-tank disposal fields and for footing drains and other subsurface drainage. It is lightweight, easily joined, and corrosion-resistant.

(2) *Types and Sizes,* This pipe is available in plain and perforated types. Both plain and perforated pipe comes in 5- and 8-foot lengths. The plain pipe ends are tapered 2 degrees from a 1/16-inch shoulder (Figure 6-47). Diameter sizes range from 2 to 8 inches.

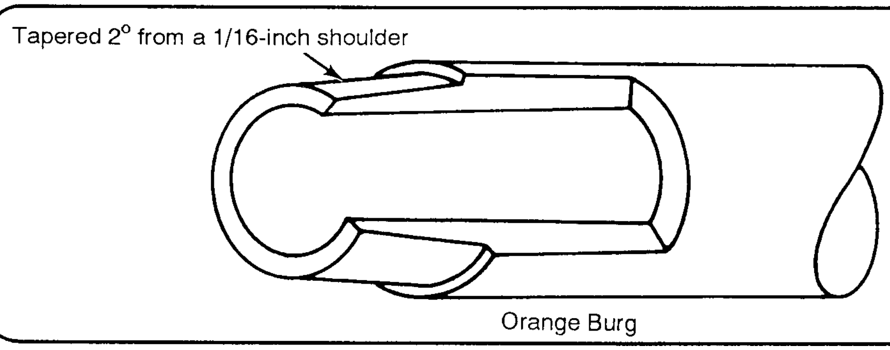


Figure 6-47. Bituminous-fiber pipe

(3) *Fittings.* Fittings for bituminous-fiber pipe are similar in shape to cast-iron fittings. An adapter fitting can be used to connect the pipe to cast-iron, threaded-steel, or plastic pipe (Figure 6-48). Plain piping is joined by driving the pipe and fitting together. Perforated pipe is joined with a snap-collar fitting.

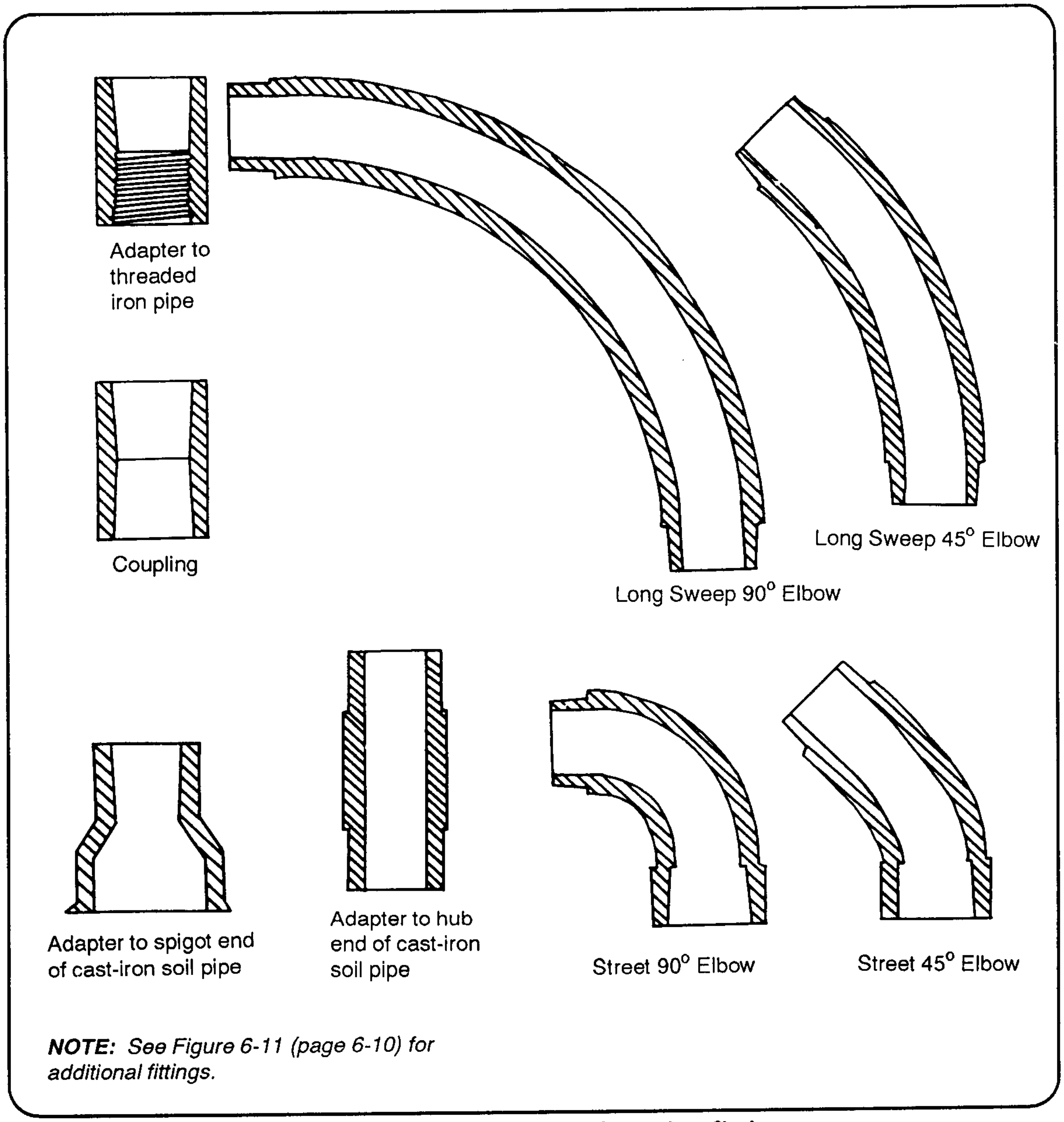


Figure 6-48. Bituminous-fiber pipe fittings

(4) *Cutting.* Fiber pipe is easily cut with a crosscut or rip handsaw. The crosscut produces less shredding and makes a cleaner cut. A miter box ensures the required square cut.

(5) *Tapering.*

Step l. Check that the end of the pipe has been cut square.

Step 2. Insert the center guide of the tapering tool (Figure 6-49) into the pipe until the cutter bracket rests on the end of the pipe.

Step 3. Expand the center guide by turning the expander handle clockwise until the guide fits tightly inside the pipe.

Step 4. Set the cutter against the pipe and tighten the nut on the cutter bracket.

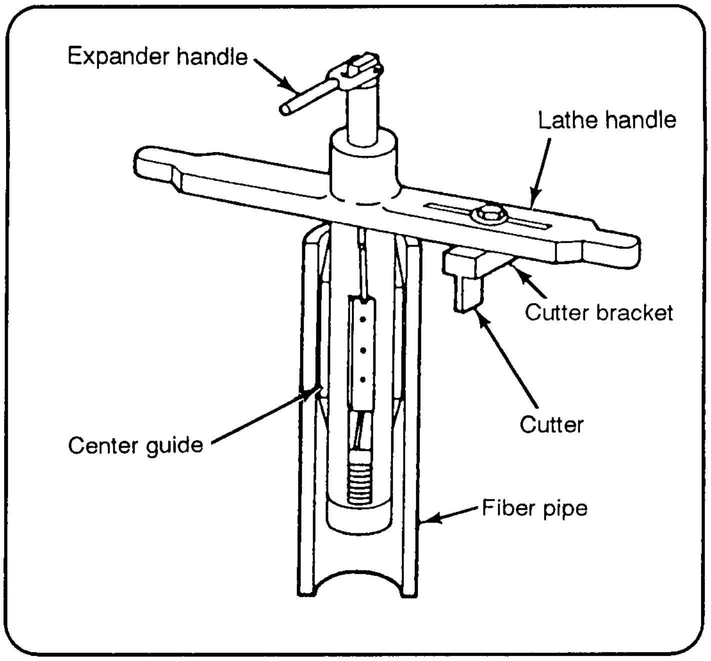


Figure 6-49. Fiber pipe tapering tool

Step 5. Turn the handle one full turn.

Step 6. Loosen the cutter bracket nut, reset the cutter against the pipe, and tighten the nut again.

Step 7. Repeat Steps 5 and 6 until the shoulder at the end of the taper is about l/16-inch wide.

Step 8. Turn the expander handle counterclockwise to loosen the center guide and withdraw the tool.

***NOTE:** Do not take too big a cut on one turn. Cuts should be thin and yield small, flaky bits. If an ordinary page vise is used to hold the pipe for tapering, be careful not to crush the pipe by overtightening the vise.*

(6) *Joining.* Fiber pipe and fittings are joined by a friction joint (Figure 6-50), as follows:

Step 1. Inspect the tapers on both the pipe and fitting to make sure they are free from grease or burrs.

Step 2. Put the fitting and pipe together. The fitting should slide up easily to within 1/4 to 1/3 inch of the shoulder on the taper.

Step 3. Place a wooden block against a fitting to be joined to an installed pipe or against the pipe end to be joined to an installed fitting. Hold the block steady with one hand and have a helper brace the line during the driving.

Step 4. Tap the block lightly with a sledge (Figure 6-50) to drive the pipe and fitting together until the fitting butts against the taper shoulder. The driving produces enough heat to fuse a watertight joint of the pipe and fitting.

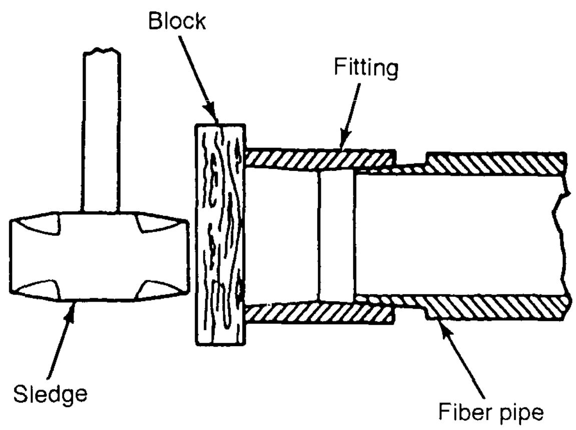


Figure 6-50. Joining fiber pipe

b. *Concrete Pipe and Fittings.*

(1) *Use.* Concrete pipe is used underground for sanitary and storm drainage pipelines.

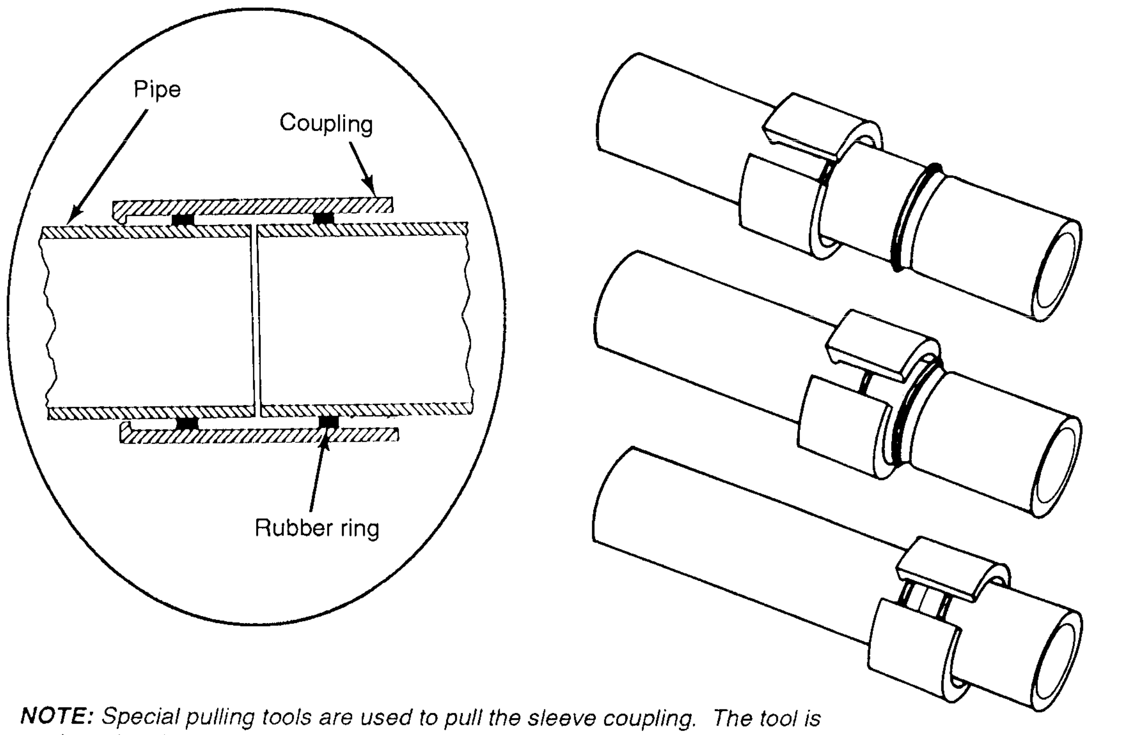
(2) *Types and Sizes.* This pipe is made with cement and sand. Cement pipe is supplied in two grades: (1) nonreinforced and (2) reinforced with wire or steel bars. This pipe comes in various lengths and diameters.

(3) *Fittings.* A coupling is used to join pipe lengths. It consists of a cement sleeve and two rubber rings (Figure 6-51, page 6-40). Other fittings are similar to cast-iron soil pipe fittings.

(4) *Measuring.* Concrete pipe comes in many sizes and types. In general, measurements may be made as for cast-iron soil pipe, allowing for the distance the spigot enters the hub or where the tongue enters the groove.

(5) *Cutting.* Cutting is seldom necessary because of the variety of lengths available. Nonreinforced hub-and-spigot concrete pipe may be cut the same as vitrified-clay pipe. Cutting tongue and groove pipe creates difficult joining problems. Methods of cutting reinforced-concrete pipe are not covered in this manual.

(6) *Joining.* Joints in concrete pipe are generally made with hot-poured bituminous compound and oakum just as for vitrified-clay pipe. Manufacturer's instructions should be followed when using these joining compounds.



NOTE: Special pulling tools are used to pull the sleeve coupling. The tool is anchored to the second pipe and the coupling pulled toward it.

Figure 6-51. Cement-pipe coupling

c. *Vitrified-Clay Pipe and Fillings.*

(1) *Use.* Vitrified-clay pipe, also called *terracota,* is used underground for sanitary and storm drainage pipelines outside of buildings.

(2) *Lengths and Sizes.* This pipe has hub-and-spigot ends in lengths of 2, 2 1/2, and 3 feet. Diameter sizes range from 4 to 42 inches.

(3) *Fittings.* Clay pipe fittings are similar to cast-iron soil pipe fittings.

(4) *Measuring.* Measure vitrified-clay pipe using one of the methods in paragraph 6-3b (pages 6-4 and 6-5). The overall length of a pipe section is its laying strength plus the length of telescoping. Telescoping varies from 1 1/2 inches for 4-inch pipe to 4 inches for 42-inch pipe.

(5) *Cutting.* Since clay pipe comes in short lengths, it seldom has to he cut. When it must be cut, use a brick chisel and hammer. Score the pipe lightly around its circumference and then repeat the process, deepening the cut gradually until the pipe breaks cleanly. Clay pipe is brittle, so it must be cut with care to avoid uneven breaks.

WARNING
Wear safety glasses when cutting clay pipe to avoid eye injury.

(6) *Joining.* Joints on vitrified-clay pipe are made with bituminous compounds with oakum or cement mortar joints molded on the hub-and-spigot ends of the pipe. However, the mechanical seal joint has replaced the cement joint for this type of pipe.

(a) Bituminous compound and cement mortar joint.

Step 1. Insert the spigot end of one pipe or fitting into the hub end of another and align the two pipes.

Step 2. Pack the hub with a 3/4-inch layer of oakum.

Step 3. Fill the joint entirely with bituminous compound and tamp in securely.

Step 4. Finish the joint with a neatly beveled edge around the pipe.

Step 5. Remove surplus mortar or bituminous compound.

(b) Mechanical seal joint. An improved type of interlocking mechanical-compression joint, scaled at the factory, has replaced the cement joint for use with vitrified-clay pipe. This speed seal is made of permanent PVC and is called a *plastisol joint connection.*

Step 1. Spread a solution of liquid soap on the plastisol joint to help the joint slip into place.

Step 2. Insert the spigot end into the bell or hub.

Step 3. Give the pipe a strong push to make the spigot lock into the hub seal.

(c) Resilient and rigid joints. Resilient and rigid joints available for this pipe are the same as for fiber pipe (see paragraph 6-8a(6), page 6-38).

d. *Cast-iron Pressure Pipe.* Cast-iron pressure pipe, also called *corporation*, is used for water supply mains. It may be hub-and-spigot pattern or have flanged ends for bolting connections. Fittings similar to those for cast-iron soil pipe are available.

NOTE: *Cast-iron pressure pipe is seldom used today.*

CHAPTER 7
VALVES AND FAUCETS

A valve is a device (usually made of bronze) to start, stop, and regulate the flow of liquid, steam, or gas into, through, or fiom pipes. Faucets are valves that turn on or turn off hot and cold water in lavatories, sinks, bathtubs, and showers. This chapter covers installation and repair of valves and faucets.

Section I. Valves

7-1. Types. Many types of valves are used. The most common types are shown in Figure 7-1. (Appendix A includes a list of valves and the symbols used for those valves on construction plans.)

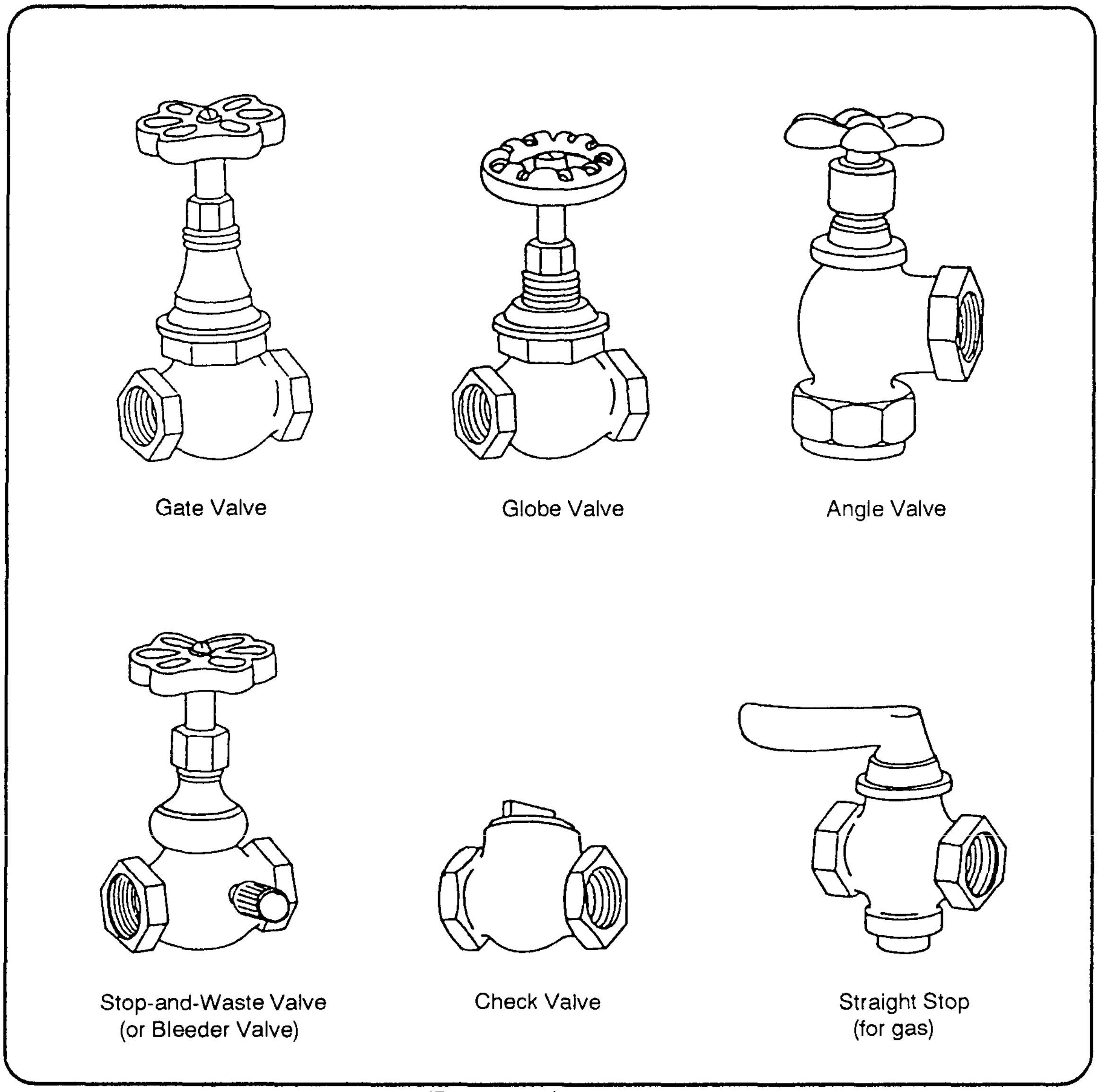


Figure 7-1. Valves

a. *Gate Valve.* A gate valve is used to start or stop liquid, steam, or gas flow. This valve has a split or solid wedge disc, which fits into a machine surface called a *seat.* The valve is operated by raising the disc to start the flow and seating the disc to stop the flow. Gate valves come in three models: (1) rising stem outside screw and yoke, (2) rising stem inside screw, and (3) nonrising stem inside screw.

b. *Globe Valve.* A globe valve is a compression-type valve that controls the flow of liquid by means of a circular disc, forced (compressed) onto or withdrawn from an annular ring scat that surrounds the opening through which liquid flows. All globe valves operate with a rising stem.

c. *Angle Valve.* An angle valve is a globe valve with the inlet and outlet at a 90-degree angle to one another. These valves are recommended for frequent operation, throttling, and/or a positive shutoff when closed.

d. *Check Valve.* A check valve permits the flow of liquid within the pipeline in one direction only and closes automatically to prevent backllow. A check valve can be a swing- or *lift-type.* Swing-check valves arc used in pipelines where pressure and velocity of flow are low. Lift-check valves are used where pressure and velocity of flow are high.

c. *Stop-and-Waste Valve.* A stop-and-waste valve, also known as a bleeder valve, has a plug on the outlet side that allows water to be drained from pipelines.

f. *Other Valves.* Other valves are—

- Reducing valves, used to reduce water pressure going into a building.
- Pressure- or temperature-relief valves for water heaters.
- Flushometer valves in urinals and water closets. (See Figure 4-6, Page 4-7.)
- Foot, check, gauge, and relief valves on centrifugal pumps. (See Chapter 11.)

NOTE: Gas *and water valves are not interchangeable. (See Appendix A for a list of valves and their symbols.)*

7-2. Repair and Maintenance. Valves and fixture-control (operating) devices are a vital part of a plumbing system. Leakage and wear 01 valves and control devices may require simple or extensive repair. Check all valves regularly for leaks. Most leaks are from leaky washers or bonnets, which have been used for a long period of time. The plumber must determine the malfunction and make the repair.

a. *Gate Valve.* Repair of the gate valve is similar to that of the globe valve. However, the part of the gate valve that usually needs attention is the bonnet packing. Use the procedures in Figure 7-2.

b. *Globe Valve.* To repair a globe valve, use the procedure in Figure 7-3 (Page 7-4).

c. *Angle Valve.* This valve is repaired the same as a globe valve. (See Figure 7-3.)

d. *Check Valve.* To repair swing-check and lift-check valves, use the procedures in Figure 7-4 (pages 7-5 and 7-6).

GATE VALVE

NOTE: During disassembly, check all parts for wear and replace as needed.

Leak at stem and packing nut.

Step 1. Tighten the packing nut. If the leak continues, turn off water supply.

Step 2. Remove the wheel handle, packing nut, and old packing.

Step 3. Set in the new packing.

Step 4. Replace the packing nut and wheel handle.

Step 5. Turn on the water supply and check for leaks.

Valve will not close properly to stop water flow.

Step 1. Turn off the water supply; then disassemble the valve from the wheel handle to the body.

Step 2. Resurface the disc with a mixture of oil and lapping compound.

Step 3. Reassemble the valve.

Step 4. Turn on the water supply and check for leaks and proper operation.

Unknown malfunction in valve.

Step 1. Turn off the water supply; then disassemble the valve until you find the fault.

Step 2. Replace faulty parts and reassemble the valve.

Step 3. Turn on the water supply and check for leaks and proper operation.

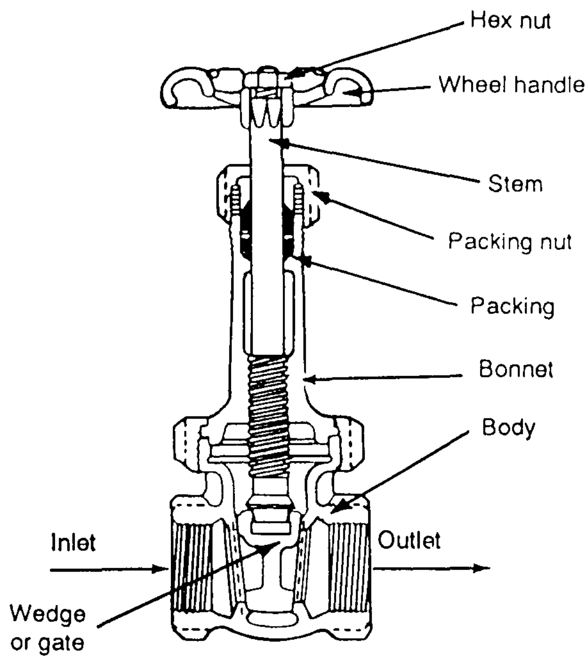


Figure 7-2. Gate-valve repairs

GLOBE VALVE

Leak at stem and packing nut.

Step 1. Tighten the packing nut. If the leak continues, turn off the water supply.

Step 2. Remove the wheel handle, packing nut, and old packing.

Step 3. Set in new packing.

Step 4. Replace the packing nut and the wheel handle.

Step 5. Turn on the water supply and check for leaks.

Valve will not regulate or control the amount of water flow.

Step 1. Turn off the water supply.

Step 2. Disassemble the valve from the wheel handle to the body.

Step 3. **Composition disc:** Remove the old disc and replace it with a new one.

Plug or conventional disc: Remove the disc and insert a washer; then lay the disc to the seat for a snug fit.

Step 4. Reassemble the valve.

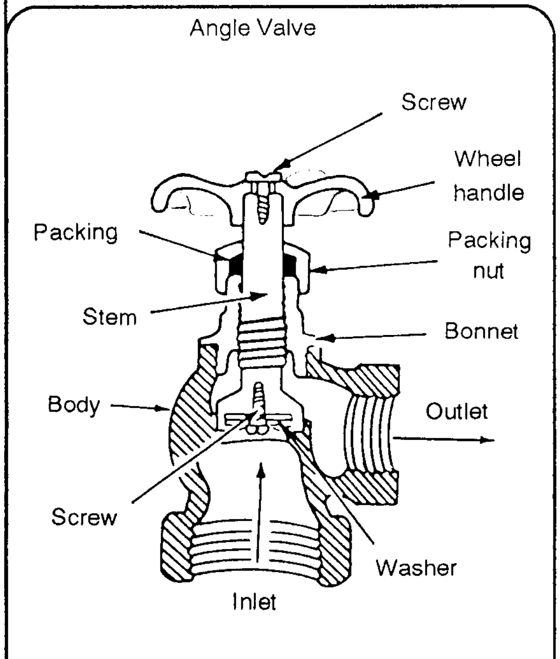
Step 5. Turn on the water supply and check for leaks and proper operation.

Unknown malfunction in valve.

Step 1. Turn off the water supply; then disassemble the valve until you find the fault.

Step 2. Replace faulty parts and reassemble the valve.

Step 3. Turn on the water supply and check for leaks and proper operation.



NOTE: Use globe-valve repairs for this valve.

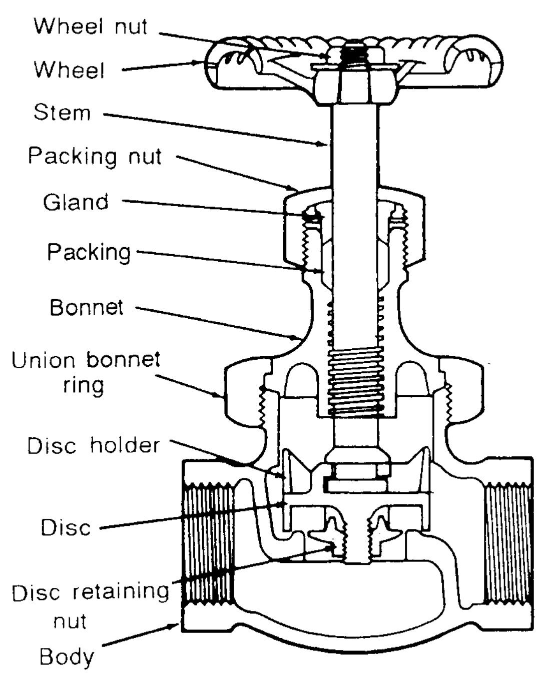


Figure 7-3. Globe-valve repairs

SWING-CHECK VALVE

NOTE: During disassembly, check all parts for wear and replace as needed.

Loose disc locknut, causing water backflow.

Step 1. Turn off the water supply and remove the cap.

Step 2. Tighten the locknut.

Step 3. Replace the cap.

Step 4. Turn on the water supply and check for leaks and proper operation.

Hinge not closing completely.

Step 1. Turn off the water supply and remove the cap.

Step 2. Replace hinge pin and/or hinge with hinge pin.

Step 3. Replace the cap.

Step 4. Turn on the water supply and check for leaks and proper operation.

Worn disc face, causing a leak.

Step 1. Turn off the water supply and remove the cap.

Step 2. Remove the locknut and then the disc.

Step 3. Attach a new disc to the hinge and tighten the locknut.

Step 4. Replace the cap.

Step 5. Turn on the water supply and check for leaks and proper operation.

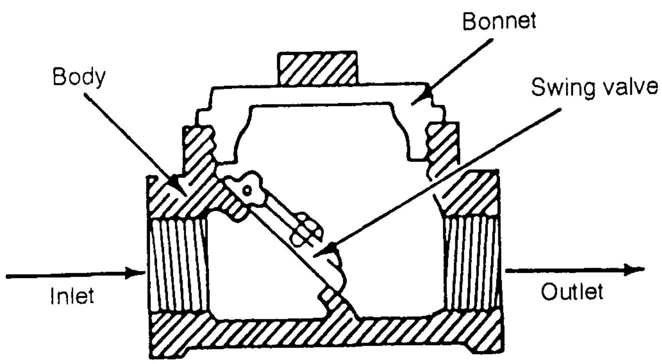


Figure 7-4. Check-valve repairs

LIFT-CHECK VALVE

To avoid repair or replacement of the lift-check valve, inspect them once a year.

- Inspect for wear, freedom of motion, and alignment.
- Inspect the clapper and body seat rings.
- Remove any dirt or foreign matter lodged in the valve.
- If disc or body seat-ring surfaces show signs of wear or corrosion, resurface or replace them.

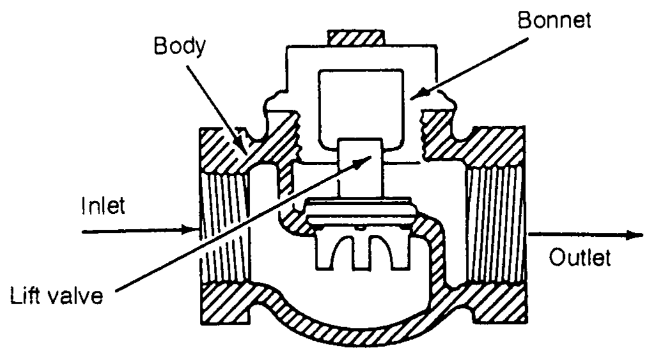


Figure 7-4. Check-valve repairs (continued)

Section II. Faucets

7-3. Types. All lavatories, sinks, bathtubs, and showers may have compression or noncompression faucets.

a. *Compression Faucet.* A compression (or *washer)* faucet works by raising the washer on a seat for water flow and compressing the washer onto the seat to stop the water flow. A compression faucet can be a single faucet for hot and cold water or a combination faucet (Figure 7-5).

b. *Noncompression Faucet.* A noncompression faucet (commonly called *washerless)* has a single lever or knob that opens and closes ports for water flow and shutoff. Noncompression faucets come in three basic types: valve. ball, and cartridge (Figure 7-6). They are controlled by a single handle.

c. *Bathtub Faucets.* This faucet may be a combination compression faucet or a single--knob, noncompression faucet (Figure 7-7. page 7-8), These faucets are mounted in the wall on the drain end of a bathtub, with or without a shower.

