

Mechanical Equipment - Course 430.1

PIPING, TUBING AND JOINTS

Operation of all our plants depends on the transport of fluids (liquids, vapours and gases). This vital function is accomplished by using fluid conduits. This name is used to distinguish them from electrical conduits which are used for a different purpose and a substitution by each other is not acceptable.

There are two types of fluid conduits: PIPES and TUBES . Although they are used basically for the same purpose there is a number of distinguishing features which will influence the decision which one to use for a particular application. These features are listed and discussed in the following text.

SIZES

Piping is available in a limited number of sizes which are standardized for each type of material. An example of a standard for a carbon and alloy steel pipe is in the Table 1. Generally speaking any size outside this table would have to be specially ordered by the customer and it will be called tubing. Inspecting the table the first column specifies the Nominal Pipe Size (N.S.) in inches. The second column gives the Outside Diameter (O.D.) in inches. Up to and including N.S. 12" the N.S. is different from O.D. For N.S. 14" and up N.S. corresponds with O.D.

Wall thickness of a pipe is specified by the Schedule Number (Sch. No.). Columns three to 12 give wall thicknesses for different nominal sizes and various Schedule Numbers. Logically the Inside Diameter (I.D.) of a pipe is obtained by subtracting two wall thicknesses from the O.D.

Example: Find I.D. of the pipe N.S. = 1" Sch. No. 40, 80 and 160, from the Table:

	N.S.	O.D.	Nominal Wall Thicknesses		
			Sch. No. 40	80	160
I.D. =	1"	1.315"	0.113"	0.179"	0.250"
			1.089"	0.957"	0.815"

The O.D. for a particular nominal size remains identical for various Schedule Numbers, but the I.D. is changing accordingly.

Another important conclusion is that the nominal size up to 12" does not correspond with either O.D. or I.D.

CARBON AND ALLOY STEEL PIPE

Nominal Wall Thickness

Nominal Pipe Size	Outside Diameter	Sched. No. 10	Sched. No. 20	Sched. No. 30	Sched. No. 40	Sched. No. 60	Sched. No. 80	Sched. No. 100	Sched. No. 120	Sched. No. 140	Sched. No. 160
1/8	0.405	.....	.....	.....	0.068	.....	0.095	.....	.....	.....	.....
1/4	0.540	.....	.....	.....	0.088	.....	0.119	.....	.....	.....	.....
3/8	0.675	.....	.....	.....	0.091	.....	0.126	.....	.....	.....	.....
1/2	0.840	.....	.....	.....	0.109	.....	0.147	.....	.....	.....	0.187
3/4	1.050	.....	.....	.....	0.113	.....	0.154	.....	.....	.....	0.218
1	1.315	.....	.....	.....	0.133	.....	0.179	.....	.....	.....	0.250
1-1/4	1.660	.....	.....	.....	0.140	.....	0.191	.....	.....	.....	0.250
1-1/2	1.900	.....	.....	.....	0.145	.....	0.200	.....	.....	.....	0.261
2	2.375	.....	.....	.....	0.154	.....	0.218	.....	.....	.....	0.343
2-1/2	2.875	.....	.....	.....	0.203	.....	0.276	.....	.....	.....	0.375
3	3.500	.....	.....	.....	0.216	.....	0.300	.....	.....	.....	0.438
3-1/2	4.000	.....	.....	.....	0.226	.....	0.318	.....	.....	.....	.....
4	4.500	.....	.....	.....	0.237	.....	0.337	.....	0.438	.....	0.531
5	5.563	.....	.....	.....	0.258	.....	0.375	.....	0.500	.....	0.625
6	6.625	.....	.....	.....	0.280	.....	0.432	.....	0.562	.....	0.718
8	8.625	.....	0.250	0.277	0.322	0.406	0.500	0.593	0.718	0.812	0.906
10	10.750	.....	0.250	0.307	0.365	0.500	0.593	0.718	0.843	1.000	1.125
12	12.750	.....	0.250	0.330	0.406	0.562	0.687	0.843	1.000	1.125	1.312
14	14.000	0.250	0.312	0.375	0.438	0.593	0.750	0.937	1.093	1.250	1.406
16	16.000	0.250	0.312	0.375	0.500	0.656	0.843	1.031	1.218	1.438	1.593
18	18.000	0.250	0.312	0.438	0.562	0.750	0.937	1.156	1.375	1.562	1.781
20	20.000	0.250	0.375	0.500	0.593	0.812	1.031	1.261	1.500	1.750	1.968
24	24.000	0.250	0.375	0.562	0.687	0.968	1.218	1.531	1.812	2.062	2.343
30	30.000	0.312	0.500	0.625	.....	.....	.....	.....	.....	.....	.....

