Lesson Six — Fittings

Preface

Previous lessons in this unit explained how plant piping systems circulate fluids (liquid or gases) from one point to another. Piping, tubing, and hoses and their applications were covered. In addition to understanding piping, tubing, and piping systems, three other elements: valves, accessories, and fittings are equally important. Valves (which regulate the flow and the pressure of fluid) and accessories (components that protect the line in operation) must also be understood.

This lesson describes common pipe and tube fittings, and explains their basic functions and applications. Information is also given about the symbols used to represent them on drawings and prints.

Fittings

6.01 FITTINGS are the components used in a piping system to connect sections and change the direction of flow. The function of fittings is the same for both pipes and tubes. Pipe fittings and tube fittings are similar in shape and type, even though pipe fittings are usually heavier than tube fittings. Any of several methods can be used to connect fittings to pipe or tubing. Most tubing is threadless, because it doesn't have the wall thickness needed to carry threads. But pipes, having heavier walls, are often threaded.

6.02 The simplest way to change the direction of a pipe would simply be to bend it if it were easy to do. In fact, this is sometimes done, but usually by the pipe manufacturer rather than on the job. Many larger shops are equipped with their own pipe-bending machines, however, and they bend pipe regularly. Improperly made bends can restrict fluid flow by changing the shape of the pipe, and weakening the pipe wall. Proper tube bending, on the other hand, is a common practice. Although a tubing line requires fewer fittings than a pipeline, many fittings are still used.

6.03 Fittings are made from a number of materials including steel, bronze, cast iron, plastic, and glass. As you might expect, they are furnished in the same broad range of sizes as pipe and tubing.

6.04 As for piping, tubing, and hose, standards have been established to ensure that fittings are made from the proper materials and are able to handle the pressures required of them. They are also made to specific tolerances, so that they will properly match the pipe or tubing that they join.

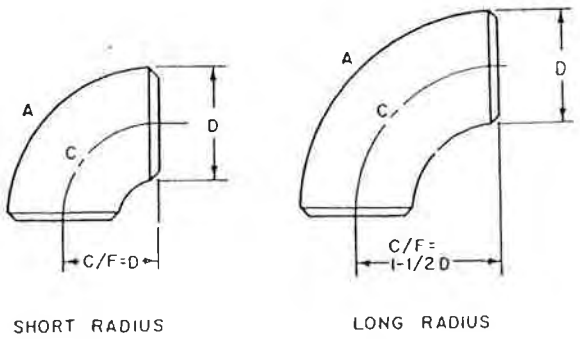


Fig. 6-1. Short- and long-radius elbows.

For example, the term "250 lb" refers to the pressure at which the fitting can safely be used. In other words, a fitting rated at 250 lbs. can be used in a line which is carrying up to 250 psi.

Functions of Fittings

6.05 Fittings change the direction of flow, provide branch connections, change the sizes of lines, and close lines.

Changing the Direction of Flow

6.06 An elbow (or "ell") is used to change the direction of flow, usually in a 45° or 90° turn. Elbows are among the most commonly used fittings in piping systems. Elbows are available with other angles, as well. Although in tubing systems turns are mostly made by bending, elbows are also used.

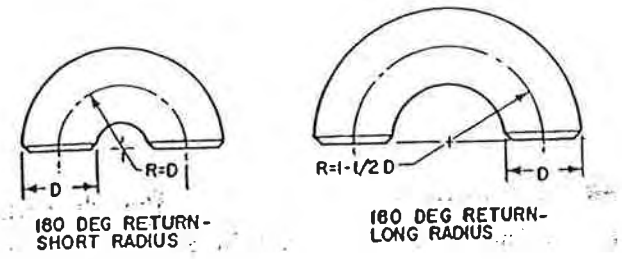
6.07 Two types of elbow fittings are shown in Fig. 6-1 – long radius and short radius. As you can see from the bottom elbow, the long-radius fitting has the more gradual curve of the two. The important dimension is the center-to-face distance. It is the distance between the center of the fitting (A) and a line (C) drawn down from the face (D) of the fitting at the other end. This is shown in these drawings. In the long-radius elbow the center-to-face distance is always 1-1/2 times the diameter of the fitting. Or, as shown, C/F = 1-1/2 D. "C" is "center," "F" stands for "face," while "D" represents "Diameter." This type of elbow is used for service where the rate of flow is critical, and space no problem. The gradual curve minimizes flow loss caused by frictional resistance and turbulence.

