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

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

* 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 6-1). 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](image)
(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).

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

*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](image)

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](image)
(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 1-inch, threaded-pipe engagement:

![Figure 6-5. Offset measurement](image)

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**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.

\[ 1.4142 \times 40 = 56.5680 = 56 \frac{9}{16} \text{ inches of pipe} \]

*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.

\[ 45/8 + 4 5/8 = 8 10/8 = 9 2/8 = 9 1/4 \text{ (or 9 4/16)} \]

\[ 56 9/16 - 9 4/16 = 47 5/16 \]

*Step 5.* Add the sum of 1-inch pipe engagement for each fitting to 47 5/16 inches.

\[ 47 5/16 + 2 = \text{Total pipe length needed for “C”} \]
Table 6-2. Offset degree constants

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

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.

   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](image)

(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 takeoff 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](image)
• **Cleanout.** The cleanout (Figure 6-11, 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](image)
Figure 6-10. Cast-iron traps

Figure 6-11. Cast-iron fittings

NOTE: All of these fittings except the tucker coupling can be used on all types of pipe.
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).
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

<table>
<thead>
<tr>
<th>Pipe Size (inches)</th>
<th>Oakum (feet)</th>
<th>Lead (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>3</td>
<td>1 1/2</td>
</tr>
<tr>
<td>3</td>
<td>4 1/2</td>
<td>2 1/4</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>6 1/2</td>
<td>3 3/4</td>
</tr>
<tr>
<td>6</td>
<td>7 1/2</td>
<td>4 1/2</td>
</tr>
</tbody>
</table>

Figure 6-14. Tools and materials for lead joints
(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).
(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](image)

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.

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](image1)

![Figure 6-20. Ordinary and drainage pipe fittings](image2)
(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.

![Diagram of Ts](image)

**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
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.
(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. These fittings seal off a water system for testing. This rough-in system is in place until fixtures are installed.

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

(7) **Closes.** A cross joins two different pipelines in the same plane, making them perpendicular to each other. 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.

e. **Cutting and Reaming.** Steel pipe is cut and reamed using a vise, pipe cutter, and reamer. To avoid pipe waste, use 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.

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

Figure 6-25. Nipples, plugs, caps, bushings, and cross
f. Threading. Many types of pipe-threading sets are in use. A common set is one with a ratchet, 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.

Table 6-4. Thread length data

<table>
<thead>
<tr>
<th>Nominal Pipe Size (in inches)</th>
<th>Threads per inch</th>
<th>Length of Thread (in inches) approximate</th>
<th>Number of Threads to be Cut approximate</th>
<th>Total Thread Makeup Engagement (in inches) approximate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4</td>
<td>18</td>
<td>5/8</td>
<td>11</td>
<td>3/8</td>
</tr>
<tr>
<td>3/8</td>
<td>18</td>
<td>5/8</td>
<td>11</td>
<td>3/8</td>
</tr>
<tr>
<td>1/2</td>
<td>14</td>
<td>3/4</td>
<td>10</td>
<td>7/16</td>
</tr>
<tr>
<td>3/4</td>
<td>14</td>
<td>3/4</td>
<td>10</td>
<td>1/2</td>
</tr>
<tr>
<td>1</td>
<td>11 1/2</td>
<td>7/8</td>
<td>10</td>
<td>9/16</td>
</tr>
<tr>
<td>1 1/4</td>
<td>11 1/2</td>
<td>1</td>
<td>11</td>
<td>9/16</td>
</tr>
<tr>
<td>1 1/2</td>
<td>11 1/2</td>
<td>1</td>
<td>11</td>
<td>9/16</td>
</tr>
<tr>
<td>2</td>
<td>11 1/2</td>
<td>1</td>
<td>11</td>
<td>5/8</td>
</tr>
<tr>
<td>2 1/2</td>
<td>8</td>
<td>1 1/2</td>
<td>12</td>
<td>7/8</td>
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<tr>
<td>3</td>
<td>8</td>
<td>1 1/2</td>
<td>12</td>
<td>1</td>
</tr>
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<td>3 1/2</td>
<td>8</td>
<td>1 5/8</td>
<td>13</td>
<td>11/16</td>
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<td>8</td>
<td>1 5/8</td>
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<td>11/16</td>
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<tr>
<td>5</td>
<td>8</td>
<td>1 3/4</td>
<td>14</td>
<td>13/16</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>1 3/4</td>
<td>14</td>
<td>13/16</td>
</tr>
</tbody>
</table>
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 a 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](image)
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.

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).
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.
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:

**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.

(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:

*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.
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.

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**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) **Polyethylene (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.
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. 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](image)

**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](image)
(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](image)

(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 1. 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.

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 1/16-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](image)

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.
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 6-36 (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 be 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.*