SCHEDULE NUMBERS USED FOR STEEL PIPING

430.12-1

TABLE 1

Pipes made of various materials having identical Nominal Size and identical Schedule Number will have identical O.D. but different I.D., because wall thicknesses for identical Schedule Numbers will be different.

Tubing in general is any fluid conduit with sizes outside the standard for pipe. Certain sizes of tubing are so much in demand that they are commercially available and do not have to be specified and ordered. Table 2 gives basic dimensions for commercially available tubing. It should be noted that the tubing is commercially available to 2" O.D. only. But up to this size, selection of wall thicknesses is much wider than in piping.

Tubing used for fluid transport is usually called **hydraulic tubing** to differentiate it from so called **mechanical tubing** which is used in structural design and does not conform with sizes in Table 2. Bicycle frame is an example of mechanical tubing application.

There is one more type of fluid conduit whose sizes do not conform either with pipe specifications or with tube specifications. It is called **streamline copper water tubing** and is available in four types, K, L, M, and DWV. Type K is of highest quality and is used for hot and cold water, gases and steam. Other types are used for less severe services than K, such as drains, vents and low-pressure service. Popularity of this conduit is based on ease of field erection.

SPECIFICATIONS

Piping is specified by the nominal size in inches and by the schedule number, for instance 2" Sch. No. 40 + material specifications. Originally the nominal size indicated the inside diameter of the pipe. However, the range of wall thicknesses now available provides a range of inside diameters.

Tubing is specified by the outside diameter in inches and by the wall thickness usually expressed as a decimal inch or rarely as a wire-gauge number.

For example: 1/4" 0.049 + material specifications.

TOLERANCES

Piping wall thickness tolerance is up to $\pm 12\%$ of the nominal dimension.

Table —Basic Dimensions for Commercially Available Tubing

Outside Diameter d_o (in.)	Wall Thickness t (in.)	Inside Diameter d_i (in.)	Outside Diameter d_o (in.)	Wall Thickness t (in.)	Inside Diameter d_i (in.)	Outside Diameter d_o (in.)	Wall Thickness t (in.)	Inside Diameter d_i (in.)	Outside Diameter d_o (in.)	Wall Thickness t (in.)	Inside Diameter d_i (in.)	
3/8	0.020	0.089	3/8	0.035	0.130	3/8	0.049	0.777	1 1/4	0.120	1.010	
	.032	.081		.042	.118		.054	.759		1 1/2	0.085	1.370
	.035	.085		.049	.102		.065	.745			.072	1.336
1/2	0.032	0.1236	1/2	0.065	0.370	1/2	0.083	0.790	1 3/4	0.085	1.334	
	.035	.1173		.072	.350		.098	.685		.095	1.310	
				.083	.334		.100	.657		.100	1.282	
3/4	0.035	0.190	3/4	0.035	0.550	1	0.049	0.902	1 1/2	0.065	1.620	
	.042	.184		.042	.541		.068	.884		.072	1.606	
	.049	.152		.049	.527		.065	.870		.083	1.584	
	.055	.120		.055	.500		.072	.854		.095	1.560	
1	0.035	0.2425	1	0.072	0.481	1	0.095	0.810	1 3/4	0.100	1.532	
	.042	.2286		.083	.450		.100	.782		.120	1.510	
	.049	.2143		.085	.430		.120	.750		.134	1.482	
	.055	.1965										
1 1/4	0.045	0.1825	1 1/4	0.040	0.682	1 1/4	0.049	1.152	2	0.085	1.870	
				.050	.634		.065	1.134		.072	1.856	
	0.035	0.305		.065	.620		.065	1.120		.083	1.834	
	.042	.291		.072	.600		.072	1.106		.085	1.810	
	.049	.277		.083	.584		.082	1.084		.100	1.782	
1 1/2	0.049	0.350	1 1/2	0.095	0.500	1 1/2	0.085	1.060	2 1/4	0.120	1.760	
	.055	.245		.100	.532		.100	1.032		.134	1.732	

TABLE 2

Tubing wall thickness tolerance is up to $\pm 10\%$ of the nominal dimension, but the outside diameter is manufactured to close tolerances, for example 1/4" tubing will have O.D. within +0.004, -0.000 inch.