6.08 In the short-radius elbow, the center-to-face measurement equals the pipe diameter. If the lines of the whole system are long, and have many changes in direction, short-radius elbows should not be used. The greater frictional loss may require heavier pumping equipment. A long-radius elbow is preferred wherever it can be used.

6.09 As you can see, the elbows shown in Fig. 6-1 provide a 90° turn. 45° elbows are used where the total turn of the pipe is more gradual.

6.10 A RETURN BEND is a fitting that carries the fluid through a 180° (hairpin) turn. These fittings, shown in Fig. 6-2, are used for piping in heater coils and heat exchangers. Tubes can be bent into this form, and as such, they do not require any fittings in this kind of application. When straight pipes are assembled as shown in Fig. 6-3, returns are fitted to the ends of the pipes.

Fig. 6-2. Short- and long-radius return bends.



Providing Branch Connections

6.11 Pipe and tube systems are more than single lines running from one point to another point. They usually have a number of intersections. In many cases, the pattern is like that of a city street system. In other applications, the line is more like an interstate highway, which has only occasional side roads.

6.12 The following types of pipe and tube fittings are common: a TEE, shaped like the letter "T", connects three lines; a CROSS connects four lines; LATERALS or Y-FITTINGS connect three lines, one of which joins the system at a 45° or 60° angle.

6.13 These fittings are shown in Fig. 6-4. In the drawing the fittings are threaded. But threading is only one of several ways to connect fittings to

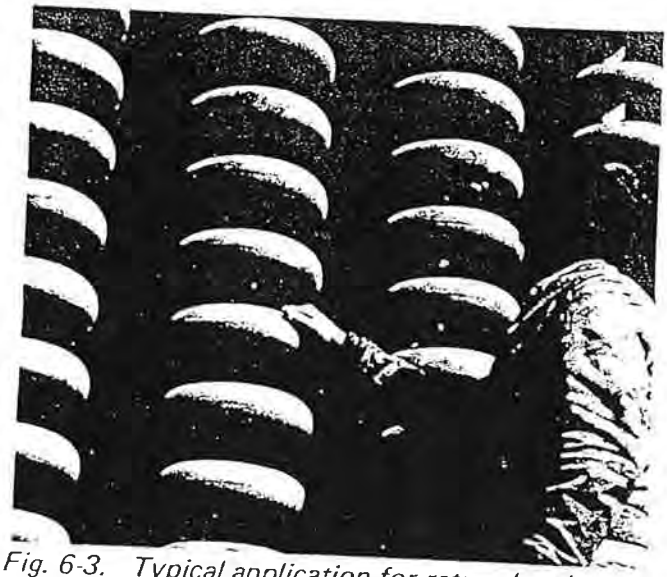


Fig. 6-3. Typical application for return bends.

pipe. For the text that follows, use Fig. 6-4 and the discussion will be easy to follow.

6.14 The tee fitting in Fig. 6-4 (top left) permits flow at right angles to the main flow. The main flow passes through the straight "run" of the tee. The 90° outlet is referred to as the "branch" of the tee. In a STRAIGHT TEE all three outlets, the run as well as the branch, are the same size. In a REDUCING TEE, the branch outlet is smaller than the run outlets, thus reducing the flow of material through that section of the system. The function of a cross is to provide 90° outlets opposite each other. All four outlets in a STRAIGHT CROSS are equal in dimension. In a REDUCING CROSS the two branch outlets are smaller than the run outlets, again to obtain the desired material flow and pressure through the system. At top center of Fig. 6-4 a lateral or Y-fitting, which amounts to a fork in the road, is shown.

Changing Line Sizes

6.15 The function of a REDUCER is to reduce a line to a smaller pipe size. One reason for doing so is to increase flow pressure in a piping system. Another is to reduce the volume of fluid. This is the same principle used in supplying water to a house or building from a water main, and for distributing the water within the building. At least one face of the fitting matches the large pipe. One or more other faces match the smaller pipe. Any of the fittings just described can be obtained as reducers. Many such fittings are shown in Fig. 6-4. Study the figure until you have identified all of the fittings as to type. Then look carefully to see which outlets are reduced. Reducing can also be accomplished by means of a BUSHING inserted into a fitting.

Caps, Plugs, and Couplings

6.16 PIPE CAPS are used to close or seal off the end of a pipe or tube. This can be done where part of the system has been dismantled. Where the system now ends, a short length of pipe may be left to make a possible later reconnection. The pipe end must be "corked." A cap does the trick.

