FLUID POWER

FLUID POWER EQUIPMENT

TUTORIAL – PIPE WORK

This work covers part of outcome 2 of the Edexcel standard module:

UNIT 21746P APPLIED PNEUMATICS AND HYDRAULICS

The material needed for outcome 2 is very extensive so the tutorial is presented as a series.

OUTCOME 2 Investigate the construction and operation of pneumatic and hydraulic components, equipment and plant.	• Identify and describe the features of pneumatic and hydraulic equipment. • Analyse the performance characteristics of pneumatic and hydraulic equipment.

The series of tutorials provides an extensive overview of fluid power for students at all levels seeking a good knowledge of fluid power equipment. This tutorial probably covers more than that required for the module but studying it will increase your total knowledge of fluid power systems.

On completion of this tutorial you should be able to do the following.

- Explain the definitions of pipes and tubes.
- Describe the materials used for pipes and tubes.
- Describe the methods used to form pipes and tubes.
- Describe the methods used to join pipes and tubes.
- Describe the various types of fittings used in pneumatics and hydraulics.
- Explain the purpose of flexible hoses and how to fit them correctly.
- Explain the importance of clamping pipes and tubes.

1. INTRODUCTION

Pipe work must be properly engineered as poorly designed pipe work will result in extra maintenance and cost. The pipe work system must be able to withstand vibration and thermal expansion so it should be adequately supported but allow flexibility where required. The pipes must be of sufficient size to pass the fluid without excessive pressure loss. The fittings and bends should not produce excessive restriction to the flow.

2. PIPES AND TUBES

Pipes are specified by their nominal bore diameter. The outer diameter depends upon the thickness of the wall. Fittings must take account of this and are generally made to fit the outside. Pipes are still commonly made to imperial sizes (British Standard Pipe) and 1 inch BSP means it has a 1 inch nominal bore. Metric pipes are often just inch sizes converted to mm so that a 1 inch pipe becomes a 25 mm pipe and a 2 inch becomes a 50 mm pipe.

Tubes are specified by their outside diameter and they are made to standard sizes. Sizes in fractions of an inch are still available but metric is becoming more popular such as 15 mm, 16 mm and so on. The bore diameter depends upon the thickness of the wall and consequently it is possible to have the same size tube with different bore diameters. Fittings are easily made to fit tubes as the sizes are standard.

2.1 MATERIALS AND RATINGS

MATERIAL	PRESSURE	USE/COMMENTS
Copper	0 - 100 bar depending on bore.	Easy to manipulate Permanent non flexible.
Polyurethane	0 - 8 bar depending on bore.	Flexible Available in many colours.
Nylon	0 - 30 bar depending on bore.	Flexible. Softens with heat. Kinks Available in many colours.
Welded seam steel pipe	0 - 100 bar	Difficult to manipulate. Air main supplies.

2.2 BENDING

Steel and copper pipes or tubes should be bent with the correct bending tools. These will have an inner circular former with a groove to fit the tube. This ensures the correct bend radius for the size. A straight former with a groove to fit the tube is placed over the outside to ensure no kinking when the bend is formed. The minimum bend radius is nominally 3 pipe diameters minimum. You should always leave a straight length of at least 2 diameters at the ends to accommodate the fittings. Large pipes are heated before bending and this produces scale.

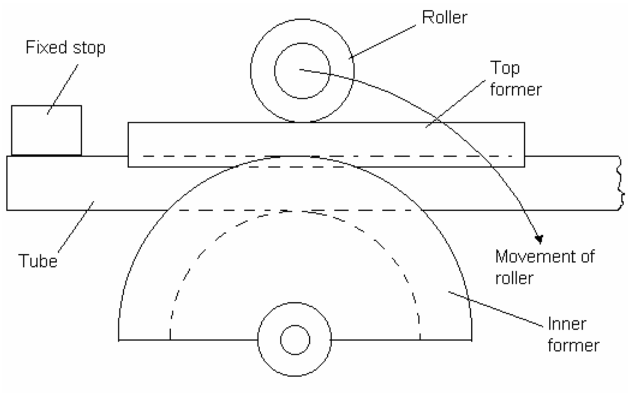


Figure 1

2.3 CUTTING

A disc type cutter may be used on copper or thin gauge steel tube but these tend to thicken the ends and mark the outside. It is preferable to use a proper jig to clamp the pipe/tube and cut it with a hacksaw. The jig ensures the blade does not slip and scratch the outside and that the cut is square. Hacksaws produce metal chips and these must be cleaned out. The cut ends should be deburred with a proper coning tool on the inner and outer edges.