PLIABILITY - BENDING

Piping - Although it is possible to bend a pipe, this time-consuming and skill-requiring procedure is seldom used. Instead, fittings-elbows are used.

Tubing - is made of relatively malleable materials and can be bent easily, up to 1/2" manually. This reduces number of fittings, hence less leakage, better appearance and lower erection cost.

MATERIALS

Piping - Most common material of piping in our plants is steel. Majority of applications are satisfied by carbon steel. Stainless steel is found mainly in the Moderator System and certain Hydrogen Sulfide Systems.

Cast iron is used for low pressure water distribution and sewage disposal.

Wrought iron pipe is rare.

Copper alloy pipe is not much used.

Plastic pipes are slowly gaining popularity, particularly where corrosion is a problem and the system is at low pressure and temperature. Materials used are PVC, Polyethylene, ABS, Polybutylene and fiberglass reinforced epoxy or polyester.

Tubing - Carbon Steel tubing is used for steam tracing and generally on the turbine.

Stainless Steel tubing is used on high-pressure steam and water (D₂O in particular) instrumentation, collection and sampling and on the fuelling machine systems.

Copper tubing is used in low-pressure oil and hydraulic systems as well as instrument air systems.

Plastics - Various plastic material tubing is used in drain lines, low-pressure oil lines, hydrogen leak collection, wire joining and some more. The selection includes reinforced tygon, tygon, Polypenco, shrinkage PVC, flexible vinyl.

The only material used commonly in other industries but seldom in our plants is Aluminum.

COST

Although a cost of piping is lower than of tubing this disadvantage of tubing can be offset by the ease of erection and a lower possibility of leakage. Each application has to be analyzed and the best solution applied.

JOINTS

Joints may be of two general types - permanent and dismountable due to the explained differences between piping and tubing it is logical to expect differences between joints used on piping and on tubing. The most common types are explained in the following text.

Piping Joints

A permanent joint used on piping is a welded joint. Two ends of piping are prepared and then welded. It is a good joint, very seldom needing any further attention.

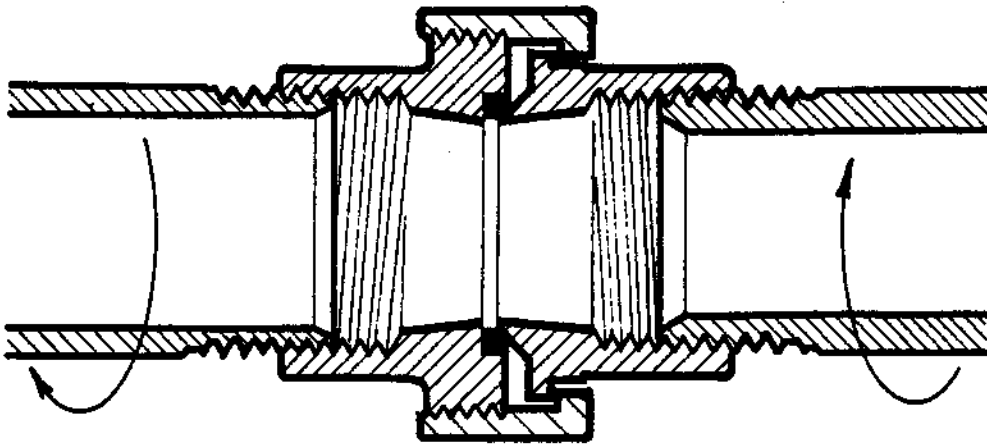
Dismountable joints used on piping are:

Threaded joint, two ends of piping are threaded using a pipe thread and they are held together and sealed by a coupling or a union both having the internal thread. They differ in that unions are made up of three different pieces, the coupling is one piece and pipe lines connected with unions do not have to be removed in order to change the fittings. A coupling and a union are shown in Figure 1.