6.17 PLUGS are used to close openings in fittings. Suppose a three-pipe connection is required now, but a fourth pipe is to be connected at this same point in the near future. A cross fitting is used. Three of its outlets are connected into the system. The fourth outlet, unused at the moment, is fitted with a plug. Plugs also provide a means of access into the piping system, in case the line becomes clogged.

Fig. 6-4. Common threaded pipe fittings.

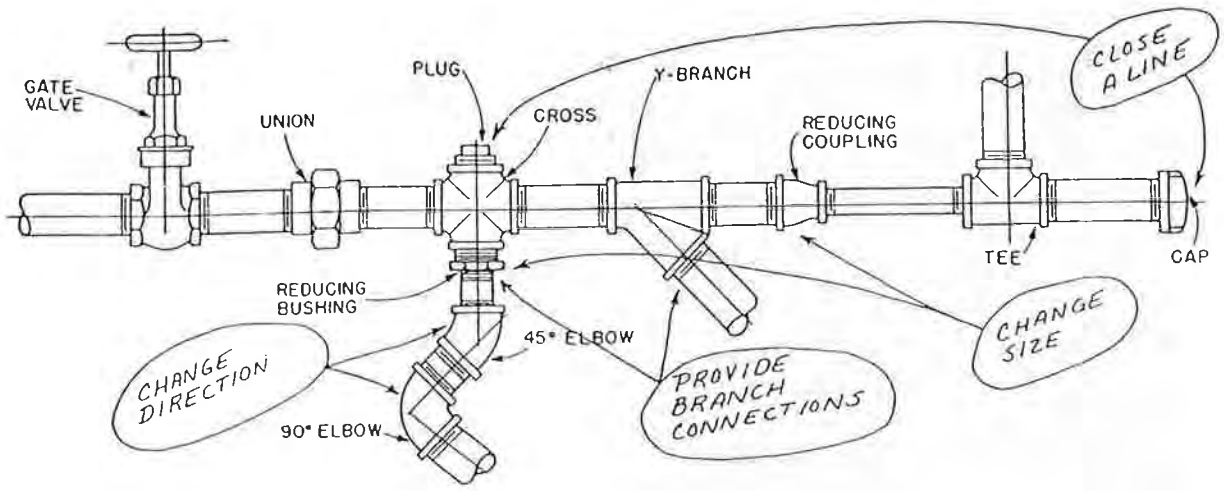


Fig. 6-5. Functions of fittings.

6.18 Another function of fittings is to connect two lengths of pipe together. This is done by means of a UNION, or COUPLING. Such fittings do not change the direction of flow, or provide for a branch line, or stop the pipe. A coupling is a threaded sleeve. A union is usually made in three pieces: the thread end, the bottom end, which has threads on the I.D., and the ring, which has an inside flange at one end, and is threaded in the I.D. at the other end. Unions make it easy to connect or disconnect pipes without disturbing the position of the pipes.

6.19 Figure 6-5 is a diagram of a shortened piping system, drawn to show the fittings that have been described. In an actual piping system it is unlikely that you will find so many fittings so close together in a line.

6.20 The fittings illustrated up to this point are for piping. Figure 6-6 illustrates what tube fittings look like. Note that they have the same names as pipe fittings. From your study of this lesson so far, you should be able to readily find an elbow, a union, a tee, a cap, a cross, and a reducing fitting. Because tube fittings are connected by other means than those used for connecting pipes, the outlet faces are different from those of pipe fittings. However, as intersections and ends in the tubing system, they serve the same purpose as the pipe fittings already described.

How Fittings are Connected

6.21 Pipe fittings are either SCREWED, FLANGED, or WELDED. These methods are

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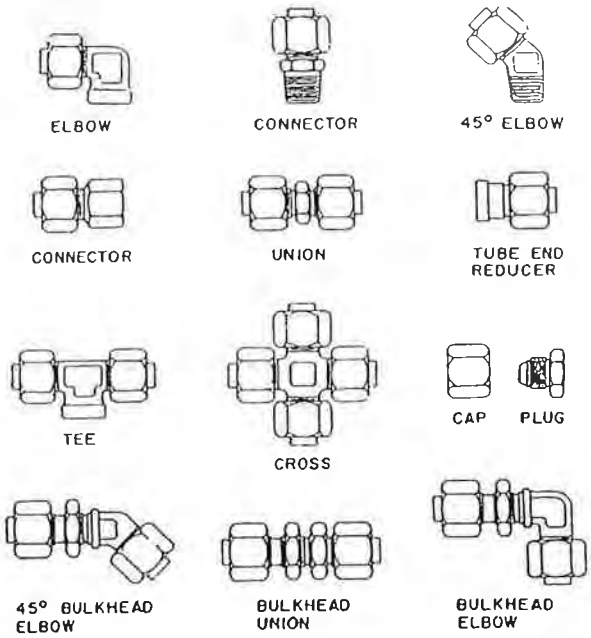

Fig. 6-6. Tubing fittings.