Plastic tubes are cut square with simple sharp bladed cutters.

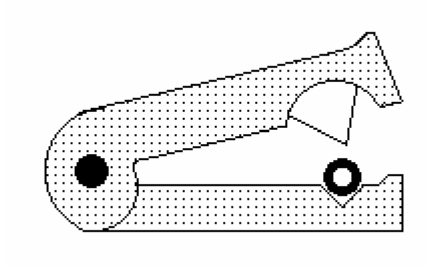


Figure 2

2.4 TREATMENT

If a steel pipe has been heated, it is advisable to thoroughly clean it by pickling in acid, knocking out the bits by tapping it and flushing it through with high pressure water. Finally the pipe should be lightly oiled by pulling through an oily lint free cloth.

3. FLEXIBLE HOSES

For pneumatics, flexible tubes are nylon or polyurethane although rubber hoses may be used as well. If there is a danger of the tubes kinking, suitable angles end connectors should be used as shown below. Flexible pipes are used to

- Prevent the transmission of vibrations.
- Allow relative movement between the ends.

For example hydraulic pumps are connected to the system with a flexible hose to prevent vibration being passed to the metal pipes. Another example is on pivoting cylinders where the pipe must bend as the cylinder moves.

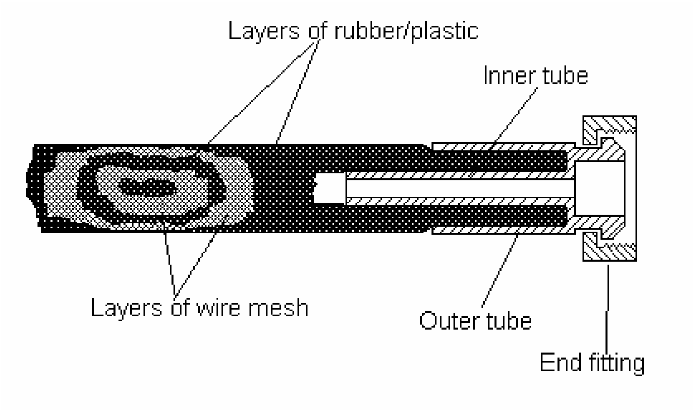
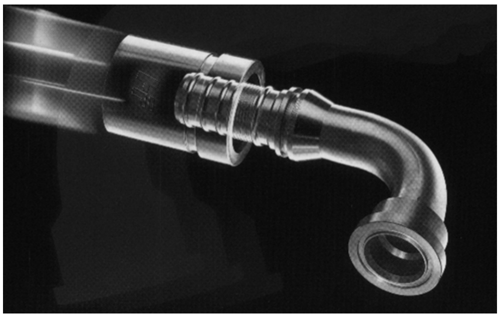


Figure 3

The hose is constructed from layers of rubber/plastic and wire mesh as shown.

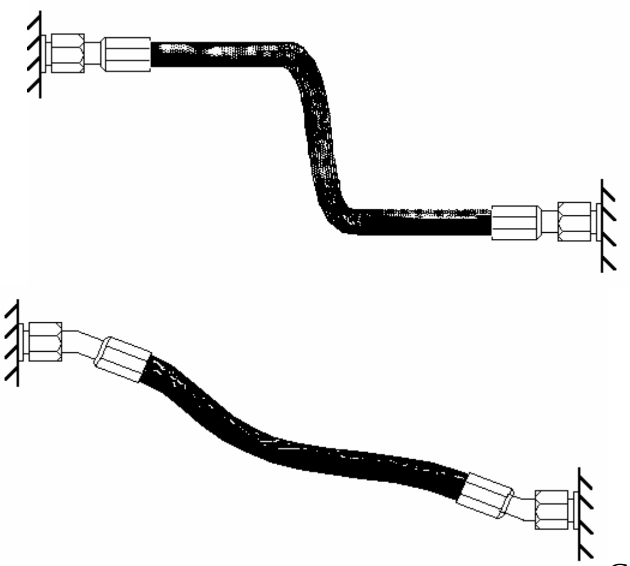
The end fitting consists of an inner and outer tube. The hose is sandwiched in between the two. The outer tube is squeezed in a special machine to grip the hose between the two.