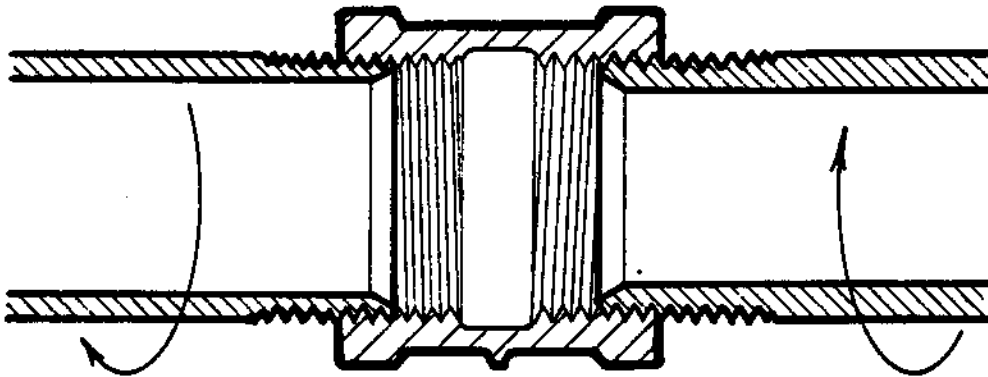
Flanged Joint, consists of two flanges, each attached to the end of to-be-connected pipe, bolts holding these two flanges together and squeezing a gasket, which seals the joint. Various types of flanges used in our plants are shown in Figure 2. The position of a pipe and the welds are shown in dotted lines. The strongest one is a welding neck flange which is used in high temperature, high pressure systems.

Victaulic is a trade name for a joint shown in Figure 3. It can be called a selfenergizing seal, because the process fluid has an access into the gasket (ring) and pushes it against the pipe. The higher the internal pressure the higher the sealing pressure.

This type of joint is mainly used in cold water systems, like service water system, cooling water system, chilled water system and so on where temperature is below approximately 95°C. Victaulic joints using better material gasket can be used up to 175°C.



