Lecture 5

DISTRIBUTION OF FLUID POWER

Learning Objectives

Upon completion of this chapter, the student should be able to:

- Write the points to be considered for the selection of hydraulic conductors.
- Differentiatebetween burst pressure and working pressure.
- List commontypes of fittings used in fluid power.
- List common types of screws used in fluid power.
- Explain varioustypes of joints used in fluid power.
- Write guidelinesfor the selection of plastic conductors.
- Explain varioustypes of hoses used in fluid power.
- Explain theuse of rotary joints and quick couplings.

1.1 Introduction

The size of pipe, tubing or hose for plumbing fluid power systems is very important. If the size with too small an inside cross-sectional area is used, the oil is forced to flow at a high rate of speed, and this creates excessive power loss and heat generation in the oil. If the size used is larger than necessary, then the power transfer is good and heat generation is low but the time and cost of installation are more than they should be. Pressure losses are present only when fluid is moving. Force can be transmitted from one end of fluid column to other with virtually no loss but when the fluid starts to move, which is necessary to transmit work or power, then the losses start. This chapter deals with selection of distribution systems, losses in fluid power transmission lines and its effect on the performance of fluid system.

1.2 Choice of Distribution

A fluid distribution system is composed of pipes, tubings, hose assemblies, manifolds and fittings so arranged that the fluid is carried with minimum losses from the reservoir through controls and working components and is then returned. All materials used to convey fluid power are commonly classified as *conductors* and the various fittings for connecting components are classified as *connectors*. More than one type of conductors may be used in the same installations. Conductors are generally steel regardless of conductor material and they may be coated with cadmium or some other corrosion-resistant material. Stainless steel conductors or fittings may be used if extremely corrosive environments are anticipated, but the high cost of such conductors and fitting precludes the general use of this material. Copper can never be used in a hydraulic system because it catalyzes the oxidation of petroleum fluids, while zinc, magnesium and cadmium cannot be used because they are rapidly corroded by glycol fluids. A galvanized pipe is unsatisfactory because galvanization tends to flake off into the system.

The choice of pipe, tube or hose depends on the operating pressures of system and flow. Other important factors include environmental conditions, type of fluid and operating temperature, shock loads, relative motion between connected parts, practicality and compliance with certain standards. The material used must have a continuous operating pressure rating so that it can withstand working pressures and provide a factor of safety for short-lived pressure peaks resulting from a hydraulic shock. Hydraulic shocks occur due to sudden stopping or reversing a flow that is backed by large flow forces, sudden deceleration, stopping or reversing of heavy workloads.

The following points must be considered both while designing the system and selecting a conductor:

- The working strength of conductor must be sufficient to contain fluid under all normal operating conditions, and there must be sufficient reserve strength to withstand shock loads due to system operations.
- The mechanical strength of the conductor must be sufficient to span the distance required by the machine configurations and to withstand mechanical vibrations that may be encountered.
- The interior surface of the conductor must be as smooth as possible to minimize friction.
- The pipe size must be adequate to permit design flow at a reasonable fluid velocity.
- Conductors should be positioned so that they cannot be damaged by normal operations at and around the machine.
- Conductors should be supported in such a way that vibrations and shocks to them are minimized.
- Conductor runs may frequently be reduced by using manifolds or by using machine structural components as conductors.

1.3 Conductor Sizing

The pressure rating of various conductors depends on the tensile strength of the material used and the wall thickness of the conductor. The wall thickness and safety factors recommended by the fluid power industry standards are based on calculations using Barlow's formula

$$\text{Minimum wall thickness} = \frac{\text{Maximum wall thickness} \times \text{OD of conductor}}{2 \times \text{Tensile strength}(\sigma)}$$

The formula is adequate for practical purposes in selecting conductor wall thickness to withstand the maximum rate of surge peak pressures at frequencies developed by cycling of the hydraulic equipment operation. Surge pressures that may be encountered within a system are rarely known and seldom appreciated in their full potential strength.

In addition to normal working pressure and surge pressure peaks, there may be mechanical stresses produced by thermal expansion, abuse and environmental factors. Evaluation of all phenomena is difficult, so a higher factor of safety is used. Table 1.1 shows the typical specification of a hydraulic pipe.