Another design used a threaded inner tube and the fitting is screwed into the hose.

The termination may be a simple straight end or an elbow of various angles. Selecting the correct end fitting minimises bending and stretching of the hose. When fitting a hose, care must be taken neither to twist it along its length nor to stretch it, as this may cause the fitting to come off under pressure.

Figure 4



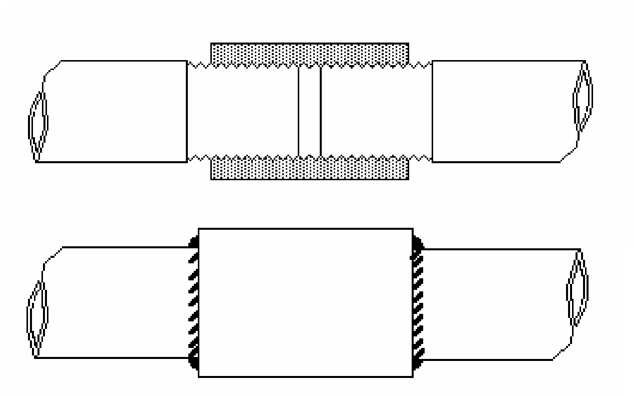
The diagram shows the incorrect and the correct way to fit a hose. Angled end fittings should be used to reduce the bending. Note that a small amount of flex must be allowed in the tube so that it is not stretched as the ends are done up.

Incorrect

Correct

Figure 5

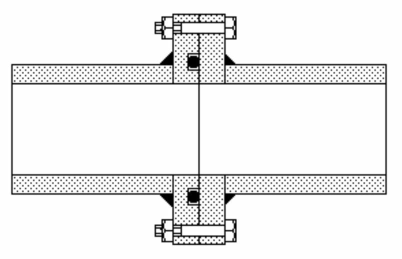
4. JOINING



One way to join large pipes is by threading the outside and then joining them by screwing them into a threaded sleeve as shown. The threads must be sealed with sealant or tape.

Welded sockets are also common for hydraulic systems and these have no possibility of leaking.

Figure 6



Another way to join them is with flanges. The pipes must be attached to the flange by screwing them together or by welding them. The faces of the flange must be sealed with a gasket or sealing ring.

Figure 7

5. END TERMINATIONS

Pipes, tubes and hoses must be connected either to each other or to port connections. There are many designs for these mating connections. One of the most common is a range of fittings called compression fittings.

5.1 COMPRESSION JOINTS

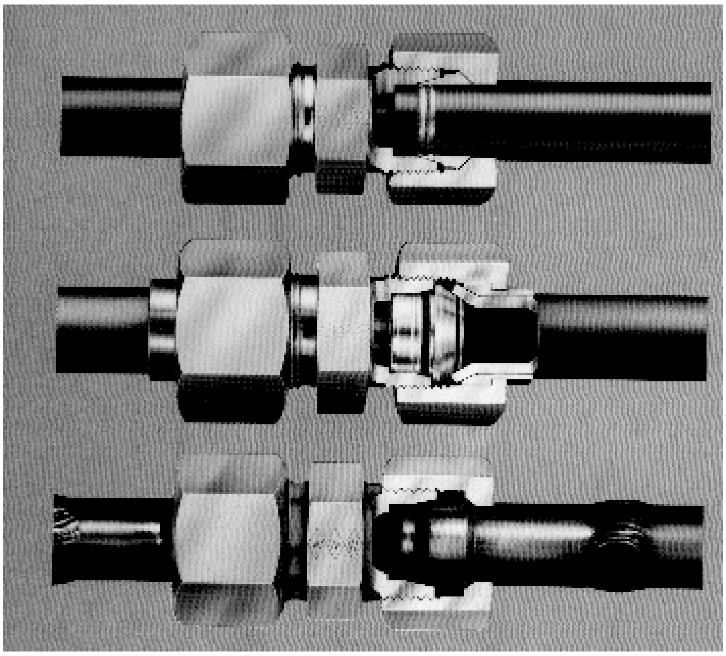


Figure 8

The picture shows three types of hydraulic compression joints.