a) Union



b) Coupling

Figure 1

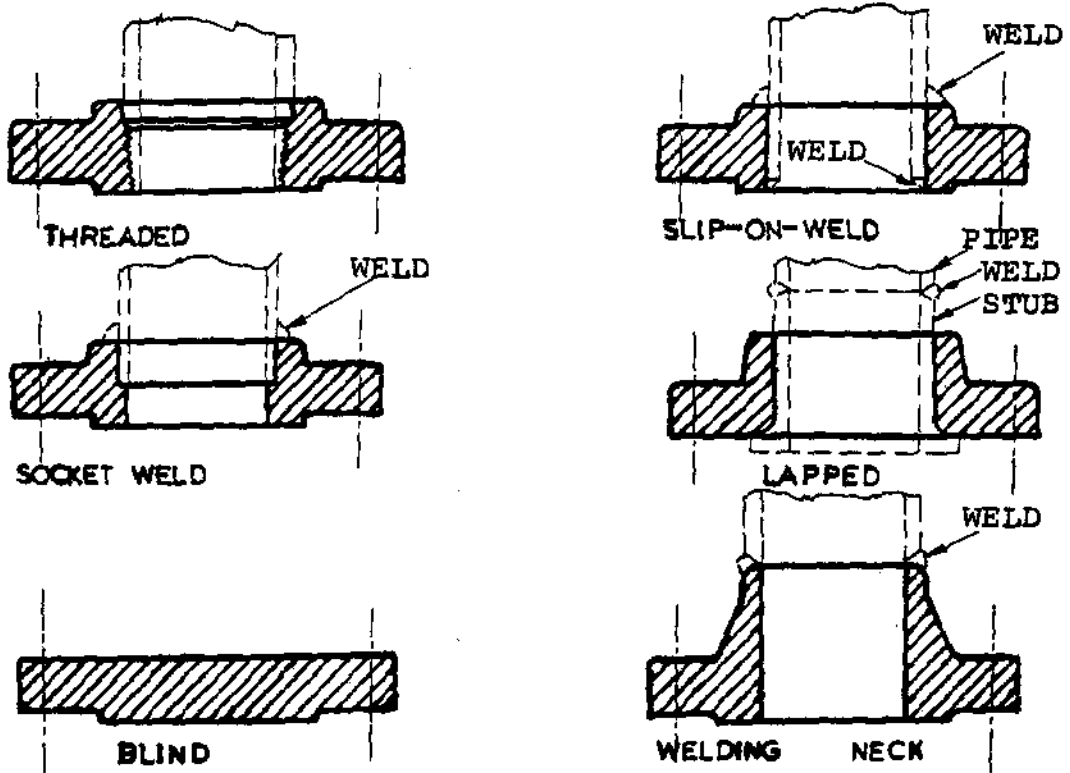


Figure 2

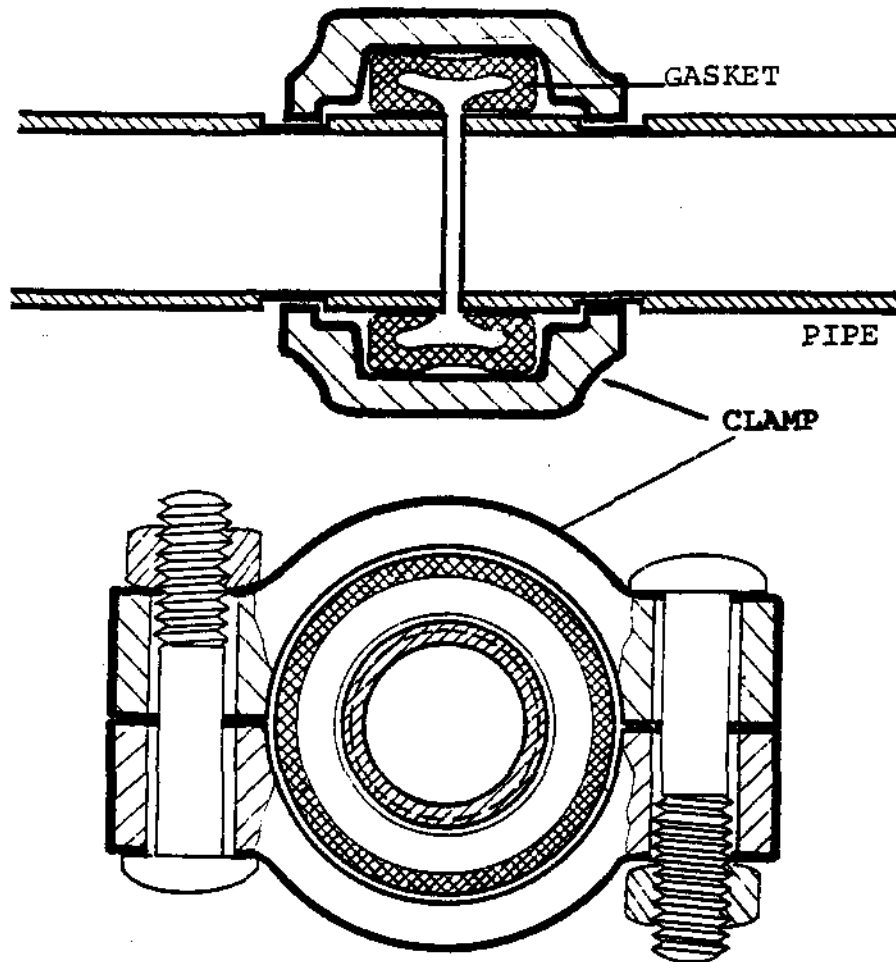


Figure 3

Grayloc is a trade name for a connection used for critical applications demanding "zero" leakage. Grayloc connectors are in service at pressures from hard vacuum to 420 MPa and at temperatures from -220°C to 925°C . In our plants they are used in Heat Transport System, particularly for the attachment of feeder pipes to the end fittings. Figure 4 shows the cut-away and the cross-section through this joint. Two "arms" of T-shaped seal ring are formed by the flexible, tapered sealing lips which during the make-up are forced against the slightly sharper taper of the sealing surfaces in the hub. The amount of their deflection is controlled by coming of the seal ring rib flash with the hub faces. Pressurized fluid inside makes the seal even tighter. This concept makes the grayloc ring a self-energized seal.

Tubing Joints - Permanent joints used on tubing are welded, brazed or adhesively bonded. The last method is not yet used in our plants, other types of permanent joints are not common either. The bulk of tube joints are dismantable.