Fig. 6-7. Methods of connecting fittings to pipe.

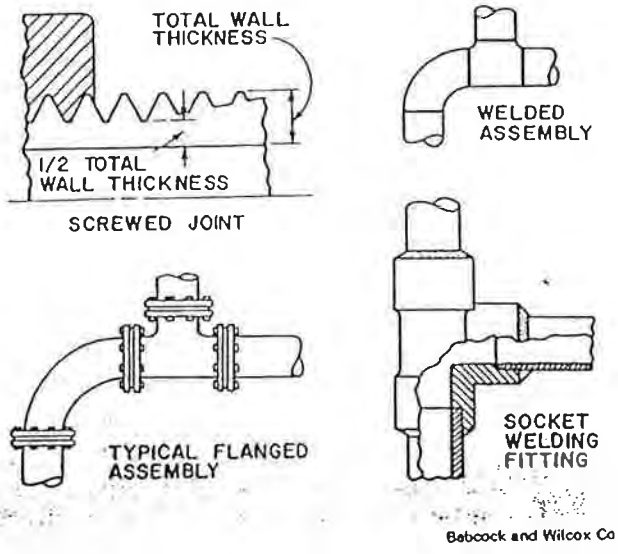

Fig. 6-8. Correct and incorrect threads.

shown in Fig. 6-7. Each method is widely used, and each has its advantages.

Screwed Connections

6.22 SCREWED fittings are joined to the pipe by means of threads. In an original installation, or when a section of pipe must be replaced, threaded connections have the advantage that they can be easily tailored to the job. Once the right pipe length has been obtained, the threading is done on the job. However, cutting of threads may penetrate as deeply as one-half the wall thickness, weakening the pipe in the joint area.

6.23 Because threaded joints can be potential problem areas, especially where higher pressures are involved, the threads must be properly cut in the first place. Hand threading is made easiest when the correct "pumping" action is used, a technique that can only be acquired on the job. The technique consists of rotating the tap or die to take a cut and then backing it up to help clear the chips. A generous supply of the proper thread-cutting oil is a further safeguard against poor thread. The oil serves to keep the material lubricated and cool as the thread is cut. Figure 6-8 shows properly and improperly cut threads. The thread job that is rejected was done with an insufficient amount of cutting oil, or the wrong kind.

Fig. 6-9. Sealing tape applied to threaded fittings.

6.24 The traditional method of ensuring a good seal in a threaded fitting is to coat the threads with a paste dope. A new method is to wind the threads with Teflon® tape as shown in Fig. 6-9. Starting back about two threads from the end of the pipe, wind the tape on until it extends slightly beyond the fitting. The illustration shows connections to a liquid filter and several fittings of the kinds described in this lesson. Look for the following: elbow joints, unions, and straight tees with plugs. You should find four elbows, two unions, and two tees.

Flanged Connections

6.25 Flanged fittings are forged or cast pipe fittings as shown in Fig. 6-7. The flange is a rim or ring at the end of the fitting, which mates with another section. Pipe sections are also made with flanged ends. Another type of flange is the COMPANION FLANGE, which is a separate ring slipped over the end of a pipe and then fastened to it.

6.26 Flanges are joined by being bolted together and by welding. The faces may be ground and lapped to provide smooth, flat surfaces. In all cases, it is necessary to provide a tight joint to prevent leakage of fluid and pressure.

6.27 Figure 6-10 shows a typical example. The mating parts are bolted together with a gasket between their machined faces to ensure a tight seal. The procedure involves clean parts, proper alignment and support of the pipes, correct insertion of gaskets, and proper tightening of bolts.