The top one shows the type with a compression ring or olive.

The middle one shows the type with a flared end on the pipe.

The bottom one shows the type with a welded nipple.

5.2 COMPRESSION RING.

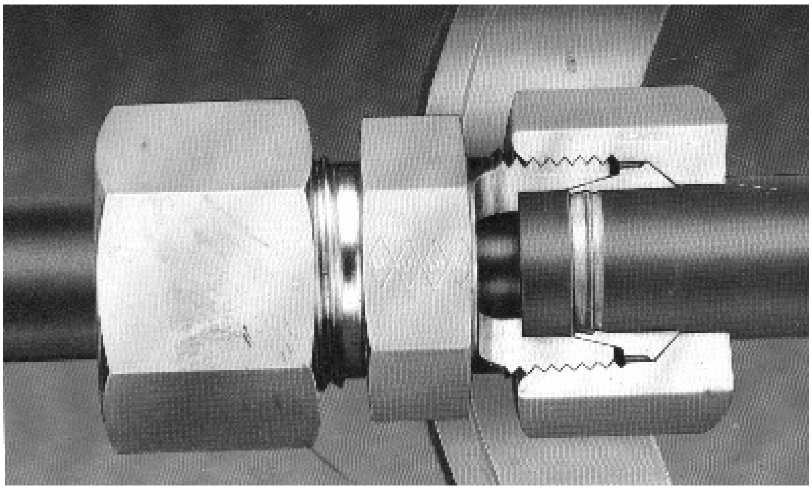


Figure 9

The picture shows the compression ring type more clearly. Compression rings and nuts are used for smaller bore tubes. There are various names for these, such as tube nuts, tube sleeves, olives and so on. They are available for a range of pressures and fluids with many variations in the design and quality. The diagram shows a basic fitting.

5.2.1 INSTRUCTIONS FOR MAKING A TYPICAL PNEUMATIC JOINT

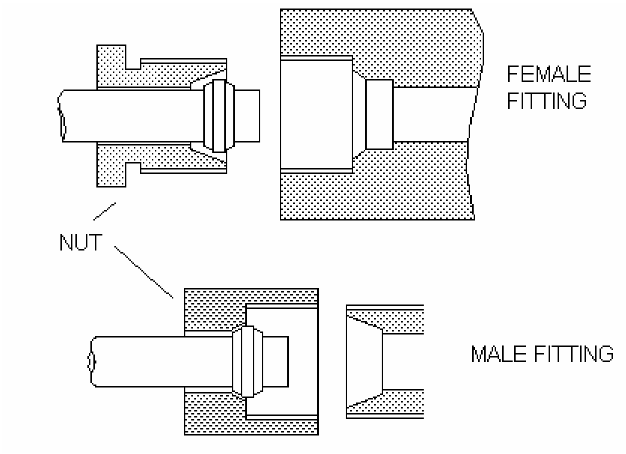
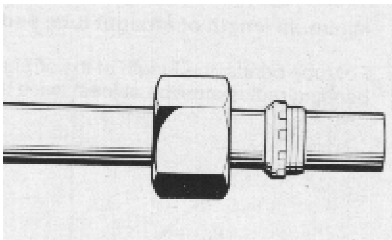


Figure 10

1. Cut the tube clean and square.
2. Deburr.
3. Lightly oil.
4. Put nut on tube and then sleeve.
5. Insert tube into fitting and hold firmly in place.
6. Tighten nut until resistance is met. Continue tightening with spanner until the nut touches the stop on the sleeve.

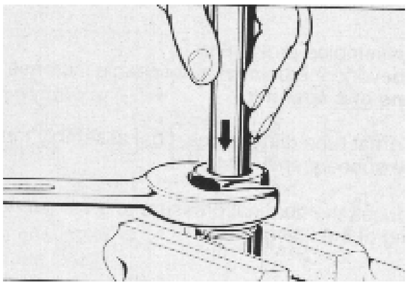
5.2.2 INSTRUCTIONS FOR MAKING A TYPICAL HYDRAULIC JOINT

Cut the tube and bend it to fit the system requirements. Use a cutting jig and a hacksaw. Deburr the ends (outer and inner edges) with a coning tool. Using a suitable stud connector in the vice, make the compression joint at each end as follows.