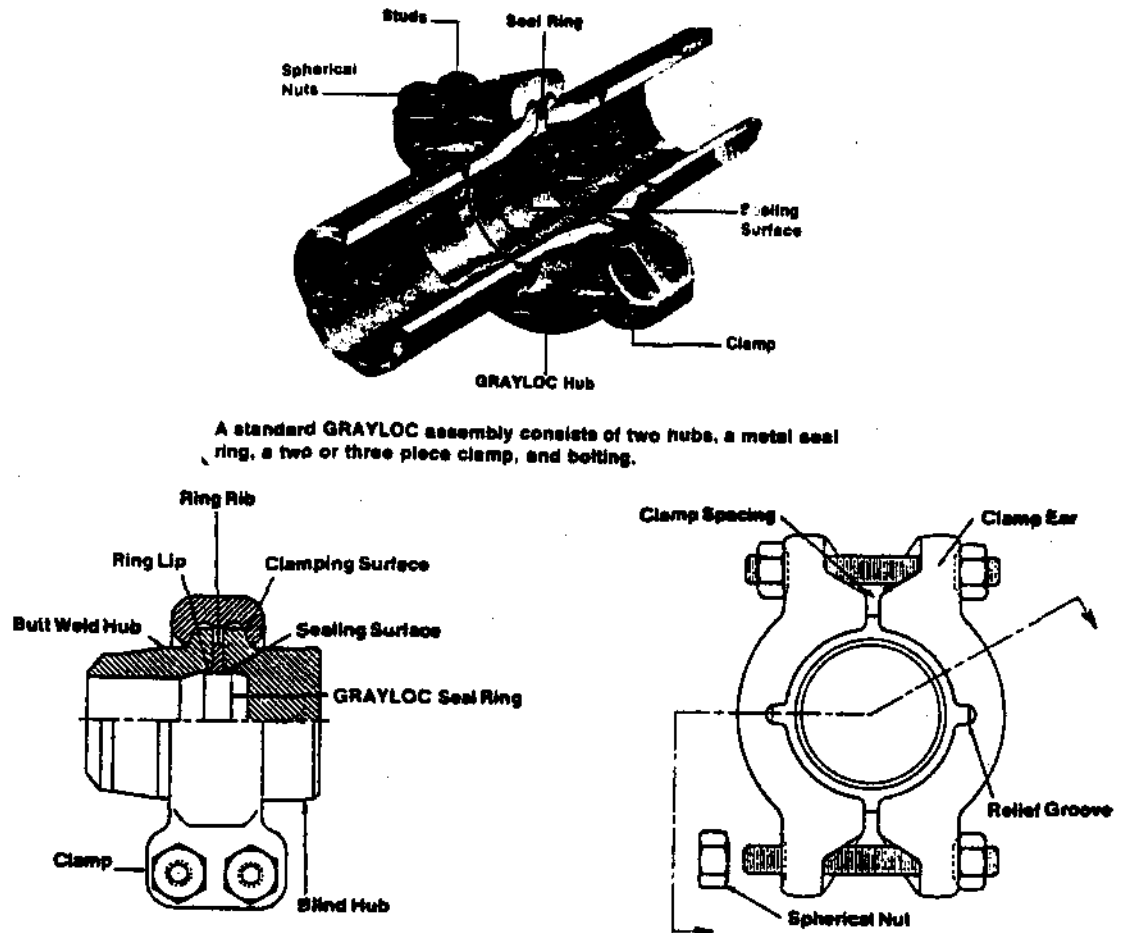
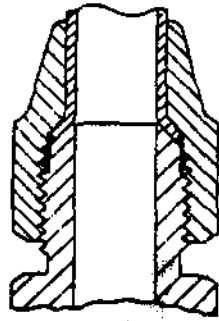


Figure 4

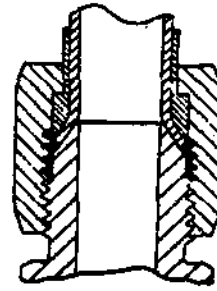
Flare Joint - The end of tubing is flared using a special flaring tool. The flare angle is either 37° or 45° . The flared end of the tubing is then pressed by the nut against the mating surface of the body of the fitting. Several different flared joints are available: a basic two-piece type (Figure 5 (a)) and an improved three-piece type (Figure 5 (b)).

They can be single or double flare as shown in Figure 6.