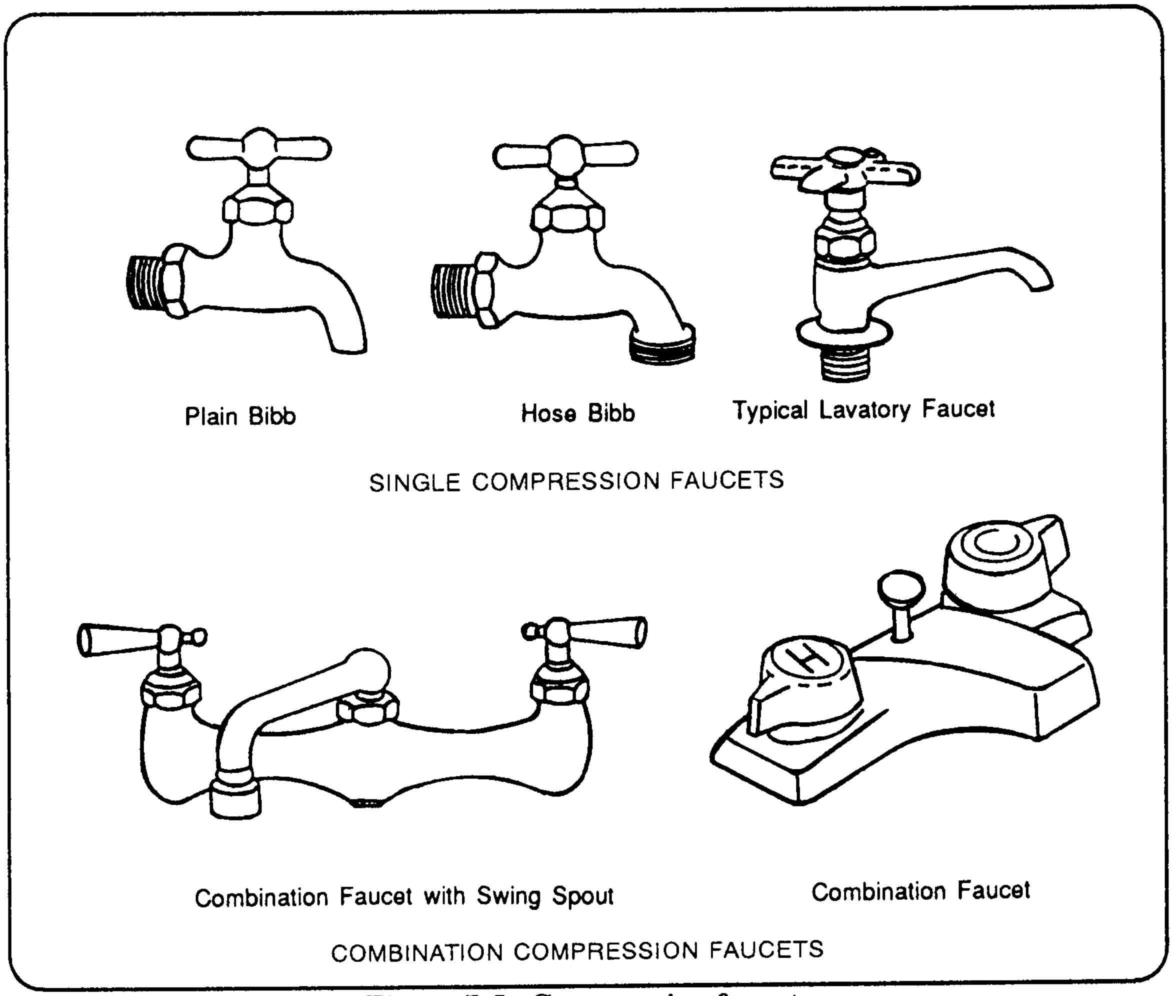


Figure 7-5. Compression faucets

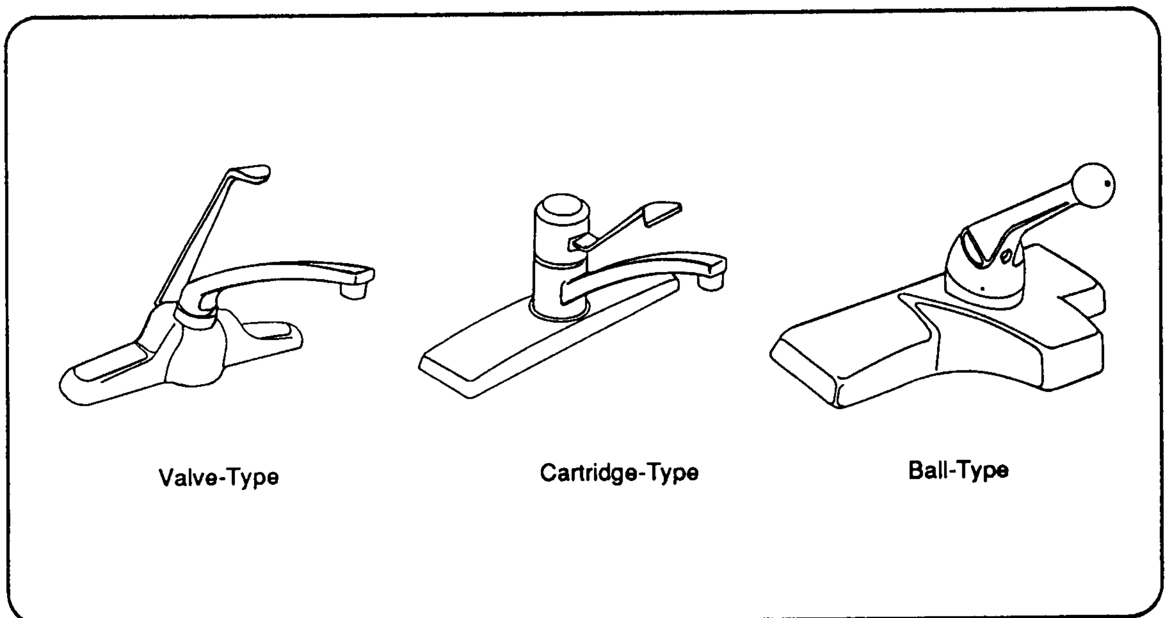


Figure 7-6. Noncompression faucets

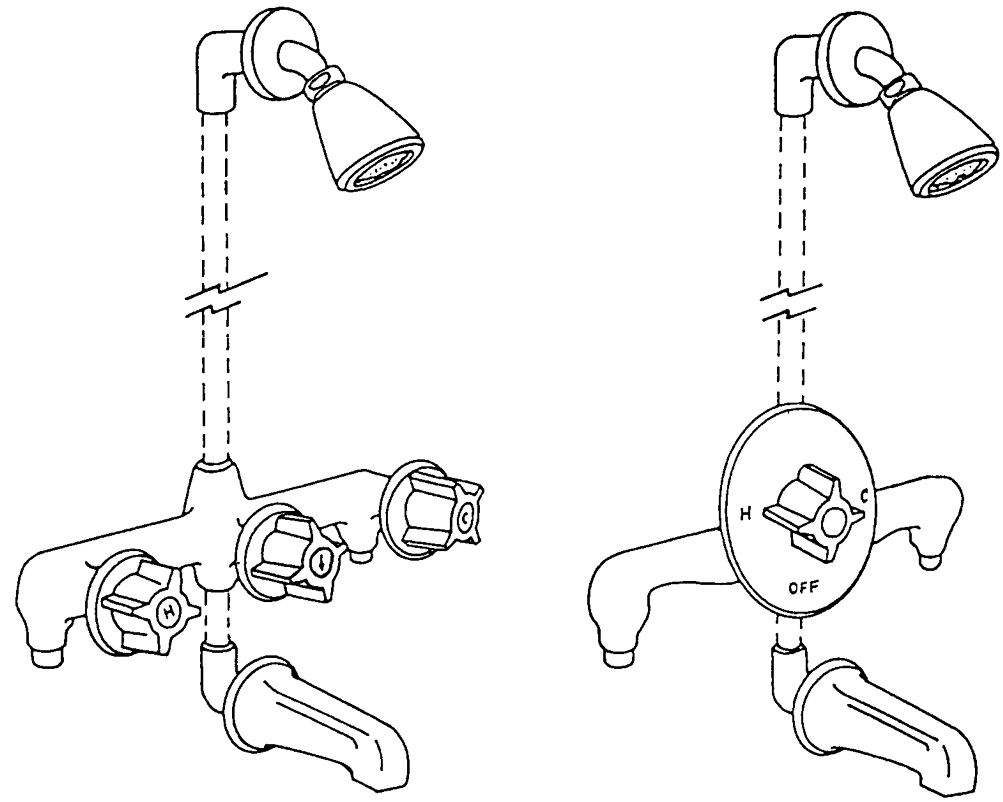


Figure 7-7. Bathtub faucets

7-4. Installation. Install faucets as follows (Figure 7-8):

Step 1. Apply plumber's putty on the bottom of the faucet (either single or combination). If a gasket comes with the combination faucet, putty is not required.

Step 2. Place the faucet on top rear of the bowl, with the threaded end through the holes.

Step 3. Place a washer and attach a locknut to each threaded end under the bowl.

Step 4. Tighten each locknut with a basin wrench.

Step 5. Wipe OH any excess putty, if used, around the faucet.

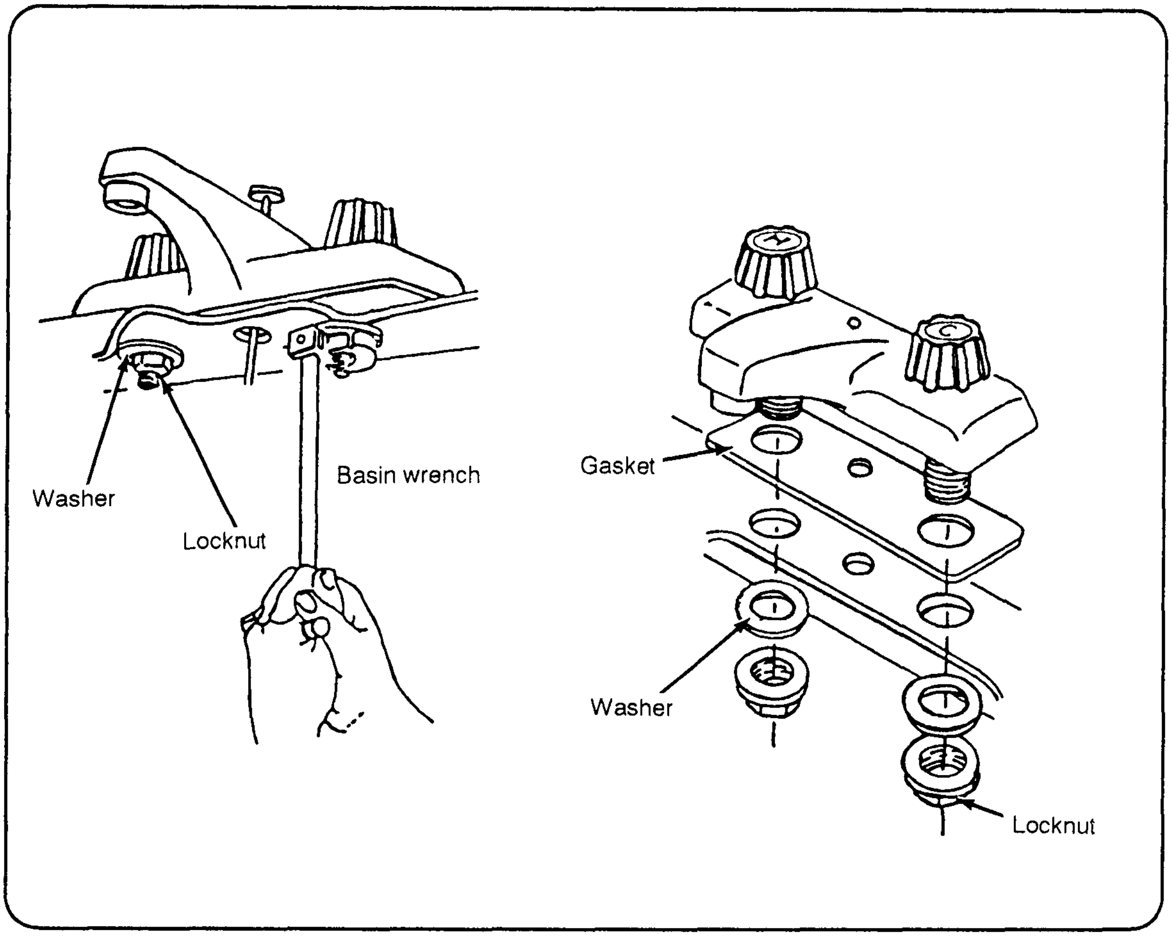


Figure 7-8. Faucet installation

7-5. Repairs. Before repairing any faucet, drain it by turning the water off at the fixture shutoff valve.

a. *Compression Faucets.* When repairing compression (or washer) faucets, always check the valve seat. If it is chipped or rough, reface it with a refacing tool.

- Single *Compression Faucets.* Use the procedures in Figure 7-9 (pages 7-10 and 7-11).
- *Combination compression Faucets.* Use the procedures in Figure 7-9 (pages 7-10 and 7-11).

b. *Noncompression Faucets.* The noncompression (or *washerless)* faucets—ball, valve, and cartridge—have different internal working parts. Use the procedures in Figure 7-10 (pages 7-12 and 7-13).

c. *Bathtub and Shower Faucets.* These faucets function the same as compression and noncompression faucets on sinks and lavatories. Although tub and shower faucets are styled differently than sink and lavatory faucets, repair methods are similar. Figure 7-11 (page 7-14) shows a breakout of the internal parts of bathtub and shower compression and noncompression faucets.

d. *Bathtub Faucets.* Bathtub faucets can be either the compression or noncompression type. Figure 7-12 (page 7-15) shows a breakout of the internal parts of bathtub compression and noncompression faucets, The malfunctions and repairs are similar to lavatory faucets.

COMPRESSION FAUCETS

NOTE: During disassembly, check all parts for wear and replace as needed.

Leak at stem and packing.

Step 1. Turn off the water supply at the shutoff valve, and remove the cap, screw, and handle.

Step 2. Remove the packing nut, the old packing material, and the washer.

Step 3. Place a new washer onto the stem's lower end, and reassemble all parts in order.

Step 4. Turn on the water supply and check for leaks and proper operation.

Leak at spout.

Step 1. Turn off the water supply at the shutoff valve. Remove the cap, screw, and handle.

Step 2. Remove the packing nut with a wrench; then remove the stem from the body.

Step 3. Remove the screw and washer from the bottom of the stem.

Step 4. Place a new washer onto the bottom of the stem.

Step 5. Check the valve seat inside of the body. If it is chipped or rough, reface the seat with a refacing tool. If the seat is even, place the stem into the body.

Step 6. Reassemble all parts in the proper order.

Step 7. Turn on the water supply and check for leaks and proper operation.

Leak at base of body.

Step 1. Turn off the water supply at the shutoff valve. Remove the cap, screw, and handle.

Step 2. Remove the packing nut with a wrench.

Step 3. Remove the worn washer from the packing nut.

Step 4. Slide a new washer into the packing nut for a snug fit.

Step 5. Reassemble parts in the proper order.

Step 6. Turn on the water supply and check for leaks and proper operation.

Figure 7-9. Compression faucet repairs

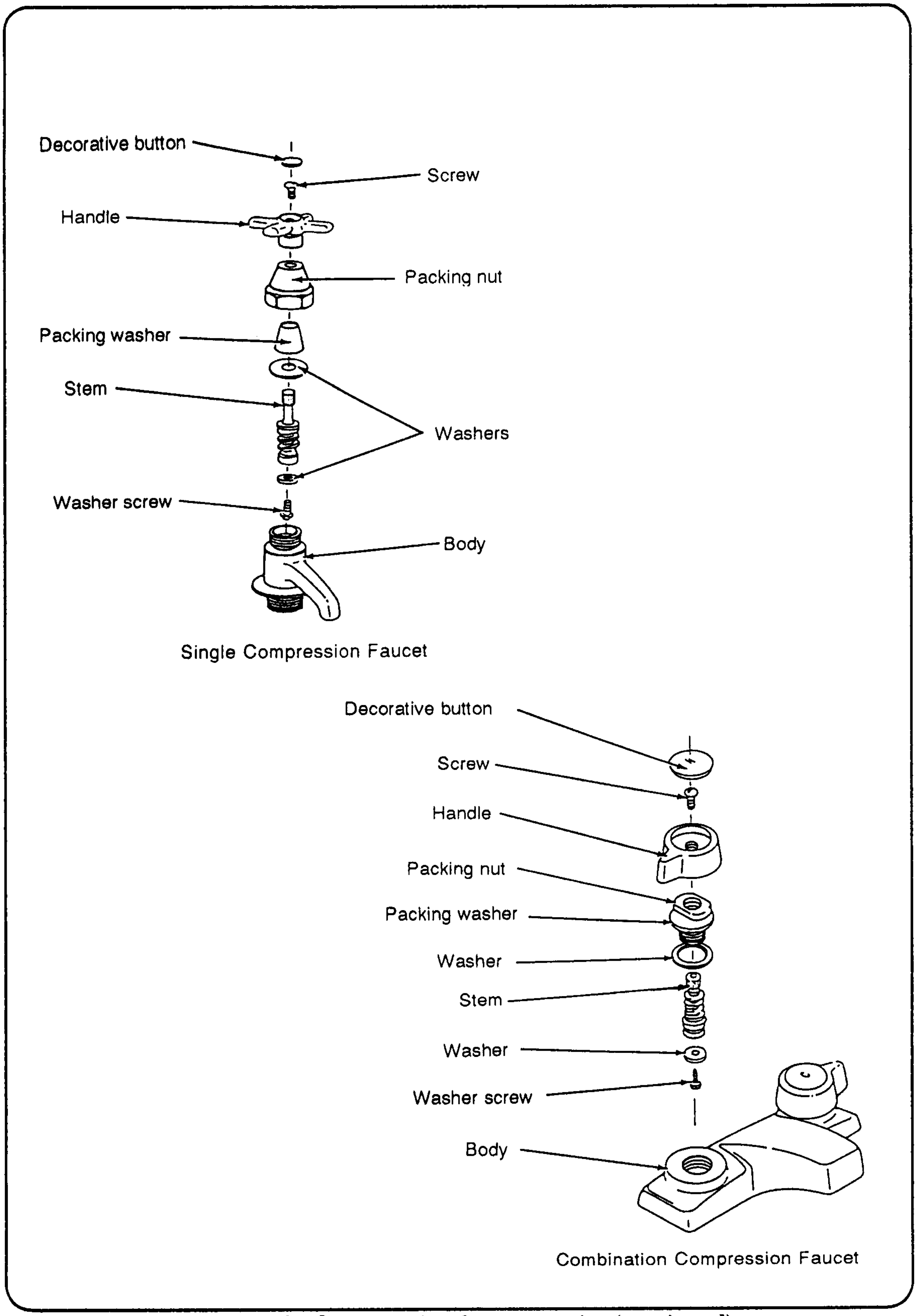


Figure 7-9. Compression faucet repairs (continued)

NONCOMPRESSION FAUCETS

NOTE: Before repairing a faucet, drain it by turning the water off at the fixture shutoff valve. During disassembly, check all parts for wear and replace as needed.

Ball faucets. Leaks in this type of faucet can be caused by a corroded or gouged selector ball or by worn rubber valve seats.

Step 1. Remove the lever handle by loosening the set screw.

Step 2. Remove the cap and pull out the ball with the cam assembly.

Step 3. Use needle-nose pliers to remove the two rubber valve seats and springs.

Step 4. Replace the rubber seats and/or the selector ball.

Step 5. Reassemble the faucet, making sure that the slot in the ball lines up with the metal protection on the housing. Check for leaks.

Valve faucets. Leaks in this type of faucet can be caused by a worn O-ring at the base of the spout or by other worn internal parts.

Step 1. Remove the spout and lift off the escutcheon. Remove the plugs on each side, turning them counterclockwise and pulling out the gasket, strainer, spring, valve stem, and valve seat.

Step 2. Remove the seat with a seat-removal tool or allen wrench.

Step 3. Reassemble the faucet and check for leaks.

Metal cartridge faucets. Leaks in these faucets are usually caused by two O-rings in the faucet body. Replacing the O-rings should eliminate the leaks.

Step 1. Remove the screw and push a screwdriver down the hole to keep the stem in place while removing the handle and cover.

Step 2. Unscrew the retaining nut and remove the spout. The body of the faucet is exposed to get to the O-rings.

Step 3. Replace the O-rings.

Step 4. Reassemble the faucet and check for leaks.

Ceramic-disc cartridge faucet. In the ceramic disc, leaks are caused by a worn or corroded disc.

Step 1. Press the tile lever/knob all the way back to remove the set screw.

Step 2. Remove the lever/knob and the two set screws under the spout.

Step 3. Disengage the stopper mechanism under the lavatory and remove the ceramic cartridge, which is held by two brass screws.

Step 4. Replace the cartridge.

Step 5. Reassemble the stopper mechanism and the faucet. Check for leaks.

NOTE: If the faucet malfunctions due to corrosion or wear, use the manufacturer's instructions to make repairs.

Figure 7-10. Noncompression faucet repairs

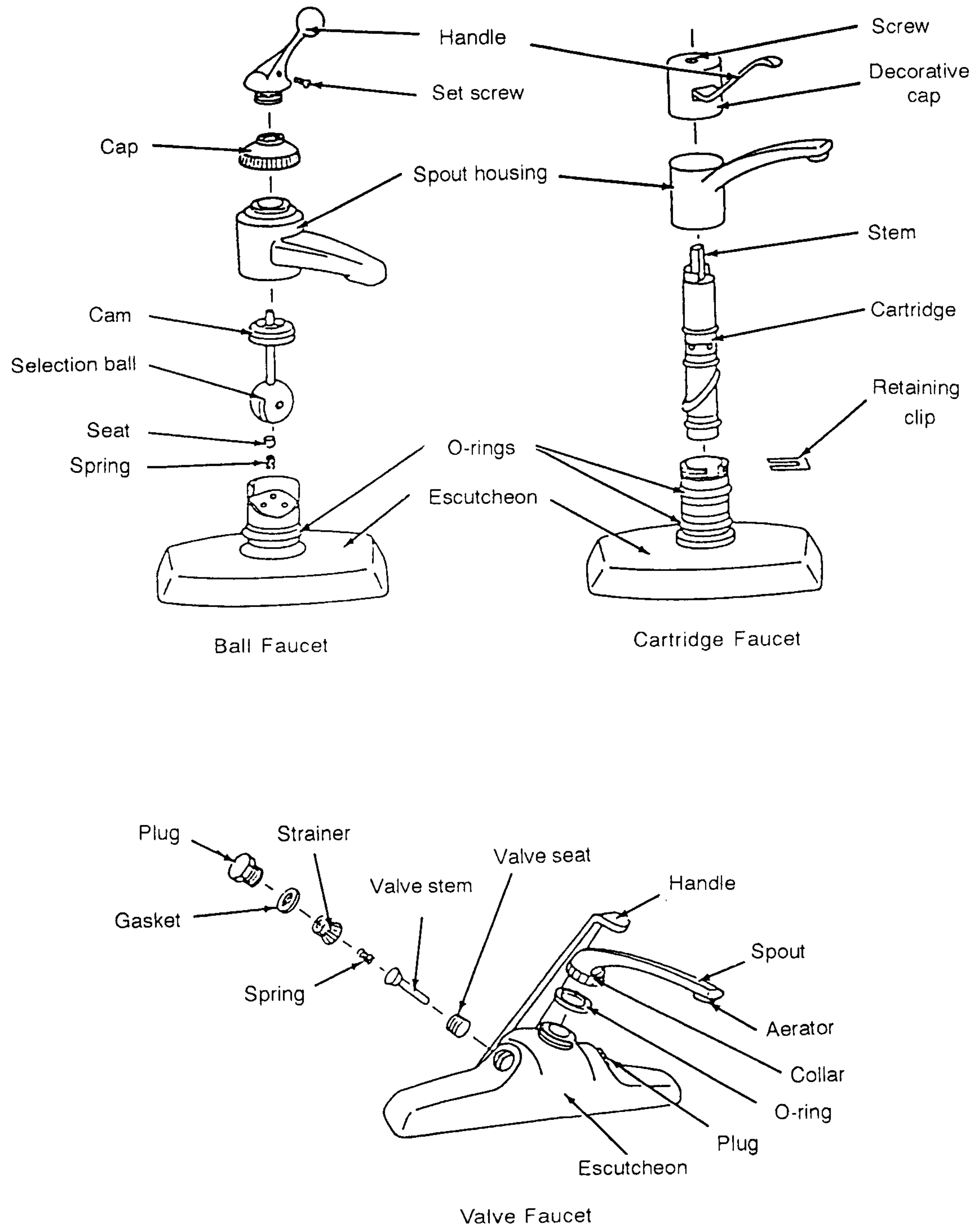


Figure 7-10. Noncompression faucet repairs (continued)

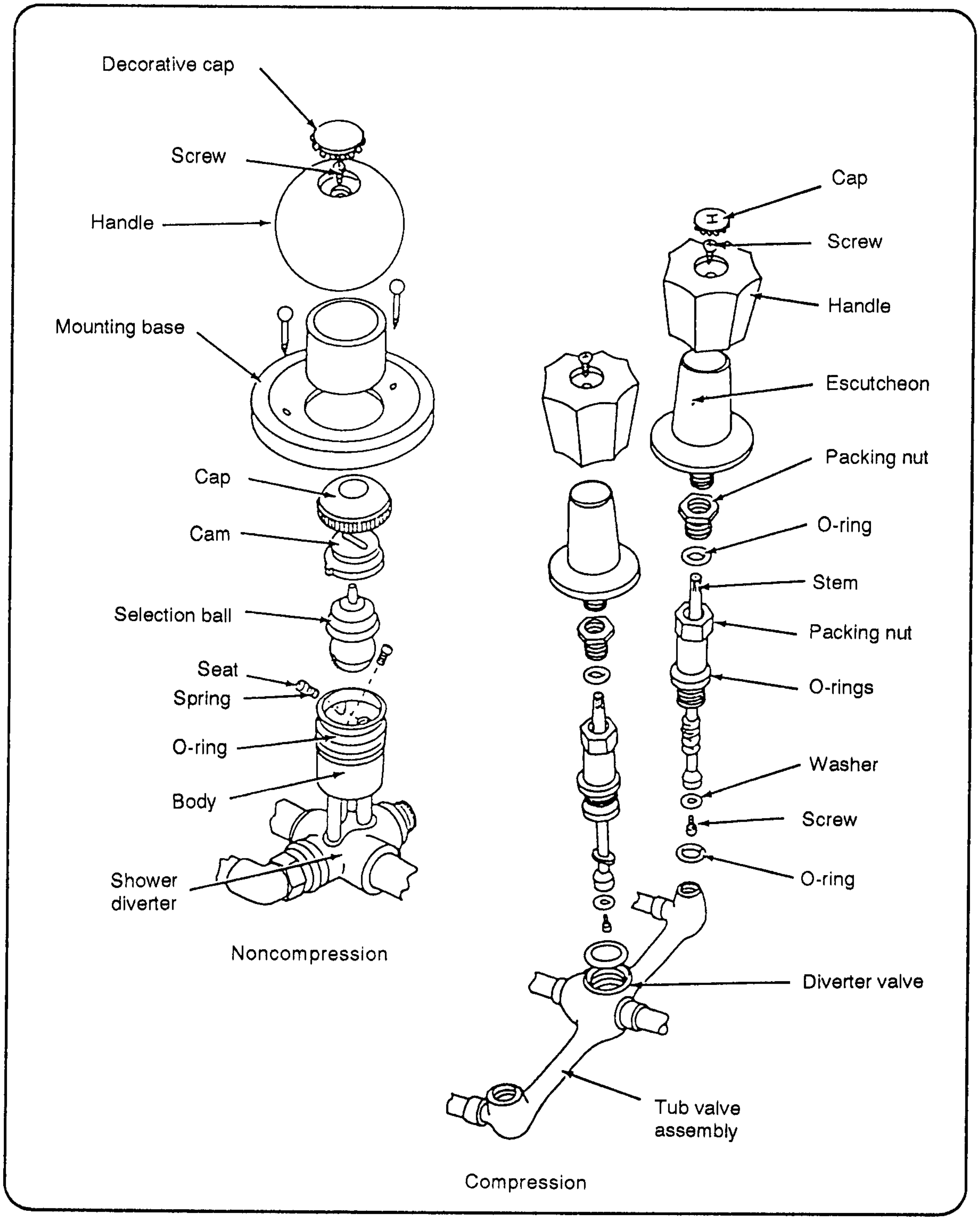


Figure 7-11. Bathtub and shower faucet breakout

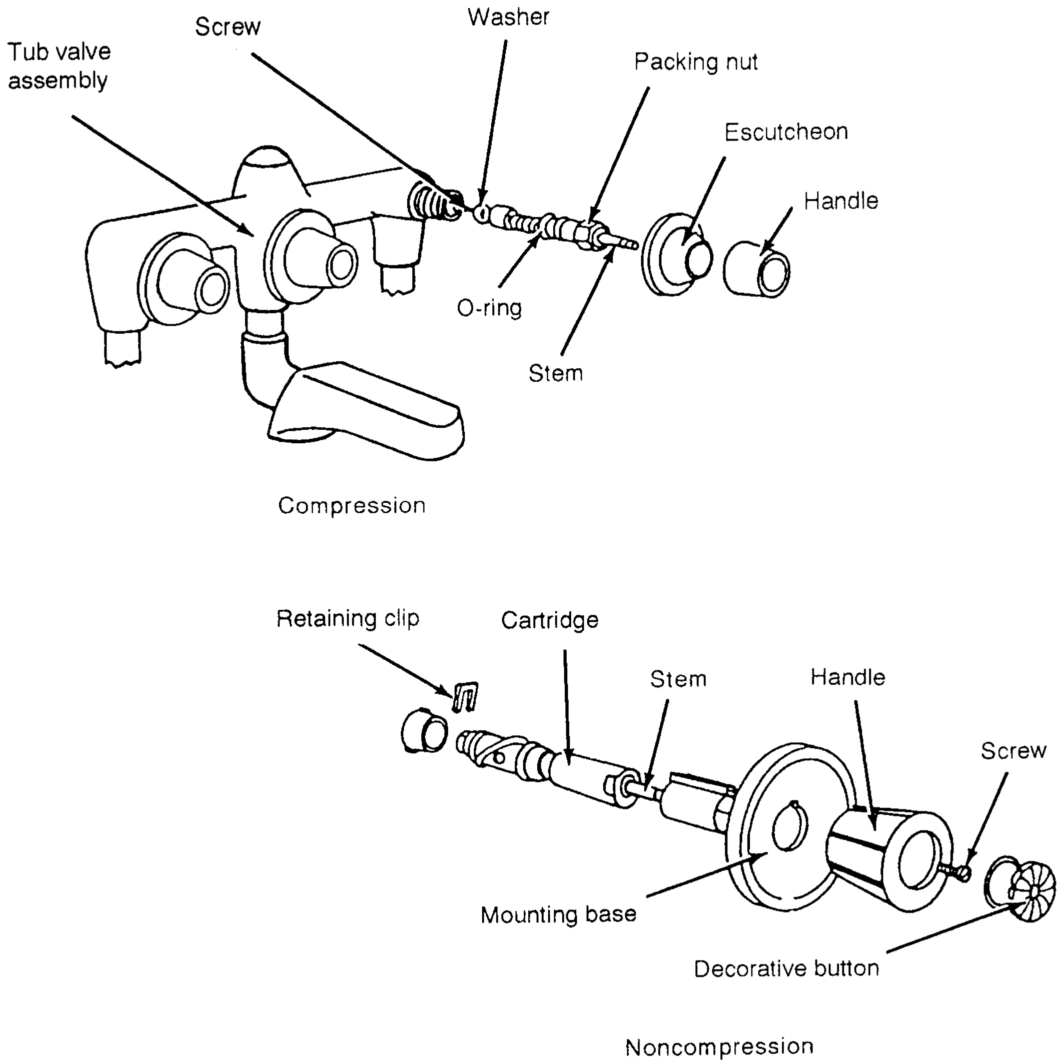


Figure 7-12. Bathtub faucet breakout

CHAPTER 8
STACKS AND BRANCHES

Stacks are the vertical main pipes in a plumbing system. They carry wastes to the house drain. Brunches are the pipes that carry the discharge from the fixtures to the stacks. A soil branch carries water-closet waste; a waste branch carries wastes from all other fixtures. Most buildings do not have separate soil and waste stacks, so a single, stack known as the ***soil-and-waste stack*** *or simply* ***the soil stack*** *(or* ***stack),*** *carries both soil and waste.*

8-1. Pipe Selection. Stacks and branches may be made of cast-iron, iron (threaded), copper, or plastic pipe. Soil stacks are usually made of hubless cast iron with neoprene sleeve gaskets or of plastic pipe. Copper pipe is also used for soil stacks because it is easily installed. Branches are usually made of either threaded galvanized-steel pipe with recessed drainage fittings, copper pipe (DWV), or plastic pipe (ABS).

8-2. Pipe Size.

a. *Stack.* The stack is sized in the same way as the building and house drain. Determine the total DFUs using Chapter 1, paragraph 1 -16b(l) (page 1-14). Then, apply this number to Table 8-1 to find the proper stack size. Continuing the example in Chapter 1, paragraph 1-16b, (page 1-1 5), the 41 DFUs would require a 3-inch stack for cast-iron, steel, or plastic pipe and a 2-inch stack for copper pipe.

Table 8-1. Maximum fixture units per stack

Size of Pipe (in inches)	Fixture Units per Stack
3	60
4	500
5	1,100
6	1,900
8	3,600
10	5,600
12	8,400

b. *Branches.*

(1) Water Closets. A water closet has no individual waste pipe. Usually, it is connected directly into the stack with a short branch attached to a closet bend. The closet bend is 3 or 4 inches in diameter if it is cast iron, steel, or plastic and 3 inches if copper.

(2) *Lavatories.* Because lavatories are used for washing, stoppages can occur in the waste pipe. Improve drainage by using a minimum number of fittings and no long, horizontal runs. The minimum pipe size for lavatory waste is 1 1/4 inches. If other than copper pipe is used, 1 1/2 inches is more satisfactory.

(3) *Urinals.* Urinals present a particular problem because foreign matter is often thrown into them. Therefore, a urinal should be equipped with an effective strainer. The size of the waste pipe should be 2 inches if it is cast iron, steel, or plastic and 1 1/2 inches if copper.

(4) *Showers.* The diameter of the waste pipe for a single shower is 2 inches for cast iron, steel, or plastic and 1 1/2 inches for copper. To handle the flow during peak use, a shower room requires a waste pipe of 3 or 4 inches in diameter. Stoppages seldom occur in shower waste pipes.

(5) *Sinks.*

(a) *Kitchen Sink.* A kitchen sink needs a 1 l/2-inch waste pipe because of food wastes flushed into the sink. The waste pipe must be short and as free from offset as possible.

(b) *Slop Sink. The* two styles of slop (utility) sinks are trap-to-floor (stand trap) and trap-to-wall. Each is used for disposing of wash water, filling mop buckets, and washing out mops. The trap-to-floor requires a 3-inch waste pipe. The trap-to-wall requires a 2-inch waste pipe. In both types, copper pipe may be a size smaller.

(c) Scullery Sink. Scullery sinks are for general kitchen use. A 2-inch waste pipe should be used because a large amount of grease is passed into the pipe through a grease trap.

(6) *Drinking Fountains.* Since drinking fountains carry clear water waste, a 1 l/4-inch pipe is ample.

8-3. Installation. The stack is one continuous pipe run that goes from the house drain up through the roof. However, certain sections of the run are named for their function, as shown on Figure 8-1.

a. *Stack.* Installation of the stack requires the following connections:

- *From the House Drain to the First Branch Takeoff.*

  Step 1. Connect the stack to the house drain using a long sweep 1/4 bend to keep pressure to a minimum.

  Step 2. Connect a test T to the bend with a piece of pipe long enough to raise the side opening of the test T 12 inches above the finished floor.

  Step 3. Add other pipe until the desired height of the first branch takeoff is reached.

  Step 4. At this point, install a sanitary T or combination Y and 1/8 bend.

- *To the Main Soil-and-Waste Vent.* The main soil-and-waste vent extends above the top branch fitting, which runs through the roof (without connecting it to the main vent). Usually this vent is connected to the main vent and is called the *main soil-and-waste vent.*
- *Vent through the Roof (VTR).* After the main vent T is installed, run the main soil-and-waste vent through the roof to form the VTR. The VTR pipe must be as large or larger than the stack and must extend a minimum of 12 inches above

the roof. It can be either straight from the stack or offset. To make the opening in the roof watertight, use roof flashing. In areas of below-freezing temperatures, frost may close the vent at its roof outlet. To prevent this, you may use a pipe that is a size or two larger than the stack. Other methods are insulation, high flashing, and a frost-proof cover over the pipe.