Table 1.1 Typical specification of a hydraulic pipe

Standard followed	DIN 2391
Outer diameter	0.5–12 inch
Thickness	0.039-0.472 inch
Steel grade	16Mn (DIN 2391 ST 35.8 / 37.4)
Composition	C(0.13), Si(0.37),Mn(0.65), P(0.035), Cr(0.3)max, Ni(0.25), Cu(0.2)
Manufactured	Cold drawn
Surface treatment	Copper coated

1.4 Burst Pressure and Working Pressure

When a valve is closed suddenly, high surge pressure can burst pipe lines. The burst pressure is the pressure of the fluid that causes the pipe to burst. This occurs when the tensile stress developed due to pressure (σ) equals the tensile strength (S) of the pipe material:

$$t = \frac{p \times d}{2 \times \sigma}$$

We can rewrite this expression in terms of the tensile strength of material:

$$t = \frac{p \times d}{2 \times S}$$

If p_{BP} is the burst pressure then we can write

$$p_{\mathrm{BP}} = \frac{2t\,S}{d}$$

The working pressure (WP) is the maximum safe operating fluid pressure and is defined as the burst pressure divided by an appropriate factor of safety (FOS):

$$\text{Working pressure} = \frac{\text{Maximum (Burst) pressure}}{\text{Factor of safety}} = \frac{p_{\mathrm{BP}}}{\mathrm{FOS}}$$

A factor of safety ensures the integrity of the conductor by determining the maximum safe level of working pressure. Industry standards recommend the following factors of safety based on corresponding operating pressures:

- FOS = 8 for pressures from 0 to 70 bar
- FOS = 6 for pressures from 70 to 180 bar
- FOS = 4 for pressures above 180 bar

If a fluid system is subjected to high-pressure shocks, then an FOS of 10 is used.

Example 1.1

A pump produces a flow rate of 75 LPM. It has been established that the fluid velocity in a discharge line should be between 6 and 7.5 m/s. Determine the minimum and maximum pipe inside diameter that should be used.

Solution:

Flow rate = Discharge= 75 LPM = 0.075/60=1.25×10^{-3} $\mathrm{m^3/s}$

Now

Discharge = Area $\times$ Velocity

$$A_{\min} = \frac{\pi}{4}(d^2) = \frac{\text{Discharge}}{\text{Velocity(maximum)}} = \frac{1.25 \times 10^{-3}}{7.5} = 0.0001667\ \mathrm{m}^2$$

Solving we get $d = 14.5\ \mathrm{mm}$ (for the maximum velocity). So

$$A_{\max} = \frac{\pi}{4}(d^2) = \frac{\text{Discharge}}{\text{Velocity (minimum)}} = \frac{1.25 \times 10^{-3}}{6} = 0.0002804\ \mathrm{m}^2$$

Solving, we obtain $d = 16.3\ \mathrm{mm}$ (for the minimum velocity).

Example 1.2

A steel tubing has an outside diameter of 30 mm and an inside diameter of 24 mm. It is made up of commercial steel of the tensile strength of 520 MPa. What is the safe working pressure? Assuming that tubing is subjected to a high-pressure shock, determine the tensile stress for an operating pressure of 10 MPa.

Solution:

$$\text{Bursting pressure} = p_{\text{BP}} = \frac{2\,t\,S}{d} = \frac{2\times3\times517}{24} = 129.3\ \text{MPa}$$

Since the tubing is subjected to a high-pressure shock, we can take factor of safety as 10:

$$\text{Working pressure} = \frac{\text{Maximum pressure}}{\text{Factor of safety}} = \frac{129.3}{10} = 12.93\,\text{MPa} = 129.3\,\text{bar}$$

The tensile stress is

$$\sigma = \frac{p\times d}{2\times t} = \frac{10\times0.024}{2\times0.003} = 40\,\text{MPa}$$