6.28 As with all joints, clean each part for best results. Use a solvent-soaked rag to remove the rust-preventing grease which is put on flanges at the factory. Next, clean off any dirt and grit particles. Clean the gasket. When the pipe is in place, it should be supported, in such a way that

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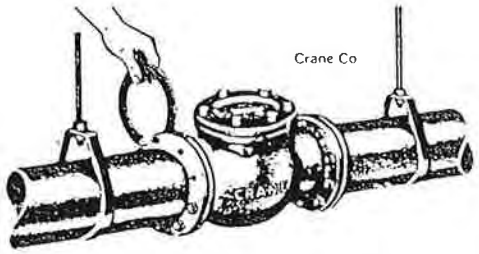

Fig. 6-10. Assembling a flanged joint.

the flange will not be required to support it. Line up the flanges properly, and check the joint with a spirit level, both horizontally along the pipes, and vertically across the flange faces.

6.29 Coat gaskets lightly with graphite, oil, or some other recommended lubricant to make them easier to remove if the joint is opened later. With the flanges secured in position, insert the gasket and half of the bolts at the bottom of the fitting to hold the gasket in place. Give the remaining bolts a shot of thread lubricant and slip them into place. Tighten the nuts by hand. For final tightening, the procedure is somewhat like that used when you change an automobile wheel. That is, tighten the nuts on opposite sides, so as to load all the bolts evenly. Then keep going over and across, tightening the nuts until the joint is equally tight at every nut.

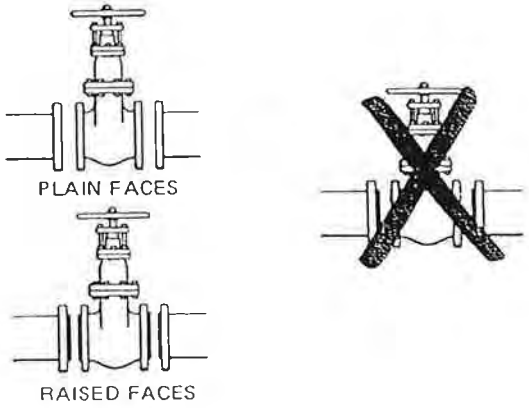

Fig. 6-11. Flanged joints require matching faces.

6.30 Some flanges have raised faces and others have plain faces. Like faces must be matched. See Fig. 6-11. A flange with a raised face should never be joined to one with a plain face. You will find that steel flanges have raised faces, and iron or bronze flanges usually have plain or flat faces. When 125-pound iron or bronze flanges are joined to steel flanges, the raised face on the steel flange should be machined off. A full-faced gasket is preferred. Flanged fittings are relatively heavy and must be supported. They also take up considerable space.

6-1. Improperly made bends restrict _____ _____.

6-2. Fittings are made in the _____ size ranges as pipe and tubing.

6-3. The designation "250 lb" refers to the _____ at which a fitting may safely be used.

6-4. Name four functions of fittings.

_____

_____

_____

_____

6-5. Elbows are made with either a _____ radius or a _____ radius.

6-6. In a reducing tee, the branch is smaller than the _____.

6-7. When cutting pipe threads, use a generous supply of the proper _____ _____ oil.

6-8. A flange with a raised face should never be joined to one with a _____ face.
(raised/plain)

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Fig. 6-12. Expansion joint.

General Rubber Corp.

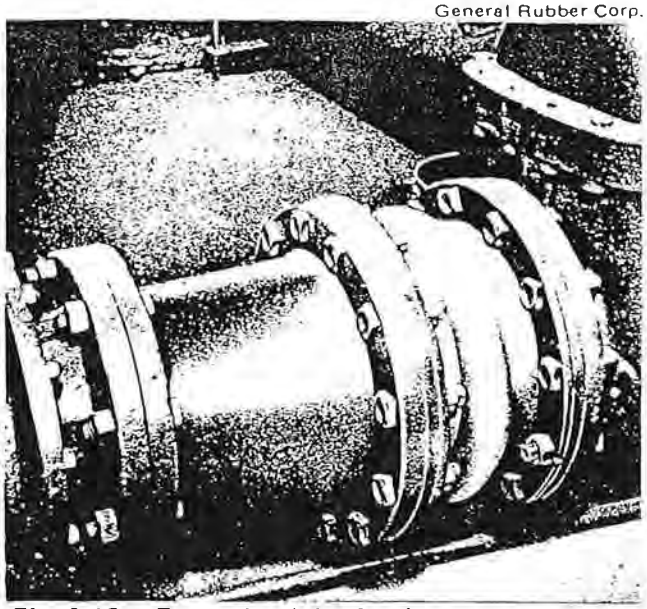


Fig. 6-13. Expansion joint in place.