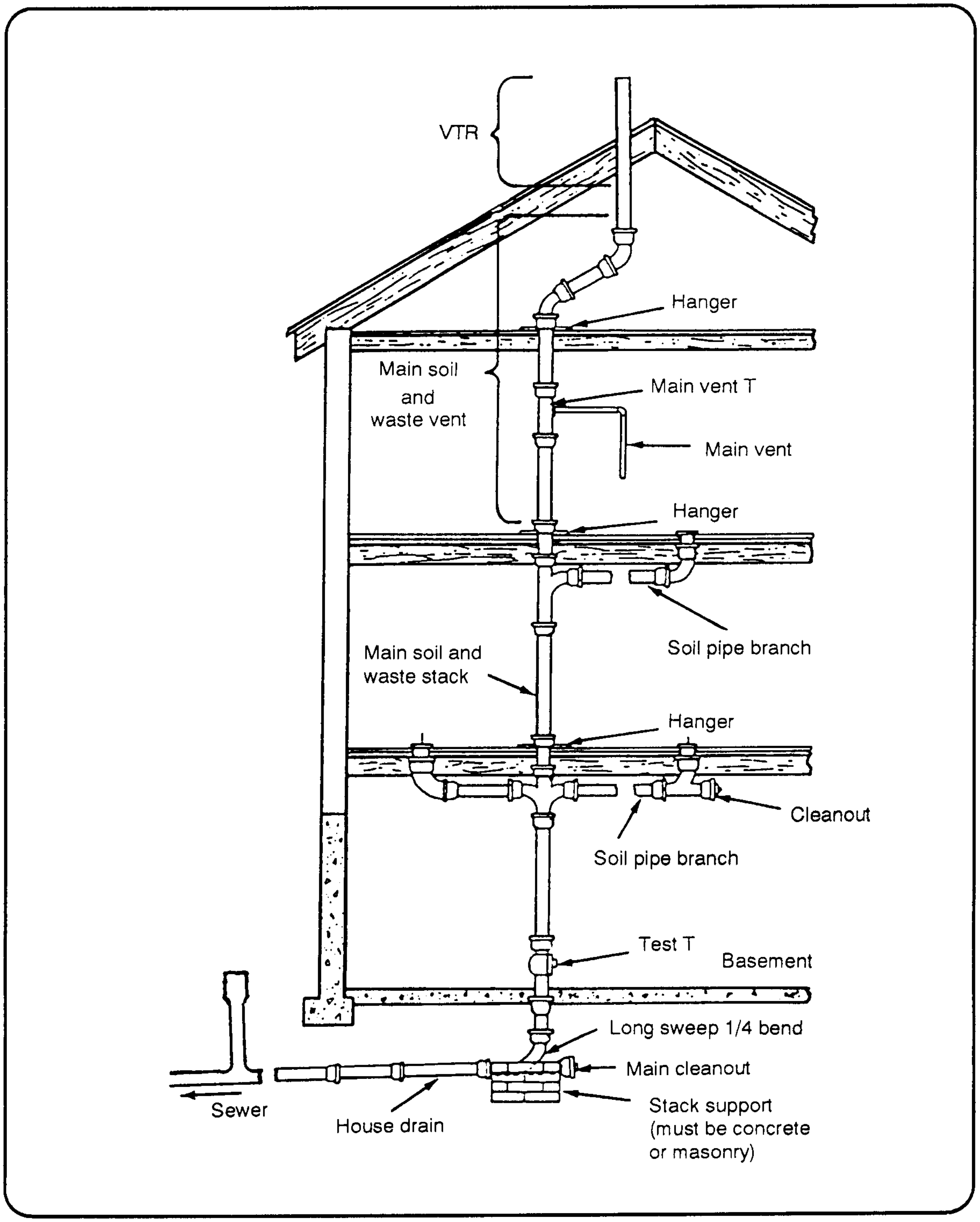


Figure 8-l. Stack and branches

b. *Main Vent T.* The main vent T should be placed in the stack at least 6 inches above the flood level of the highest fixture in the installation. It joins the main vent to the main soil-and-waste vent.

c. *Branches.*

(1) *Slope.* Horizontal branches are run from the takeoffs on the soil stack to the various fixtures. Branches should slope 1/4 inch per foot from the fixture to the stack. A convenient tool for checking slope is a carpenter's level.

(2) *Cleanouts.* Waste lines should have as many cleanouts as needed to clear stoppages and simplify repairs. Install a cleanout for every change of direction and for each horizontal line 2 feet long or longer. The cleanouts should be the same diameter as the waste line.

(3) *Sizes.* Branch sizes are determined by the number of drainage fixture units. No branch may be larger than the soil (waste) stack.

8-4. Stack and Branch Supports. Stacks and branches should be supported so that the weight of the pipe will not bear on joints, since they are the weakest points in the line. Cast-iron soil pipe stacks and branches should be supported at all joints. The bend at the base of the stack should rest on a concrete or masonry support, as shown in Figure 8-1 (page 8-3). The (vertical) stack may be supported on each floor with special hangers, by placing wood strips under two sides of the hub or by wrapping strap iron around the pipe at the hub and suspending it from joists. Horizontal cast-iron runs of piping must be supported by sturdy iron-ring hangers. The support should be as close to the caulked joint as possible. Support threaded, galvanized-iron/steel waste pipe, plastic pipe, and copper-tubing drain and vent lines at each floor level.

8-5. Testing. After installing the waste system, test it to see that all joints are leakproof.

a. *Galvanized-Iron/Steel, Copper, and Plastic Piping.* To test these types of piping, choose either the water or the air test on page 8-5.

b. *Other Types of Piping.* Before doing a water or an air test, do the following 12-hour test:

Step 1. Seal all branches and vent lines, and place a test plug in the test T (Figure 8-2) at the base of the slack.

Step 2. Fill the system with water from the top of the main soil-and-waste vent, and keep it filled for at least 12 hours to allow the oakum in the joints to swell and form a watertight seal.

After completing this 12-hour test, choose either a water test or an air test.

Water Test

Step 1. Seal the branches and vent lines and place a test plug in the test T.

Step 2. Fill the system with water and check for a drop in the water level.

Step 3. If the water level drops noticeably, check each joint for leaks. The test is satisfactory if the water level does not fall more than 4 inches in a 30-minute period.

Step 4. Leaking joints must be made watertight, and any defective material must be replaced.

Air Test

A special plug, through which air is pumped into the system, is required for this test. In a cast-iron soil pipe system, close all openings after you have drained the water.

Step 1. Apply an air pressure of about 5 psi (measured by a gauge).

Step 2. A drop in the mercury column on the gauge shows a leaky joint. In a satisfactory test, the line should hold 5 psi for 15 minutes.

Step 3. Listen for the sound of escaping air to help locate leaks. If no sound is heard and pressure is falling, apply a soap solution to the joints in the area of the leak. If there is a leak, bubbles will form.

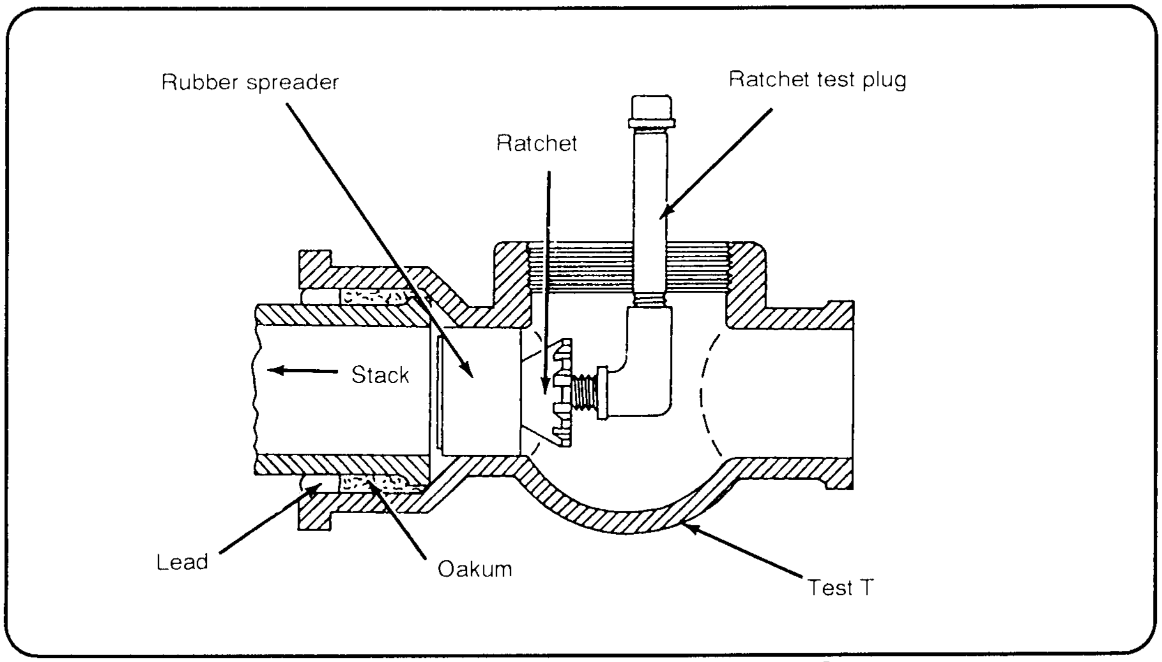


Figure 8-2. Test T with plug inserted

CHAPTER 9
TRAPS AND VENTS

A vent is a pipe or opening that brings outside air into the plumbing system and equalizes the pressure on both sides of a trap to prevent trap seal loss. A trap provides a water seal that keeps sewer gases from entering a building through a waste outlet.

Section I. Traps

A trap is a fitting or device that, when properly vented, provides a water seal to prevent the discharge of sewer gases without affecting the flow of sanitary drainage through it.

9-1. Use. Traps are used on some fixtures and floor drains inside buildings. The P-trap is used in a partition to connect a drain to a waste branch. A running trap is used in a building's drain line when the local plumbing code requires that the building drain be trapped.

9-2. Types. The types of water-seal traps are P-trap, S-trap, 3/4 S-trap, and drum trap (Figure 9-l). The most common type is a P-trap. (See also cast-iron traps in Figure 6-10, page 6-10.)

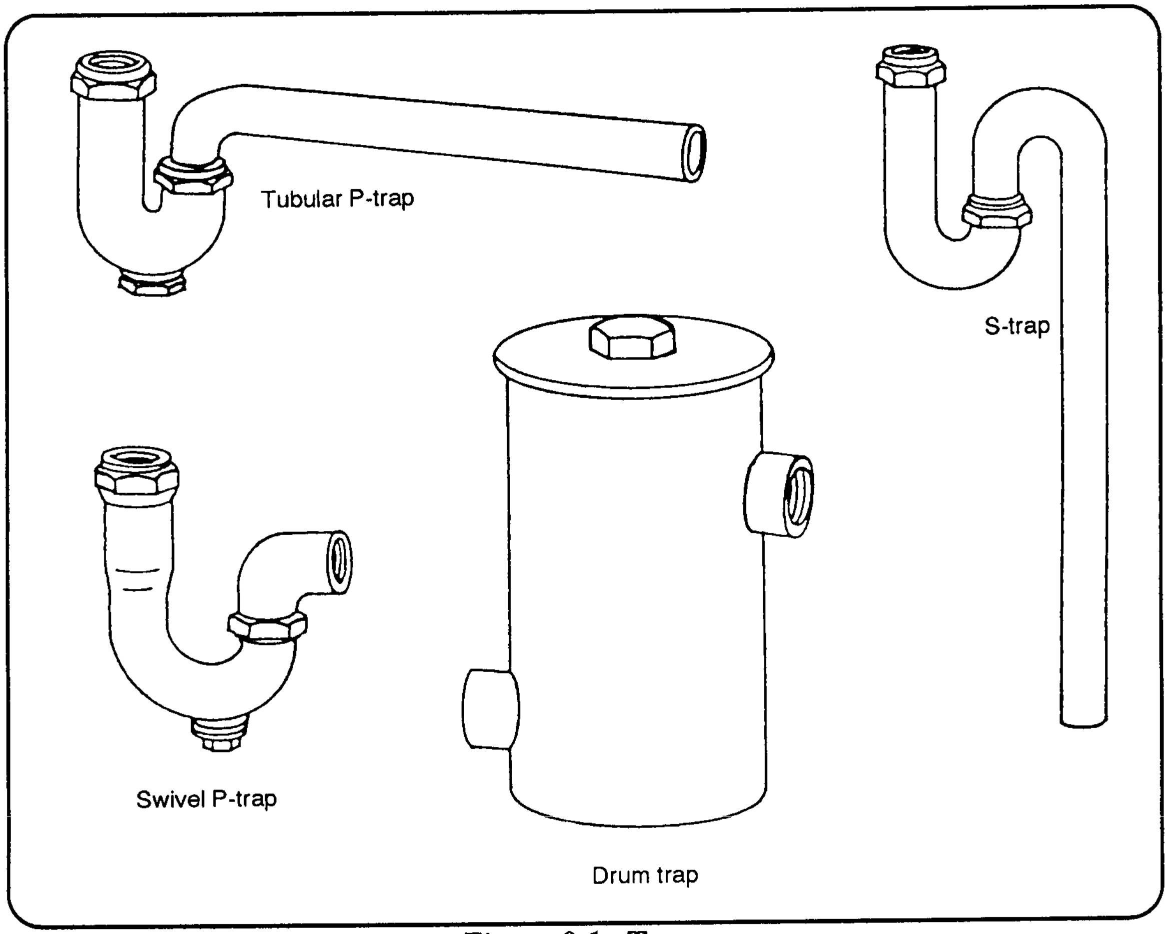


Figure 9-1. Traps

a. *P-Trap.* This trap is the most widely used for fixtures. It can be either plastic or chromed, tubular brass. The most common diameter sizes are 1 1/4 and 1 1/2 inches. Most P-traps have a cleanout plug, since the traps are subject to stoppage.

b. *Drum Trap.* This trap is used mostly for bathtubs, but it can also be used in kitchen sinks. Drum traps are designed in several styles, depending on the manufacturer and the material used. This trap has the advantage of containing a larger volume of water and discharging a greater volume of water than a P-trap. A drum trap is 3 or 4 inches in diameter with the trap screw one size less than the diameter.

c. *S-Trap and 3/4 S-Trap.* The full S-trap and 3/4 S-trap are not used in modern plumbing. If an S-trap or 3/4 S-trap is in place, remove it and replace it with a P-trap.

9-3. Trap Seal Loss. The trap seal (Figure 9-2) is a liquid content in the U-shaped part of the trap. The most common trap seal has a depth of 2 inches between the weir and the top dip. The deep-seal trap has a depth of 4 inches. If the trap's water seal is lost, dangerous sewer gases can enter the building through the fixture.

a. *Inadequate Venting.* Trap seal loss usually results from inadequate venting of the trap. Venting a plumbing system allows the atmosphere to enter the discharge side of a trap, preventing loss of water seal by siphonage. At sea level, atmospheric pressure is about 14.7 psi. This pressure varies only slightly on the fixture side of the water seal in a trap. Any difference between this pressure and the pressure on the discharge side forces the water seal in the direction of less pressure. Venting the discharge side of the trap to the atmosphere tends to equalize these pressures.

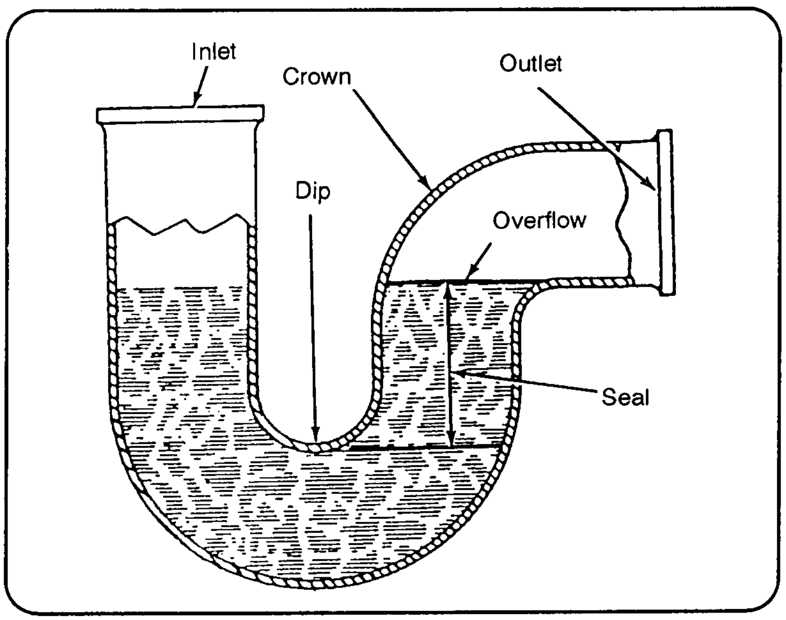


Figure 9-2. Trap seal

b. Direct Siphonage. Direct siphonage, or self-siphonage, as shown in Figure 9-3, occurs in unvented traps that serve oval bottom fixtures such as lavatories. Such fixtures discharge their contents rapidly and do not have the final small trickle of water needed to reseal the trap. When the plug is withdrawn, the water flows out fast and completely fills the waste pipe. The water displaces the air that normally fills the waste pipe, lowering the atmospheric pressure on the discharge side of the trap. Atmospheric pressure on the fixture side forces the water through the trap, and the seal is lost.

In a lavatory with a flat bottom, the last few ounces of water flowing into the trap come in a slow trickle, resealing the trap. Showers, laundry tubs, sinks, and bathtubs rarely lose trap seal by direct siphonage.

Fixture manufacturers have tried to combat siphonage by reducing the diameter of the lavatory outlet to 1 1/4 inches and recommending that it be connected to a 1 l/2-inch waste pipe. In such a connection, the water volume does not completely fill the waste pipe, and the air in the pipe maintains atmospheric pressure on the outlet side of the trap.

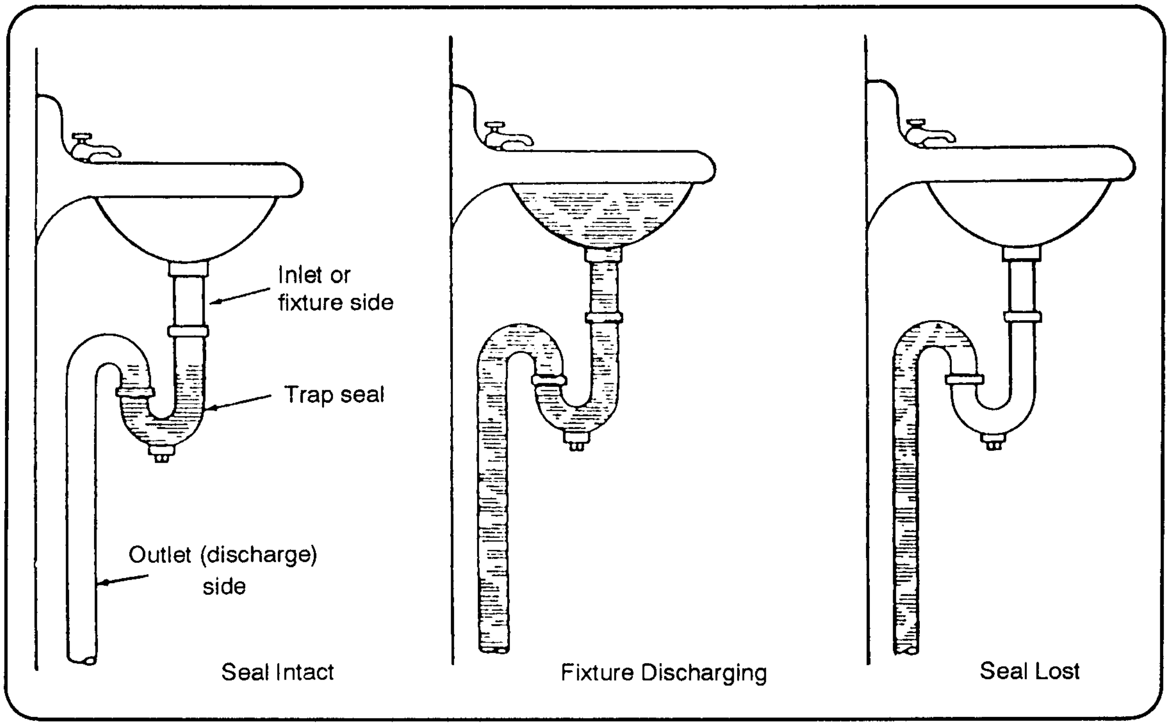


Figure 9-3. Direct siphonage

c. *Indirect or Momentum Siphonage.* Indirect siphonage (Figure 9-4, page 9-4) is caused by a large discharge of water from a fixture installed one or more floors above the affected fixture. This large discharge tends to form a slug in the stack; and as this slug passes the takeoff of the fixture below it, air is pulled out of the waste line on the lower fixture. This reduces the pressure on the discharge side of the trap. There is no reseal until there is a discharge from the lower fixture.

d. *Back Pressure.* Back pressure within a sanitary drainage system is caused by simultaneous fixture use that overtaxes the plumbing system, causing a positive pressure that affects the water seal of a trap. A large flow may completely fill the pipe, causing the compressed atmospheric gases to offer resistance because they cannot slip past the flow of the water and exhaust at a roof terminal. As the water falls, the pressure increases and compresses the air, and the trap seal blows out of the fixture (Figure 9-5, page 9-4).

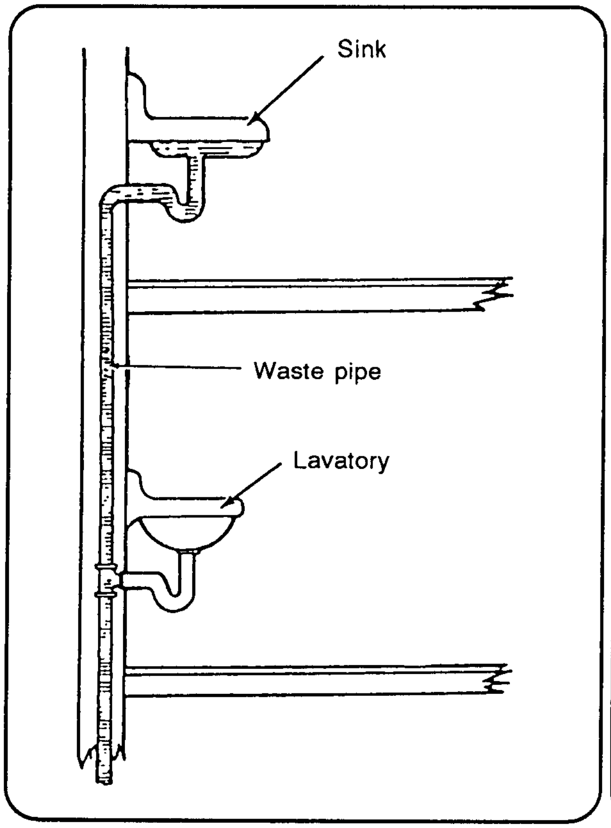


Figure 9-4. Indirect siphonage

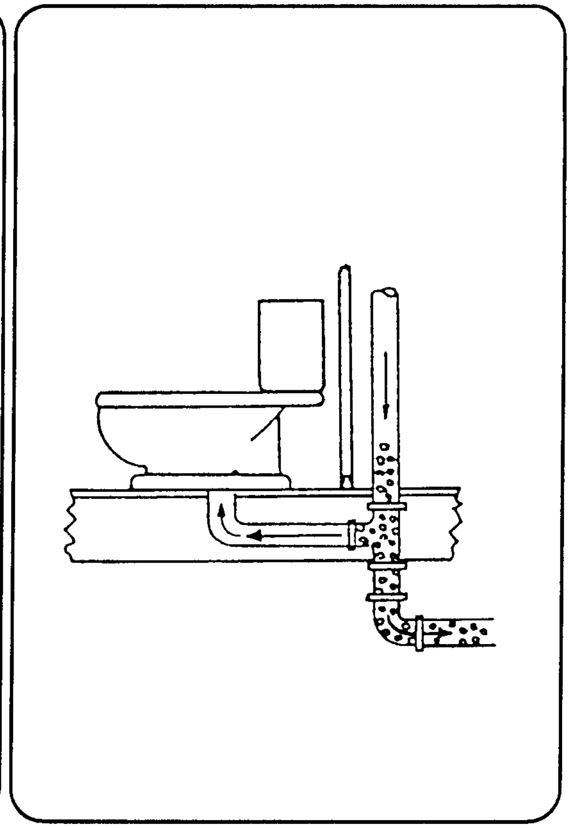


Figure 9-5. Trap seal loss by back pressure

e. *Capillary Action.* Loss of trap seal by capillary action is caused by a foreign object lodged in the trap. The object acts as a wick and carries the water from the trap over the outlet side into the waste pipe until the seal is ineffective (Figure 9-6). Rags, string, lint, and hair commonly cause this problem.

f. *Evaporation.* Loss of trap seal from evaporation only occurs when a fixture is not used for a long time. The rate of evaporation in a trap depends on the humidity and temperature of the atmosphere. A trap in a warm, dry place will lose water seal by evaporation more rapidly than one in a cool, damp place. Ventilation does not solve the problem. The use of a deep-seal trap is the best solution. One disadvantage is that solid wastes collect in the bottom of the trap and clog the pipe

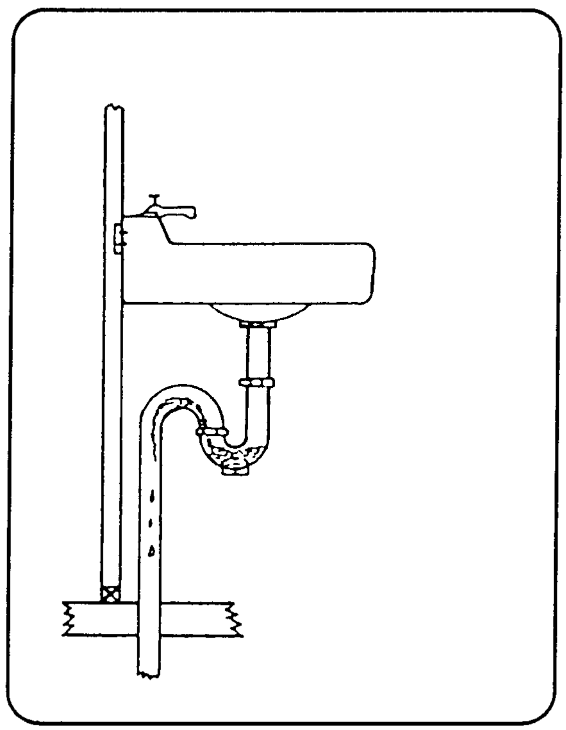


Figure 9-6. Trap seal loss by capillary action

Section II. Vents

The main vent is a vertical pipe connecting fixture vents to the main soil-and-waste vent or directly to the atmosphere. In a building of three or more stories, the main vent should be connected to the bottom of the soil stack to prevent pressure on the lower branches.

9-4. Installation. A typical stack and vent installation is shown in Figure 9-7. Usually the main vent is within several feet of (parallel to) the main soil-and-waste stack, but it may be offset where there are space problems. Branches from the main vent are used in installations.

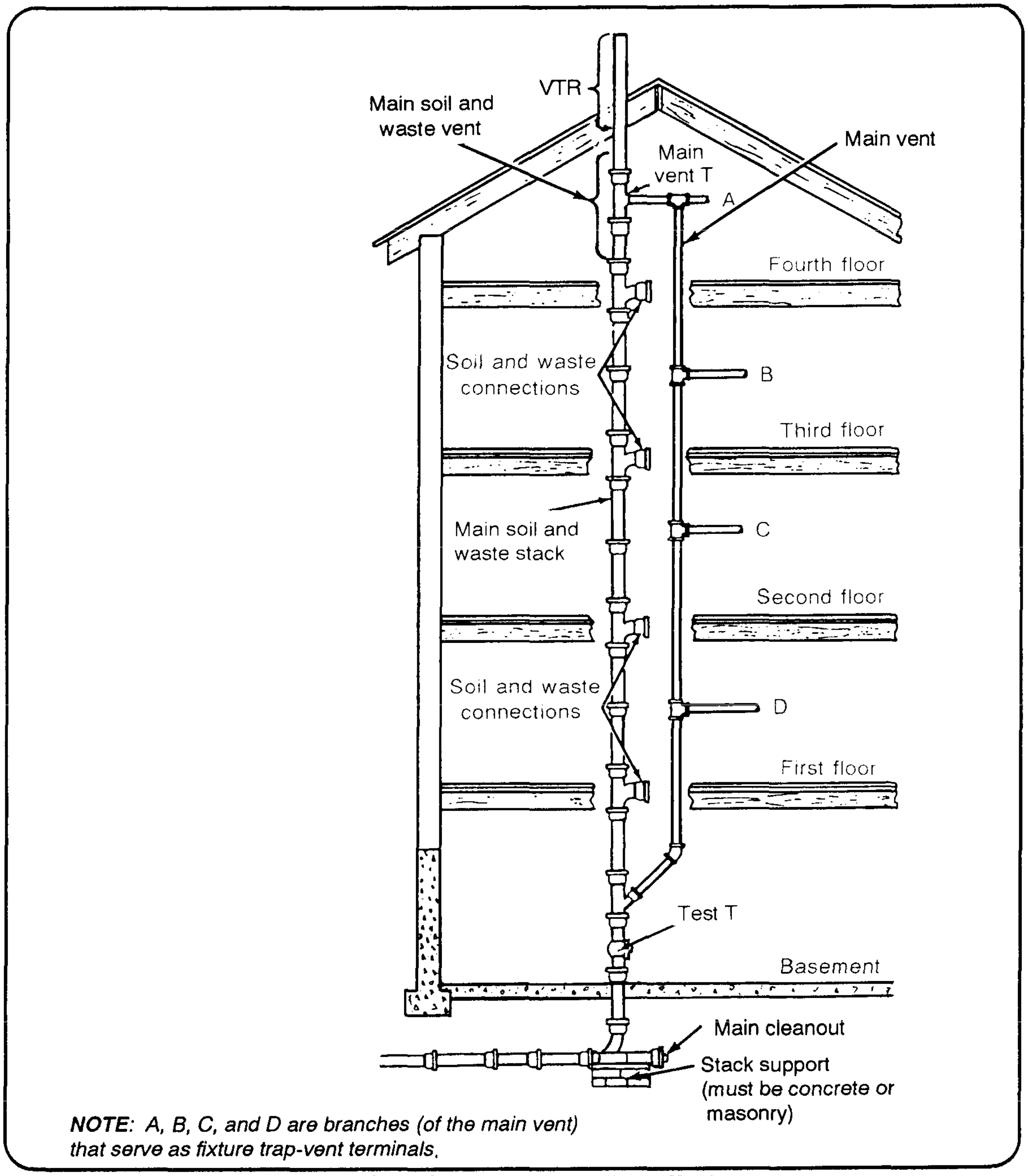


Figure 9-7. Stack and vent installation

a. *Single-Fixture Vent.* The individual vent (also referred to as a *back vent* or *continuous vent)* shown in Figure 9-8 is most common. This vent can be adapted to all fixtures. It prevents both direct and indirect siphonage. Assuming a drop of 1/4 inch per foot, the maximum distances between fixture trap and vent are listed in Table 9-1.

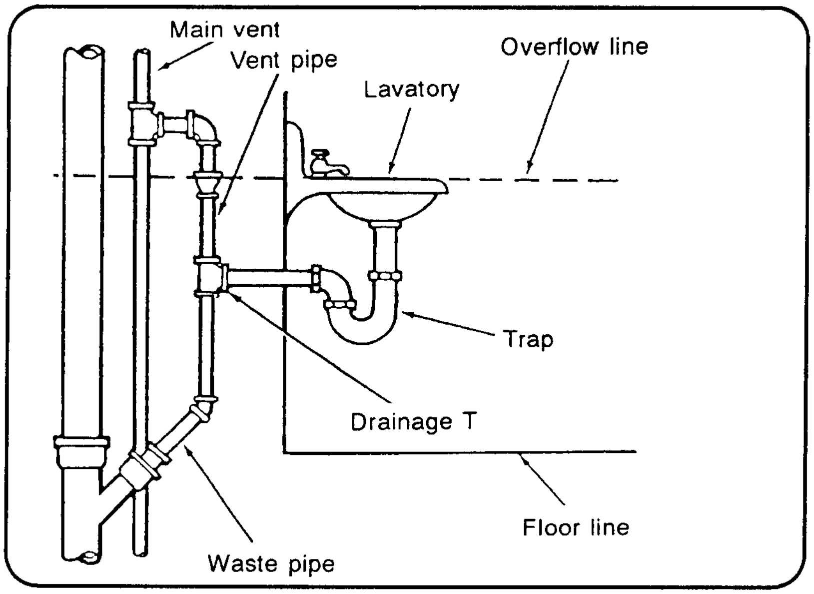


Figure 9-8. Single-fixture vent

Table 9-1. Determining pipe size from fixture to vent

Distance from Fixture Trap to Vent	Size of Fixture Drain (in inches)
2 feet 6 inches	1 ¼
3 feet 6 inches	1 ½
5 feet	2
6 feet	3
10 feet	4

b. *Battery of Fixture Vents.* Batteries of two or more fixtures can be individually vented (Figure 9-9). Each vent ties into a vent pipeline (branch) connected to the main vent.