1.5 Steel Pipes

Steel pipes are still extensively used in fluid power systems, although they are rapidly being supplemented by steel or plastic tubing. The major disadvantages of steel pipes are their weight and the large number of fitting requirement for connection . Its greatest advantage is its mechanical strength and particularly its ability to withstand abuse. Steel pipes are sized according to the nominal diameter that is neither the outside nor the inside diameter, while the wall thickness is specified by a schedule number. Most of the industries seldom use metric designation while designing and buying pipes. The prime considerations for selecting conductors for a hydraulic power system are the type of materials, capacity and pressure rating. Piping has originally been classified by weight as standard, extra heavy and double extra heavy. This classification has been superseded by classification according to schedule numbers. A hot- or cold-drawn seamless pipe is recommended for use in a hydraulic system and must be internally free from rust scale and dirt.
Schedule numbers run from 40 (earlier standard) to 80 (earlier extra duty) and to 160 (earlier double extra duty). Table 1.2 shows the usage of schedule pipes under fluid power standards. Industry hydraulic standard recommends a 4:1 factor of safety for systems operating above 180–200 bar. Steel pipe fittings are most often fabricated from malleable iron that has a sufficient strength and ductility to withstand forces encountered in a fluid power system.

Table 1.2 The usage of schedule pipes under fluid power standards

Normal Pipe Size (in.)	Pipe Outside Diameter (in.)	Schedule 40		Schedule 80		Schedule 160	
		ID (in.)	WP (psi)	ID (in.)	WP (psi)	ID (in.)	WP (psi)
1/8	0.405	0.269	590	0.215	2100	–	–
1/4	0.540	0.364	1250	0.302	2620	–	–
3/8	0.675	0.493	1090	0.423	2300	–	–
1/2	0.840	0.622	1350	0.546	2420	0.466	7380
3/4	1.050	0.824	1160	0.742	2080	0.614	6000
1	1.315	1.049	1260	0.957	2070	0.815	5720
1-1/4	1.660	1.380	850	1.278	1550	1.160	4470
1-1/2	1.900	1.610	800	1.500	1450	1.338	4100
2	2.375	2.067	720	1.939	1330	1.689	3580
21/2	2.875	2.469	970	2.323	1550	2.125	3940
3	3.500	3.068	875	2.900	1400	2.624	3520

It is to be noted that for a given nominal size of pipe, the wall thickness increases as the schedule number increases. Table 1.4 shows the usage of metric pipes. These metric designations are not common in industry.

Table 1.4 The usage of metric pipes under fluid power standards

Tube OD (mm)	Tube ID (mm)	Wall Thickness (mm)	Tube OD (mm)	Tube ID (mm)	Wall Thickness (mm)	Tube OD (mm)	Tube ID (mm)	Wall Thickness (mm)
4	3	0.5	14	10	2.0	25	19	3.0
6	4	1.0	15	12	1.5	25	17	4.0
6	3	1.5	15	11	2.0	28	24	2.0
8	6	1.0	16	12	2.0	28	23	2.5
8	5	1.5	16	10	3.0	30	24	3.0
8	4	2.0	18	15	1.5	30	22	4.0
10	8	1.0	20	16	2.0	35	31	2.0
10	7	1.5	20	15	2.5	35	29	3.0
10	6	2.0	20	14	3.0	38	30	4.0
12	10	1.0	22	20	1.0	38	28	5.0
12	9	1.5	22	19	1.5	42	38	2.0
12	8	2.0	22	18	2.0	42	36	3.0

Example 1.3

A steel tube of inner diameter 25 mm has a burst pressure of 50 MPa. If the tensile strength is 380 MPa, find the minimum acceptable OD.

Solution: The bursting pressure is given by

$$p_{\mathrm{BP}} = \frac{2\,t\,S}{d}$$

$$\Rightarrow 50 = \frac{2 \times t \times 380}{0.025}$$

Solving we obtain $t = 1.644 \times 10^{-3}$ m = 1.644 mm. Now

$$\text{OD} = \text{ID} + 2t = 25 + 2 \times 1.644 = 28.3 \text{ mm}$$

Example 1.4

What is the minimum size of commercial pipe tubing with a wall thickness of 2 mm required at the inlet and outlet of a 75 LPM pump? The inlet and outlet velocities are limited to 1.2 and 6.1 m/s, respectively.