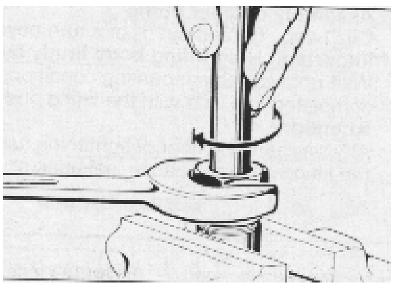
Clean and oil the pipe. Slide on the tube nut. Slide on the compression ring with thin edge towards the end of the tube.

Figure 11



Insert the tube into the fitting and run the nut on until hand tight. Tighten the nut with a spanner until resistance is felt.

Figure 12



Turn the nut about another half turn. Remove and inspect the joint. You should have about 4 mm of tube showing through the ring.

When both ends have been completed, attach a fitting with a blanking plug to one end and attach the other end to the connection on the test rig.

Figure 13

5.3 FLARED PIPE.

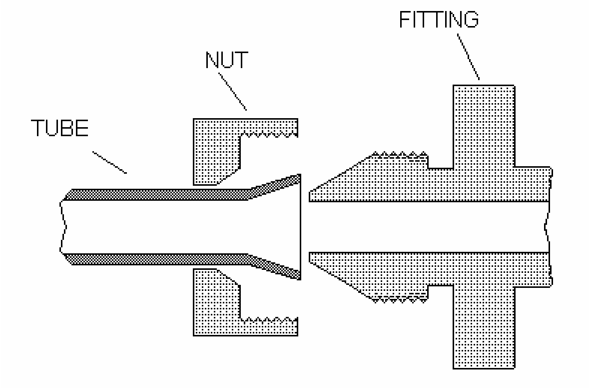


Figure 14

This system uses a cone and nut as shown. This has the advantages of a compression fitting but needs no tube sleeve. Metal tubes are flared with a special tool but plastic pipes are forced on and this allows quick fitting with no special preparation.

5.4 WELDED NIPPLE.

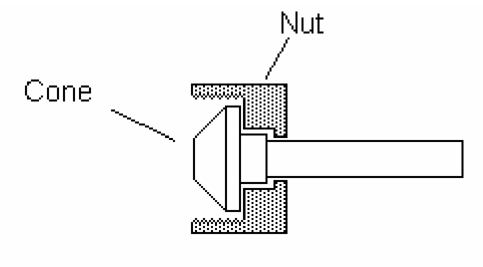


Figure 15

The cones are sometimes welded or brazed to the pipe as shown.
There are many designs and standards for the end terminations of hydraulic fittings. Terminations which use a tube nut and sleeve must match each other and manufacturers use their own patented designs. Fittings from different manufacturers are rarely compatible.

6. HOSE TERMINATIONS

Figure 16

The end terminations for hoses and coned fittings are more standard. The two important aspects are the size of the thread and the angle of the cone. One of the most popular standards is still based on BSP with either male or female cones. America uses another standard based on National Pipe Threads (NPT). Because of the proliferation of standards, a joint international conference produced a new standard to replace these and this is known as JIC. Unfortunately, this became just another standard to add to the others. Various metric standards such as DIN (The German standard) are fairly common now. These often incorporate an O ring seal on the cone for improved sealing.

7. <u>STUDS and ADAPTERS</u>

Stud fittings connect pipes and hoses to units such as cylinders. Adapters join them to each other or adapt the size of a stud. Adapters enable different sizes and different standards to be joined. The stud end screws into the port. The fitting end matches the fitting on the pipe or hose. The stud may have a parallel thread or a tapered thread. A very common thread standard is still the British Standard Pipe (BSP). These are designated as G followed by the size in fractions of an inch. G3/4 means 3/4 inch BSP for example. Metric sizes are taking over and M10 means 10 mm thread for example. The addition of the letter T means tapered thread and the letter P means parallel thread. For example G3/8 P means a 3/8 inch BSP parallel thread. America uses NPTT and NPTP in the same way.