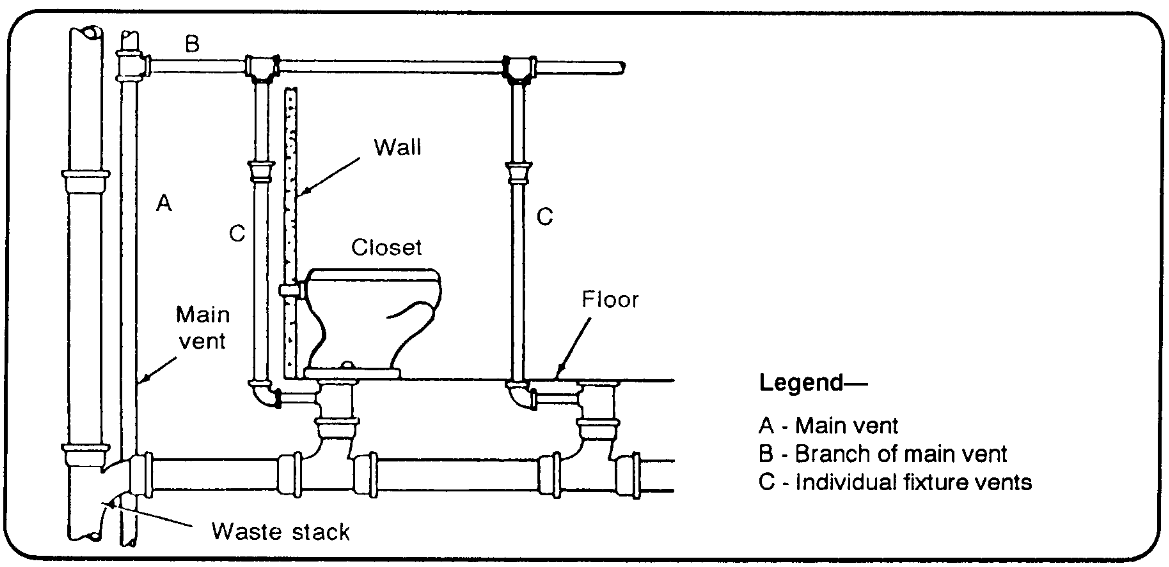


Figure 9-9. Row of fixture vents

c. *Common Vent.* Fixtures mounted side by side or back to back on a wall are common vented. In the common vent, both fixtures discharge into a double sanitary T with deflectors (Figure 9-10). This venting system usually is found in buildings where two bathrooms have a common partition.

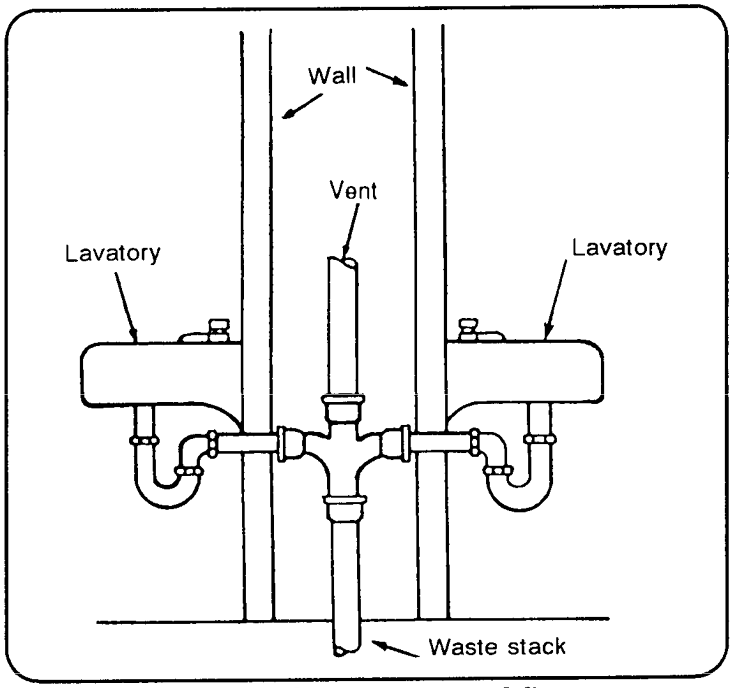


Figure 9-10. Common-vented fixtures

d. *Circuit Vent.* The circuit vent (Figure 9-11) extends from the main vent to connections on the horizontal soil or waste branch pipe between the fixture connections. This vent is used in buildings having a battery of two or more fixtures, such as lavatories. A maximum of eight fixtures are permitted on any one circuit vent. The circuit vent is usually installed between the next to the last and the last fixture on the line. Since some fixtures discharge their waste through a part of the pipe that acts as a vent for other fixtures, the vent may become clogged. Reduce clogging by connecting the vent into the top of the branch rather than its side. Water and waste from the last fixture scours the vents of the other fixtures.

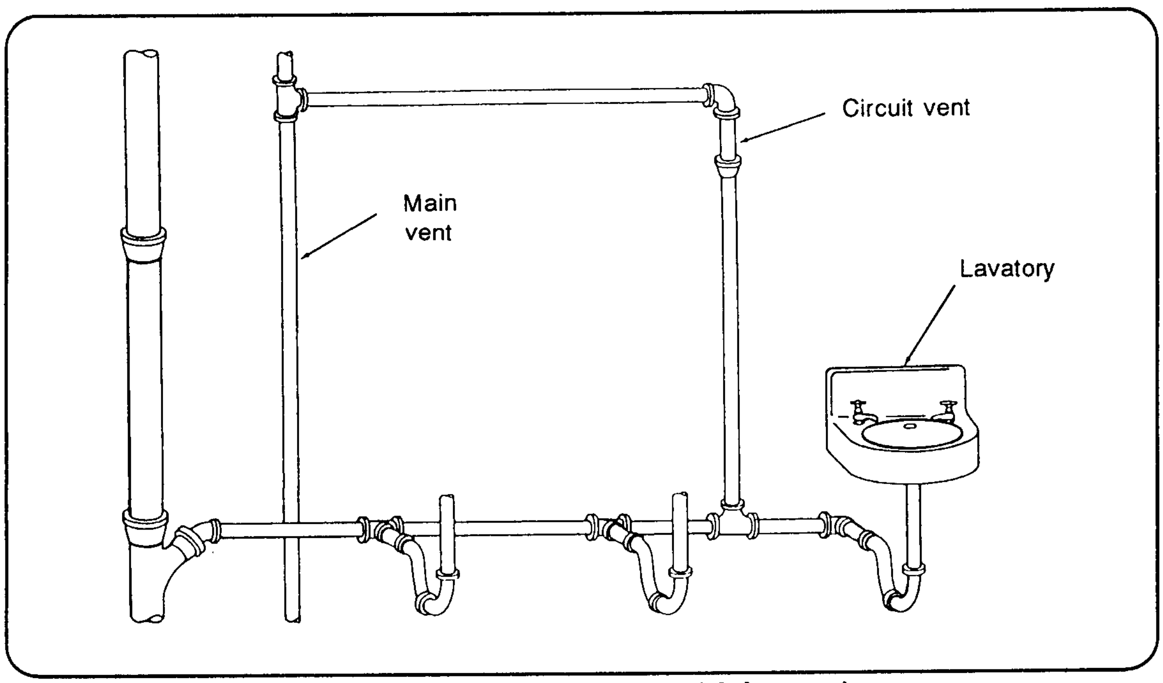


Figure 9-11. Circuit venting with lavatories

c. *Wet Vent.* The wet vent (Figure 9-12) is part of the vent line through which liquid wastes flow from another fixture that has an individual vent. It is used most commonly on a small group of bathroom fixtures. A disadvantage is that the vent tends to become fouled with waste material, which reduces its diameter or causes a stoppage. The size of the pipe for a wet vent must be large enough to take care of the fixtures based on the total DFUs.

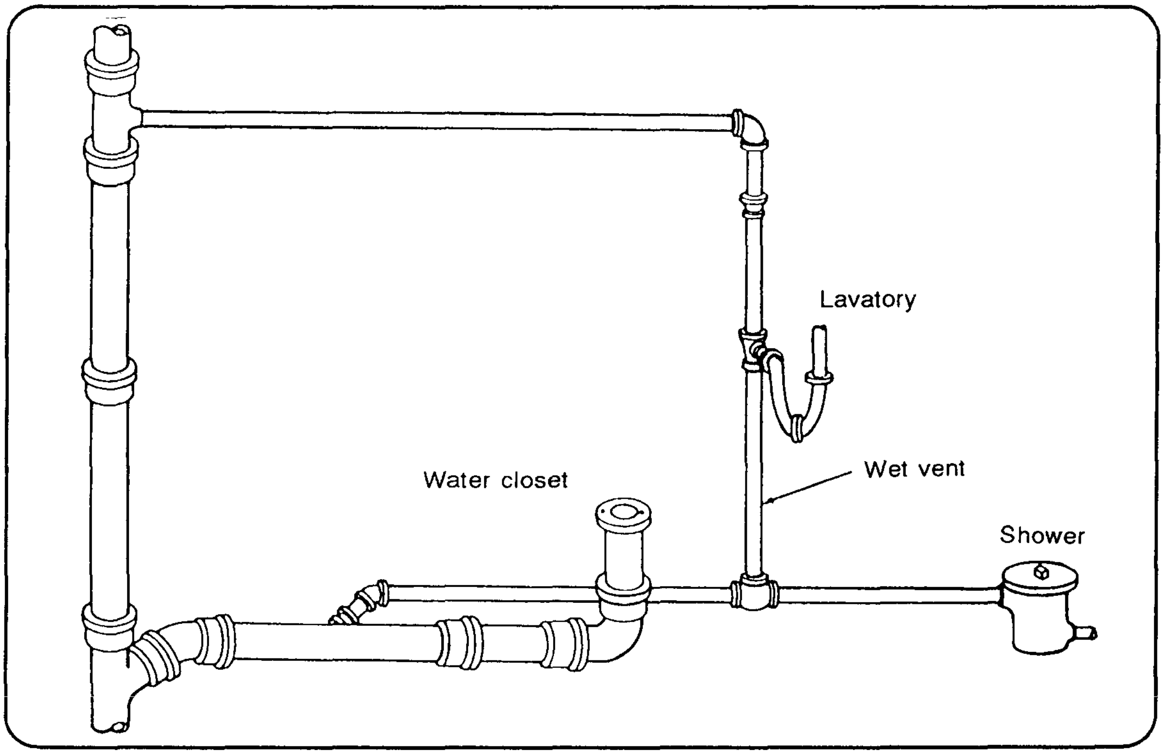


Figure 9-12. Group of wet-vent fixtures

9-5. Sizes. Never use a pipe smaller than 2 inches in diameter.

a. *Main Vent.* To determine the correct pipe size for the main vent, use Table 9-2 along with the number of DFUs, the length of the vent, and the diameter of the soil-and-waste stack. The main vent must be at least one-hall the size of the stack, and the main soil-and-waste vent must be at least as large as the stack.

b. *Individual Fixture Vent.* A pipe less than 1 1/4 inches in diameter should not be used for ventilation because waste materials may cause stoppages. Table 9-3 lists the recommended sizes (in diameter) for individual, branch, circuit, and stack vents.

Table 9-2. Size and length of main vents

Diameter of Soil-and-Waste Stack (in inches)	Number of DFUs to be Connected	Maximum Permissible Developed Length of Vent (in feet)							
		Diameter of Vent (in inches)							
		1 ½	2	2 ½	3	4	5	6	8
1 ½	8	150							
2	12	75	310						
2	24	70	300						
2 ½	42	35	140	450					
3	30	20	80	260	650				
3	60	18	75	240	600				
4	100		35	100	260	1,100			
4	250		30	95	240	1,000			
4	500		22	70	180	750			
5	550			28	70	320	1,000		
5	1,100			20	50	240	750		
6	950				20	95	240	1,000	
6	1,900				18	70	180	750	
8	1,800					30	80	350	1,100
8	3,600					25	60	250	800
10	2,800						30	80	350
10	5,600						25	60	250

EXAMPLE

What size main vent (diameter) would you need for the following: soil-and-waste stack diameter of 3 inches, DFUs of 59, and a 2OO-foot vent length? Use the following steps with Table 9-2:

Step 1. Read down the first column to **3.**

Step 2. Find 30 in the second column.

Step 3. **Go** to the next higher number, 60 (since there are 59 DFUs).

Step 4. Read across to the figure that is closest to 200, and select 240.

Step 5. Read up from 240.

Result: The main vent would be 2 1/2 inches in diameter.

Table 9-3. Size of individual, branch, circuit, and stack vents

Fixture	Minimum Size of Vent (in inches)
Lavatory	1 ¼
Drinking fountain	1 ¼
Sink	1 ½
Shower	1 ½
Bathtub	1 ½
Laundry tub	1 ½
Slop sink	1 ½
Water closet	2

CHAPTER 10
STEAM, GAS, AND AIR PIPING

Steam piping is used mainly for heating systems. Gas and air piping is used *for many purposes, but mainly for boiler rooms and heating plants. Steam piping is not interchangeable with gas and air piping.*

10-1. Steam Piping. Steam is used mainly for space heating, cooking, and laundering. Steam is produced in a boiler and passes through steam headers and branch takeoffs to the steam appliances. Most steam pipes are wrought-iron or steel with threaded joints. Large, high-pressure, high-temperature systems use bolted-flange joints (see Figure 6-24, page 6-20).

a. *Pipe Size.* Do not use a main that is less than 2 inches in diameter. The diameter of the far end of the supply main should be no less than one half the diameter at the largest part. Where supply mains are smaller than one half, they should have eccentric couplings, level with the bottom of the pipes.

b. *Installation.*

(1) *Piping.*

(a) *Pipe Expansion.* Install steam piping systems with the atmospheric temperature varying from O°F (-18°C) to 100°F (38°C), depending on the locality and the season of the year. When steam passes through a pipe, the temperature of the pipe becomes the same temperature as the steam. This temperature change causes the pipe to expand and increase in length. For a temperature change of 900°F, steel pipe would expand about 8 1/2 inches per 100 feet of length. To prevent undue stress on the pipe and transfer of this stress to appliances, you should place a flexible connection, which will expand and contract with the pipe. Install bends and loops in the pipe to absorb the forces set up by expansion and contraction.

(b) *Pitch of Pipes.* As steam passes through the piping to the appliances that it serves, it cools and condenses to waler. This water must be returned to the boiler where it is changed back to steam. When installing steam systems, all pipes must be properly pitched (sloped) to allow the drainage of condensate. Sloping pipes toward the boiler prevents water from collecting in pockets in return condensate steam lines.

The pitch of the main should not be less than 1/4 inch per 10 feet. The pitch of horizontal runouts to risers and radiators should not be less than 1/2 inch per foot. Where this pitch is not possible, runouts over 8 feet long should be one size larger than otherwise needed.

NOTE: *Faulty piping installation causes most snapping, cracking, and rattling noises in steam distribution systems or return systems. Live steam in contact with water or moisture in the pockets causes water hammer. This condition may occur in the distribution system because of high water levels in boilers. It occurs more often in return condensate steam lines when steam is leaking or blowing directly through traps into these lines.*

(2) *Valves.* The gate valve is the most satisfactory valve to use for steam piping. When open, it allows ready passage of steam; when closed, it forms a leakproof shutoff. Globe valves should not be used with fiber disc washers because fiber disc washers wear rapidly under conditions of high pressure and temperature.

(3) *Insulation.* Quality pipe insulation should be used for piping between the boiler and the appliance. It may be a preformed type, which is strapped around the piping; or the cement type, which is mixed with water and molded around the pipe by hand.

c. *Safety.*

- Before attempting maintenance, shut off all steam lines and remove the pressure.
- Allow lines to cool before working on them.
- Insulate all steam lines passing within 6 inches of combustible materials.
- Insulate exposed steam lines that are within easy reach of personnel.
- Equip all steam boilers with proper pressure- and temperature-relief valves.
- Test all new installations before use. Steam lines are usually tested under an air pressure of 125 psi.

DANGER

Because of the high pressures and temperatures, death or physical injury can result from failure to use caution and to follow procedures in steam, gas, and air piping systems. (See safety precautions for each system.)

10-2. Gas and Air Piping.

a. *Gas System.* Gas piping is used for heating. Fuel gas is manufactured or natural. In its natural state, it is colorless and odorless with a specific gravity of about one-half that of ordinary air. Chemicals are added so users can detect a gas leak by its odor. Natural gas (methane) is not poisonous but can cause sullocation in a closed space. Manufactured gas can be poisonous, since it may contain carbon monoxide. It is explosive under certain conditions. Installation standards must be met when gas is distributed. Fuel gas is generally distributed by steel gas mains.

(1) *Installation.* Piping used for water services is suitable for use in gas piping. Iron or steel pipe with threaded joints is usually used for gas services since fuel gas does not corrode these metals. Use galvanized pipe from the meter main to the building; the branches can be copper. Lead pipe or rubber tubing should not be used to carry gas.

Plastic pipe can also be used for gas services. When plastic pipe is used, joints must be heat-welded, not glued or cemented. Plastic pipe should not be installed above ground in distribution systems with pressure greater than 50 psi of grade, or where the operating temperatures will be below -20°F or above 100°F (-29°C or 38°C). Further information on plastic pipe and fittings can be found in American Gas Associates' *Plastic Pipe Manual for Gas Service.*

The installation and support of gas piping is the same as for water piping. Since fuel gas contains moisture, all gas pipes should slope. Capped drip legs should also be installed to allow drainage of moisture, which might condense in the pipe. These drips must be checked and emptied when necessary. Do not install drips where moisture may freeze. Traps in the pipes should be avoided. Take all branches off the top of the service pipe to prevent waler from collecting in the branches. Gas piping should be exposed, and unions and bells should be visible to allow frequent inspections.

(2) *Testinq.* After installation, air test the entire gas main and service line system under *a* pressure that is at least 50 percent of the operating pressure. Test pressure must be at least 75 psi.

b. *Air Systems.* Air piping is used for heating. For special purposes such as automotive service stations, machine shops, or laundries, a compressed-air system may be used.

(1) *Compressed-Air System.* The air is compressed in an electric, a gasoline, or a diesel-driven compressor (Figure 10-1) and stored in a tank until needed. Air is drawn into the compressor, reduced in volume, and passed through a check valve into the storage tank. The pressure-control valve and safety valve regulate the operation of the compressor. When the amount of air stored in the tank reaches the desired pressure, the compressor shuts off automatically. If the pressure-control valve fails, the safety valve reduces the pressure on the tank, which prevents an explosion. Compressed air is drawn from the tank through a reducing valve with a gauge on either side. The reducing valve may be set to furnish any desired pressure to the equipment, regardless of the air pressure within the tank.

(2) *Installation.* Installation standards for air piping are the same as for gas piping. However, to reduce friction loss of pressure, avoid pipes that have sharp bends.

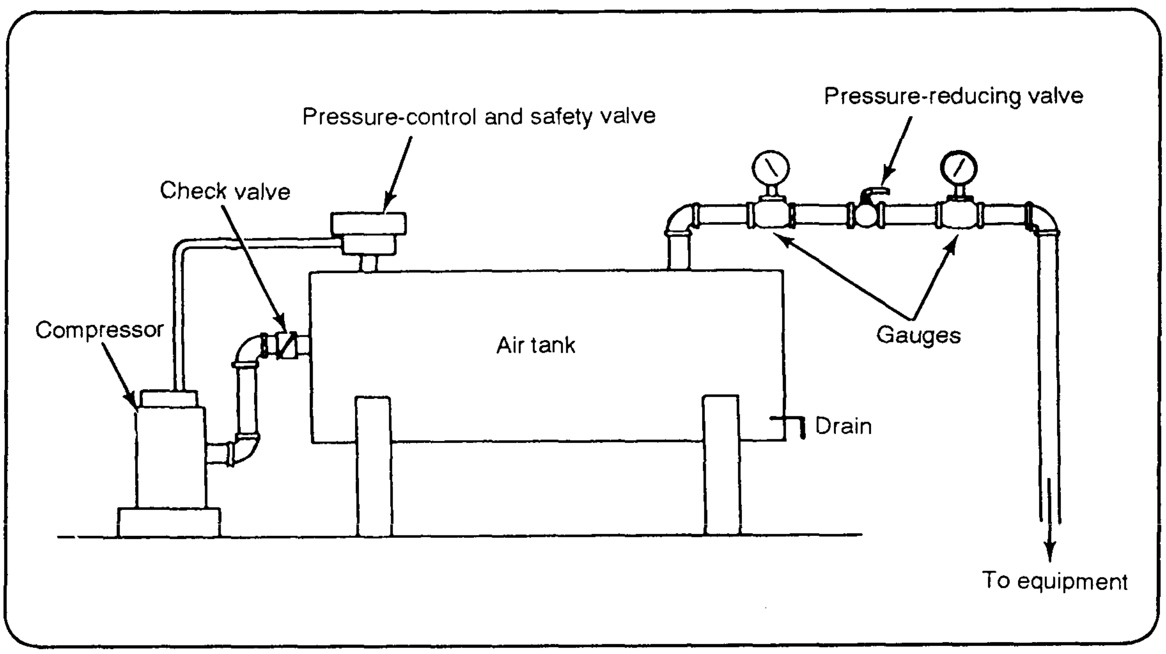


Figure 10-1. Air compressor and tank

c. *Underground Installations.* Many gas and air pipes are laid underground. Threading of pipe reduces the wall thickness by about 40 percent, and the pipe is more likely to corrode or be damaged by vibration. For this reason, dresser couplings are used for underground piping instead of threaded joints. Dresser couplings provide leakproof joints without reducing pipe wall thickness. Figure 10-2 shows dresser couplings for large and small pipe.

- *Large-sized pipe.* A dresser coupling is suitable for large-sized pipe. It has a seamless body with gaskets and flanges bolted together to form a flexible leakproof joint. Since these couplings are used on large steel gas pipes, gas companies (rather than plumbers) usually install them.
- *Small-sized pipe.* The dresser coupling for small-sized pipe is made of a seamless body with two gaskets, two retainers, and two octagonal end nuts. Dresser couplings are available in sizes from 3/8 inch to 2 inches.

d. *Safety.* Both gas and air piping are explosive under certain conditions.

- Smoking is not permitted in an area where gas piping is being installed or repaired.
- Never use matches to test for gas leaks.
- Locate meter and riser pipes some distance from electric meters, switches, fuses, and other equipment.
- Install adequate pressure-reliel valves on air compressors.
- Test all lines before use.
- Remove pressure from all lines before working on them.
- In unheated locations, provide protection for the pipes against freezing of condensed water.

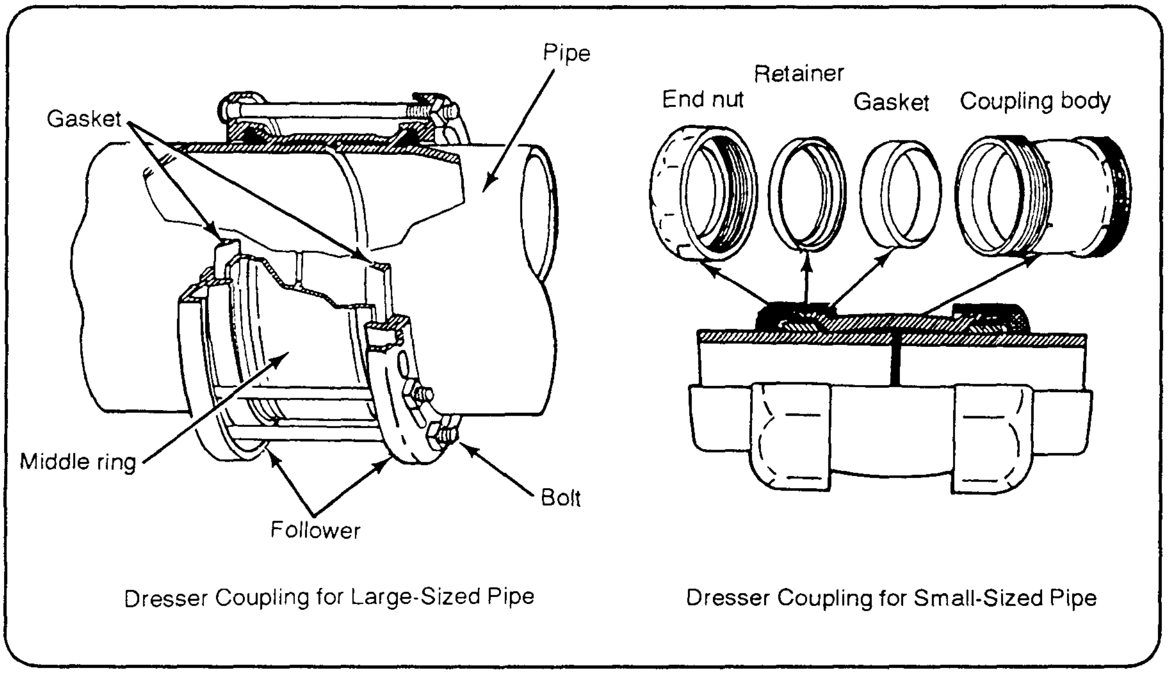


Figure 10-2. Dresser couplings

CHAPTER 11
PUMPS

Many kinds of pumps are in general use. The type of purnp chosen depends on its use, *the volume of liquid to be pumped and the distance or height to which the liquid must be delivered. This chapter covers centrifugal pumps. However, there are other pumps such as the sump, rotary, and reciprocal. Since there are many different models of pumps, refer to the manufacturer's manual for specific operation and repair.*

Pumps deliver water to a water distribution or plumbing system. They increase water pressure within the system and/or pump water from its source into a storage tank or reservoir, or they pump wastes into a sewer or drainage line. They are used in booster systems to maintain adequate pressure within buildings or to increase pressure for high-rise buildings.

11-1. Characteristics. In centrifugal pumps (Figure 1l-l), when a liquid whirls around a point, a centrifugal force is created forcing the fluid outward from the center. The larger centrifugal pumps can develop a pressure great enough to raise a column of liquid more than 100 feet. The capacity of centrifugal pumps ranges from 5,000 to 200,000 GPH.

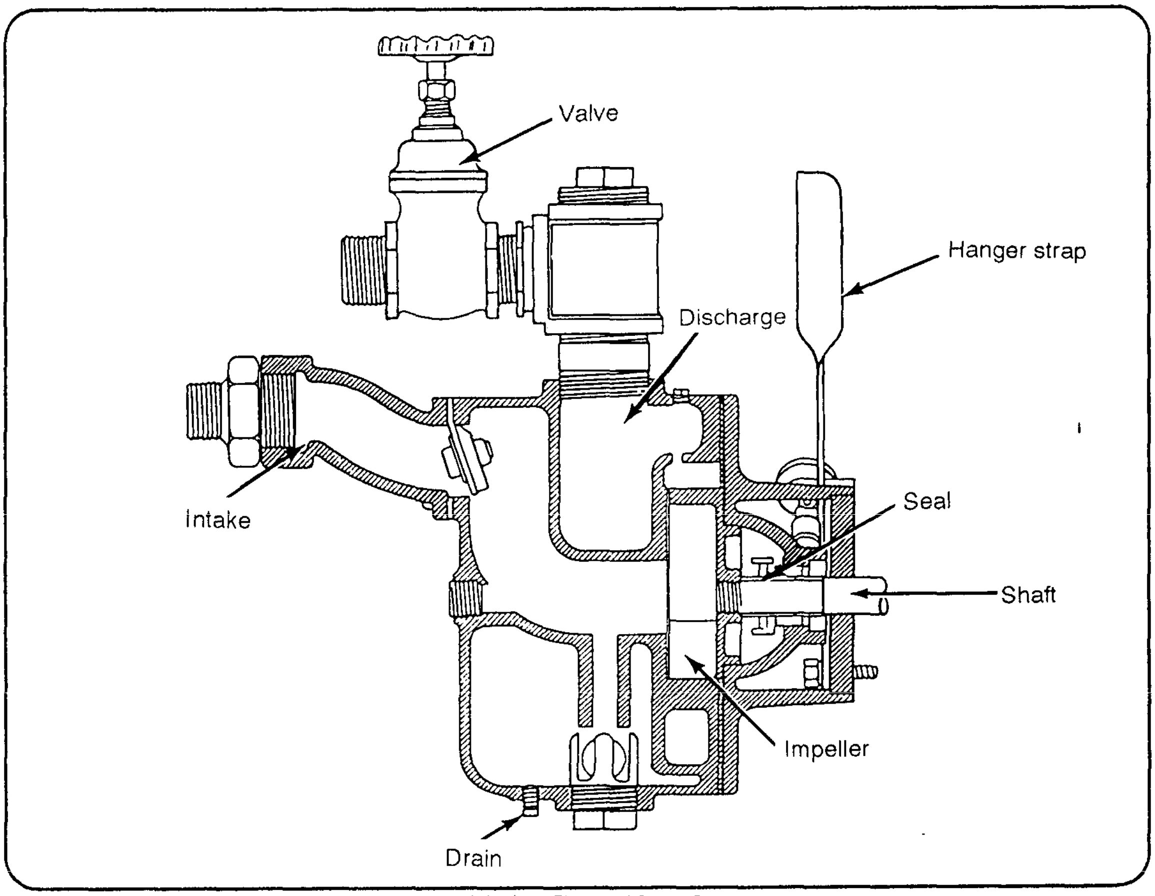


Figure 11-1. Centrifugal pump

a. *Impeller.* The centrifugal pump is simple and efficient. A set of rotating vanes, called *impellers,* is mounted inside a *volute* (a snail-shaped channel for the water). The diameter of the volute increases toward the outlet opening, or direction of flow. As liquid passes into the gradually widening channel, the speed decreases and the pressure increases. An intake passage leads the liquid to the impeller, a discharge passage leads it away, and a seal on the impeller shaft keeps the liquid inside the pump and the air outside the pump.

b. *Head.* Head is the force exerted by a column of fluid measured at its lowest point. The head capacity of a pump is the pressure it must produce to overcome the pressure of the fluid. If the head is increased and the speed is unchanged, the amount of water discharged will decrease, and vice versa. If the head is increased beyond the head capacity of the pump (shutoff head), no water will be pumped. The impeller simply churns the water inside the case, heating the water and the pump.

c. *Primer.* The centrifugal pumps issued for general use are self-priming (Figure 11-2). They are rated at 125 GPM at a 50-foot head. Each pump has a priming chamber, which eliminates repriming when the pump is stopped unless the priming chamber has been drained. The pump is set on a frame and is driven by a 2-cylinder, 3-horsepower, military standard engine. The unit is close-coupled, and the impeller in the pump is attached directly to the end of the engine crankshaft. A self-adjusting mechanical seal prevents water leakage between the pump and the engine. The only required adjustment is a slight turn on the grease-cup nut. This pump works best at a suction lift of 15 feet. At greater suction lifts, its capacity and efficiency rapidly decrease.

11-2. Types. Centrifugal pumps are either submerged or submersible.

a. *Submerged.* When the pump motor is placed above the water level with the pump itself in the water, it is a submerged pump. The motor is usually mounted near the wellhead and is connected to the pump by a shaft. The submerged pump is used mainly for shallow wells because long pump shafts vibrate.

b. *Submersible.* A submersible pump is connected directly to an electric motor in a single casing. The unit is lowered into the well with the motor above the pump. Both motor and pump may be below the water level. A waterproof cable connects the motor to the control box at ground level. A suitable discharge hose or pipe is connected to the housing elbow. The submersible pump should be used when the suction lift exceeds 25 feet, or if it would be difficult to set up a separate prime mover close to the water.

11-3. Installation and Operation. To install pumps, the plumber must know the types of pumps and how they work. The following points are important when installing or operating a centrifugal pump:

- Set the pump on a firm foundation to avoid vibration.
- Locate the pump as close to the water supply as possible.
- Make sure the suction hose does not have a collapsed lining or any breaks, cuts, or pinholes.

- Tighten hose connections, and screw nipples tightly to prevent air leaks. Use pipe cement. Rigid hose is preferred on the discharge side.
- Support the piping so that its weight is not carried by the pump.
- Reduce friction loss by making all piping, especially on the suction side, as short as possible with few elbows.
- Place the suction pipe so it rises gradually toward the pump. (This is not necessary on a centrifugal pump that is self-priming.)

NOTE: *Install a strainer on the suction line to prevent clogging, which can reduce capacity and stop* the *pump. The net on the strainer would be at least four times the size of the net on the suction pipe. The net should be inspected and cleaned often. To decrease friction loss in long discharge lines, use a pipe that is one or more sizes larger than the discharge fitting of the pump.*

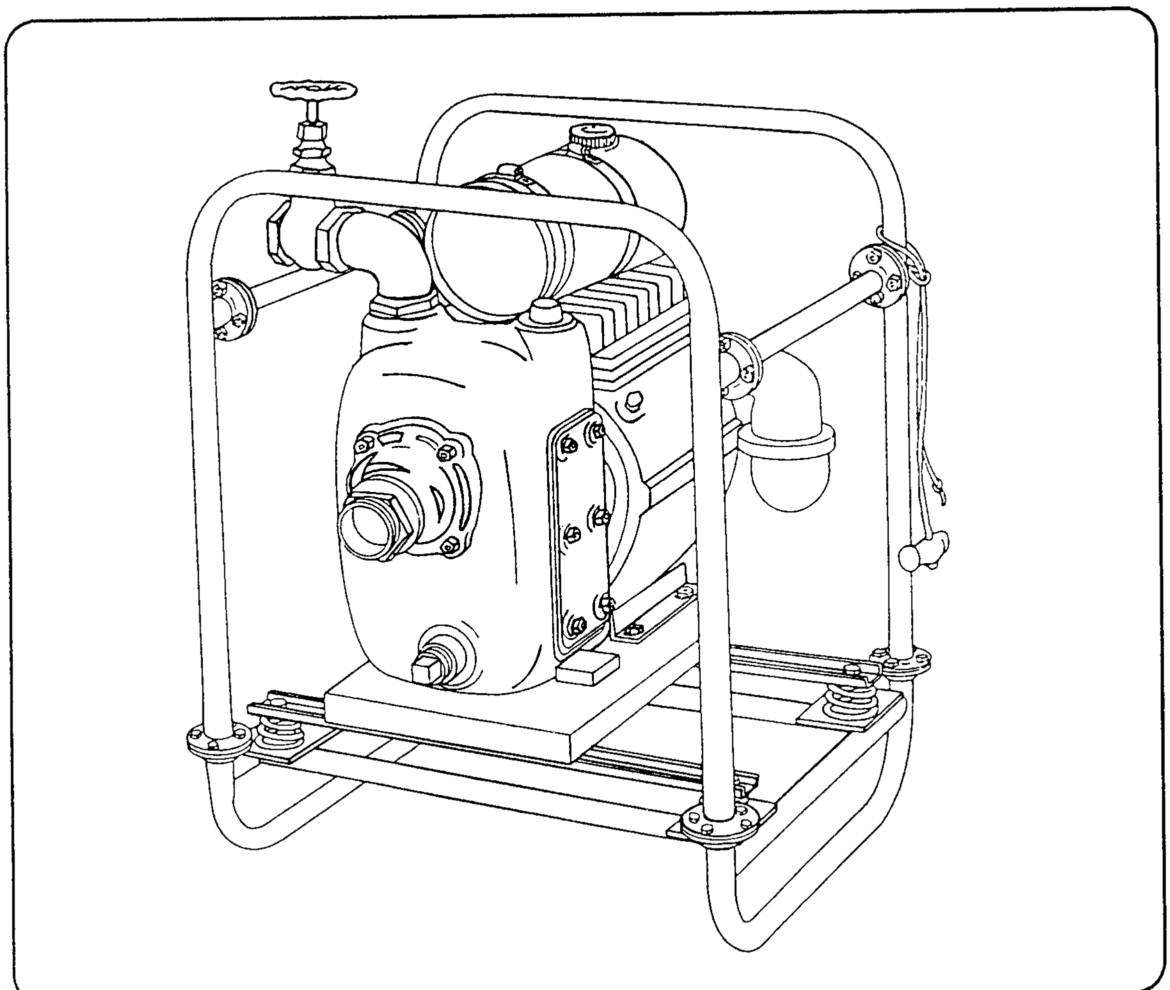


Figure 11-2. Standard 125-GPM centrifugal pump

A pump uses an outside source of mechanical power (prime mover), such as an electric motor or gasoline engine, to move liquid from one point to another, usually to raise liquid to a higher level. The pump produces a partial vacuum within itself by lowering the pressure in the intake side below the pressure of the air outside (atmospheric pressure). Atmospheric pressure outside the pump forces the liquid up through the suction line into the pump itself. If a perfect vacuum could be produced, atmospheric pressure would lift water to a maximum of 34 feet. Since a perfect vacuum is impossible because of piston slippage, valve leaks, and friction, the suction lift from the source of water to the pump must never be more than 22 to 25 feet at sea level and less at higher altitudes.