Solution: We have

$$75 \text{ LPM} = 0.075/60 = 1.25 \times 10^{-3} \text{ m}^3/\text{s}$$

We know that discharge

$$Q = \text{Area} \times \text{Velocity}$$

$$A_{\min} = \frac{\pi}{4}(d^2) = \frac{\text{Discharge}}{\text{Velocity(max)}} = \frac{1.25 \times 10^{-3}}{6.1} = 0.001042 \text{ m}^2$$

Solving, we obtain $d = 36.5$ mm (for the maximum velocity). Referring to Table 1.4 we select 42(OD) $\times$ 36(ID) for the pump inlet.

Again

$$A_{\max} = \frac{\pi}{4}(d^2) = \frac{\text{Discharge}}{\text{Velocity (min)}} = \frac{1.25 \times 10^{-3}}{1.2} = 0.0002049 \text{ m}^2$$

Solving we obtain $d = 16.2$ mm (for the minimum velocity). Referring to Table1.4, we select 22(OD) $\times$ 18(ID) for the pump outlet.

Example 1.5

What is the minimum size of commercial pipe tubing with a wall thickness of 2.4 mm required at the inlet and outlet of a 0.00189 m^3/s pump? The inlet and outlet velocities are limited to 1.92 m/s and 6.08 m/s, respectively.

Solution: This problem has to be solved by the trial-and-error method.

Pump Inlet:

(a) Using Table 1.4, let us select t = 2.5 mm, OD = 28 mm and ID = 23 mm. Now

$$\text{Velocity} = \frac{\text{Discharge}}{\frac{\pi}{4}(d^2)} = \frac{0.00189}{\frac{\pi}{4}(0.023^2)} = 4.54 \text{ m/s}$$

(b) Let us select t = 3 mm, OD = 25 mm and ID = 19 mm. Now

$$\text{Velocity} = \frac{\text{Discharge}}{\frac{\pi}{4}(d^2)} = \frac{0.00189}{\frac{\pi}{4}(0.019^2)} = 6.67 \text{ m/s}$$

(c) Let us select t = 3 mm, OD = 42 mm and ID = 36 mm. Now

$$\text{Velocity} = \frac{\text{Discharge}}{\frac{\pi}{4}(d^2)} = \frac{0.00189}{\frac{\pi}{4}(0.036^2)} = 1.86 \text{ m/s}$$

Referring to Table 1.4,we can use a 28 × 23 × 2.5 mm^3 pipe for the pump outlet and a 42 × 36 × 3 mm^3 pipe for the pump inlet.

Example 1.6

The flow rate of certain fluid in a pipe is 0.001 m^3/s and an operating pressure is 70 bar. The maximum recommended velocity is 6.1 m/s and the factor of safety of 8 is allowed. Select a metric steel tube when

(a) Material is SAE 1010 with a tensile strength of 380 MPa.

(b)Material is AISI 4130 with a tensile strength of 570 MPa.

Solution:

(a) Selection of Pipe for the SAE 1010

$$\text{Flow area} = \frac{\pi}{4}(d^2) = \frac{\text{Discharge}}{\text{Velocity(max)}} = \frac{0.001}{6.1} = 0.0001639 \text{ m}^2$$

Solving we get inside diameter $(d) = 14.4\,\text{mm}$.

From Table 1.4 we select t = 1.5 mm, ID = 12 mm and OD = 15mm. So bursting pressure is

$$p_{\text{BP}} = \frac{2\,t\,S}{d} = \frac{2 \times 0.0015 \times 380}{0.012} = 94.9 \text{ MPa}$$

The working pressure is

$$\text{Working pressure} = \frac{\text{Maximum pressure}}{\text{Factor of safety}} = \frac{94.9}{8} = 11.93\,\text{MPa} = 119.3\,\text{bar}$$

Working pressure is greater than the operating pressure of 70 bar. So we use a pipe of 15 × 12 × 1.5 mm.

(b) Selection of Pipe for the AISI 4130

$$p_{\text{BP}} = \frac{2\,t\,S}{d} = \frac{2 \times 0.0015 \times 517}{0.012} = 129.3 \text{ MPa}$$

The working pressure is

$$\text{Working pressure} = \frac{\text{Maximum pressure}}{\text{Factor of safety}} = \frac{94.9}{8} = 16.2\,\text{MPa} = 162\text{ bar}$$

Working pressure is greater than the operating pressure of 70 bar. So we use a pipe of 15 $\times$ 12 $\times$ 1.5 mm.