Other Fittings

6.31 Other fittings used for flanged connections include EXPANSION JOINTS and VIBRATION DAMPENERS. Expansion joints have three functions: (1) to compensate for expansion and contraction of the pipe; (2) to allow pipe motion either to the side or along the length of the pipe, as the pipe shifts around slightly after installation; and (3) to help dampen vibration and sounds carried along the pipe from distant pumps or other equipment (including chilled water lines in large buildings).

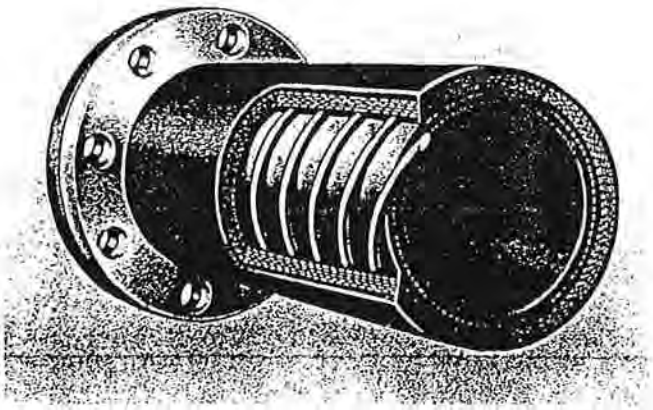
6.32 The expansion joint shown in Fig. 6-12 has a leakproof tube that extends through the bore and forms the outside surfaces of the flanges. Natural or synthetic rubber compounds are used, depending on the application. Because the fitting has full-face flanges of vulcanized rubber and fabric, no gaskets are necessary. The sealing surface permits low bolting-pressures and tends to equalize uneven surfaces to which it is connected, providing a tight seal. An installation is shown in Fig. 6-13.

6.33 Other types of expansion joints include metal bellows (or corrugated) types, slip joint types, and spiral-wound types. In addition, high temperature lines are usually made up with a large bend or loop to allow for expansion.

6.34 VIBRATION DAMPENERS are specifically designed to absorb vibration (see Fig. 6-14) that, unless reduced, would shorten the life of the pipe and service life of the operating equipment. They eliminate line noises (humming and hammering carried by the pipes).

6.35 Vibration dampeners also help reduce the effects of water hammer, the "banging of the pipes" caused by sudden changes in pressure or volumes of liquid in the pipes. To some extent, the vibration dampener absorbs pressure changes and sound. These joints have full-face rubber flanges, which eliminates the need for gaskets. The flanges are backed up by forged steel backup rings. In addition, like the typical reinforced hose covered in Lesson Five, high-strength fabric plies and a helical steel wire are embedded in the carcass for maximum stability and strength. There is a smooth, resilient tube and a rugged cover.

Fig. 6-14. Vibration dampener.



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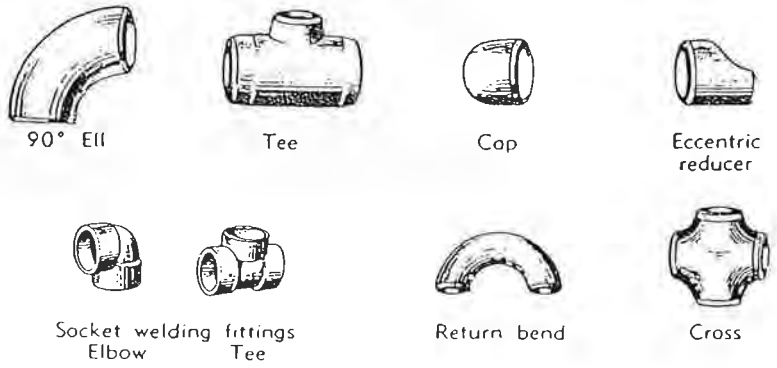