11-4. Valves.

a. *Check Valve.* This valve (on the suction side) prevents the loss of priming liquid in the pump casing during idle-pump periods. It allows liquid to flow in one direction only and usually opens or closes automatically.

b. *Foot Valve.* This valve (on the end of the suction pipe) is not required but may be provided to fill the pipe.

c. *Gauge Valve.* This valve is hand-operated by turning a wheel and is used on discharge and suction lines to cut off flow. It should never be used to throttle or control flow, since the flow of liquid corrodes the gate fence.

d. *Relief Valve.* This is a safety valve, designed to open when the liquid pressure in the pump becomes too high.

11-5. Priming. After installation, prime the pump by filling it with water. After the first priming, a self-priming centrifugal pump does not need to be reprimed unless it has been drained. To prime a pump—

Step 1. Remove the priming plug on top of the pump casing, and fill the case to the top with water. The valve on the discharge line should be wide open.

Step 2. Replace the pump.

Step 3. Start the pump.

To decrcase the load and fuel consumption on shallow suction lifts with little liquid supply to pump, reduce the engine speed by using the throttle.

11-6. Maintenance and Repair. Plumbers must know how to maintain and repair pumps.

a. *Shaft Seals.* Shaft seals and packing prevent water and air leakages. Two rings provide the shaft seal. One is scaled to the shaft, which rotates; the other is sealed to the pump casing, which is fixed. These rings press against each other, and when the engine is running, one is fixed and the other rotates. This close contact seals the pump. The lubricant is grease, oil, or the liquid that is being pumped. Carefully follow the servicing and replacement instructions on the shaft seal.

b. *Packing.* When a stuffing box is used instead of a shaft seal, packing is important. Use only soft and flexible packing. A long, fiber, tallowed flax packing is satisfactory for pumps handling cold water. If leakage cannot be reduced by drawing down on the stuffing box gland, add one ring of packing to allow further adjustment. If this does not control leakage, replace the old ring with new rings of packing.

c. *Bearings.* An oversupply of grease produces heat, which causes the grease to ooze out of the bearing housing. When bearings are removed for cleaning, they should be thoroughly dry before replacing. Ball bearings need lubrication only two or three times a year, depending on use. Clear the bearing housing once a year or year and a half with carbon tetrachloride, gasoline, or kerosene; and then relubricate it.

NOTE: *If a pump is drained, allow it to run about a minute to dry out the impeller chamber.*

11-7. Trouble Sources. Certain troubles may arise when operating a centrifugal pump. Their possible causes are listed below:

TROUBLE SOURCES

1. *Pump Does Not Prime Properly.*
   - Pump casing is not filled with water.
   - Priming hole is plugged (clean it out through the drain plug).
   - Pump is running too slowly.
   - Air is leaking from the suction line or around connections.
   - Pump seal is worn or damaged.
   - Lining of suction hose has collapsed.
   - Suction line or strainer is clogged.
   - Impeller is clogged, worn out, or broken.
   - Lift is too high for the capacity of the pump.
2. *Not Enough Water is Delivered or Water Does Not Have Enough Pressure.*
   - Engine is not running at rated speed.
   - Seal is leaking.
   - Wear causes too much clearance between impeller and pump casing.
   - Suction hose is too long, causing excessive friction loss.
   - Factors in paragraph 1, above, may apply. Check them.

CHAPTER 12
INSULATION

Insulation prevents loss of heat, freezing of hot- and cold-water pipes, condensation on cold-water pipes, and it protects against fire. Insulation can reduce noise and vibration from heating or air-conditioning equipment and reduce noise made by water flowing inside pipes. It also reduces expansion and contraction of pipes.

12-1. Types. Insulation may be either unformed blanket-type that allows shaping and wrapping or rigid, preformed sections that fit around pipe runs and other objects (Figure 12-1).

a. *Rigid Preformed Insulation.*

(1) *Frost Proof.* Frost-proof insulation is used on cold-water service lines that pass through unheated areas and those that are located outside. Common supply is 3 feet long and 1-1/2 inches thick, with a canvas cover.

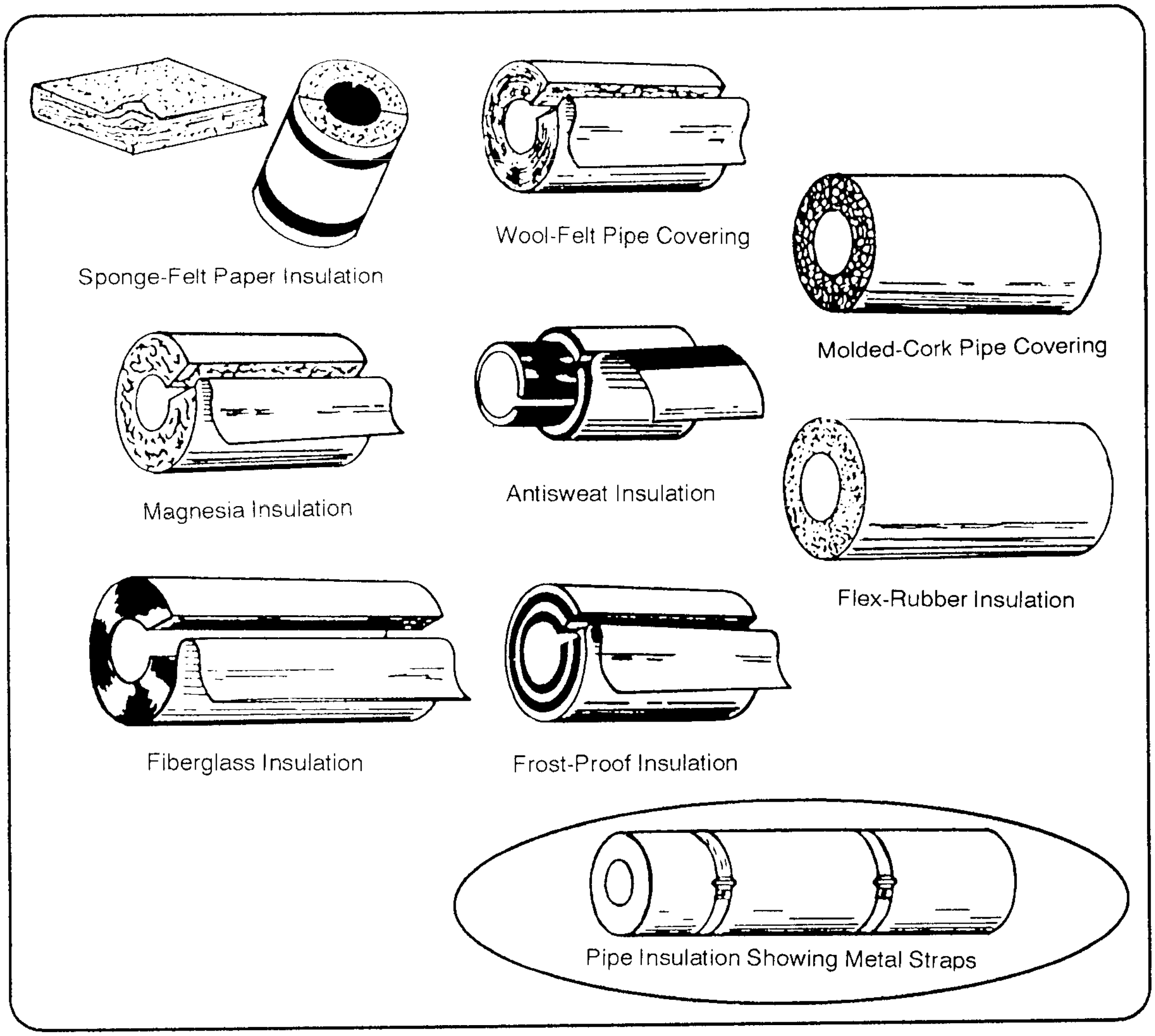


Figure 12-1. Insulation

(2) *Fiberglass.* Fiberglass insulation is shaped to fit pipes, tubing, small boilers, and water heaters. It has a long life; will not shrink, swell, rot, or burn; is easily applied; is lightweight; and saves space. It is made of very fine glass fibers bound together by an inactive resinous mixture.

(3) *Antisweat.* Antisweat insulation is used on cold-water lines. It keeps water in the pipes colder and, if properly installed, prevents the pipes from sweating. The outer layer has a nap about 3 inches long, which extends beyond the joint to help make a perfect seal. A canvas jacket is placed around each 3-foot length to protect the outer felt covering.

(4) *Cork-Pipe Covering.* This covering is a grainy material made by grinding the bark of cork trees. No other product can match its advantages. This pure, clean cork is pressed and molded to the exact size and shape and finished with a coating of plastic asphalt. It is ideal for covering brine, ammonia, ice water, and all kinds of cold-watcr lines. It has excellent insulating qualities over a wide low-temperature range. Cork-pipe covering will not rot or burn and is clean, sanitary, and odor-free. It comes in a variety of sizes and shapes that can be used on various sizes of pipes and fittings. A waterproof material should be used to coat it to keep moisture out of the insulation.

(5) *Wool-Felt.* Wool-felt is made of matted wool fibers or wool and fur or hair, pressure-rolled into a compact material. It is used on cold-water service and hot-water return lines. It is often used with alternate layers of tar paper to provide waterproof insulation.

(6) *Flex Rubber.* This insulation is a tough, flexible rubber material. It has good insulating qualities, good cementing qualities, excellcnt weather-aging qualities, and it prevents sweating of cold-water lines.

(7) *Magnesia.* This insulation has maximum strength and is very suitable for stream and hot-water lines or other pipes whose temperature dots not exceed 600°F. It has a canvas jacket and may be used on pipes up to 30 inches in diameter.

b. *Blanket Insulation.* Blanket insulation insulates against heat loss and protects against tire. This insulation is used on boilers, furnaces, tanks, drums, driers, ovens, flanges, and valves. The fiberglass type is used on small boilers and water heaters. It is used to wrap around objects that are irregular in shape and for large, flat areas. It is made in strips, sheets, rolls, and blocks. It comes in different widths and thicknesses, depending on the equipment to be insulated. It resists vermin (insects, rats, mice) and acid and is fireproof.

12-2. Installation.

a. *Pipe Covering*

(1) *Above-Ground Piping.* Each scction is split in half and has a canvas cover with a flap for quick sealing. Cheesecloth can be used in place of canvas, but it must be glued in place. Use joint collars to cover joint seams on piping exposed to outside conditions. Use metal straps at least 3/4-inch wide, placed 18 inches apart, to hold the insulation firmly (See insert in Figure 12-l).

(2) *Underground Piping.* Some underground piping must be insulated. The insulation is similar to above-ground insulation except that it needs more protection from the weather. In most cases, a concrete trench is made for installation of the piping. Molded pipe covering or loose mineral-wool or glass-wool is used. To protect the pipes from ground moisture, use coal tar as a sealer or wrap the pipes with tar paper or aluminum foil.

b. *Boiler and Tank Coverings.* An unjacketed boiler or storage tank should be insulated with an approved insulation. Some approved types are magnesia, mineral wool, calcium silicate, and cellular glass at least 2 inches thick. The insulation is kept away from the metal surface by applying it over 1 l/2-inch wire mesh, lifted by metal spacers that provide an air space of at least 1 inch. The joints should be filled with magnesia, mineral-wool, or other suitable cement. The surface of the insulation should be covered with a thin layer of hard-finished cement, reinforced with 1 l/2-inch wire mesh. The insulation must be firmly wired in place.

c. *Valve and Fitting Coverings.* Valves and fittings are covered with wool, felt, magnesia cement, or mineral-wool cement the same thickness as the pipe covering. These types of insulation are molded into shape. For magnesia- or mineral-wool-cement insulation, use cheesecloth to bind and hold it in place.

12-3. Maintenance. Properly installed insulation requires little maintenance. Insulation exposed to weather or possible damage from sharp objects must be frequently inspected. Proper installation and frequent inspections will minimize maintenance problems.

a. *Pipe Covering.* If the canvas cover gets torn or punctured, it should be patched with a piece of canvas. Only waterproof paste should be used when installing or repairing outside insulation.

b. *Leaky Pipes.* When repairing a leak in an *insuluted* pipe, the insulation must be removed back far enough to uncover the damaged pipe. When reinstalling the pipe, use the same kind of insulation used for the rest of the system.

c. *Valves and Fittings.* An inspection may reveal loose straps or loose insulation around valves and fittings. The straps should be retightened and the loose insulation replaced or glued down.

APPENDIX A
CONSTRUCTION PLANS AND DRAWINGS

Section I. Plans and Drawings

A-1. Architect's Design.

a. *Plans.* When architects design a building, they prepare a set of prints (plan) drawn to scale, with actual dimensions annotated. A plan's legend lists three sources of additional information: a *standard* detail drawing, a *special* detail drawing, and a bill of materials. Plumbers use the plan, drawings, and a bill of materials to lay out and plan a project. Refer to TM 5-704 and TM 5-302 for further information on construction prints. (Heating and plumbing systems are sometimes shown on the same plan.)

b. *Drawings.* The two types of drawings are standard detail drawings and special detail drawings. They both may show either an elevation view or a plan view. For a small structure, use only a plan view with some detail drawings, as described below:

- Standard detail drawings are indicated by a number and letter in a circle; for example (11G).
- Special detail drawings are indicated by a detail number, such as DETAIL #6.

c. *Bills of Materials.* The architect also prepares a set of specification sheets detailing the types and quality of materials to be used. (See Appendix B.)

d. *Symbols.* Plumbing symbols on construction drawings show the general location of pipes, valves, pumps, water tanks, and other items. See Section II for a list of these symbols.

A-2. Typical Water Supply and Distribution System Plan. Figure A-1 (page A-3) shows a water supply and distribution system plan for a hospital. Plumbing symbols on the construction drawing show the general location of pipes, valves, pumps, water tanks, and other items. Pipe sizes are also shown on the drawing. Additional information is given in the notes and legend on the construction drawing or blueprint.

A-3. Typical Utility and Building Waste System Plan. Figure A-2 (page A-5) is a typical utility plan for a bathhouse and latrine, showing the water system, waste system, and fixtures. This plan shows the building waste system, starting from the 4-inch drain in the shower room to the connection with the 4-inch pipe of the sewerage system. The plumber determines the exact arrangement and correct slope of the piping. In the plan view, the P-traps below the drains are specified, but not shown. Standard detail 11-Q should give information to construct two 4-inch vents to the roof. When using standard detail drawings, the plumber must make adjustments for a particular job. For a small structure of this type, only a plan view as shown will normally be provided together with detail drawings. Accompanying this plan are—

- A standard detail drawing of a water closet installation (Figure A-3, page A-6).
- A special detail drawing of the control-valve and shower-head fitting requirements (Figure A-3, page A-7).

A-4. Unit Construction and Package Unit Prints.

a. *Unit Construction Drawings.* Figure A-4 (page A-8) shows a unit construction drawing (elevation view) of a water storage tank and tower. The drawing gives the size of the tower, the steel beams and the dunnage beams, and the dimensions of the footing that supports the beams. A plan view of the tower plus a detailed drawing of the float valve are shown in Figure A-4 (page A-9).

b. *Package Units.* Package units are assembled in the field according to the manufacturer's instructions.

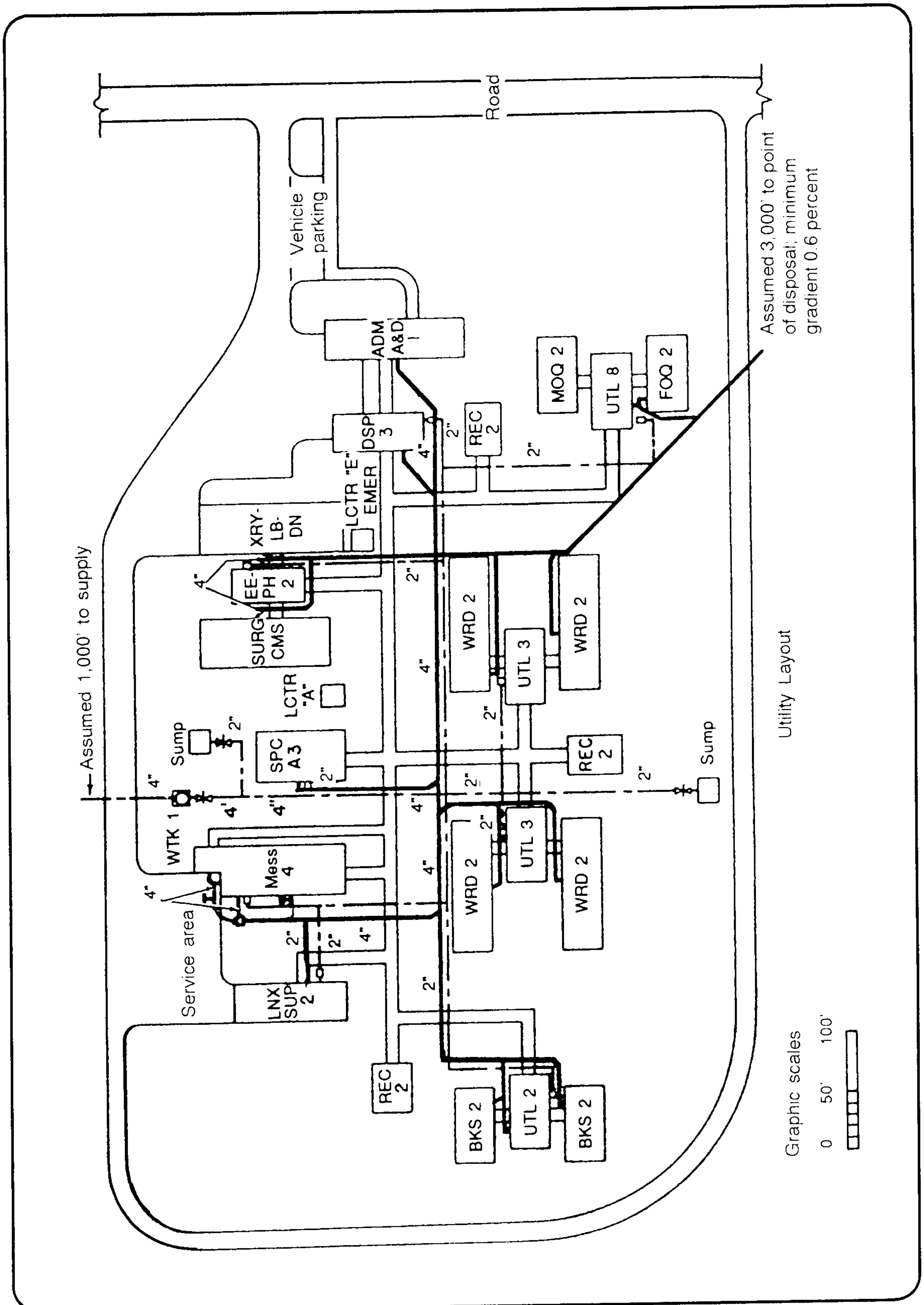
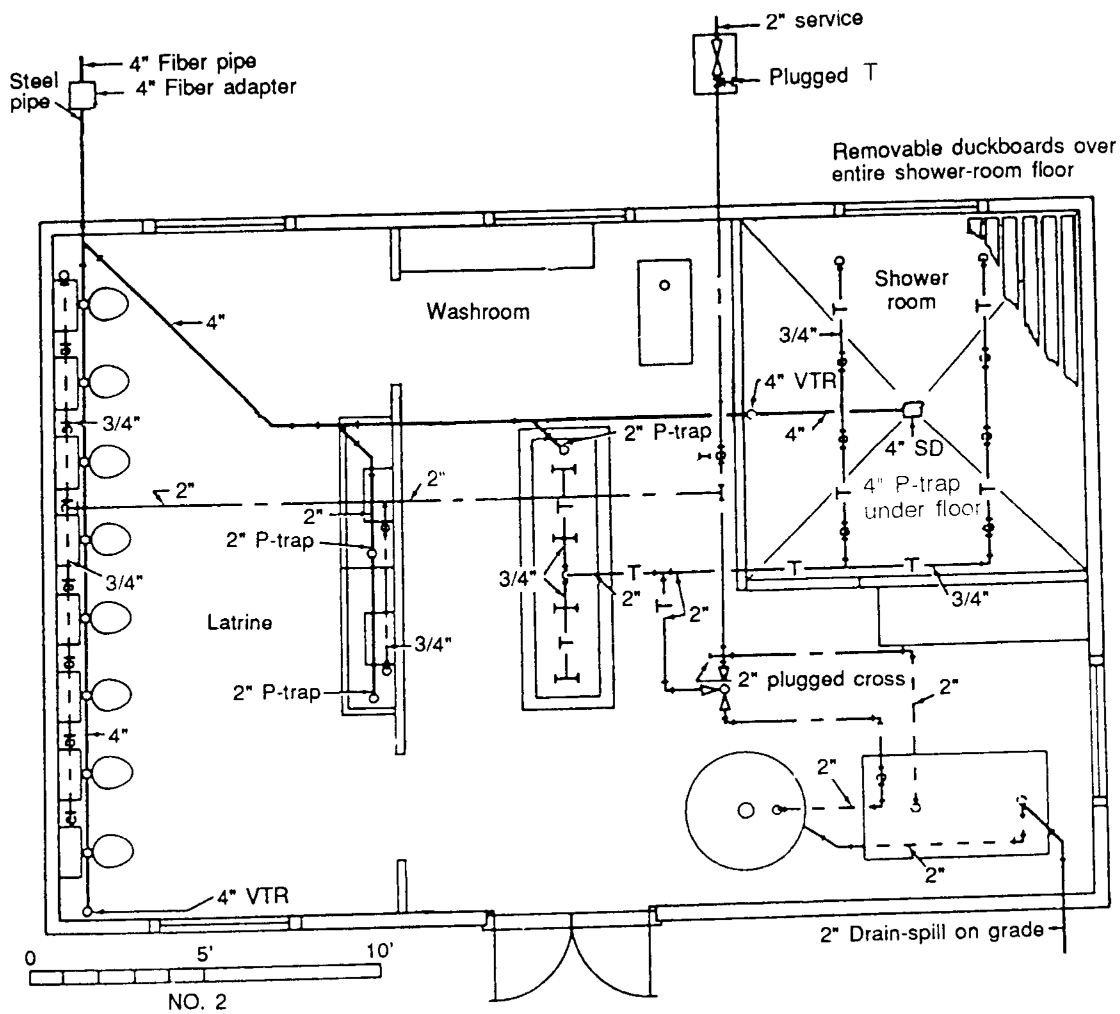


Figure A-1. Water supply and distribution system plan

SCHEDULE OF FACILITIES			
ABBREVIATION	**ITEM**	**QTY**	**SIZE OR UNIT**
	BUILDINGS		
ADM-A&D 1	ADMINISTRATION, ADMISSION, & DISPOSITION-1	1	30' X 110'
BKS 2	BARRACKS-2	2	30' X 60'
DSP 3	DISPENSARY-3	1	30' X 70'
EE-PH 2	EE & PHARMACY-2	1	30' X 60'
LNX-SUP 2	LINEN EXCHANGE & SUPPLY-2	1	30' X 90'
MESS 4	MESS BUILDING-4	1	4400 SF
FOQ 2	OFFICERS' QUARTERS-FEMALE-2	1	30' X 60'
MOQ 2	OFFICERS' QUARTERS-MALE-2	1	30' X 60'
REC 2	RECREATION BUILDING-2	3	30' X 40'
SPC A 3	SPECIAL SERVICES BUILDING-SPC-A3	1	40' X 70'
SURG-CMS	SURGERY-CENTRALIZED MATERIEL	1	40' X 100'
UTL 2	UTILITY BUILDING-2	1	30' X 60'
UTL 3	UTILITY BUILDING-3	2	30' X 60'
UTL 8	UTILITY BUILDING-8	1	30' X 60'
	WALKS-COVERED	1	8' X 1435'
WRD 2	WARD BUILDING-2-ACUTE	4	30' X 100'
XRY-LB-DN	X-RAY-LAB-DENTAL	1	40' X 110'
	OTHER CONSTRUCTION		
	ROAD-DOUBLE LANE-6"MACADAM, 1" ASPHALT	0.34	MILE
SUMP	SUMP-FIRE PROTECTION	2	10,000 GAL
	HARDSTANDS-4" MACADAM	7.1	1,000 SY
	SITE AREA	10.1	ACRES
WTK 1	WATER TANK	1	4,000 GAL
LCTR	LOAD CENTER	1	----
LCTR-EMER	LOAD CENTER-EMERGENCY	1	----

Figure A-1. Water supply and distribution system plan (continued)



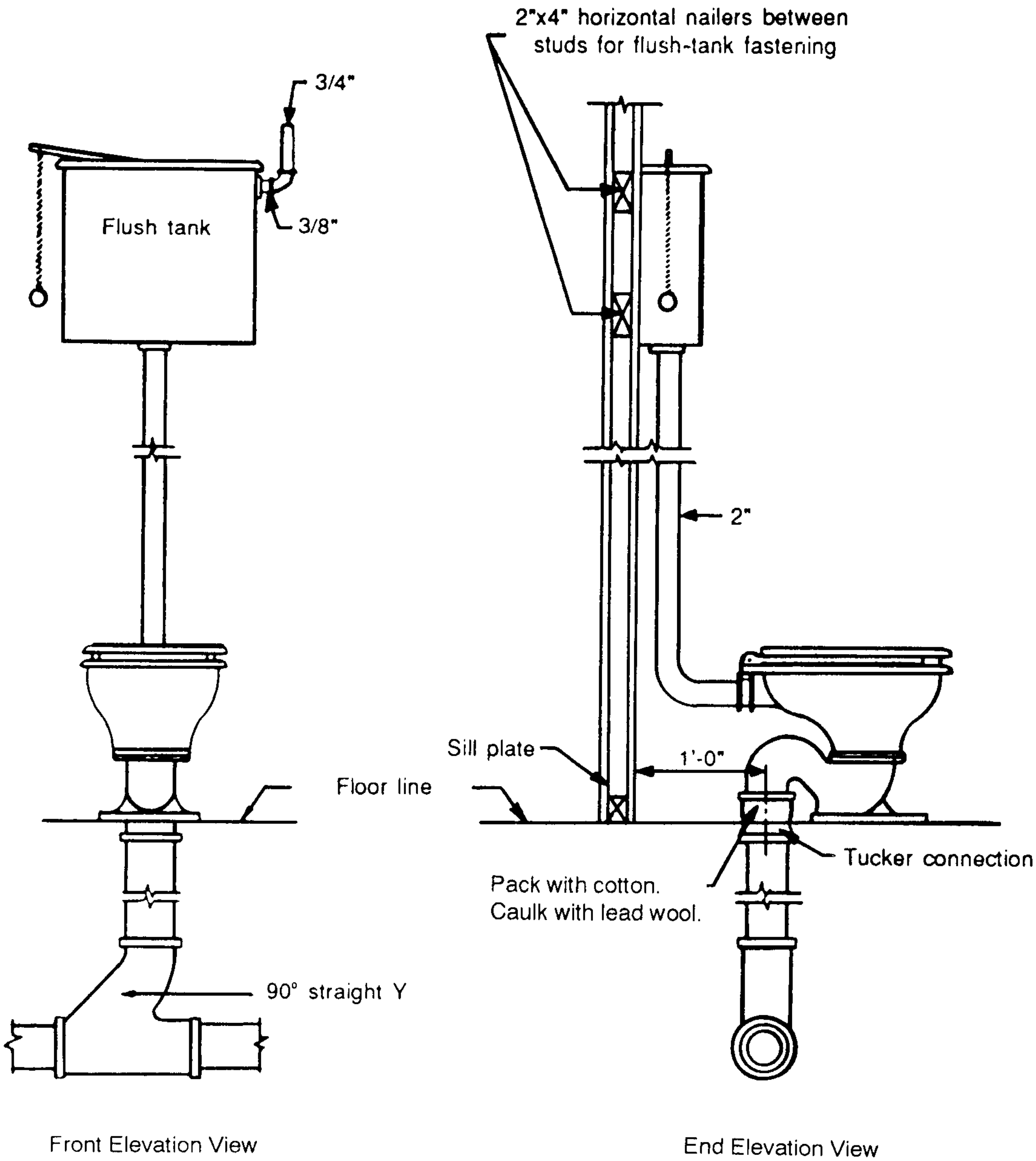
GENERAL NOTES

1. REFER TO TM 5-303 FOR BUILDING SHELL REQUIREMENTS.
2. FOR NSN BILL OF MATERIALS, REFER TO TM 5-303 BY FACILITY NUMBER.
3. FOR DETAIL NO. 1, "MIXING CONTROL FOR GROUP SHOWER" & DETAIL NO. 2, "SHOWER HEAD & CONTROL VALVE," REFER TO DWG NO. 72373BW SHEET 1 OF 1.
4. - T - INDICATES TEMPERED WATER.
5. INSTALL 45° Y-BRANCH WITH PLUG FOR C.O. ABOVE FLOOR WITH RISE FOR VTR.