1.6 Screwed Connections

Steel piping in fluid power systems is most often joined by threaded connections. Unfortunately, threading weakens the pipe thereby making it necessary to use heavier walls than would otherwise be required. This difficulty can be overcome by welding, but welded sections are not desirable in fluid power systems that require frequent disassembly. Large-diameter piping systems generally are fabricated with flanged joints.

Taper threads form a seal by an interference fit between a male and a female component when they are tightened together, and some form of jointing compound or flexible plastic tape is added to ensure a good joint. Great care must be taken when screwing taper threads into the body of a component, particularly if it is made of cast iron, otherwise the casting may be cracked.

Parallel threads are easier to manufacture and simpler to use. Joints made with parallel threads must have a sealing washer between the component body and a suitable shoulder on the pipe fitting in order to prevent fluid leakage [Fig. 1.1(c)]. Parallel thread fittings should never be used in taper thread holes or vice versa.

The most commonly used screw thread forms for hydraulic pipe fittings are as follows:

1. British standard pipe threads (BSP).
2. American National pipe threads (NPT).
3. Unified pipe threads (UNF).
4. Metric pipe threads.

1.7 Steel Tubing

Seamless steel tubing is the most widely used material for hydraulic system conductors.One major reason of its popularity is the fact that it can be easily formed to fit irregular paths so that fewer fittings are required. The obvious result is a considerably lessened chance of leakage since every connection is a potential leak point. It is also relatively small and light, thus making it easy to use.

Rigid steel tubing is either drawn or seam welded, the later sometimes used in hydraulic systems for pipe work but is generally unsuitable for higher pressure and is more difficult to manipulate as the seam tends to split when the pipe is bent.

When bending steel tubing, it is always important to use proper tube-bending equipment with fixtures of the correct size, otherwise the pipe is flattened. This reduces its cross-sectional area and causes a higher resistance to the flow of fluid. It is usual to specify hydraulic tubing by reference to the outside diameter (OD) and wall thickness. A range of standard tubes are available in both inch and metric sizes from about 5 mm OD. For most fluid power applications, the tubing used is SAE 1010 dead soft cold-drawn steel tubing. This material is easily worked and has strength equal to or greater than the schedule 80 pipe. If a greater strength is required, a similar tubing fabricated from AISI 4230 steel can be used that can withstand approximately 50% more working pressure.
Various standard wall thicknesses are available for each size of tubing, and tube manufacturers supply tables indicating the safe working pressure for each size. A minimum safety factor of 4:1

should be used when selecting the wall thickness of a tube. It means the bursting pressure of the tube must be four times the maximum fluid pressure. Obviously, thicker tubes are more difficult to manipulate, particularly with a larger diameter.
Flow rates through smooth bore tubes should normally not exceed 5m/s in pressure lines or 1.2 m/s in suction lines. Tubes used for hydraulic systems must be clean and free from rust; otherwise particles of grit may find their way into the precision equipment, causing serious damage to pumps and valves. Tubes in transit or storage should always have their open ends capped to prevent the ingress of dirt and moisture. Tubes are attached to end fittings using compression joint and flared tubes. Very large fittings are usually welded.

1.8 Compression Joints

Compression-type fittings comprise a loose ring having a cone-shaped nose that must face the open end of a tube, a mating tapered barrel and a retaining nut. The end of the tube must always be cut square and deburred before assembly. When the tube is pushed fully in the fitting and the retaining nut is tightened, the compressive action forces the nose of the ring into the surface of the metal tube, creating a permanent and very strong interference fit that is capable of withstanding pressure in excess of 350 bar.