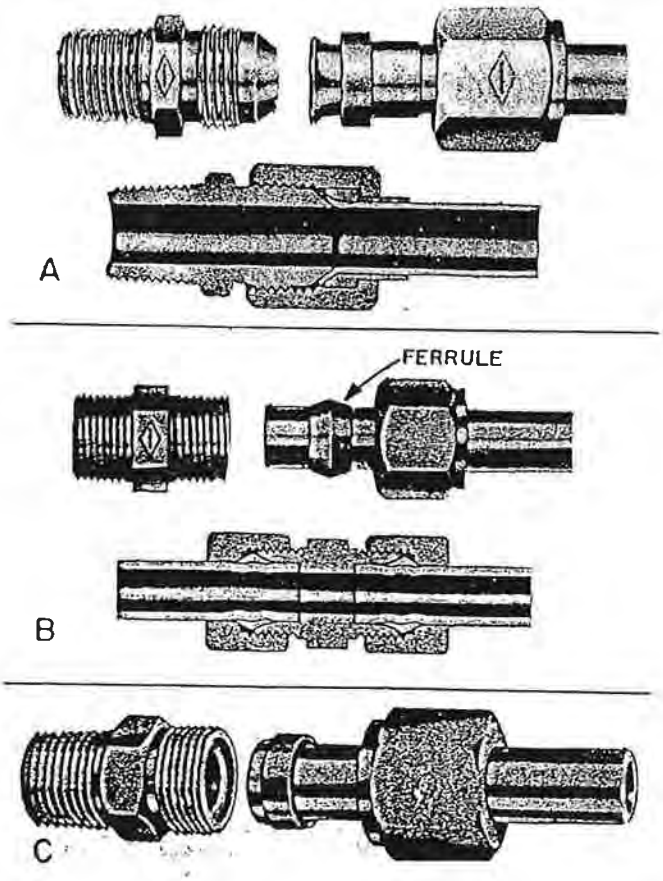
Fig. 6-15. Typical welding fittings.

Welding Fittings

6.36 Improvements in piping technology, and in welding equipment, have increased the use of welded joints. A properly welded joint is as strong as the pipe itself. A welded system is a continuous system, which combines piping, valves, flanges, and other fittings. It has a long leakproof- and maintenance-free life, a particularly important consideration where high pressures are involved. The smooth joints simplify insulation and take up less room.

6.37 Welded connections are made as outlined in Lesson Two. Note that the welding fittings shown in Fig. 6-15 are similar in function to those already mentioned, but instead of being threaded, they have beveled ends. So has the pipe to which they are connected.

Fig. 6-16. Three common tube fittings.



Tubing Fittings

6.38 Tubing is connected by flare fittings, compression fittings, and brazed or welded-flange fittings. Probably the oldest of these types is the flare fitting, of which there are two versions, one having a 37 degree angle, the other a 45 degree angle. These angles are in the fitting body's tapered or conical seat. As shown in Fig. 6-16(A), the tube end is on the right. As the first step in joining, slip the locknut and bushing onto the tube. Then flare the end of the tube. The flare matches the angle of the fitting on the left. In the lower part of Fig. 6-16(A), the tube's flared end has been butted against the fitting, and the locknut screwed tightly onto the fitting, sealing the tube connection properly.

6.39 In Fig. 6-16(B) the tube is not flared, but fitted with a ferrule that pinches the tube as the locknut is tightened on the body of the fitting. In the upper drawing, the tube is shown for the right-hand side only. In the lower drawing, the fitting has been connected to two tubes, one on each side. This is a COMPRESSION fitting.

6.40 Figure 6-16(C) shows a brazed-seal tube fitting. Like the nut-ferrule body design just described, the welded-flange type of connection is a reliable means of connecting tube components. The flange welded to the tube end fits against the end of the fitting on the left. The locknut on the right of the flange is then tightened securely onto the fitting.

6.41 Look again, at Fig. 6-6. You will note that some of the tube fittings shown have one end threaded. These are the end or terminal fittings on the tubing system. They are installed first in the wall of the equipment served by the tube line. The path of the tube is laid out from one terminal fitting to the other. The fittings, of course, must be properly lined up to match the tube that is to be connected later.

6.42 When installing terminal fittings, use an open-end wrench. A pipe wrench should never be used because its teeth will cut into the machined surfaces of the fitting. Tightening of terminal fittings is done like any other pipe thread.

6.43 Straight-thread terminal fittings are used for high-pressure system requirements. They are sealed with an O ring (or washer) made of the correct synthetic rubber compound for the application. Do not push the O ring over the threads: they might nick or score it, which can lead to a leakage problem later. Instead, push a plastic or metal "thimble" over the thread to protect them. Then push the O ring over the thimble and onto the undercut section of the fitting. The correct and incorrect procedures are shown in Fig. 6-17. The O ring and its backup washer rest against a locknut when the connection is completed. When the O ring is slipped into place, this locknut should be at the end of its thread and at the top of the undercut section of the fitting.