SCHEDULE OF DRAWINGS

DWG NO.	DESCRIPTION	SHEET NO.
72323AW	PLANS	1 OF 1
72323BW	PLUMBING DIAG & DETAILS	1 OF 1
99960AA	STANDARD DETAILS	
93222AA	WOOD FRAME CONSTRUCTION BARRACKS-TYPE BLDGS	1-7 OF 7
93101AA	STEEL FRAME CONSTRUCTION BARRACKS-TYPE BLDGS	1-4 OF 4

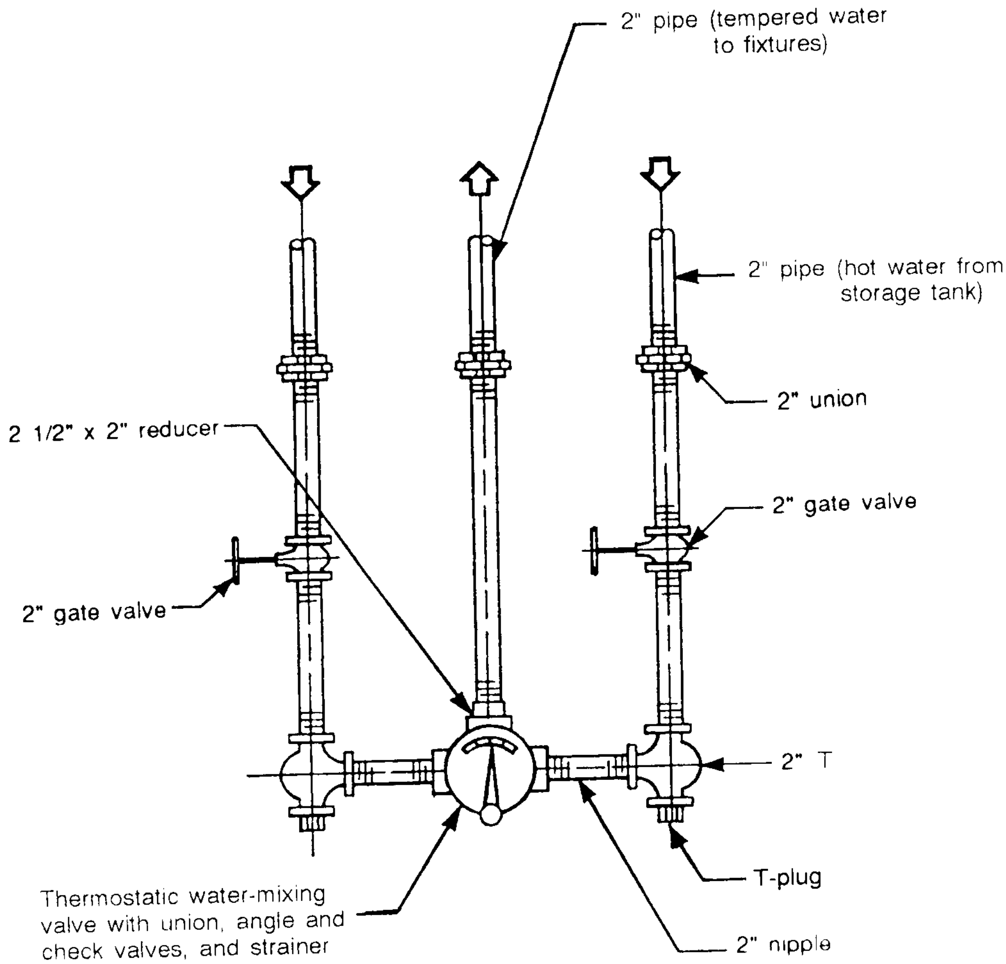
Figure A-2. Typical utility plan (bathhouse and latrine)



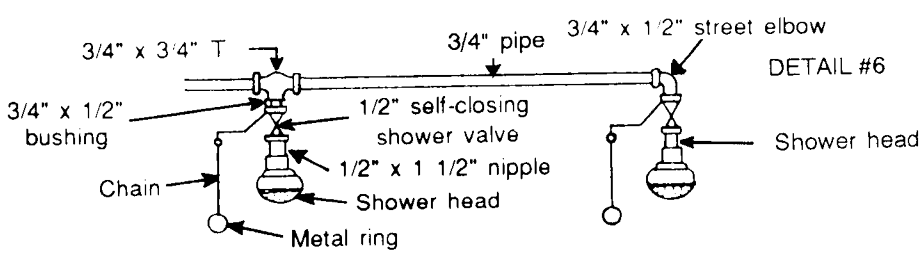
WATER-CLOSET PLUMBING DETAIL 11G

Standard Detail Drawing

Figure A-3. Detail drawings (bathhouse and latrine)



MIXING CONTROL-VALVE PIPING HOOKUP



DETAIL #6 SHOWER HEAD AND CONTROL VALVE

Special Detail Drawing

Figure A-3. Detail drawings (bathhouse and latrine) (continued)

WATER TANK AND TOWER SCHEDULE										FACILITY NO.
TYPE	TANK						TOWER			TANK AND TOWER
	BARRELS	GAL	INLET	OUTLET	DIAMETER	HEIGHT	DUNNAGE BEAM	STEEL BEAM	HEIGHT	
I	100	4,200	4"	6"	9'-2 ¾"	8'-0"	4'x6" @1'-4" 00	6B12 @1'-4" 00	30'	842103
II	230	10,300	4"	6"	15'-6"	8'-0"	4'x6" @1'-4" 00	8B13 @1'-5" 00	30'	846102
III	500	21,000	4"	6"	21'-7"	8'-0"	4'x6" @1'-8" 00	10WF21 @1'-8" 00	30'	842103

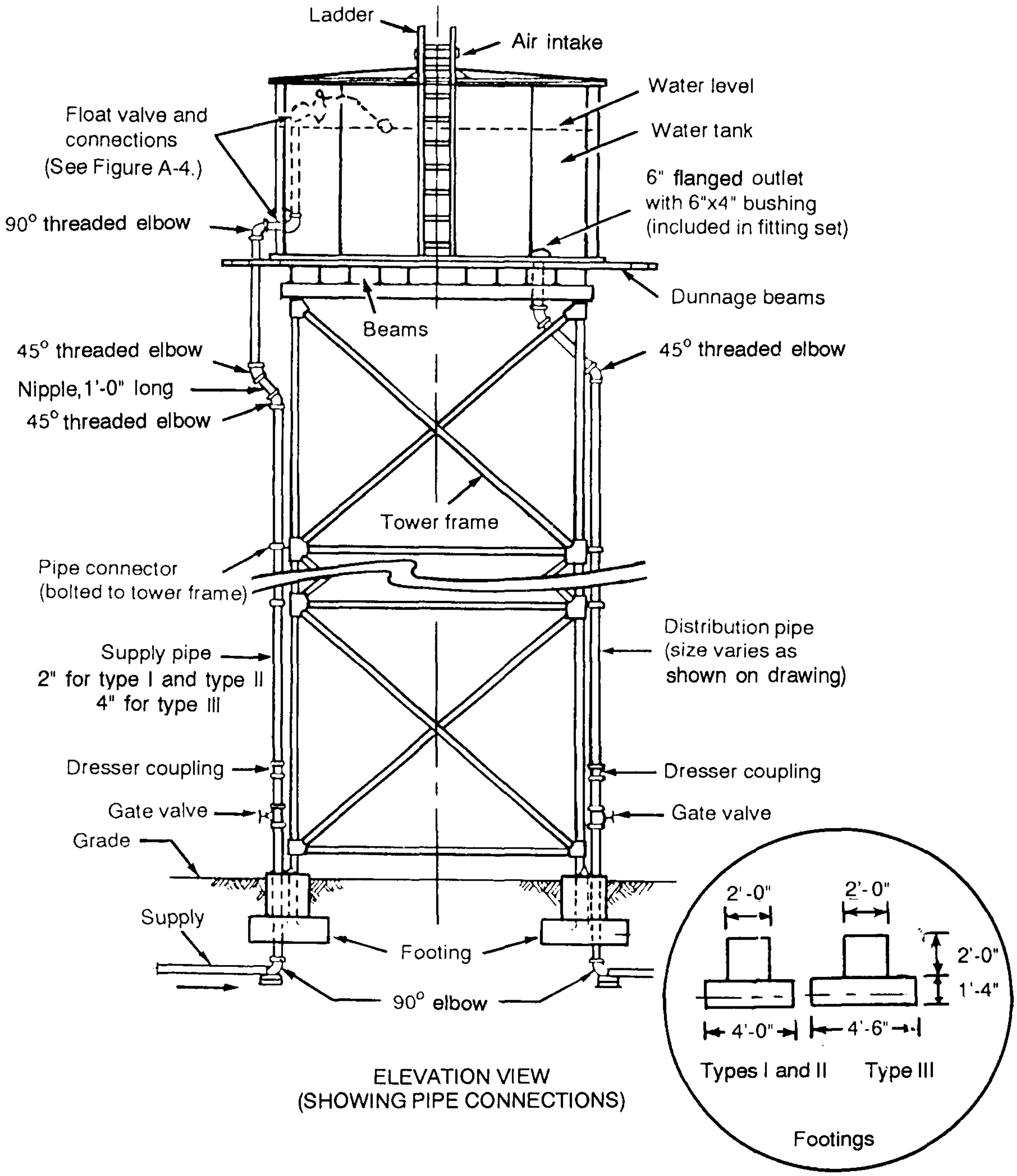
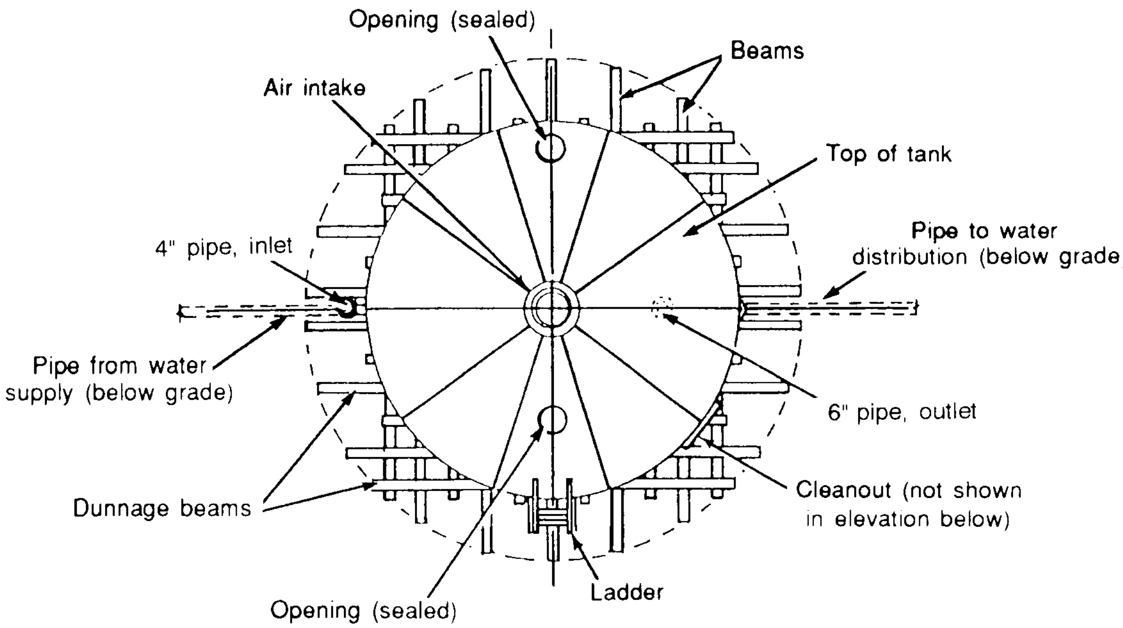
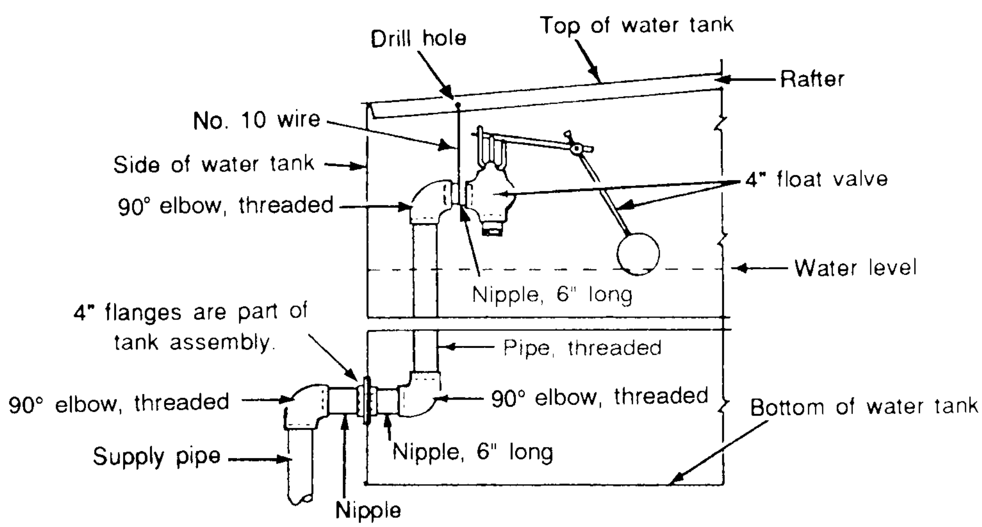


Figure A-4. Typical water storage tank and tower (detail drawing)



PLAN VIEW
(SHOWING PIPE CONNECTIONS)



***NOTE:** Pipes, valves, and fittings are 2" for Type I and Type II tanks and 4" for Type III tank.*

DETAIL DRAWING OF FLOAT-VALVE
CONNECTION (NO SCALE)

Figure A-4. Typical water storage tank and tower (detail drawing) (continued)

Section II. Plumbing and Heating Symbols

A-5. Types of Symbols.

a. *Piping Symbols.* Plans use solid or dashed lines to show the piping. The size of the piping is also shown. Piping with up to 12 inches inside diameter is referred to by its nominal size. The exact inside diameter depends on the grade of pipe; heavy grades of pipe have small inside diameters because their walls are thicker. Piping over 12 inches in diameter is rcfcrrcd to by its actual outside diameter.

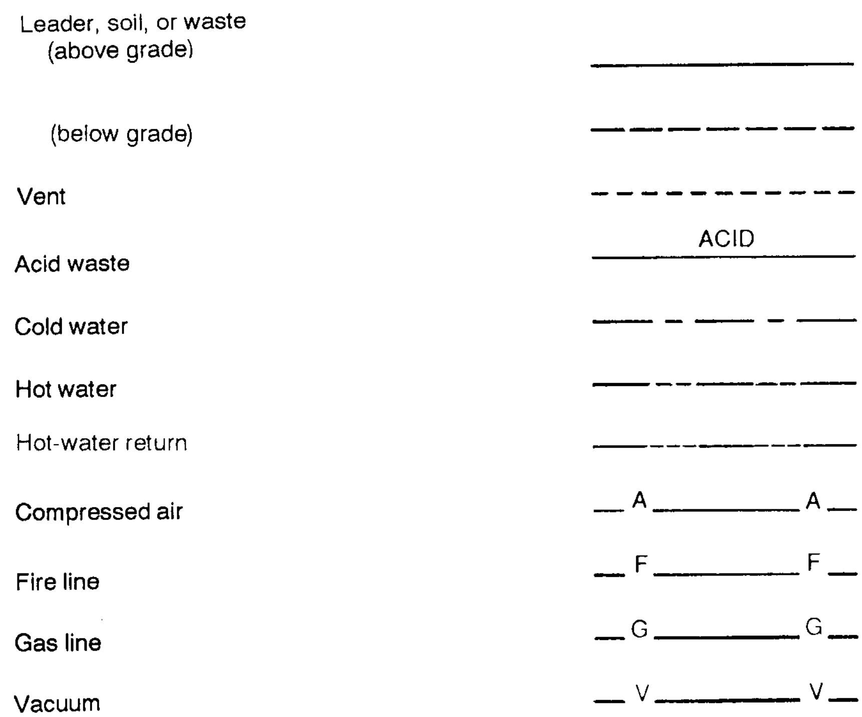
b. *Fitting Symbols.* These symbols are used with the pipe symbols to show size, method of branching, and type of fitting material to use. The most commonly used filling symbols are shown in this appendix.

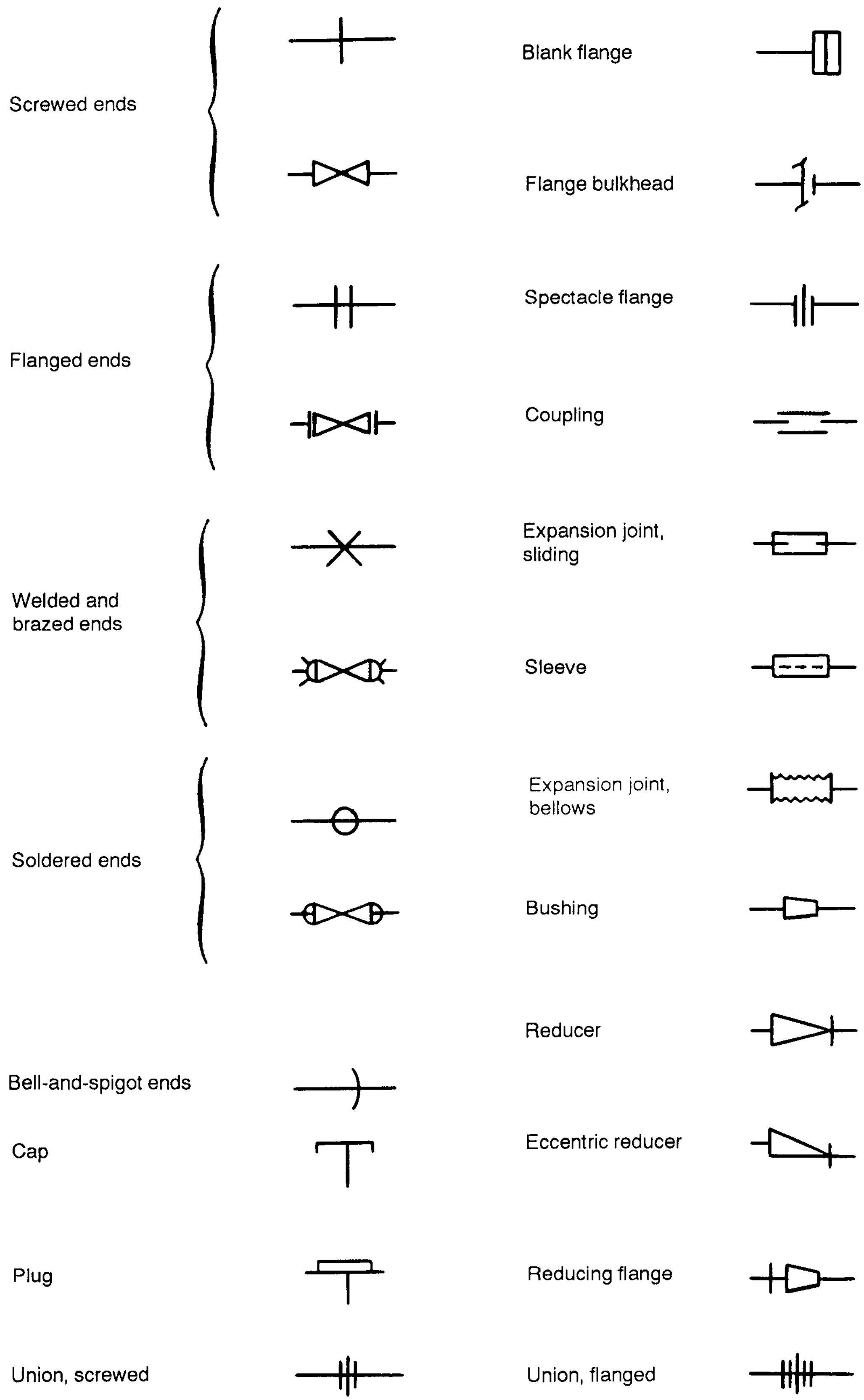
c. *Valve Symbols. A* plumbing system uses different designs and types of valves. This appendix gives a complete list of these valves and their symbols. Since drawings do not normally specify the kind of material and size of valves, use the same size and material as the connected pipes. However, if listed on the bill of material or plumbing takeoff list, valves are listed by size, type, material, and working pressure. For example: two-inch check valve, brass, 175 pounds working pressure.

d. *Fixture Symbols.* These symbols show water closets, sinks or lavatories, urinals, and floor drains. This appendix shows the most common types of fixture symbols. In most cases. the fixtures will be listed on the BOM or other documents keyed to the plumbing plan.

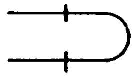
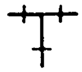
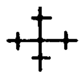
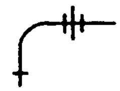
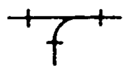
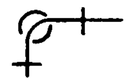
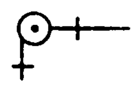
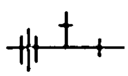
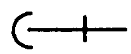
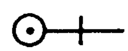
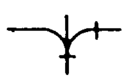
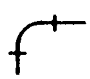
A-6. List of Symbols. Pages A-11 through A-20 show standard plumbing and heating synbols for the following:

- Piping
- Pipe Fittings
- Valves
- Plumbing Fixtures
- Heating Piping
- Heating Fittings
- Heating Fans


Leader, soil, or waste
(above grade)
(below grade)
Vent
Acid waste
ACID
Cold water
Hot water
Hot-water return
Compressed air
A A
Fire line
F F
Gas line
G G
Vacuum
V V

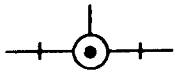


Screwed ends
Flanged ends
Welded and brazed ends
Soldered ends
Bell-and-spigot ends
Cap
Plug
Union, screwed
Blank flange
Flange bulkhead
Spectacle flange
Coupling
Expansion joint, sliding
Sleeve
Expansion joint, bellows
Bushing
Reducer
Eccentric reducer
Reducing flange
Union, flanged

Return bend		Elbow, 45 degrees	
T		Other than 90 or 45 degrees, specify angle	
Cross		Double branch, or plain double T-Y	
True Y		Reducing elbow	
Lateral, or Y		Elbow, union	
T, single-sweep, or plain T-Y		Elbow, side outlet down	
T, double-sweep		Elbow, side outlet up	
T, union		Elbow, turned down	
Through double Y		Elbow, turned up	
Through double T-Y		T, outlet down	
Elbow, 90 degrees		T, outlet up	

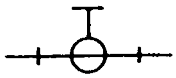
T, Side outlet down

T, Side outlet up



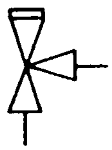
CONTROL VALVES —

Valve, general symbol

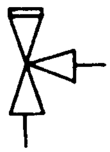


Angle

Angle,
air-operated,
spring-closing



Angle,
air-operated,
spring-opening

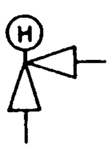


Angle,
deck-operated

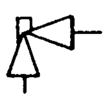
Angle, hose

Angle, high-lift

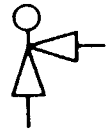
Angle,
hydraulically operated



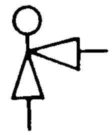
Angle,
key-operated



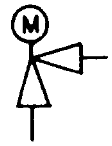
Angle,
locked closed



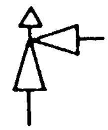
Angle,
locked open



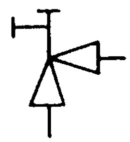
Angle,
motor-operated



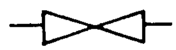
Angle, needle



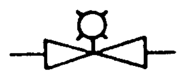
Angle,
operated at place
and adjacent space



Gate

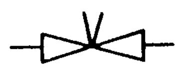


Boiler,
bottom blow

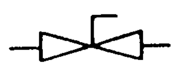


Boiler,
surface blow

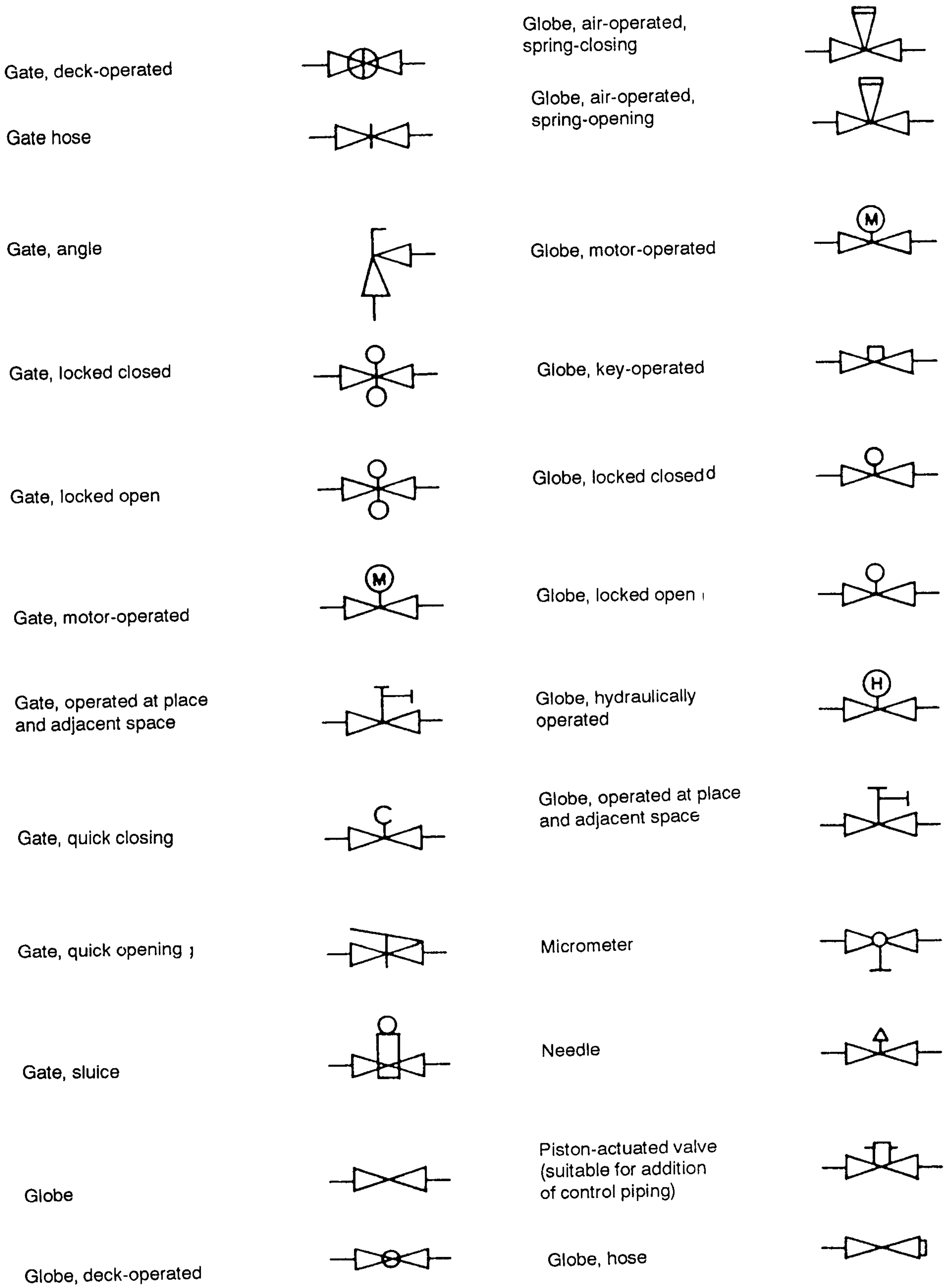
Butterfly

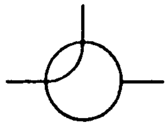
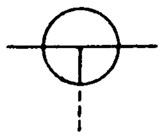
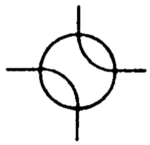
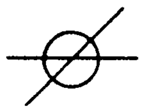
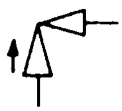
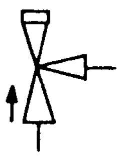
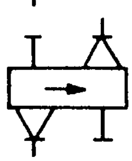
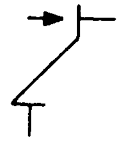
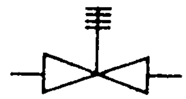
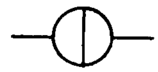
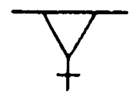
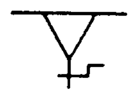
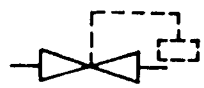
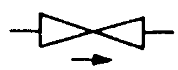
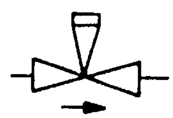
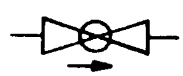
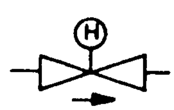


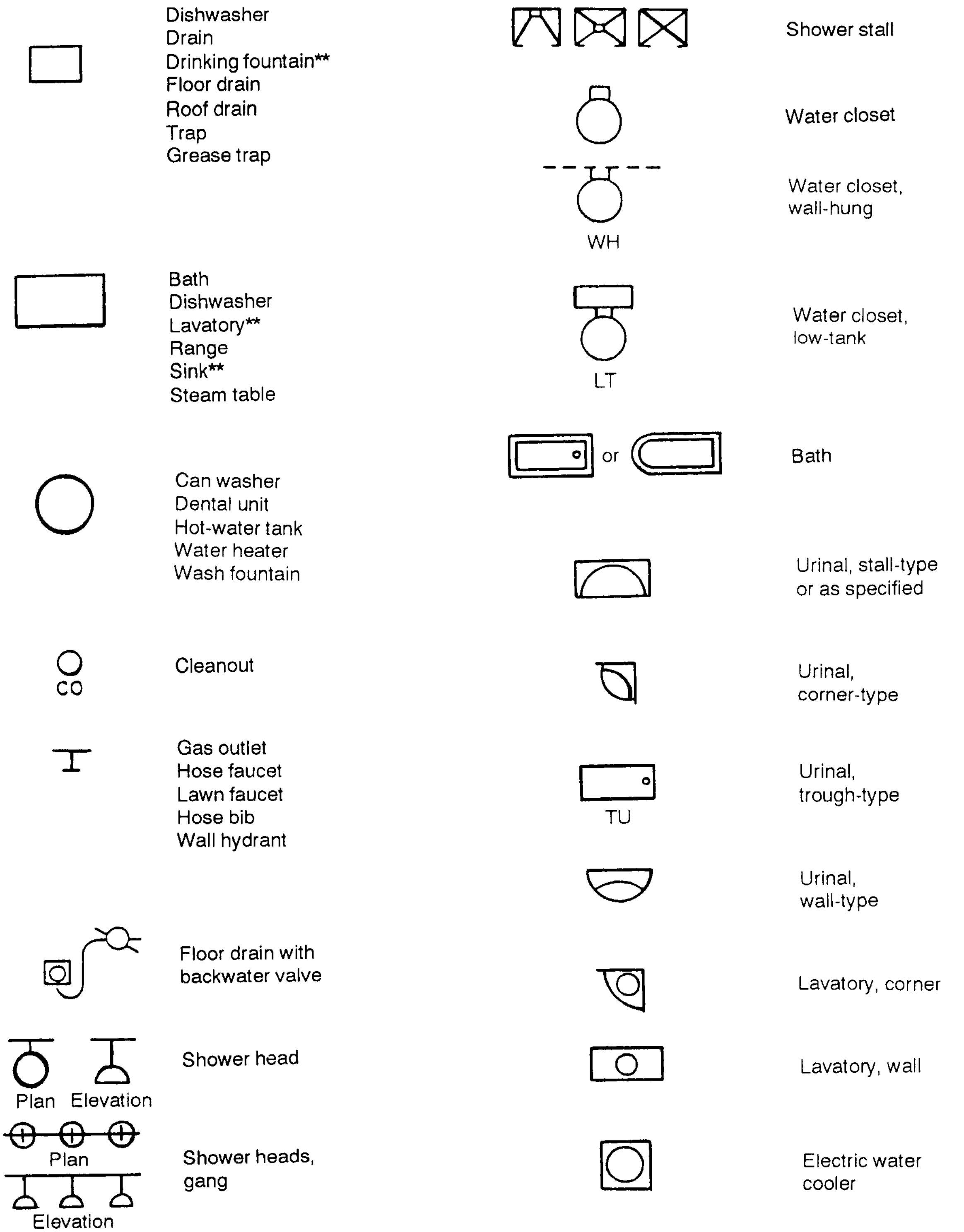
Chronometer



Cross


Gate, deck-operated
Gate hose
Gate, angle
Gate, locked closed
Gate, locked open
Gate, motor-operated
M
Gate, operated at place and adjacent space
Gate, quick closing
Gate, quick opening
Gate, sluice
Globe
Globe, deck-operated
Globe, air-operated, spring-closing
Globe, air-operated, spring-opening
Globe, motor-operated
M
Globe, key-operated
Globe, locked closed
Globe, locked open
Globe, hydraulically operated
H
Globe, operated at place and adjacent space
Micrometer
Needle
Piston-actuated valve (suitable for addition of control piping)
Globe, hose

Stop cock, plug or cylinder valve, 3-way, 2-port	
Stop cock, plug or cylinder valve, 3-way, 3-port	
Stop cock, plug or cylinder valve, 4-way, 4-port	
General symbol	
Angle, stop-check	
Angle, stop-check, air-operated, spring-closing	
Angle, stop-check, deck-operated	
Angle, stop-check-hose	
Angle, stop-check, hydraulically operated	
Angle, stop-lift-check	
Boiler feed, stop-and-check-combined	
Check, angle	
Check, ball	
Back pressure	
Cross feed	
Drain	
Dump	
Float operated	
Globe, stop-check	
Globe, stop-check, air-operated, spring-closing	
Globe, stop-check, deck-operated	
Globe, stop-check, hydraulically operated	



**Type should be given in specification or note when this symbol is used.

Air-relief line

Boiler blowoff

Compressed air

Condensate or vacuum pump discharge

Feed-waster pump discharge

Fuel-oil flow

Fuel-oil return

Fuel-oil tank vent

High-pressure return

High-pressure steam

Hot-water return

Hot-water supply

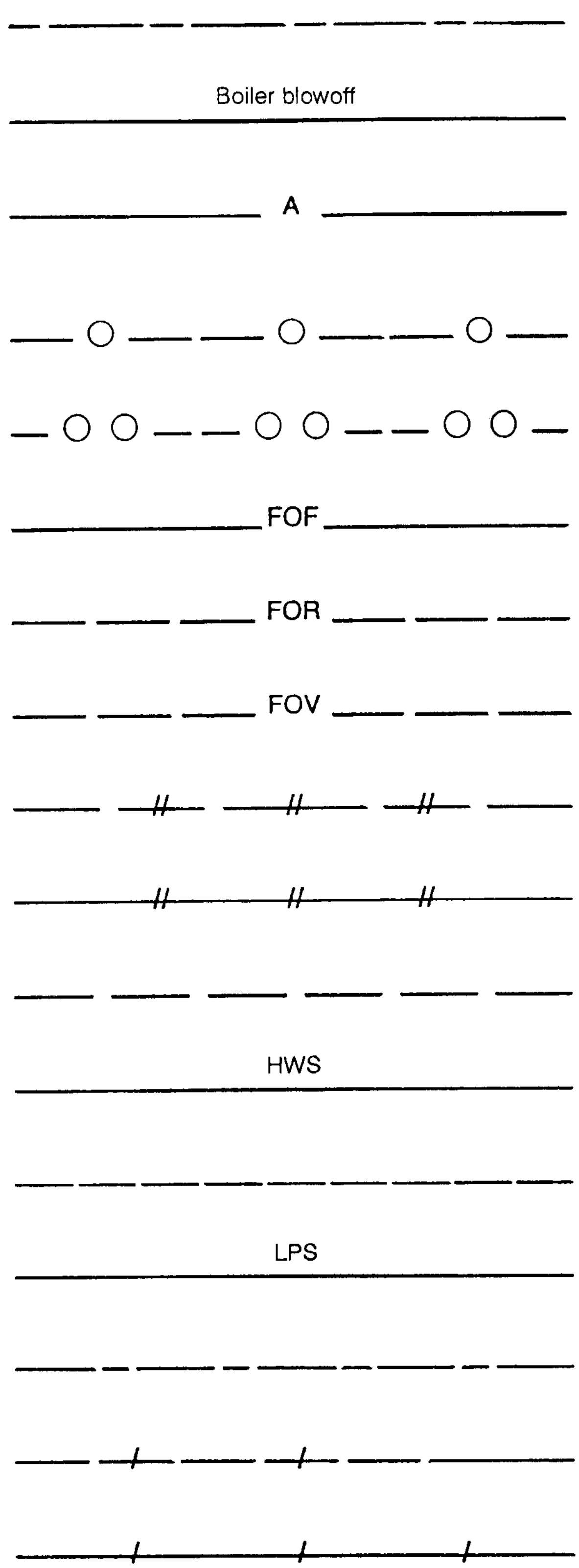
Low-pressure return

Low-pressure steam

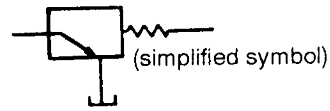
Makeup water

Medium-pressure return

Medium-pressure steam

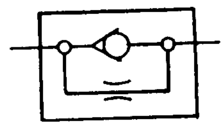


Relief valve, remotely controlled

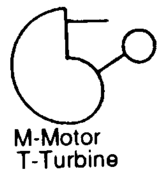


Boiler feed

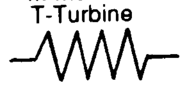
Orifice check valve



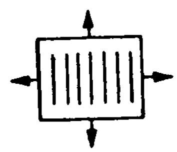
Fan blower



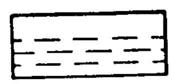
Filter



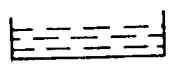
Air heater (plate or tubular)



Closed tank

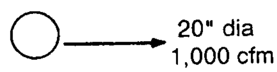


Open tank

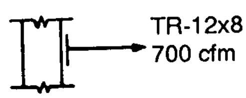


Louver opening

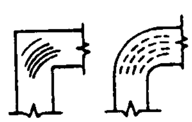
Ceiling supply outlet (indicate type)



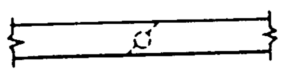
Wall supply outlet (indicate type)



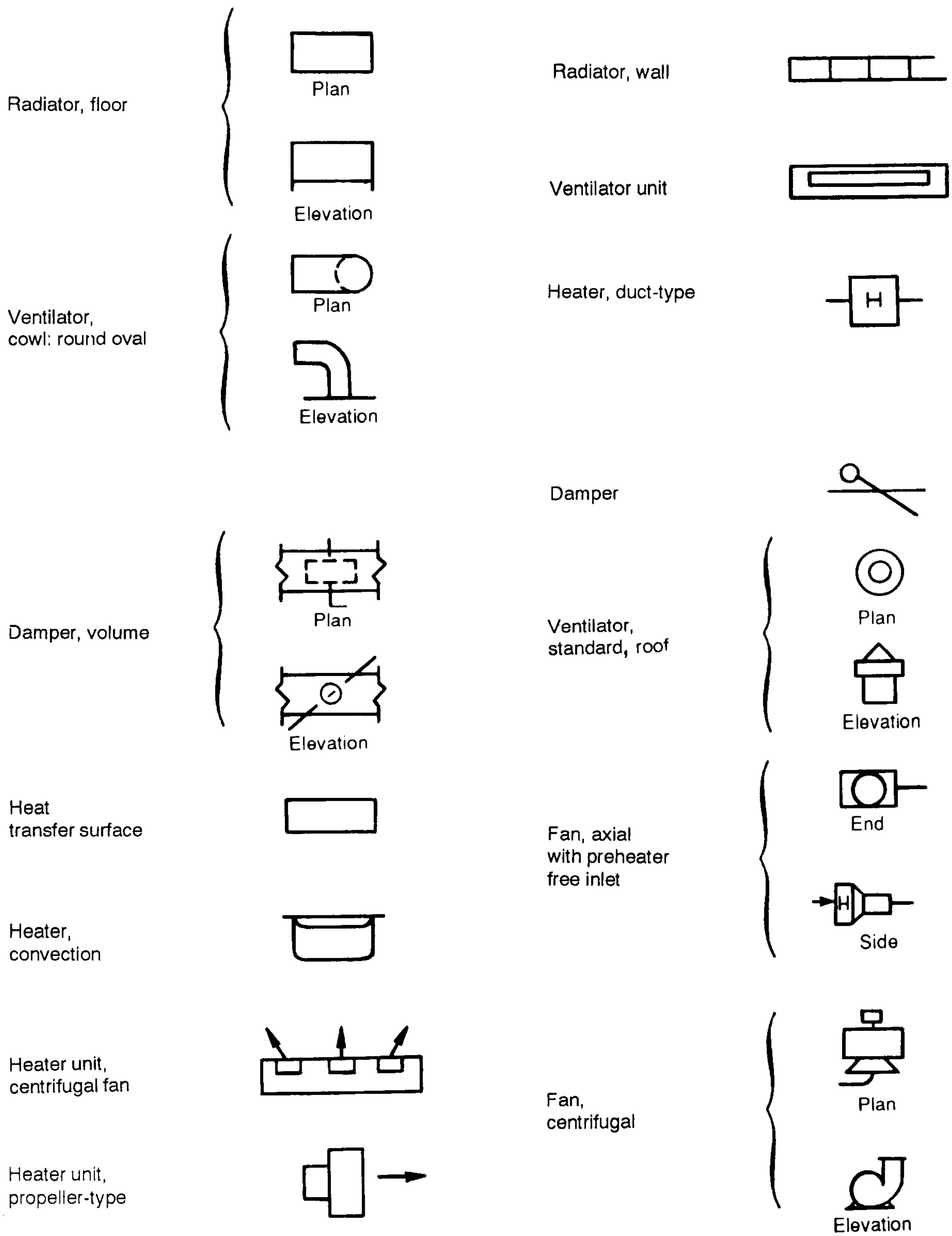
Vanes



Volume damper



Capillary tube


Radiator, floor
Plan
Elevation
Ventilator,
cowl: round oval
Plan
Elevation
Damper, volume
Plan
Elevation
Heat
transfer surface
Heater,
convection
Heater unit,
centrifugal fan
Heater unit,
propeller-type
Radiator, wall
Ventilator unit
Heater, duct-type
H
Damper
Ventilator,
standard, roof
Plan
Elevation
Fan, axial
with preheater
free inlet
End
H
Side
Fan,
centrifugal
Plan
Elevation

APPENDIX B
BILLS OF MATERIALS

B-1. Description. A bill of materials (BOM) is a list of all materials required to finish a structure. It is a tabulated statement which lists—

- Item number (parts and materials).
- Government stock size and number, if called for.
- Item name and description.
- Unit of issue.
- Quantity.
- Weight, as applicable.