1.8 Plastic Conductors

Plastic tubing is now available in polyethylene, polypropylene, polyvinyl chloride and nylon. Each material has specific characteristics that make it more suitable for some services than for others. The best procedure is to check the manufacturer's literature against the service conditions whenever plastic tubing is being considered.. In general, plastic tubing is most often used in pneumatic systems, primarily because it does not have sufficient strength to be used in most hydraulic systems. The plastics are compatible with most hydraulic fluids, however, and could safely be used in low-pressure applications.
Plastic tubing has gained rapid acceptance in the industry because it is inexpensive and extremely easy to use. It can easily be formed to fit around obstructions without special tools; it is light and easy to handle. It is also available in colors so the different circuit lines can be color coded, especially in chemical industries. Because of its resilience, it is highly resistant to damage crushing although it can be fairly easily cut. It may also be used where flexing or vibration can damage steel tubing. Plastic tubing fittings vary slightly from steel tubing compression fitting.In fact, most steel tubing fittings can be used for the same services if a special sleeve is first inserted in the tubing to give it a crushing resistance at the compression point. Although testing for a specific purpose is recommended, a 4:1 factor of safety is considered good engineering practice in most of the fluid power systems.
In general, plastic tubing can be worked and installed with the ordinary tubing tools. It cuts easily and can be heated and given permanent bends; it can be used with standard metallic compression and flare fittings designed for metal tubing. Many new developments are being made in the nature of tools, fittings, quick disconnects and other devices especially for plastic fabrications.

1.9 Flexible Hoses

Hose assemblies are primarily used to connect fluid power systems to actuators that must be located on movable parts such as a cylinder coupled to a radius arm traversing in an arc, or a motor driving a machine carriage. A hose is manufactured from natural and synthetic rubbers and several plastics. This material is supported by fabric or by wire cloth, and wire braid may be used between plies or as an outside casing for high-pressure applications. Hose assemblies of nearly any length, complete with end connections, are available from most manufacturers. It is only necessary to specify the system service pressure and the fluid that is to be used. Extreme caution should be taken in changing a fluid or replacing hoses, however, to be sure that the hose material and fluid are compatible. Table 1.6 gives some typical hose sizes for single braid high tensile strength steel wire reinforcement with an inner tube made of oil-resistant nittrile (BTN) and a cover compound made up of black neoprene (oil-resistant and abrasion-resistant type).

Table 1.6 Typical hose sizes

Hose ID		**Wire ID**	**Hose OD**	**Working Pressure**		**Burst Pressure**		**Minimum Bend Radius**	**Weight**
in.	mm	mm	mm	MPa	psi	MPa	psi	mm	kg/m
3/16	4.8	9.5	11.8	25	3630	100	14280	90	0.190
1/4	6.4	10.8	12.8	22.5	3270	90	12840	100	0.222
5/16	7.9	12.5	14.5	21.5	3120	85	12280	115	0.261
3/8	9.5	14.6	16.8	18	2610	72	10280	130	0.324
1/2	12.7	17.6	19.8	16	2320	64	9180	180	0.418
5/8	15.9	21.1	23.1	13	1890	52	7420	200	0.476
3/4	19	24.7	27	10.5	1530	42	6000	240	0.619
1	25.4	32.5	35	8.8	1280	35	5020	300	0.883
1−1/4	31.8	39.5	43.5	6.3	920	25	3600	420	1.220
1−1/2	38.1	45.8	49.8	5	730	20	2850	500	1.408
2	50.8	59	63	4	580	16	2280	630	1.889

Steel end fittings are attached in various ways by clamping or squeezing the rubber hose between a serrated inner piece and an outer retaining ring. These end fittings are available for assembly on site by the user in a variety of designs that may require the use of portable tools, or as readymade hose assemblies, in which retaining rings are usually machine swaged at the factory.In some self-assembly versions, the inner end piece is screwed into the hose on a tapered interface to provide a compressive grip. In others, the outer sleeve is split and is held together on the hose by clamping screws to provide the same effect. The advantage of self-assembled hoses is that for emergency repairs, they can be cut to exact length on site, thus reducing the need for large stocks to be maintained, but they tend to be more costly than pre-assembled hoses.
End fittings used in flexible hoses tend to have a smaller internal diameter than their equivalent rigid tube fittings, thus creating slightly more resistance to flow. Most suppliers offer straight, angled and elbow end fittings for flexible hoses, with a variety of male and female threads.

1.9.1 Designation of Hoses

Hoses are fabricated in layers of elastomers and braided fabric or braided wires. The braided fabric or wires are used to increase the strength of the hoses. The hose may have a minimum of three layers including one braided layer or can have several layers to sustain the higher operating pressures. The steel wires have a spiral weave or cross weave. Spiral reinforced hoses have high strength and require fittings to be supplied by the manufacturer. The cross woven braids are re-usable and are easy to assemble. The inner tuber material of the hose should be compatible with the fluid.