Two-Piece Type

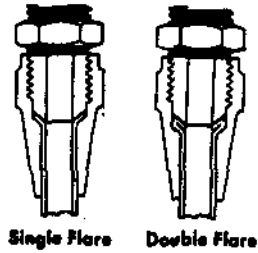
(a)



Three-Piece Type

(b)

Figure 5

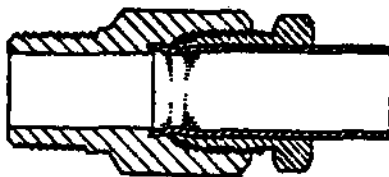


Single Flare Double Flare

Figure 6

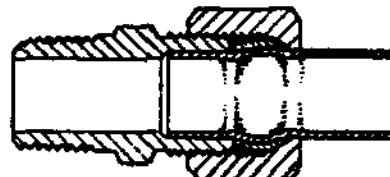
Flare fittings are not used for installation work in our plants but they can be found on purchased equipment.

Compression Fittings are also not common in our plants. Two types are available and shown in Figure 7.



Threaded Sleeve

(a)



Double Compression

(b)

Figure 7

As the nut is tightened its end (Figure 7 (a)) or end of the sleeve (Figure 7 (b)) squeeze against tubing wall to form a slight compression deflection which produces sealing action. This fitting is limited to thin-walled tubing of soft material and vibrations tend to loosen it.

The almost exclusive tube fitting in our plants, used in the installation work, is a ferrule fitting. The sealing is achieved by forcing the edge of a small ring-ferrule into the tubing wall. This interference seal is leakproof up to high pressures and the fitting resists vibrations.

The simpler version is a single-ferrule fitting which is either of a regular ferrule (Figure 8 (a)) or of an inverted ferrule type (Figure 8 (b)).

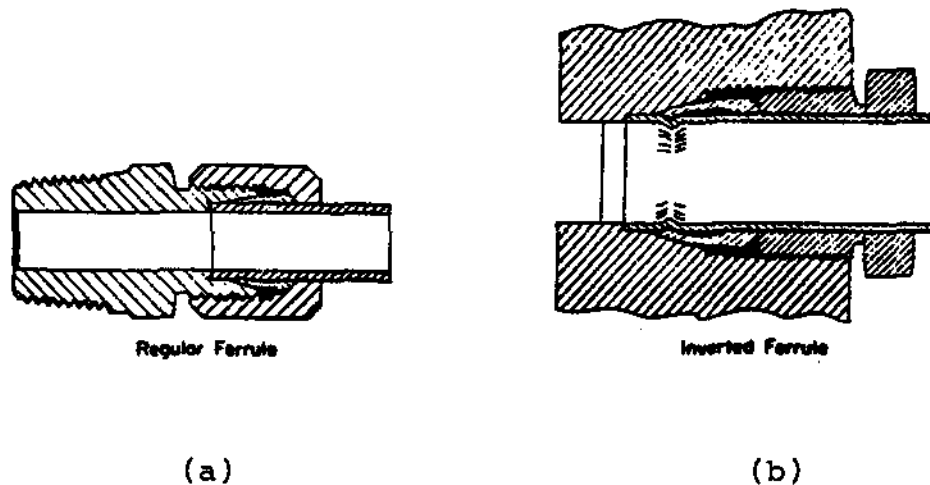


Figure 8

The bulk of tubing joints in our plants is accomplished by using double-ferrule fittings. The fitting is shown in Figure 9.

As the name implies, two ferrules are used resulting in two points of seal which makes the fitting more reliable and suitable for applications demanding "zero" leakage. It is a precision component and must be handled accordingly. Exact mounting procedures are to be followed to get the full benefit of this design. Very seldom the fitting is referred to as a double-ferrule fitting, rather a trade name is used to designate it. Although there are a number of these fittings on the market our nuclear generating stations use the Swagelok fitting and the heavy water plants use the Gyroloc fittings.

All joints discussed so far are rigid joints which do not allow any expansion due to temperature changes. But very

often this expansion must be accommodated. Tubing systems almost always include bends and this feature along with the malleable nature of tubing materials guarantees absorption of expansion. In piping systems we talk about much longer runs of much larger size conduit and the fabrication of expansion absorbing bends would often be awkward if not impossible. In this case **expansion joints** are used. Figure 10 gives most common expansion joints used today.