Table B-1 shows a portion of a BOM for plumbing in a company bathhouse and latrine. For a complete BOM, refer to TM 5-303.

Table B-1. Sample bill of materials for company bathhouse and latrine

Item Number	National Stock Number	Item Name	Unit of Issue	Quantity
1	4410-00-999-5886	Heater, water, oil-fired, 600-GPH	ea	1
2	4510-00-132-6376	Faucet, single, 3/4-NPT/M, brass, w/bib	ea	1
3	4510-00-132-6377	Faucet, single, 3/4-NPT/M, brass, w/o bib	ea	8
4	4510-00-202-7703	Shower head, 1/2-inch, chrome, fins brass	ea	8
5	4510-00-244-9979	Urinal, stationary, 4-foot trough w/tank	ea	2
6	4510-00-260-1367	Water closet w/o cover, tank/bowl separate	ea	8
7	4510-00-273-1591	Drain floor, cast-iron, 6-inch square 2-inch out	ea	1

B-2. Preparation. The designer or draftsman usually prepares the BOM when he prepares the original drawings. However, if no BOM accompanies field prints, the plumber must compile it.

The takeoff list is usually an actual count and checkoff of the items shown or specified on the construction drawings and specifications. The estimate list shows materials, such as nails, cement, lumber, pipe hangers, joint connection materials, and cutting oil that are not placed on the drawings. The material needs for a project must be calculated from a knowledge of the construction.

Architectural and engineering plans aid in listing items on the BOM. Use the indicated or scaled dimensions of the building or the utility layouts to determine the dimensions of the items of material. Figure A-2 (page A-4) shows a plan drawing of a company bathhouse and latrine. Each item on the drawing is checked, listed, and recorded by stock number and size. Definite starting points and procedures are used for each group of materials. For example, starting at the source—

- Trace the cold-water lines and check and record each item.
- Trace the hot-water lines and check and record all the items.
- Determine quantities by listing one material at a time.
- Regroup materials by size, starting with the smallest and progressing to the largest.

APPENDIX C
PIPE SIZES FOR WATER DISTRIBUTION SYSTEM DESIGN

This appendix contains information to help determine pipe sizes when designing a water distribution system.

Table C-1. Capacities of galvanized-steel/iron pipe (in GPM)

Pressure at Source (psi)	Length of Pipe (in feet)									
	20	40	60	80	100	120	140	160	180	200
3/8-inch										
10	5	3	3	2	2	2				
20	9	5	4	3	3	3	2	2	2	2
30	10	6	5	4	4	3	3	3	3	2
40		8	6	5	4	4	4	3	3	3
50		9	7	6	5	4	4	3	3	3
60		9	7	6	6	5	5	4	4	4
70		10	8	7	6	6	5	5	4	4
80			8	7	7	6	5	5	5	4
1/2-inch										
10	10	8	5	5	4	3	3	3	3	3
20	14	10	8	6	6	5	5	4	4	4
30	18	12	10	8	8	7	6	6	5	5
40	20	14	11	10	10	8	7	7	6	6
50		16	13	11	11	9	8	7	7	7
60		18	14	12	12	10	9	9	8	7
70			15	13	12	11	10	9	8	8
80										
3/4-inch										
10	22	14	12	10	8	8	7	6	6	6
20	30	22	18	14	12	12	11	10	10	8
30	38	26	22	18	16	14	13	12	12	10
40		30	24	21	19	17	16	16	15	13
50		34	28	24	21	19	18	17	16	15
60		38	31	26	23	21	20	19	18	17
70			34	29	25	23	22	21	19	18
80			36	30	27	24	23	22	21	20
1-inch										
10	40	28	22	18	16	15	14	13	12	11
20	55	40	32	27	24	22	20	19	18	16
30	70	50	40	34	30	27	25	23	22	20
40	80	58	45	40	35	32	29	27	25	24
50		65	57	45	40	36	33	31	29	27
60		70	58	50	44	40	36	34	32	30
70		76	63	54	45	42	40	37	34	32
80			65	57	47	43	39	37	35	33

Table C-1. Capacities of galvanized-steel/iron pipe (in GPM) (continued)

Pressure at Source (psi)	Length of Pipe (in feet)									
	20	40	60	80	100	120	140	160	180	200
					1 1/4-inch					
10	80	55	45	37	35	30	27	25	26	24
20	110	80	65	55	50	45	41	38	36	34
30		100	80	70	60	56	51	47	45	42
40			95	80	72	65	60	56	52	50
50			107	92	82	74	68	63	60	55
60				102	90	81	75	70	65	62
70					97	88	82	74	69	67
80					105	95	87	79	74	72
					1 1/2-inch					
10	120	90	70	60	55	50	45	40	40	35
20	170	130	100	90	75	70	65	60	55	55
30		160	130	110	100	90	80	75	70	65
40		170	150	130	110	100	90	90	80	80
50			170	140	130	120	110	100	90	90
60				160	140	130	120	110	100	100
70				170	150	140	130	120	110	100
80					160	150	140	130	120	110
					2-inch					
10	240	160	130	110	100	90	90	80	80	70
20	300	240	200	160	150	140	130	120	110	100
30		300	240	200	180	160	150	140	140	130
40			380	240	220	200	180	160	160	150
50				280	240	220	200	200	180	160
60					280	240	220	200	200	180
70					300	260	240	220	220	200
80						280	260	240	220	220

Table C-2. Capacities of copper tubing and plastic pipe (in GPM)

Pressure at Source (psi)	Length of Pipe (in feet)									
	20	40	60	80	100	120	140	160	180	200
1/2-inch										
10	8	5	4	3	3	2	2	2	2	2
20	12	8	6	5	5	4	4	3	3	3
30	15	10	8	7	6	5	5	4	4	4
40	17	12	9	8	7	6	6	5	5	4
50		14	10	9	8	7	6	6	5	5
60		15	12	10	9	8	7	7	6	6
70			13	11	10	9	8	7	7	6
80			14	12	10	10	8	8	7	7
5/8-inch										
10	12	8	7	6	5	5	4	4	3	3
20	18	12	10	9	7	6	6	5	5	5
30	22	16	12	10	9	9	8	7	6	6
40	26	18	14	12	10	10	9	8	8	7
50		22	16	14	12	11	10	9	9	8
60		24	18	16	14	13	12	11	10	9
70			20	18	15	14	13	12	11	10
80			22	19	16	15	14	13	12	11
3/4-inch										
10	20	14	10	10	8	8	6	6	6	5
20	30	20	16	14	12	10	10	10	8	8
30	36	26	20	17	15	14	13	11	10	8
40		30	24	20	18	16	15	14	13	12
50		34	28	24	20	18	16	16	14	14
60		36	30	26	22	20	18	18	16	16
70			32	28	24	22	20	18	18	16
80			36	30	26	24	22	20	18	18
1-inch										
10	50	30	24	20	18	16	14	14	12	12
20	70	45	36	30	26	24	22	20	18	18
30	80	55	45	38	34	30	28	26	24	22
40		65	55	45	40	36	32	30	28	26
50		75	60	50	45	40	36	34	32	30
60		80	66	55	50	45	40	38	36	34
70			70	60	55	50	45	40	38	36
80			80	65	60	50	50	45	40	40

Table C-2. Capacities of copper tubing and plastic pipe (in GPM) (continued)

Pressure at Source (psi)	Length of Pipe (in feet)									
	20	40	60	80	100	120	140	160	180	200
1 1/4-inch										
10	80	55	42	37	32	30	27	25	22	22
20	110	80	65	55	47	42	40	35	35	32
30		105	80	70	60	55	50	45	44	40
40		110	95	80	70	65	60	55	50	47
50			110	90	80	70	65	60	57	55
60				105	90	80	75	70	65	60
70				110	100	90	80	75	70	65
80					105	95	85	80	75	70
1 1/2-inch										
10	130	90	70	60	50	45	40	40	35	35
20	170	130	100	90	75	70	65	60	55	50
30		170	130	110	100	90	80	75	70	65
40			155	130	115	105	95	88	80	77
50			170	150	130	120	108	100	90	88
60				165	145	130	120	110	105	98
70				170	160	142	130	122	113	106
80					170	155	140	130	122	115
2-inch										
10	280	180	150	145	110	100	90	85	80	70
20	320	280	220	190	165	160	140	125	120	110
30		320	280	240	210	180	170	160	150	140
40			320	280	240	220	200	190	175	160
50				320	280	250	230	210	200	190
60					300	280	260	240	220	200
70					320	300	280	260	240	230
80						320	300	280	260	240

Table C-3. Allowance for equivalent length of pipe for friction loss (valves and threaded fittings)

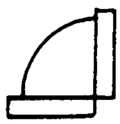
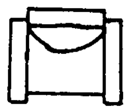
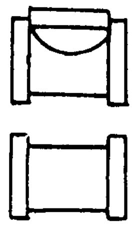
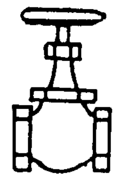
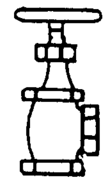
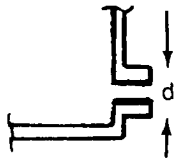
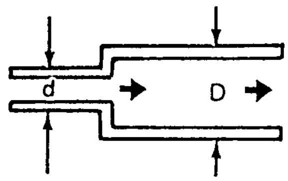
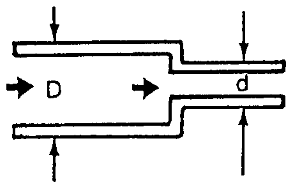
Diameter of Fitting (in inches)	90° Standard Elbow, Foot	45° Standard Elbow, Foot	90° Side T, Foot	Coupling or Straight Run of T, Foot	Gate Valve, Foot	Globe Valve, Foot	Angle Valve, Foot
							
3/8	1.0	0.6	1.5	0.3	0.2	8	4
1/2	2.0	1.2	3.0	0.6	0.4	15	8
3/4	2.5	1.5	4.0	0.8	0.5	20	12
1	3.0	1.8	5.0	0.9	0.6	25	15
1 1/4	4.0	2.4	6.0	1.2	0.8	35	18
1 1/2	5.0	3.0	7.0	1.5	1.0	45	22
2	7.0	4.0	10.0	2.0	1.3	55	28
2 1/2	8.0	5.0	12.0	2.5	1.6	65	34
3	10.0	6.0	15.0	3.0	2.0	80	40
3 1/2	12.0	7.0	18.0	3.6	2.4	100	50
4	14.0	8.0	21.0	4.0	2.7	125	55
5	17.0	10.0	25.0	5.0	3.3	140	70
6	20.0	12.0	30.0	6.0	4.0	165	80

Table C-4. Head loss, equivalent length of pipe (in feet)

	Ordinary Entrance	Sudden Enlargement			Sudden Contraction		
		d1 D4	d1 D2	d3 D4	d1 D4	d1 D2	d3 D4
Size of Pipe d (in inches)							
½	0.90	1.50	1.10	1.00	0.77	0.59	0.35
¾	1.20	2.20	1.40	1.30	1.00	0.79	0.47
1	1.50	2.70	1.70	1.60	1.30	0.99	0.60
1 ¼	2.00	3.70	2.40	2.20	1.60	1.30	0.80
1 ½	2.40	4.30	2.80	2.60	2.00	1.50	0.95
2	3.00	5.50	3.50	3.20	2.50	1.90	1.20
2 ½	3.60	6.50	4.20	3.90	3.00	2.30	1.40
3	4.50	8.10	5.10	4.90	3.80	2.80	1.70
3 ½	5.10	9.50	6.00	5.60	4.40	3.30	2.00
4	6.00	11.00	7.00	6.50	5.00	3.80	2.30
4 ½	6.60	12.00	7.90	7.10	5.50	4.30	2.60
5	7.50	14.00	8.90	8.10	6.10	4.80	2.90
6	9.00	16.00	11.00	10.00	7.70	5.70	3.50
8	12.00	21.00	14.00	13.00	10.00	7.60	4.50
10	15.00	26.00	17.00	16.00	13.00	9.70	5.70
12	18.00	32.00	20.00	19.00	15.00	11.00	6.70

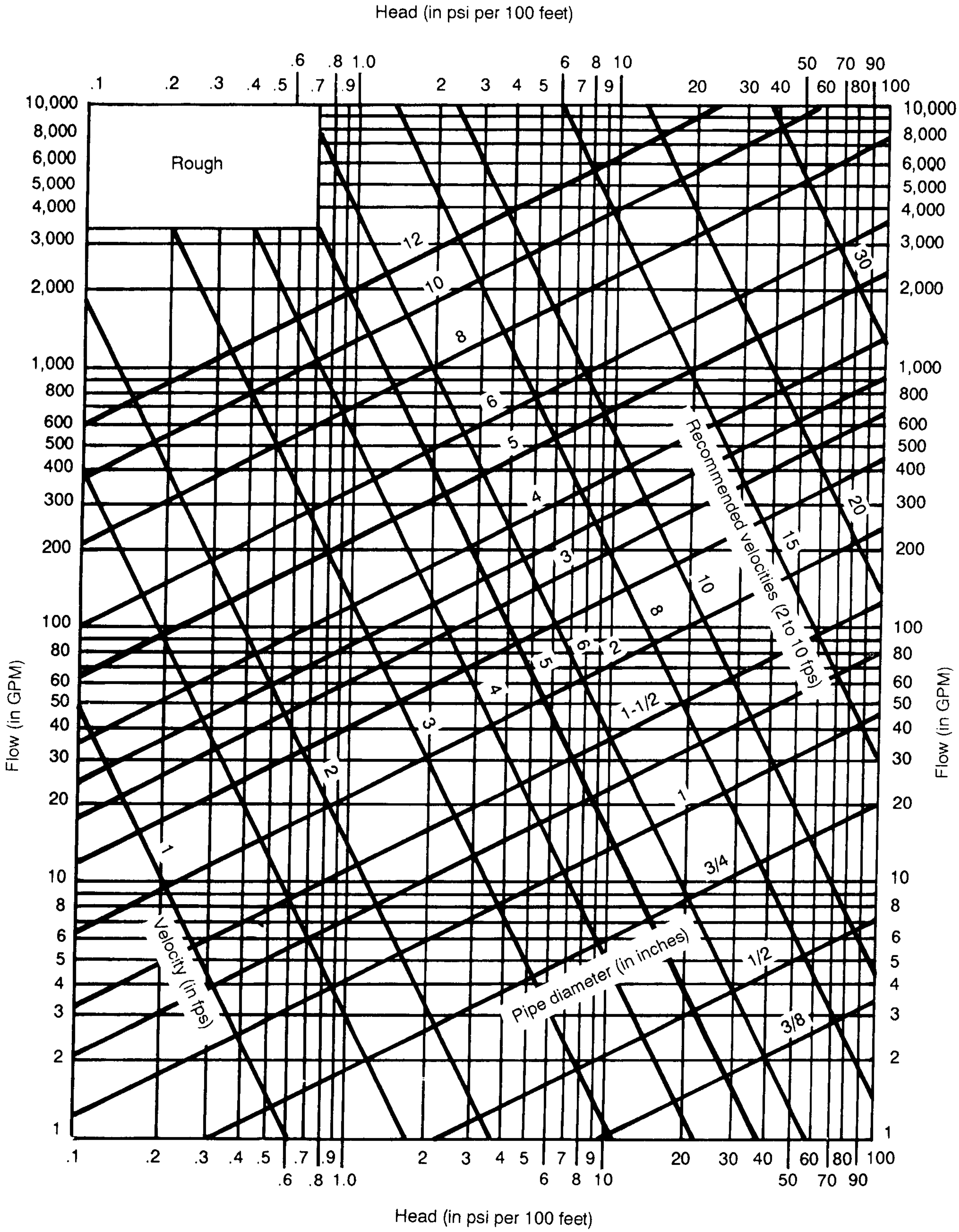


Figure C-1. Friction loss, rough pipe

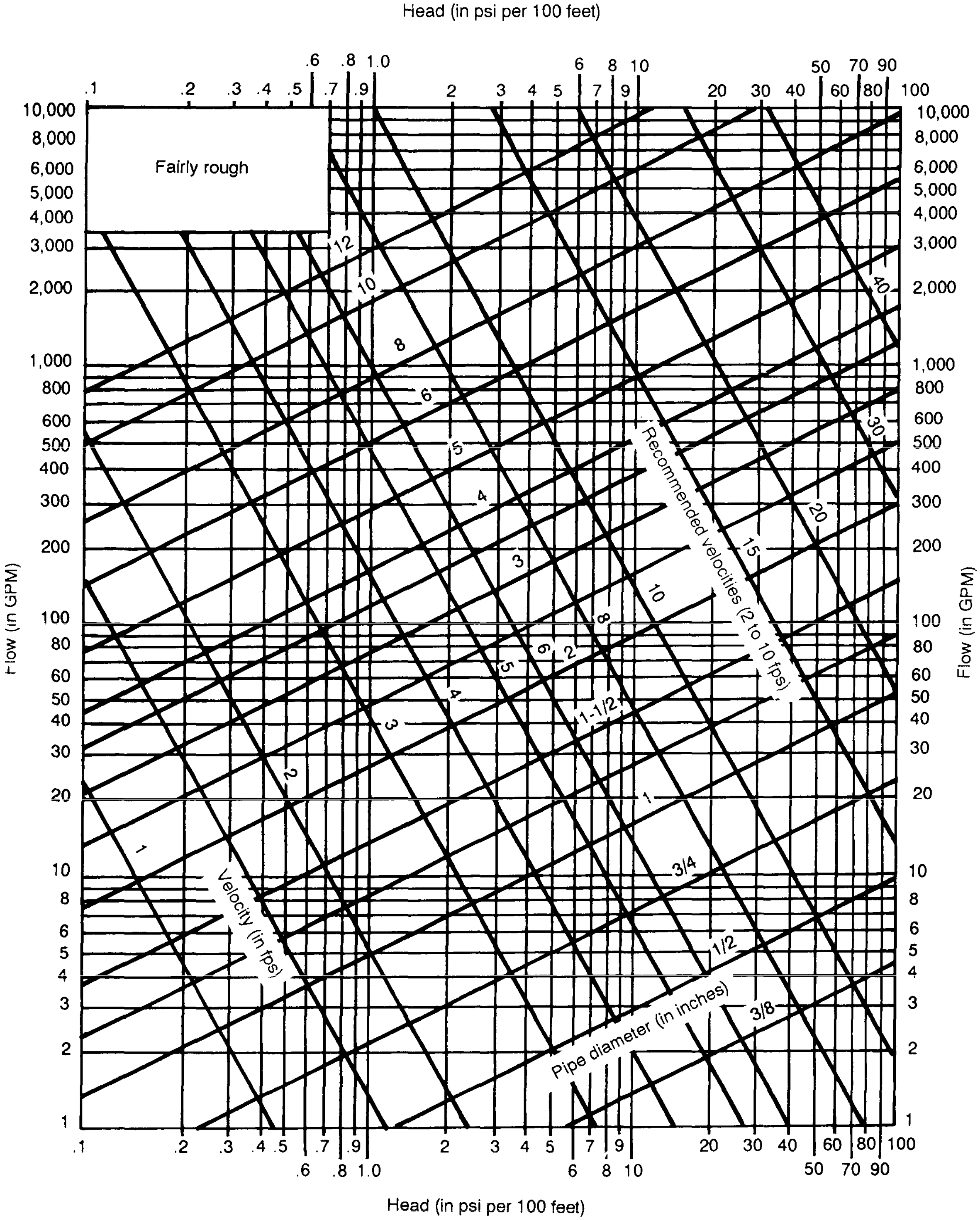


Figure C-2. Friction loss, fairly rough pipe

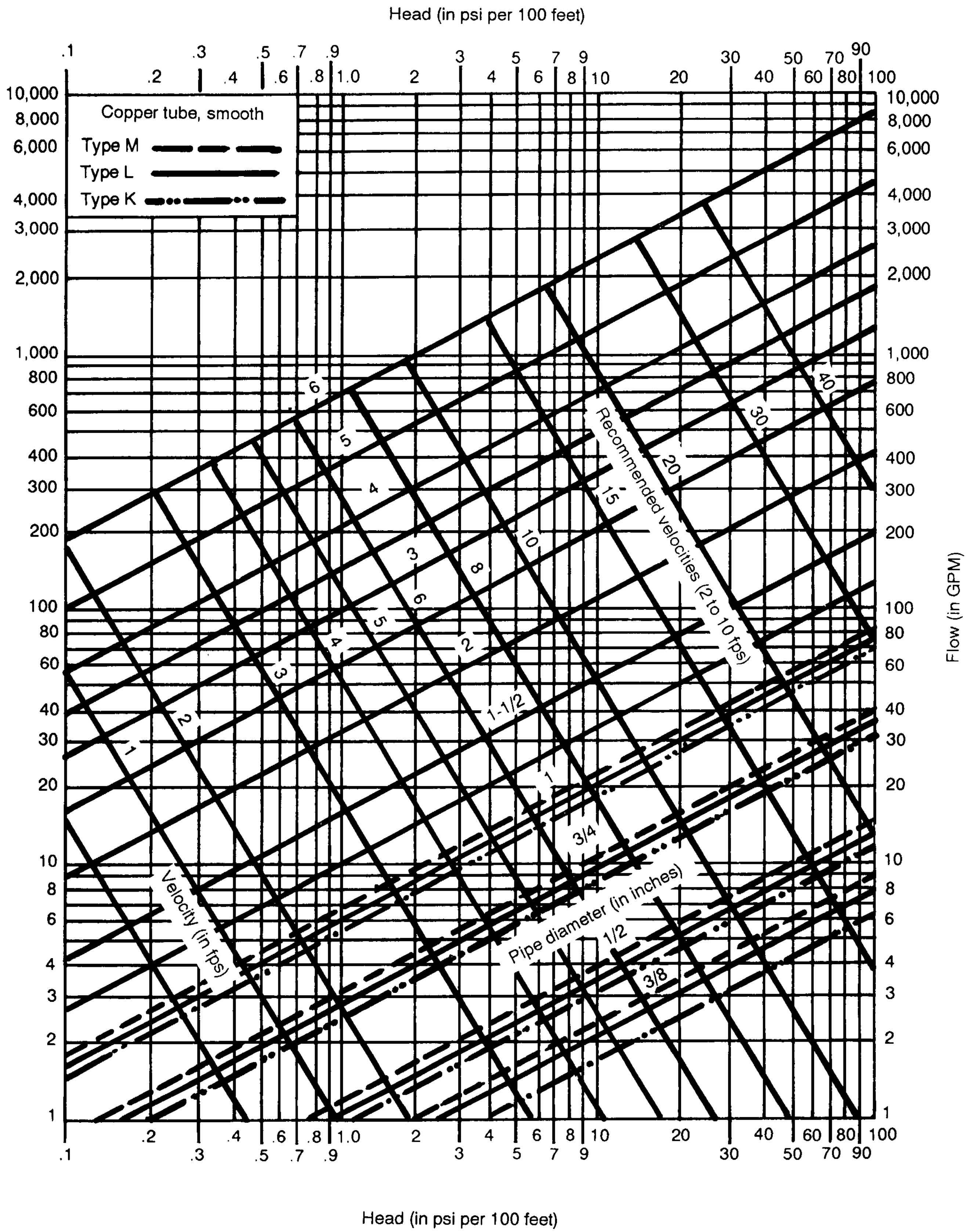


Figure C-3. Friction loss, smooth pipe

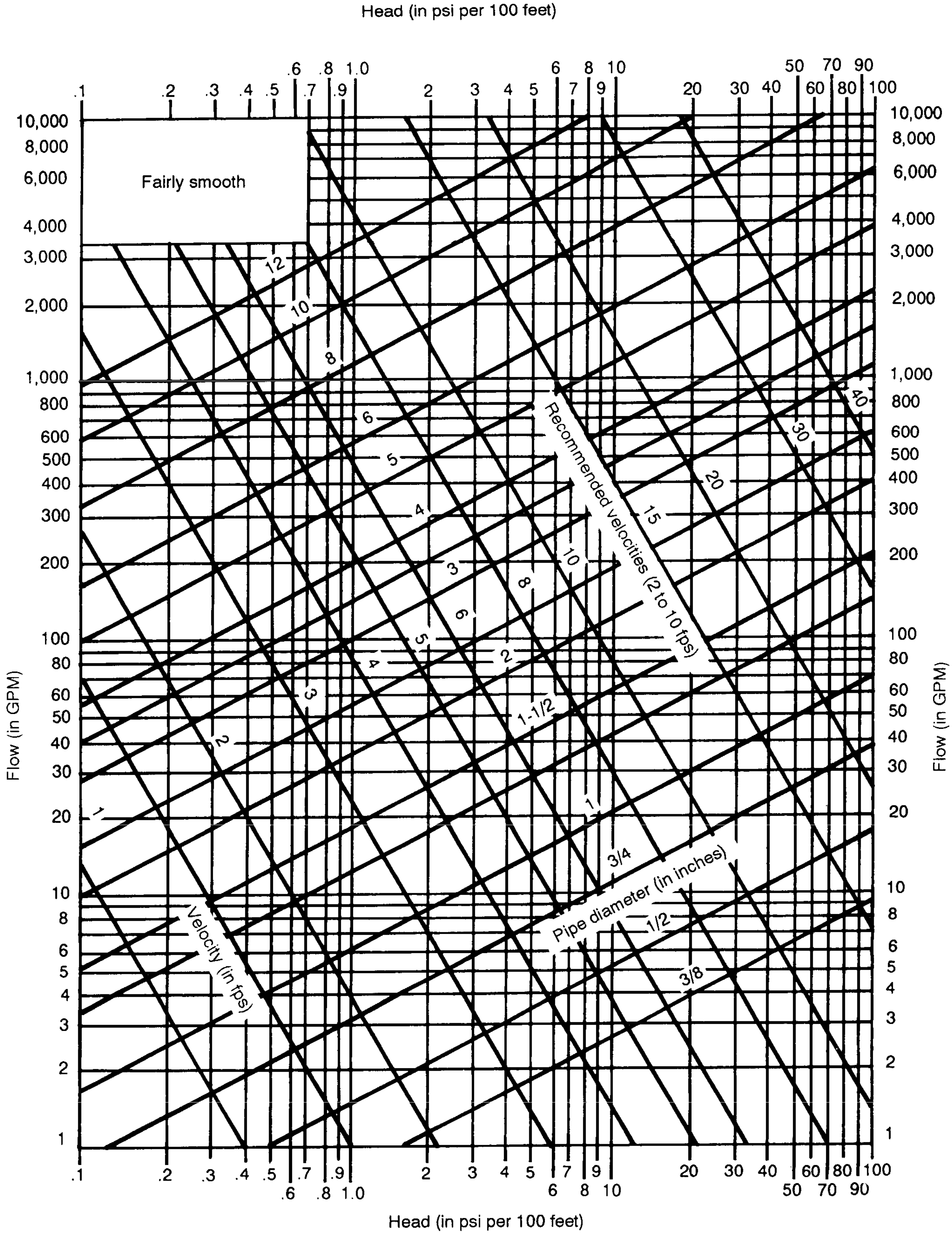


Figure C-4. Friction loss, fairly smooth pipe

APPENDIX D
DESIGN PROCEDURES
WATER DISTRIBUTION SYSTEMS

D-1. Design Procedures.

a. *Basic Concepts.* Water weighs 62.4 pounds per cubic foot.

(1) *Pressure.* Pressure (P), expressed in psi, is simply the force exerted at the base of a 1 -inch square column of water of any height (H) (Figure D-l).

$P = 0.433H$

(2) *Head.* Head is a measure of the pressure exerted by a liquid column, converted to feet of height.

$H = \frac{P}{0.433}$ or $H = 2.31$

where—
H = height.
P = pressure.

(a) Static head. Static head is the height of a fluid at rest (no flow) (Figure D-2, page D-2).

(h) Dynamic head. Dynamic head is static head minus the friction loss of a flowing liquid, expressed in feet (Figure D-3, page D-2). It is also known as *free water surface (FWS) elevation.*

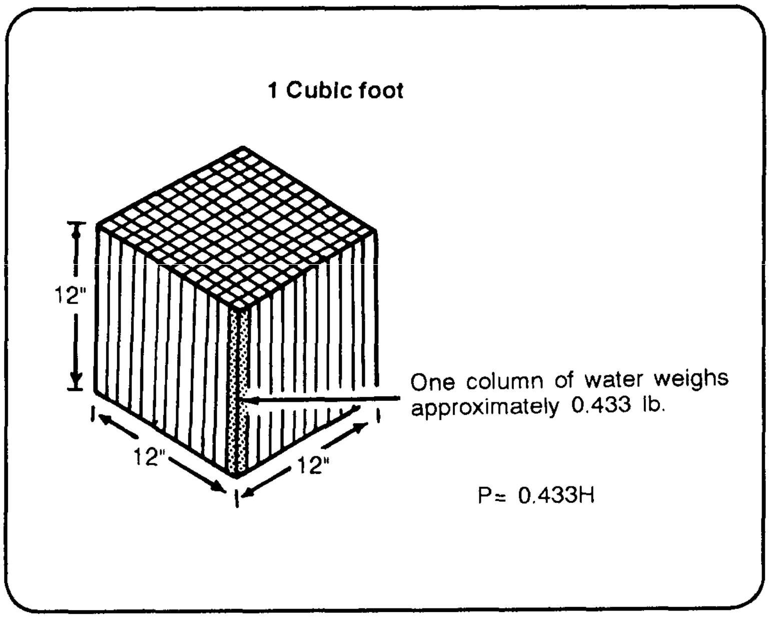


Figure D-1. Water pressure

Dynamic head = Static head - Friction loss

b. *Definitions.*

- $Pf_{allowable}$. The maximum pressure that can be lost from all sources of friction without falling below the required service-connection pressure. (Minimum service-connection pressure in the theater of operations is 20 psi.)
- Pf_{actual}. The pressure loss from all sources of friction in a pipe segment.
- $PF_{allowable}$. The allowable pressure loss in a 100-foot section.
- PF_{actual}. The actual pressure loss in a 100-foot section.

- *Equivalent Length (EL).* The length of a fitting or valve expressed in feet of straight pipe that produces the same amount of friction loss.
- *Pressure at Service Connection (Psc).* The actual pressure that will be provided to the user (building or facility).