Important considerations in the installation of hose assemblies are as follows**:**

1. Hose assemblies must be of proper overall lengths. Since a hose expands under pressure, both the hose length and space allowed for it must be adequate.
2. A hose under variations in working pressure must have enough length to expand and contract.
3. Do not clamp high- and low-pressure hoses together.
4. Never clamp a hose at a bend. Bend radii cannot absorb a change if clamped at the bend.
5. When there is a relative motion between two ends of a hose assembly, always allow the adequate length of travel.
6. To prevent twisting, a hose should be bent in the same plane as the motion of the part to which it is attached.

7. To prevent twisting in hose lines bent in two planes, clamp the hose at the change of the plane.
8. Use the proper hydraulic adaptors to reduce the number of joints and improve performance as well as appearance.
9. Wherever the radius falls below the required minimum bend, an angle adapter should be used.
10. Contact with sharp edges and rubbing against any surface should be avoided.
11. Arrange proper positioning of hose and adaptors before tightening to avoid distortion.
12. Apply clamps properly and keep tight to prevent abrasion due to line surge.
13. Be sure to use the proper strength of hose to maintain a good factor of safety.
14. Select the proper size of hose of stay within the recommended velocity range. Consult velocity-flow nomographs.
15. Prevent dirt, chips or any other foreign materials from entering the system during the fabrication of system.
16. Be sure that all the material used is compatible with the hydraulic fluid designed for the system.

1.11 Quick Disconnect Couplings

Another type of hydraulic fitting in regular use is the quick release coupling. This type of coupling in conjunction with flexible hoses connects movable components together hydraulically. Typical applications are mobile trailers and agriculture machinery towed behind tractors.

Quick release couplings usually comprise a plug and socket arrangement that provides a leak-proof joint when two parts are connected together, and that can be released easily without the use of tools. Each half of the coupling contains a spring-loaded ball or poppet that automatically closes on disconnection, so that two completely leak-free joints are obtained. Leaking during the process of disconnecting or connecting coupling is negligible

Objective-Type Questions

Fill in the Blanks

1. Stainless steel conductors or fittings may be used if extremely ________ environments are anticipated.

2. In fluid power installations, a galvanized pipe is unsatisfactory because galvanization tends to ________ into the system.

3. The choice of pipe, tube or hose depends on operating pressures of system and ________.

4. Pressure rating of various conductors depends on ________ of the material used and the wall thickness of the conductor.

5. Tubes are attached to the end fittings in various ways, some of which use metal-to-metal ________ known as a compression joint.

State True or False

1. Copper and cadmium tubing are most commonly used in a hydraulic system.

2. Steel piping in fluid power is most often jointed by threaded connections.

3. Welded sections are most desirable in fluid power systems.

4. Rigid steel tubing is generally suitable for high pressures.

5. Flow rates through smooth bore tubes should normally not exceed 1.2 m/s in pressure lines or 5 m/s in suction lines.

Review Questions

1. What is the purpose of a fluid distribution system?
2. Why should copper not be used in conductors or fitting?
3. Why can metals not be used with glycol fluid?
4. Why should the conductor have a greater strength than the system working pressure?
5. Why are smooth conductors desired?
6. What are the major disadvantages of steel pipes?
7. What is the recommended factor of safety for a fluid power system design?
8. Why is malleable iron used for steel pipe fittings?
9. What effect do threaded connections have on a fluid power system?
10. Why are unions not required in tubing systems?
11. Why is steel tubing used more often than steel pipe?
12. How do compression fittings prevent the tube from blowing out under pressure?
13. How can steel tube fittings be used with plastic tubings?
14. What major advantages does plastic tubing have over steel tubing?
15. What are the two disadvantages of steel pipes?
16. Define the burst pressure and working pressure of hydraulic pipes.
17. What is the use of quick disconnect coupling?
18. What is the difference between hydraulic tubing and hoses?
19. What is the difference between flared fitting and compression fitting?
20. List the factors influencing the selection of hoses.