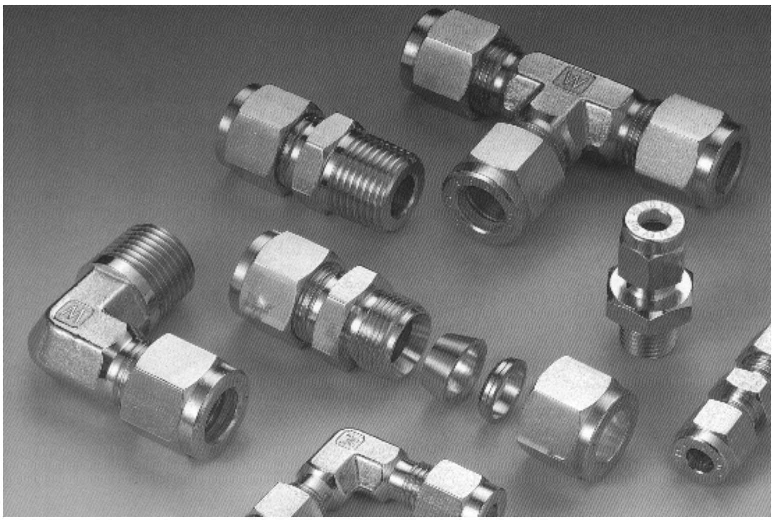


Figure 17

The diagram shows a typical pneumatic stud with push in connection. These are simple and quick to use with plastic tubes. The collet is expanded by the tube and clips into a groove. The O ring seals the tube. To release the tube, the collet must be pushed in.

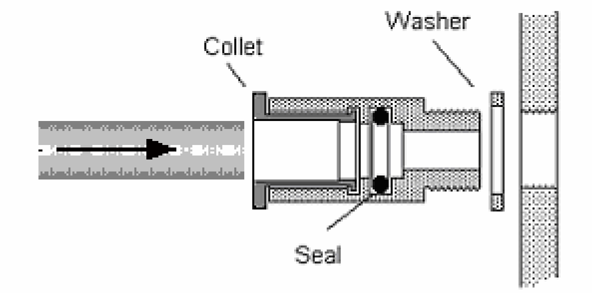


Figure 18

The next diagram shows a straight connector for joining two plastic tubes by pushing them together.

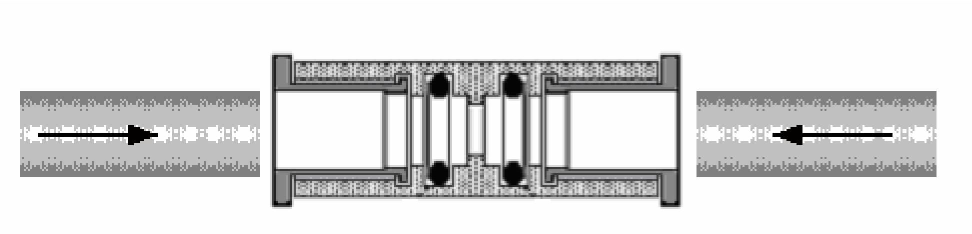


Figure 19

A range of push in fittings is available and the sizes may be adapted to larger or smaller tubes.

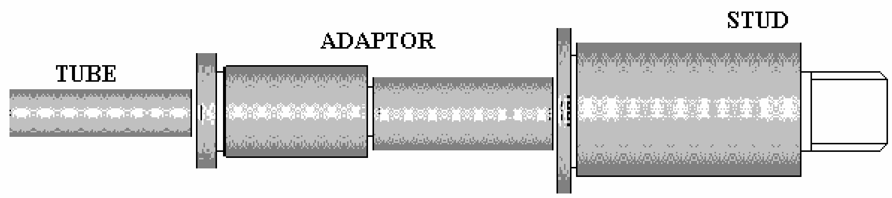


Figure 20

The next diagram shows typical hydraulic adaptors for changing sizes and joining to hoses.