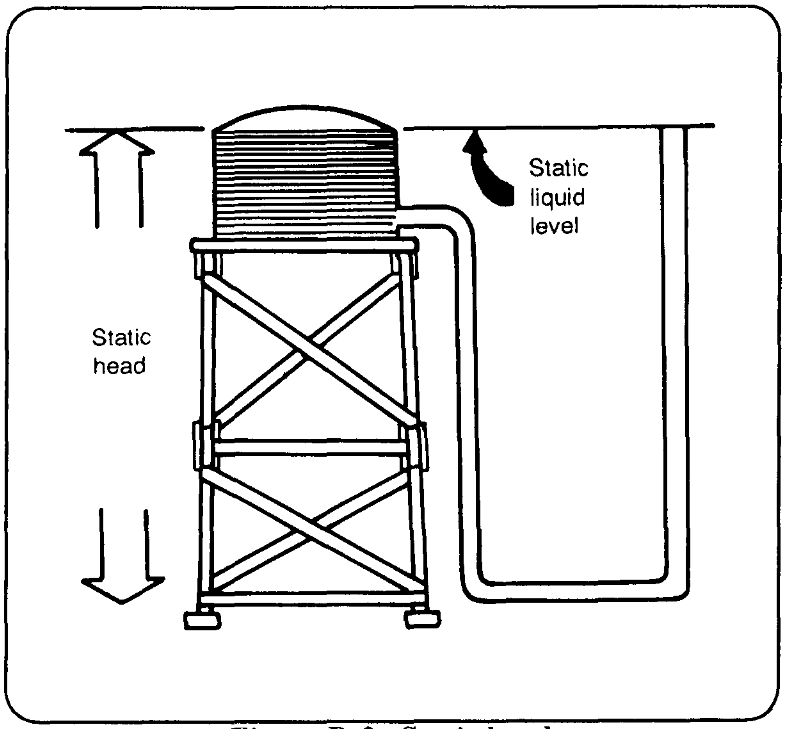


Figure D-2. Static head

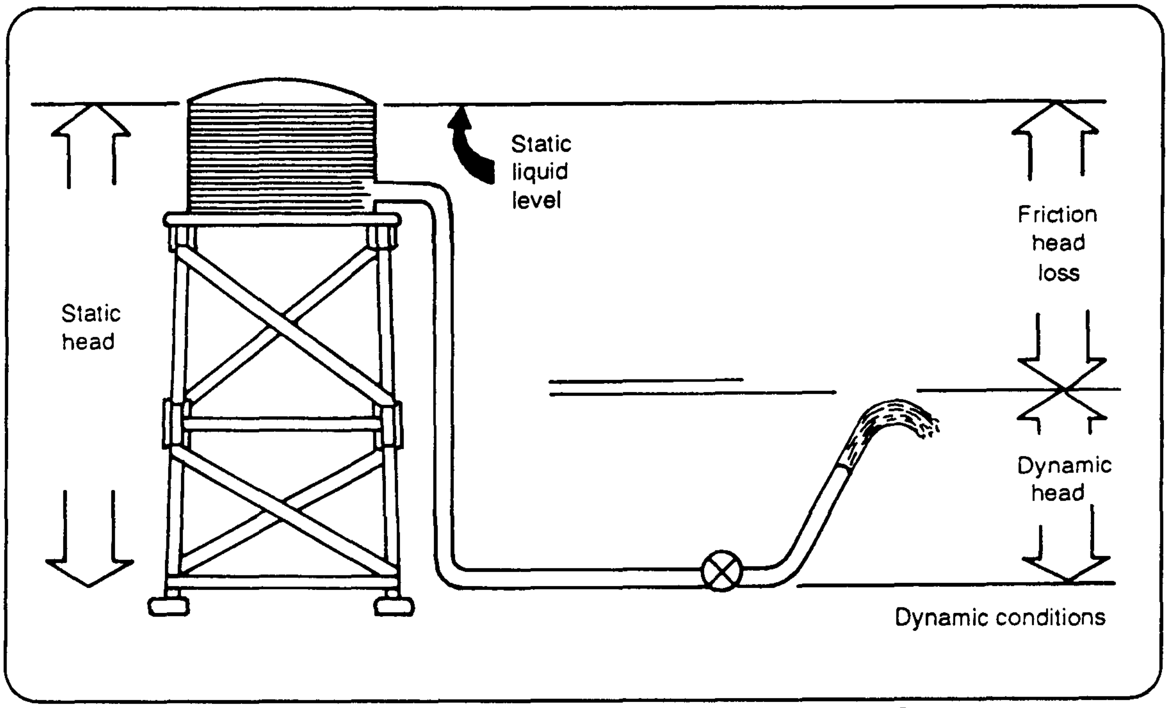


Figure D-3. Relation of static and dynamic heads

D-2. Dynamic Distribution System Design. Dynamic water distribution systems are designed using the following procedures. When working the two examples on pages D-4 through D-9, refer back to the procedures below.

DESIGN PROCEDURES

Step 1. Determine the quantity (Q) of the flow rate, in GPM.

Step 2. Determine $Pf_{allowable}$ for each line.

$$Pf_{allowable} = H(E_1 - E_2) - \text{required pressure}$$

where—

$Pf_{allowable}$ = *allowable pressure loss, in psi.*
H = *height (0.433)*
E = *elevation, in feet.*

Step 3. Determine pipe length (in feet).

Step 4. Determine $PF_{allowable}$ in a 100-foot section of pipe.

$$PF_{allowable} = \frac{Pf_{allowable}}{\text{total system length}} \times 100'$$

where—

$PF_{allowable}$ = *allowable pressure loss in a 100-foot pipe section, in psi.*
$Pf_{allowable}$ = *allowable pressure loss, in psi.*

Total system length is in feet.

Find the fluid's actual velocity, which should be between 2 and 10 feet per second (fps), and find PF_{actual} (from Figures C-1 to C-4, pages C-8 to C-11.)

Step 5. Determine size of the pipe and the velocity (from Tables C-3 and C-4, pages C-6 and C-7).

Step 6. Determine Pf_{actual}.

$$Pf_{actual} = \frac{PF_{actual}}{100'} \times \text{system length}$$

where—

Pf_{actual} = *actual pressure loss from all sources, in psi.*
PF_{actual} = *actual pressure loss in a 100-foot pipe section, in psi.*

System length is in feet.

DESIGN PROCEDURES (continued)

Step 7. Determine EL for fittings. Go back to ***Step 4*** and recalculate $PF_{allowable}$. If pipe size changes in appropriate friction loss table (Figure C-1 through C-4, pages C-8 to C-11), then find the new velocity and PF_{actual} from Tables C-3 and C-4 (pages C-6 and C-7). EL is negligible if there is 1,000 feet or more between fittings.

Step 8. Determine FWS elevation.

$$FWS = E_{BT} - (H \times PF_{actual})$$

where—
FWS = free water surface, in feet.
E_{BT} = elevation at bottom of the tank, in feet.
H = height or head (constant 2.31).
*PF_{actual} = actual pressure factor (from **Step 6**), in psi.*

Step 9. Determine pressure at service connection.

$$P_{SC} = H(E_{BT} - E_{SC}) - Pf_{actual}$$

where—
P_{SC} = pressure at service connection, in psi.
H = height (0.433).
E_{BT} = elevation at the bottom of the tank, in feet.
E_{SC} = elevation at service connection, in feet.

EXAMPLE
WATER LINE DESIGN 1

Step 1. Determine Q from **Tank to A**.

Q = 230 GPM (see Figure).

Step 2. Determine $Pf_{allowable}$.

$$Pf_{allowable} = H(E1 - E2) - required\ pressure$$

$$0.433(135 - 70) - 20 = 8.14 \text{ psi}$$

Step 3. Determine pipe length. Pipe length is 1,300 feet (see Figure D-4).

Step 4. Determine $PF_{allowable}$ in a 100-foot section.

$$PF_{allowable} = \frac{Pf_{allowable}}{total\ system\ length} \times 100'$$

$$\frac{8.14}{1{,}300'} \times 100' = 0.63\ psi$$

Step 5. Select a 6-inch diameter pipe and a velocity of 2.6 fps (intersection of selected pipe and Q). See Figure C-3, page C-10.

Step 6. Determine Pf_{actual}.

$$Pf_{actual} = \frac{PF_{actual}}{100'} \times system\ length$$

$$\frac{0.29}{100'} \times 1{,}530.5' = 4.44\ psi$$

Step 7. Determine EL. EL is 230.5 feet

Step 8. Not applicable.

Step 9. Determine pressure at service connection.

$$P_{SC} = H(E_{BT} - E_{SC}) - Pf_{actual}$$

0.433(135 - 70) - 4.44 = 23.7 psi

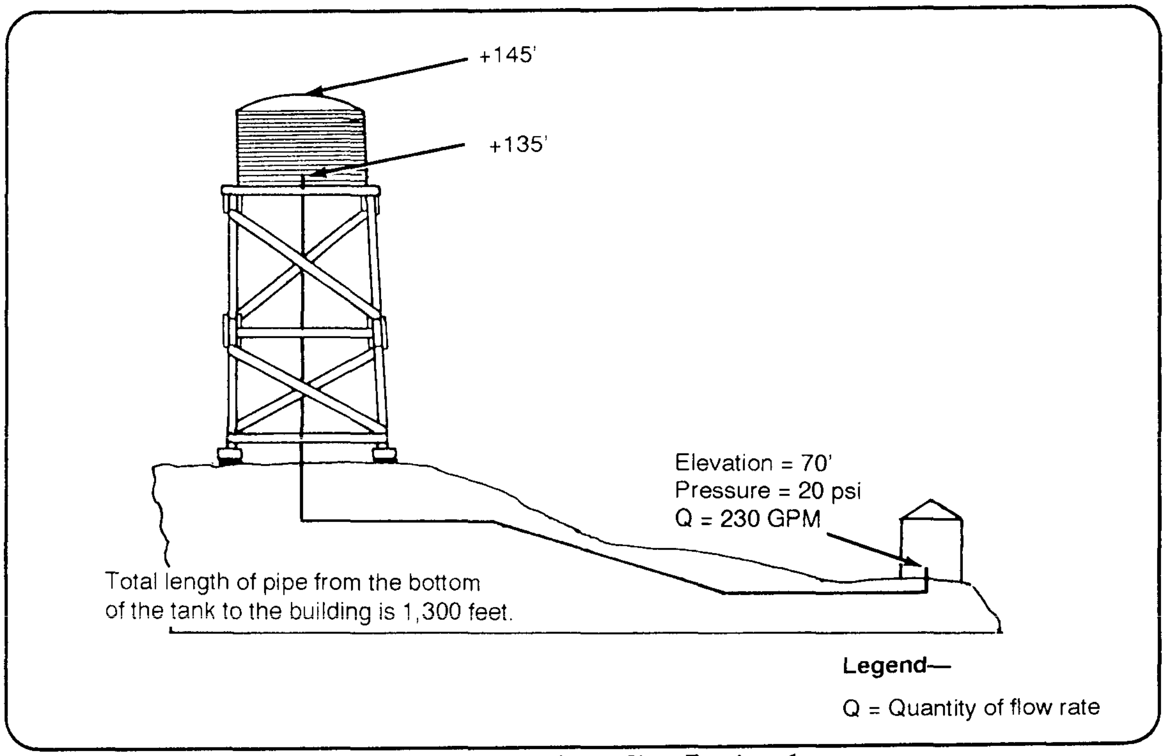


Figure D-4. Water line Design 1

EXAMPLE
WATER LINE DESIGN 2

Step 1. Determine Q from **Tank to A**.

$Q = Q_B + Q_C$ (Use Table D-1 (page D-9) to find the fixture unit (FU) values and Table D-2 (page D-10) to find flow rate quantity (Q) demands.)

$FU = WC(FU) + UR(FU)$
$FU_B = 1(10) + 2(10) = 30$ *FU; therefore,* $Q_B = 41$ *GPM*
$FU_C = 10(10) + 4(10) = 140$ *FU; therefore* $Q_C = 77.5$ *GPM*
$Q = 41 + 77.5 = 118.5$ *GPM*

NOTE: *Elevation at the bottom of the tank is used. This corresponds to the minimum (worst-case) operating pressure.*

Step 2. Determine $Pf_{allowable}$.

$Pf_{allowable} = H(E_1 - E_2) - \text{required pressure}$

Tank to B: 0.433(145 - 85) - 20 psi = 5.98 psi

Tank to C: 0.433(145 - 70) - 20 psi = 12.48 psi

Step 3. Determine pipe length (see Figure D-5).

Step 4. Determine $PF_{allowable}$ in a 100-foot section.

$$PF_{allowable} = \frac{Pf_{allowable}}{\text{total system length}} \times 100'$$

Tank to B: $\frac{5.98}{190} \times 100' = 3.14\ psi$

Tank to C. $\frac{12.48}{180} \times 100' = 6.93\ psi$

Select that portion of the water line that allows for the least amount of pressure loss ($PF_{allowable}$). In this example, **Tank to B** is the smallest.

PF_{actual} for **Tank to C** is 1.7 psi (see Figure C-3, page C-10).

Step 5. Select a 3-inch diameter pipe and a velocity of 5.0 fps (intersection of selected pipe and Q). See Figure C-3, page C-10.

Step 6. Determine Pf_{actual}.

$$Pf_{actual} = \frac{PF_{actual}}{100'} \times \text{system length}$$

Tank to A: $\frac{1.7}{100'} \times 45 = 0.77\ psi\ lost$

Step 7. Not applicable.

Step 8. Determine FWS elevation for **Tank to A**.

$FWS_A = E_{BT} - (H \times PF_{actual})$

$145 - (2.31 \times 0.77) = 143.23$ ft

Step 9. Not applicable.

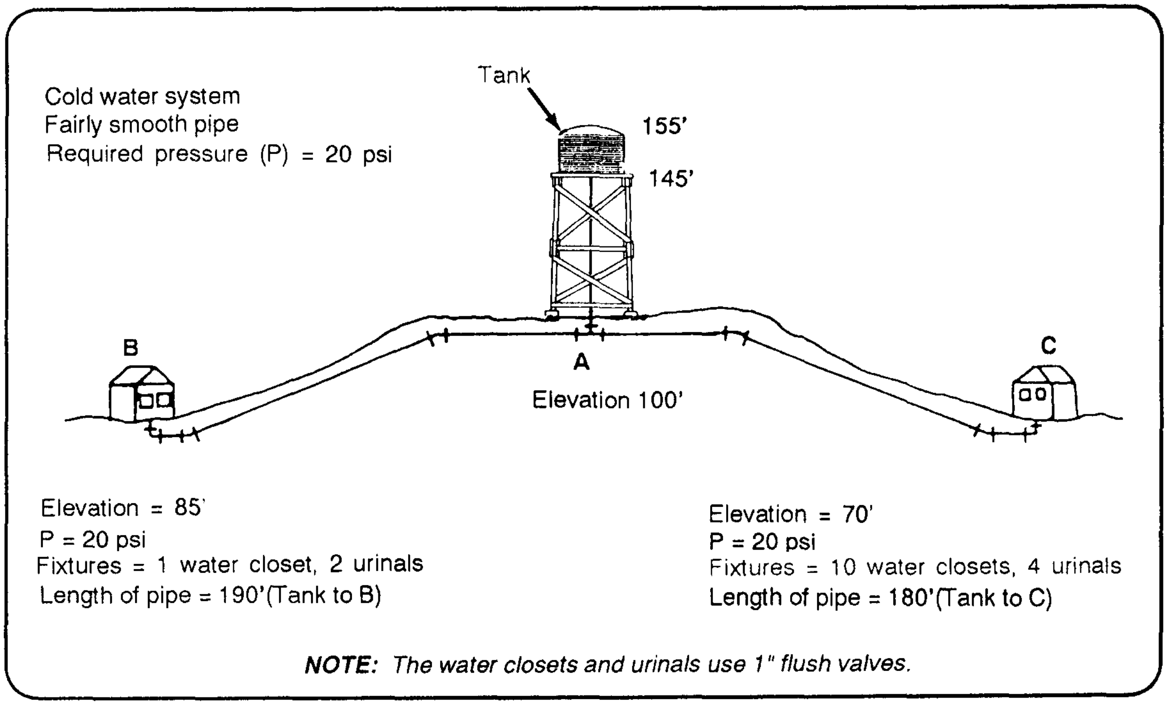


Figure D-5. Water line Design 2

Design A to C

Step 1. Determine Q from **A to C**

$Q_C = 77.5$ (from *Step 1*, page D-5)

Step 2. Determine $Pf_{allowable}$.

$Pf(allowable) = H(E_1 - E_2) - required\ pressure$

$0.433(143 - 70) - 20$ psi $= 11.6$ psi

Step 3. Determine length of pipe (see Figure D-5).

*Total length = length **T to C** - length **T to A***

$180' - 45' = 135'$

Step 4. Determine $PF_{allowable}$ in a 100-foot section.

$$PF_{allowable} = \frac{Pf_{allowable}}{total\ system\ length} \times 100'$$

$$\frac{11.6}{135'} \times 100' = 8.6\ psi$$

Step 5. Select a 2-inch diameter pipe and a velocity of 7.6 fps (intersection of selected pipe and Q).

Step 7. EL for **A to C** is 28.4.

Step 4. Determine $PF_{allowable}$ in a 100-foot section.

A to C: $\frac{11.6}{135' + 28.4'} \times 100' = 7.09 psi$

Step 6. Determine Pf_{actual}.

$$Pf_{actual} = \frac{PF_{actual}}{100'} \times system\ length$$

$$\frac{5.3}{100'} \times 163.4 = 8.66\ psi$$

Step 8. Determine FWS. FWS_A = 143 feet.

Step 9. Determine pressure service connection at C.

$P_{SC} = H(E_{BT} - E_{SC}) - PF_{actual}$

0.433(143 - 70) - 8.92 = 22.7 psi

All system parameters are within acceptable limits. No redesign is necessary.

Design A to B:

Step 1. Determine Q from **A to B.**

Q_B = 41 (from ***Step 1***, page D-5)

Step 2. Determine $Pf_{allowable}$.

$Pf_{allowable} = H(E1 - E2) - required\ pressure$

0.433(143 - 85) - 20 psi = 5.1 psi

Step 3. Determine length of pipe (see Figure D-5).

Total length = length ***T to B*** *- length* ***T to A***

$190' - 45' = 145'$

Step 4. Determine $PF_{allowable}$ in a 100-foot section.

$$PF_{allowable} = \frac{Pf_{allowable}}{total\ system\ length} x\ 100'$$

$$\frac{5.1}{145} x\ 100' = 3.52\ psi$$

Step 5. Select a 2-inch pipe diameter with a velocity of 4.2 fps (intersection of selected pipe and Q). See Figure C-3, page C-10.

Step 7. EL for **A to B** is 28.4

Step 4. Determine $PF_{allowable}$ in a 100-foot section.

A to B: $\frac{5.1}{145' + 28.4'} x\ 100' = 2.94 psi$

Step 6. Determine Pf_{actual}.

$$Pf_{actual} = \frac{PF_{actual}}{100'} x\ system\ length$$

$$\frac{1.9}{100'} x\ 178.4' = 3.39\ psi$$

Step 8. Determine FWS. FSW_A = 143 feet.

Step 9. Determine pressure at service connection B.

$$P_{SC} = H(E_{BT} - E_{SC}) - Pf_{actual}$$

$$0.433(143 - 85) - 3.39\ psi = 21.7\ psi$$

System parameters are within acceptable limits.

Table D-1. Fixture unit values

Type of Fixture	Fixture Unit Value
Water closet (flush valve)	10.0
Water closet (flush tank)	5.0
Urinal (1-inch flush valve)	10.0
Urinal (3/4-inch flush valve)	5.0
Shower head	4.0
Kitchen sink	4.0
Lavatory (bathroom) sink	2.0
Service (slop) sink	3.0
Laundry tub (dishwasher)	3.0
Laundry (wash) machine, 8 pounds	3.0
Laundry (wash) machine, 16 pounds	4.0
Water fountain	0.25

Notes:
1. If the type of water closet is not specified, the theater of operations standard for water closets is with flush valve (fixture unit value = 10.0).
2. If the type of urinal is not specified, the theater of operations standard for urinals is with 3/4-inch flush valve (fixture unit value = 5.0).

Table D-2. Flow rate quantity demands

Supply System Predominantly for Flush Tanks		Supply System Predominantly for Flushometers	
Load (in Water-Supply Fixture Units)	**Demand (in GPM)**	**Load (in Water-Supply Fixture Units)**	**Demand (in GPM)**
6	5.0		
8	6.5		
10	8.0	10	27.0
12	9.2	12	28.6
14	10.4	14	30.2
16	11.6	16	31.8
18	12.8	18	33.4
20	14.0	20	35.0
25	17.0	25	38.0
30	20.0	30	41.0
35	22.5	35	43.8
40	24.8	40	46.5
45	27.0	45	49.0
50	29.0	50	51.5
60	32.0	60	55.0
70	35.0	70	58.5
80	38.0	80	62.0
90	41.0	90	64.8
100	43.5	100	67.5
120	48.0	120	72.5
140	52.5	140	77.5
160	57.0	160	82.5
180	61.0	180	87.0
200	65.0	200	91.5
225	70.0	225	97.0
250	75.0	250	101.0
275	80.0	275	105.5
300	85.0	300	110.0
400	105.0	400	126.0
500	125.0	500	142.0
750	170.0	750	178.0
1,000	208.0	1,000	208.0
1,250	240.0	1,250	240.0
1,500	267.0	1,500	267.0
1,750	294.0	1,750	294.0
2,000	321.0	2,000	321.0
2,250	348.0	2,250	348.0
2,500	375.0	2,500	375.0
2,750	402.0	2,750	402.0
3,000	432.0	3,000	432.0
4,000	525.0	4,000	525.0
5,000	593.0	5,000	593.0
6,000	643.0	6,000	643.0
7,000	685.0	7,000	685.0
8,000	718.0	8,000	718.0

GLOSSARY

' foot, feet.

" inch, inches.

A

ABS. acrylonitrile butadiene styrene.

AGA. American Gas Association.

angle valve. A globe valve with the inlet and outlet that are 90° to one another.

AR. Army regulation.

atmospheric pressure. The pressure at the atmosphere at sea level (14.7 psi).

B

backflow. Water flowing in a pipe in the reverse of the intended direction.

back pressure. The pressure within a sanitary drainage or vent pipe system that is greater than the existing atmospheric pressure.

ball cock. A valve that is opened or closed by the fall or rise of a ball float on water in a water-closet tank.

battery of fixtures. A group of similar adjacent fixtures that discharge into a common sanitary drainage horizontal branch line. Also called *fixtures in a row*.

bell (or hub). That portion of a pipe which, for a short distance, is sufficiently enlarged to receive the end of another pipe of the same diameter for the purpose of making a joint.

bell and spigot. *See* **hub and spigot.**

bibb cock. A faucet having a bent-down nozzle. Also called *bibcock*.

bibcock. *See* **bibb cock.**

bill of materials (BOM). Contains all the materials necessary to complete a job.

boiler. That part of a furnace in which steam is generated for heating or for the production of power.

bonnet. (1) A cover for an open fireplace or a cowl or hood to increase the draft of a chimney. (2) A metal covering for valve chambers, hydrants, or ventilation.

branch. Any part of a plumbing pipe system except risers, mains, or stacks.

branch vent. A vent pipe connecting one or more individual vents to the main vent (or *vent stack*).

building sanitary drain. A drain (within a building) that disposes of sewage only.

bushing. A plug designed to be threaded into the end of a pipe. One end is bored and tapped to receive a pipe of smaller diameter than that of the pipe into which it is screwed.

C

C. celsius.

cap. A short, closed cylinder to screw on the end of a pipe.

capillary action. When dry soil grains attract moisture in a manner somewhat similar to the way clean glass does.

check valve. A valve which allows water flow in one direction only and automatically closes to stop backflow. Two types of check valves are *swing-check* and *lift-check*.

chlorination. The principle method of sterilization for the destruction of pathogenic organisms in sewage treatment. It is also used to remove certain tastes and odors in a water purification system.

circuit vent. A vent that extends from the main vent to connections on the horizontal soil or waste branch pipe between the fixture connections.

cleanout. A plugged fitting placed in a sanitary drainage system which can be removed to clean the inside of pipes. A *main cleanout* (or *stack cleanout*) is located at the bottom of the stack; other cleanouts are located near fixtures.

CMF. career management field.

combination sewer. A sewer that disposes both sewage and storm water.

common trap seal. A P-trap with a 2- to 4-inch depth water seal.

common vent. A connection at the junction of two fixture drains serving as a vent for both fixtures. Also known as a *unit vent*.

compression faucet. A faucet that shuts off the water flow by compressing a washer down onto a seat.

condensate. Droplets of water that form on the outside of a cold-water pipe when it is exposed to warm air. Also called *condensation*.

condensation. *See* **condensate.**

corporation stop. A valve placed on the water main.

corrosion. The thinning of the wall of a metal pipe caused by electrolysis. *See also* **electrolysis** and **dielectric union.**

coupling. A fitting with inside threads only, used for connecting two pieces of pipe.

CPVC. chlorinated polyvinyl chloride.

curb stop. A valve placed outside a building on the water-service line near a curb.

D

deep-seal trap. A P-trap with a 4-inch depth water seal.

DFU. *See* **drainage fixture unit.**

diaphragm valve. A valve closed by the pressing of a diaphragm against an opening or one in which the motion of a diaphragm under pressure controls its opening and closing.

direct siphonage. *See* **self-siphonage.**

dielectric union. Used to connect dissimilar metals, such as galvanized-steel/iron pipe to copper pipe, to prevent corrosion.

dosing tank. A filter tank with an automatic siphon for discharging sewage into the distribution pipes when the tank is full, cutting off when the tank is empty.

downflow (downfeed) system. A steam-heating system in which the supply mains are above the level of the heating units that they serve.

drain. A pipe, channel, or trench through which waste water or other liquids are carried off.

drainage. A system of drains; the act or means of draining.

drainage fixture unit (DFU). Common measure of one DFU equals 7.5 gallons per minute discharge.

drip line. The return pipes through which the condensation from a radiator flows back to the boiler.

dry return. A return pipe in a steam-heating system that enters the boiler above the water line carrying condensation, water, air, and so forth.

drum trap. A cylindrical trap with an inlet and outlet pipe smaller than its diameter. Normally used in bathtubs.

duct. Pipe, tube, or channel used to convey air, water, gases, or liquids.

DWV. drain waste vent.

dynamic head. Static head minus the friction losses of a flowing liquid, expressed in feet. Also called *free water surface (FWS)* elevation.

E

eccentric fitting. A fitting in which one end is offset from the center line.

effluent. The liquid discharged from a septic tank or sewage disposal plant.

electrolysis. Chemical breakdown by electric current. Also referred to as *electrolytic action.*

F

F. fahrenheit.

factor of simultaneous use. The percentage of fixtures potentially in use at a given time. An estimate of the total demand on a water supply system.

fixture demand. *See* **maximum fixture demand.**

fixtures in a row. *See* **battery of fixtures.**

fixture supply. A water supply pipe connecting the water service.

fixture supply riser. A vertical water supply pipe to bring water to fixture branches.

floor drain. A fixture used to drain water from floors into the plumbing system.

flow pressure. The pressure of a water supply line near a faucet while the faucet is wide open with water flow.

flow rate. The volume of water used by a plumbing fixture in a given time, in gallons per minute.

flush valve. A valve located in a water-closet tank for flushing water closets.

flushometer valve. The valve in a flushometer that discharges a predetermined amount of water for flushing urinals or water closets.

flux. A substance (as rosin) applied to surfaces to be joined by soldering, brazing, or welding to clean and free them from oxide and promote their union.

FM. field manual.

fps. foot (feet) per second.

free water surface (FWS) elevation. See *dynamic head.*

friction loss. *See* **pipe friction.**

ft. foot, feet.

furnace. That part of a heating plant in which combustion of fuel takes place.

FWS. *See* **free water surface.**

G

gal. gallon, gallons.

gate valve. A valve that starts and stops the flow of liquid by means of a wedge disk.

globe valve. A valve that controls the amount of water flow by means of a circular disk.

GPD. gallons per day.

GPH. gallons per hour.

GPM. gallons per minute.

grade. The fall slope of a pipeline in reference to a horizontal plane.

grease trap. A device for solidifying and separating grease from domestic wastes and retaining them so that they may be removed, thus preventing the stoppage of waste pipes.

H

hangers. *See* **pipe supports.**

head. A measure of the pressure exerted by a liquid column, converted to feet of height.

horizontal pipe. Any piece of pipe which makes an angle of less than 45° from the horizontal.

house drain. That part of the lowest horizontal piping of a plumbing system that receives the discharge from soil, waste, and other drainage pipes inside of any building and conveys the discharge to the house sewer.

house sewer. The part of the sewerage system that begins just outside the building foundation wall and ends at the main sewer in the street or at a septic tank.

hub. A bell-shaped end of cast iron pipe.

hub-and-spigot joint. Each length of cast-iron pipe is made with an enlarged (bell or hub) end and a plain (spigot) end. The spigot end of one length fits into the bell end of the next length and is made tight by caulking.

I

Imhoff tank. A circular or rectangular two-story septic tank having a greater efficiency than an ordinary septic tank.

in. inch, inches.

indirect siphonage. Caused by a large discharge of water which tends to form a slug in the stack; and as this slug passes the takeoff of the fixture below it, air is pulled out of the waste line on the lower fixture. Also called *momentum siphonage.*

individual vent. A pipe that is installed to vent a single fixture.

inlet. An L connected with a pipe discharging into a combined or storm sewer. The open end is protected by a cast-iron frame and grating to allow the entrance of storm water.

K

K. thick-walled copper tubing.

L

L. (1) elbow (2) medium-walled copper tubing.

lavatory. A fixture for washing hands and face, found in a bathroom.

lb. pound, pounds.

leaching tank. A tank made of wood, concrete, or masonry used for disposal of raw sewage from short time installations or septic tank effluent from long time installations.

lift-check valve. *See* **check valve.**

M

M. thin-walled copper tubing.

main cleanout. *See* **cleanout.**

main soil-and-waste stack. Vertical piping that extends one or more floors and receives the discharge of water closets. It can also receive discharge from other fixtures. Called a *soil stack* when receiving discharge from water closets and a *waste stack* when receiving discharge from other fixtures.

main soil-and-waste vent. The upper part of the stack, where it connects to the main vent and to the VTR. Also called *stack vent* or *vent stack* in this manual. *See also* **main vent.**

main vent. The main pipe of the venting system to which branch vents are connected. The main vent runs parallel to and is then connected to the upper section of the stack, which runs through the roof (VTR) to release harmful sewer gases from a building. *See also* **main soil-and-waste vent.**

main vent T. The T that connects the main vent to the stack.

maximum fixture demand. The total amount of water needed to supply all fixtures at the same time.

minus pressure. A pressure within a pipe of less than atmospheric pressure. Also known as *negative pressure.*

N

negative pressure. See *minus pressure.*

nipple. A short length of pipe threaded at both ends and less than 12-inches long.

no. number.

noncompression faucet. A faucet with a single lever or knob that opens and closes ports for water flow and shutoff. Also called *washerless* faucet.

O

oakum. Hemp used for caulking.

offset. The combination of elbows or bends that bring one pipe section out of alignment but parallel with the other section.

P

PB. polybutylene butadeine.

PE. polyetylene.

pipe friction. Resistance to flow. Also called *friction loss.*

pipe suppots. Any device used for supporting and securing pipe and fixtures. Also called *pipe hangers.*

plenum. An enclosed space where the pressure of the air is greater than the outside atmosphere.

plumbing fixture. A receptacle designed for wastes to be discharged into a sanitary waste system.

plus pressure. The pressure within a sanitary drainage or vent pipe system that is greater than the atmospheric pressure. Also known as *positive pressure.*

positive pressure. *See* **plus pressure.**

pressure-reducing valve. A valve for reducing steam pressure in heating systems where boilers are operated, for power purposes, at high pressure.

psi. pounds per square inch.

P-trap. A P-shaped pipe commonly used on plumbing fixtures.

PVC. polyvinyl chloride.

R

reducer. Any one of the various pipe connections so constructed as to permit the joining of pipes of different sizes, such as reducing L, reducing sleeve, reducing T, and so forth.

riser. See **fixture supply riser.**

rough-in. The installation of all sections of a plumbing system that can be completed prior to the wall or fixture placement.

run. That portion of a pipe or fitting continuing in a straight line in the direction of flow of the pipe to which it is connected.

S

sanitary drainage pipe. Installed pipes that remove waste water and waterborne waste.

sanitary sewer. A sewer that carries only sewage.

sedimentation. The suspended solids pulled down by gravity when the velocity of sewage is reduced.

self-siphonage. The loss of the trap seal as a result of removing the water from the trap caused by fixture discharge. Also called *direct siphonage.*

service L. An elbow having an outside thread on one end.

service T. A T having inside thread on one end and on the branch but outside threads on the other end of the run.

on the other end of the run.

sewage. Any refuse or waste matter carried off by a sewer.

sewerage system. A system of underground pipes for carrying off waste water and refuse.

sewage treatment. Any artificial process to which sewage is subjected in order to remove or alter its objectionable qualities and render it less dangerous or offensive.

sewer. Any underground pipe that carries out waste water and refuse.

siphonage. The suction created by the flow of any liquid in pipes.

soil and waste stack. *See* **main soil-and-waste stack.**

soil pipe. A term generally applied to cast-iron pipe in 5-foot lengths for house drainage. The pipe carries the discharge of water closets containing fecal matter.

soil stack. *See* **main soil and waste stack.**

spigot. (1) The ends of a pipe that fit into a bell. *See also* **hub-and-spigot joint.** (2) It is also another name for a faucet.

stack. Any vertical soil, waste, or vent piping. *See also* **main soil-and-waste stack** and **main soil-and waste-vent**.

stack cleanout. *See* **cleanout.**

stack vent. *See* **main soil-and-waste vent..**

static head. Height of a fluid at rest (no flow).

stop and waste valve. A valve that has a part that can be opened to allow water to drain from piping to the valve.

storm drain. Receives storm water, clear rain, or surface-water waste only.

supports. *See* **pipe supports**.

SW. service weight.

swing-check valve. *See* **check valve.**

T

T. A fitting for connecting pipes of unequal sizes or for changing direction of pipe runs. A bullhead T has an outlet larger than the opening on the run; a straight T has all openings of the same size.

TM. technical manual.

TRADOC. United States Army Training and Doctrine Command.

trap seal. A column of water between a P-trap's crown weir and the top dip. The trap is equalized by the atmospheric pressure on one side and the discharge pressure on the fixture side. *See also* **common trap seal** and **deep-seal trap**. Any difference between the two pressures causes *trap seal loss.*

U

unit vent. *See* **common vent.**

urinal. A water-flushed fixture designed to directly receive urine.

V

vacuum. An air pressure less than that exerted by the atmosphere.

vapor heating. A system for warming buildings consisting of a two-pipe gravity return system of steam circulation in which provision is made to retard or prevent the passage of steam from the radiator into the return main, and in which the air from the system, as well as condensed water, is carried back to a point near the boiler. Then the air is expelled from the mains and the water is returned to the boiler.

vent pipe. Any small ventilating pipe running from various plumbing fixtures to the vent stack.

vent stack. *See* **main soil-and-waste vent.**

vent through the roof (VTR). The section of the stack that runs through the roof, after the main vent T is installed.

vertical pipe. Any pipe that makes less than 45° from a vertical plane.

VTR. *See* **vent through the roof.**

W

wall hung. A plumbing fixture that is supported from a wall.

waste stack. *See* **main soil and waste stack.**

water closet. A water-flushed plumbing fixture designed to accept human semisolid waste directly.

water hammer. A concussion or sound of concussion of moving water against the sides of a pipe (as a steam pipe).

water seal. *See* **trap seal.**

weir. Any type of bulkhead or dam over which a liquid flows.

wet vent. A vent that also serves as a drain.

X

XH. extra heavy weight.

Y

Y. A fitting, either cast-iron or wrought-iron, that has one side outlet at any other angle than 90°. The angle is usually 45° unless otherwise specified.

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