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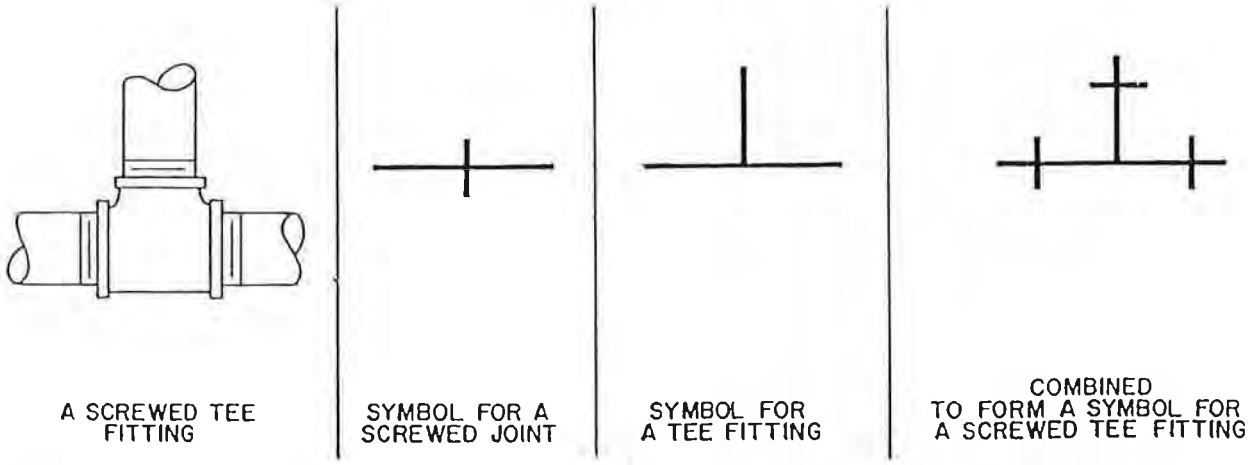
Fig. 6-17. Correct and incorrect replacement of O rings.

Drawing Symbols

6.44 As a maintenance craftsman, recognize and know the symbols used to represent the various fittings on drawings of pipe and tube systems. These symbols are logical. Figure 6-18 shows how joint and fitting symbols are combined to form a single schematic symbol. This figure is a drawing of a tee fitting. Note that the symbol for a screwed joint is a vertical line; the symbol for a tee joint is an upside-down "T". Put them together and the combined symbol is the result.

6.45 Table 6-1 shows a number of symbols for the joints and fittings discussed in this lesson. The key to studying it is to check one column from top to bottom, looking for the common element in every symbol in the column. For example, you will find that each item in the "welded" column has a crossmark, which is the symbol for a welded joi. All the soldered joints have circles on them. The single-line symbol representing a threaded connection is in each symbol in the "screwed" column. Each symbol also identifies the type of fitting (elbow, tee, or reducer). Refer to the illustrations of these fittings shown earlier in this lesson and you will see the relationships.

Fig. 6-18. Schematic symbol for a Tee fitting.



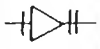
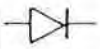
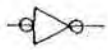
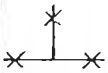
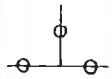
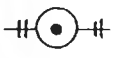
Purpose	Type of Fitting		Flanged	Screwed	Welded	Bell-and-Spigot	Soldered
Change Direction	ELBOW	45 DEGREE					
		90 DEGREE					
		90 DEGREE TURNED DOWN					
		90 DEGREE TURNED UP					
Change Pipe Size	REDUCER						
	BUSHING						
Provide Branch Connections	LATERAL (Y-FITTING)						
	TEE	STRAIGHT					
		OUTLET UP					
		OUTLET DOWN					
	CROSS	STRAIGHT SIZE					
Close Off A Pipe Line	PLUG	PIPE PLUG					
	CAP						

Table 6-1. Symbols for joints and fittings.

the expansion and contraction of piping.

_____

6-10. To allow for expansion, high-temperature pipelines usually have large expansion _____.

6-11. Name the fitting specifically designed to absorb vibration.

_____

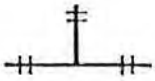
6-12. A properly welded joint has the advantage of being as _____ as the pipe itself.

6-13. The seat of a flared tube fitting has an angle of either ____° or ____°.

6-14. A _____ wrench should NOT be used for tightening a terminal fitting.

6-15. Name the joining process represented by this symbol. 

_____

6-16. What kind of fitting does this symbol represent? 

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