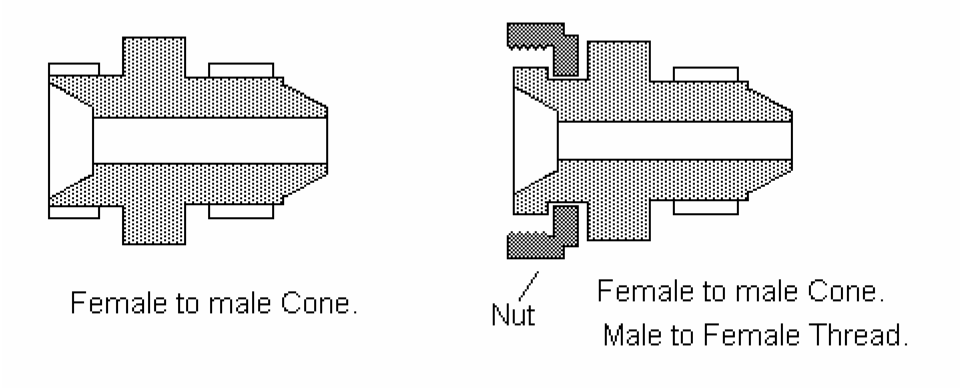


Figure 21

Parallel threads are sealed by using a washer under the hexagon. For high pressure, Dowty washers are used but copper or plastic washers will do for low pressures. Studs with tapered threads are forced into the port so that the thread deforms as it is tightened. The seal is basically a metal to metal seal where the two are squeezed together but it is normal to coat the thread with a soft material to ensure no leaks. Mastic and PTFE tape is common. Sometimes the thread has a plastic ring fitted to them to do the same job with no preparation required. Tapered studs are intended to be a permanent connection as they damage the port threads.

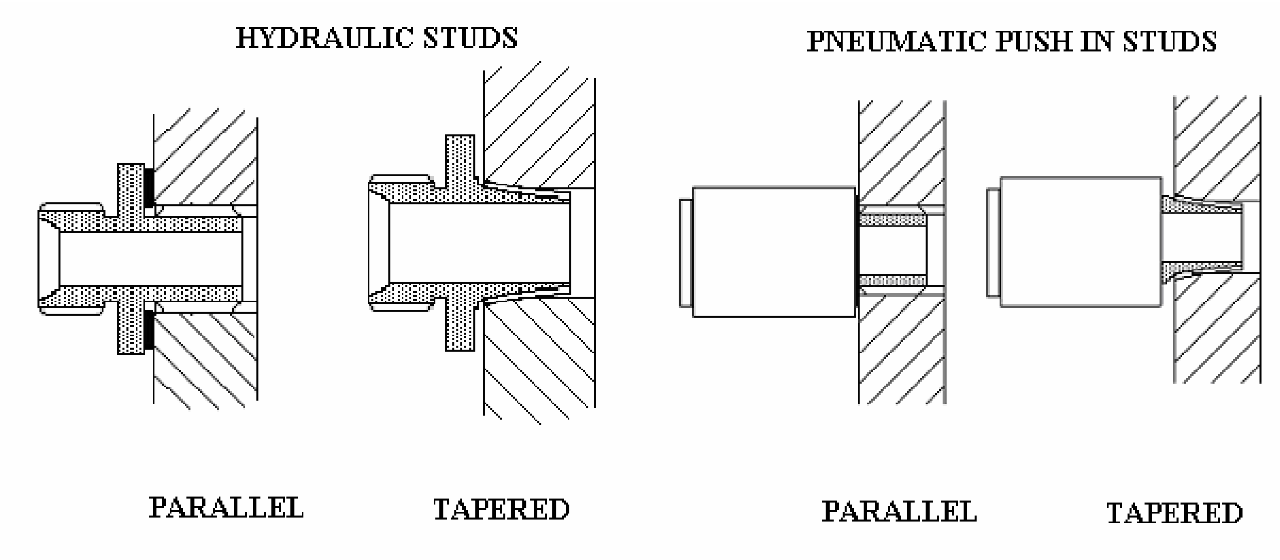


Figure 22

8. SNAP CONNECTORS

Snap connectors are used for the quick connection and disconnection of pipes.

A typical use is on mobile trailers and agricultural machinery where the machine has to be disconnected from the power pack in order to change the machine.