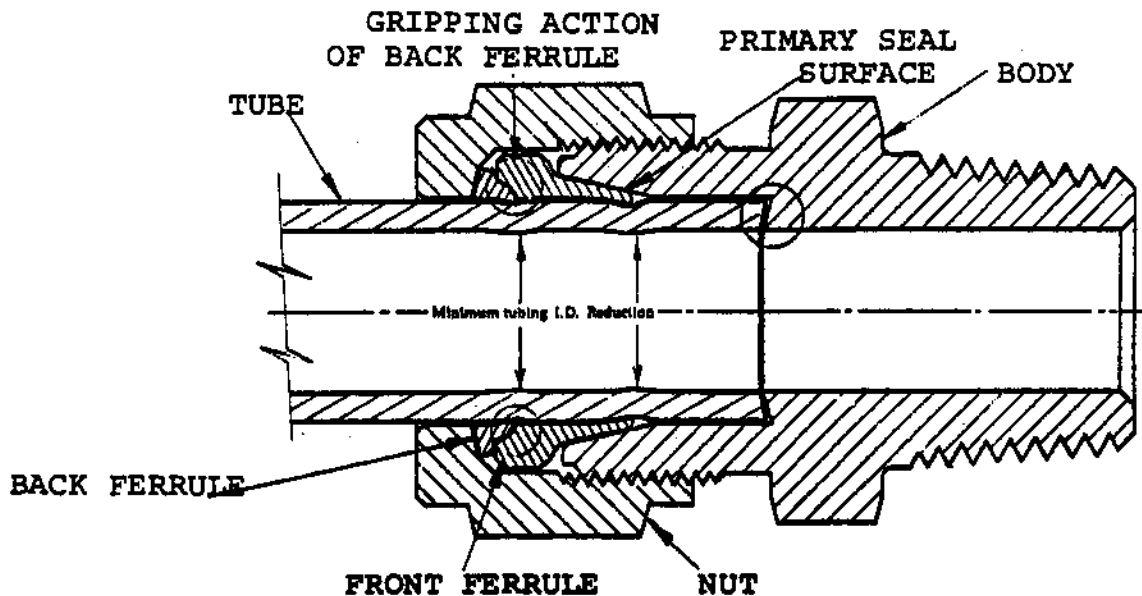
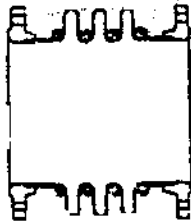
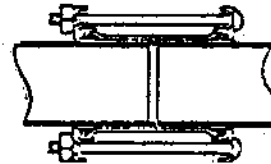


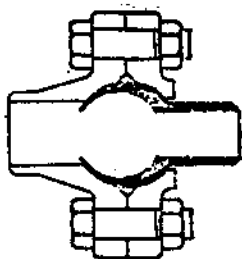
Figure 9



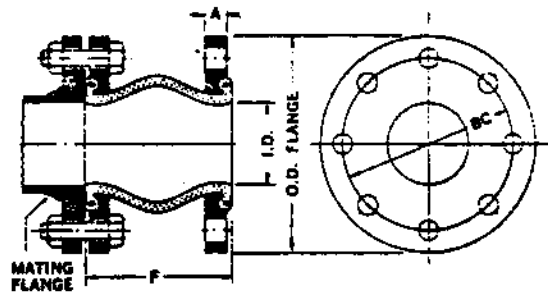
Bellows Expansion Joint
can be braced for higher
operating pressures.



Slip Type Expansion Joint
is self sealing, provides
some angular movement.



Ball Joints in series
can be used instead of
pipe loops for moderate
pressure.



Garflex expansion joints
feature a molded, elasto-
meric bellows having a ball-
shaped design.

Figure 10

ASSIGNMENTS

1. What are the two types of fluid conduit used in our stations and what is the principal difference between them?
2. How is a pipe specified?
How is a tube specified?
3. Explain the term "Nominal Size" and Schedule Number".
4. N.S. 4" Schedule 40 carbon steel pipe and N.S. 4" Schedule 40 brass pipe. What will be identical on these pipes?
5. Name the pipe joints and give the preferred ones for high temperatures, high pressure application and for extreme applications where "zero" leakage is demanded.
6. Which of the tube joints is most commonly used in our plants and why?

K. Mika