Figure 23

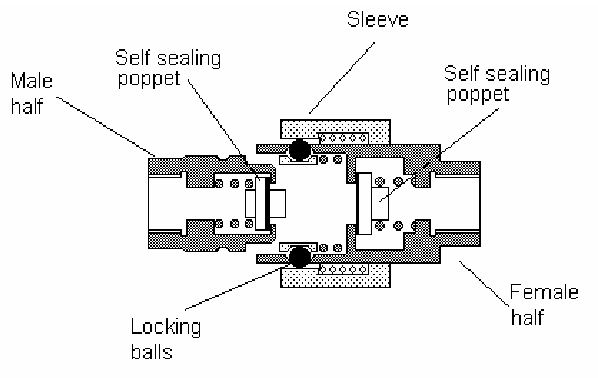


Figure 24

The connector has a male and a female half both of which are self sealing when disconnected. Disconnection produces a small loss of fluid but modern designs reduce this to a minimum. In order to make the connection, the sleeve is drawn back to release the locking balls. The male end is inserted and the balls lock into a groove on it. The sleeve is then released to hold the balls in place.

9. BANJO JOINTS

These are swivel joints. The tube is terminated in a ring or banjo which is clamped to a port as shown with a seal each side. The seals allow the joint to swivel about the pin.

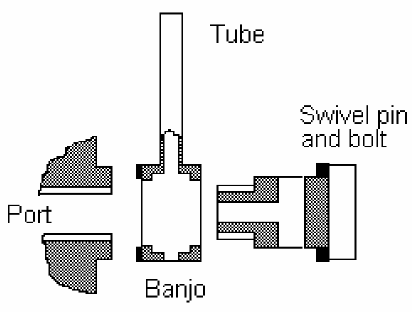
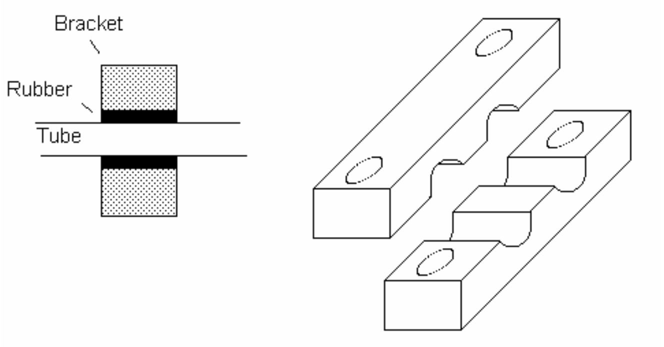


Figure 25

10. CLAMPING



Tubes should be anchored to a firm surface to prevent vibration and sagging which would lead to eventual fracture. A split bracket such as that shown is a good firm way of doing this. A rubber sleeve will help to reduce the vibration and prevent crushing of the tube. It also allows sliding movement as the tube warms and cools.

Figure 26

Plastic tubes may be clamped in neat bundles as shown to make a tidy layout around the equipment.

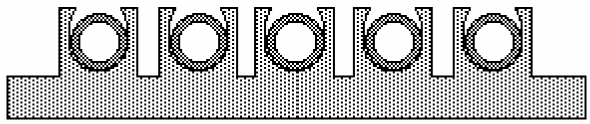


Figure 27

SELF ASSESSMENT EXERCISE

You should read your notes on pipes, tubes and fittings used in hydraulic and pneumatic systems and then answer the following questions.

1. Which is defined by its outer diameter, a pipe or a tube? ________________

2. Olives or compression rings are used in compression fittings. Are they used on tubes or pipes?

   ____

3. Hydraulic pumps should be connected to the system with flexible hoses. Why is this?

   ____

4. State one other important reason for using a flexible hose.

   ____

5. From a choice of cold drawn seamless steel tube or copper tube, which would you use for :

   i) Hydraulic oil at 200 bar. _______________________________________

   ii) Hydraulic oil at 30 bar. _______________________________________

6. Compression fittings used to make joints must do two things. One is to make a good seal. What is the other?

   ____

7. What is the main reason for firmly attaching pipes and tubes to the frame of the machinery with suitable brackets?

   ____

8. Show how you would connect the two stud fittings on the diagram with a flexible hydraulic hose using suitable end fittings.