Symbols for hydraulic components

Objectives : At the end of this lesson you shall be able to
- **read and interpret the circuit symbol**
- **state the uses of symbol in hydraulic components**

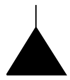
In a hydraulic circuit symbols are used to represent individual component to impart representation of hydraulics system in diagrams. A symbol identifies a component and its function. These symbols are as per ISO 1219 standards.

Pump and motor

Hydraulic pump and motor are represented by means of a circle. Triangle within the circle represent the direction of flow and position of triangle differentiates between the symbol of pump or motor.

If triangle is filled darkened means it is meant for hydraulics fluid but if triangle is not filled means it is for gaseous pressure media or Pneumatic energy. (Figs 1 & 2)

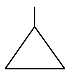
Fig 1



HYDRAULIC ENERGY

FIN4318211

Fig 2

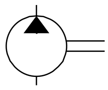


PNEUMATIC ENERGY

FIN4318212

Symbols of pump and motor (Figs 3 to 9)

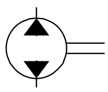
Fig 3



UNIDIRECTIONAL FIXED DISPLACEMENT PUMP

FIN4318213

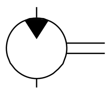
Fig 4



BIDIRECTIONAL FIXED DISPLACEMENT PUMP

FIN4318214

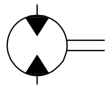
Fig 5



UNIDIRECTIONAL HYDRAULIC MOTOR

FIN4318215

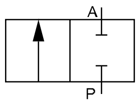
Fig 6



BIDIRECTIONAL HYDRAULIC MOTOR

FIN4318216

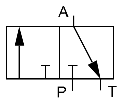
Fig 7



2/2-WAY VALVE

FIN4318217

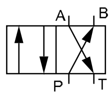
Fig 8



3/2-WAY VALVE

FIN4318218

Fig 9



4/2-WAY VALVE

FIN4318219

Direction control valve

Direction control valves are represented by several connected squares.

- The number of squares indicates the number of switching positions.
- Arrows in the squares indicate the direction of flow.
- Lines indicate how the ports are interconnected in the different switching position.

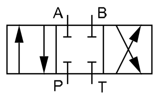
Port designation

P	Pressure port
T	Tank port
A	Service port (output port)
B	Service port (output port)
L	Leakage port

Copyright Free Under CC BY Licence

Symbols of Direction control valve (Figs 10 to 11)

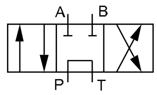
Fig 10



4/3-WAY CLOSE CENTRE VALVE

FIN431821A

Fig 11



4/3-WAY OPEN CENTRE VALVE

FIN431821B

Port should always be represented in the neutral position of valve.

The neutral position is a position which automatically come in valve due to spring force when no any command is available in valve, it is also the initial position unless otherwise actuated.

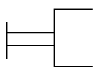
Actuating mechanism of Valve

The switching position of direction control valve can be changed by various actuation methods.

Different mechanisms of actuation of valve are shown in fig.12 to fig.19.

Mechanical actuation

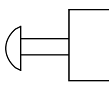
Fig 12



GENERAL MANUAL OPERATED

FIN431821C

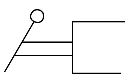
Fig 13



PUSH BUTTON

FIN431821D

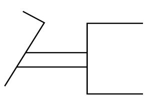
Fig 14



LEVER

FIN431821E

Fig 15

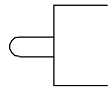


PEDAL

FIN431821F

Manual actuation

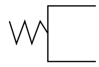
Fig 16



PUSH PIN

FIN431821G

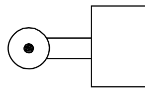
Fig 17



SPRING

FIN431821H

Fig 18

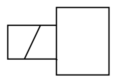


ROLLER

FIN431821I

Electrical actuation

Fig 19



SOLENOID

FIN431821J

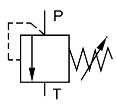
Pressure control valve

Pressure control valve are represented by a single squares. Arrow within the square indicate the direction of fluid flow.

The position of arrow within the square indicates whether the valve is normally open or normally closed.

Symbols of pressure control valve(Fig.20 to Fig.22)

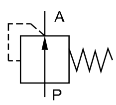
Fig 20



PRESSURE RELIEF VALVE

FIN431821K

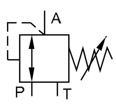
Fig 21



PRESSURE REDUCING VALVE

FIN431821L

Fig 22



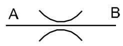
PRESSURE REGULATOR

FIN431821M

Copyright Free Under CC BY Licence

Flow control valve(Fig.23 to Fig.25)

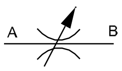
Fig 23



FIXED FLOW CONTROL VALVE

FIN431821N

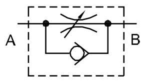
Fig 24



VARIABLE FLOW CONTROL VALVE

FIN431821O

Fig 25



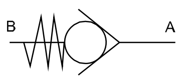
ONE WAY FLOW CONTROL VALVE

FIN431821P

Non-return valves

The symbol of non-return valve is a ball which is pressed against a sealing seat. (Fig. 26 to Fig.28)

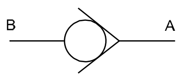
Fig 26



SPRING LOADED NRV

FIN431821Q

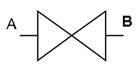
Fig 27



UNLOADED NRV

FIN431821R

Fig 28



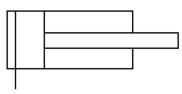
SHUT-OFF VALVE

FIN431821S

Cylinder

Single acting cylinders have one port and double acting cylinder have two ports.(Fig.29 to Fig.31)

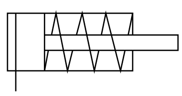
Fig 29



SINGLE ACTING CYLINDER

FIN431821T

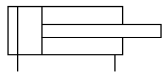
Fig 30



SINGLE ACTING CYLINDER WITH SPRING

FIN431821U

Fig 31



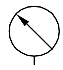
DOUBLE ACTING CYLINDER

FIN431821V

Measuring devices

Measuring devices are shown in the Fig.32 to Fig.36.

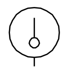
Fig 32



PRESSURE GAUGE

FIN431821W

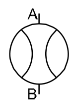
Fig 33



TEMPERATURE GAUGE

FIN431821X

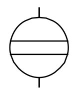
Fig 34



FLOW METER GAUGE

FIN431821Y

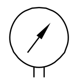
Fig 35



LEVEL GAUGE

FIN431821Z

Fig 36

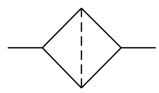


DIFFERENTIAL PRESSURE GAUGE

FIN43182A1

Other symbols(Fig.37 to Fig.39)

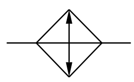
Fig 37



FILTER OR STRAINER

FIN43182A2

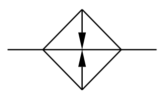
Fig 38



COOLER

FIN43182A3

Fig 39



HEATER

FIN43182A4

Copyright Free Under CC BY Licence

Symbols using Line (Fig 40 to Fig 46)

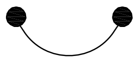
Fig 40

WORKING LINE

Fig 41

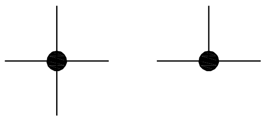
DRAIN OR BLEED LINE

Fig 42



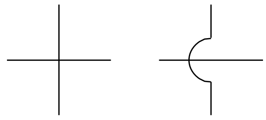
FLEXIBLE PIPE FLEXIBLE HOSE

Fig 43



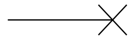
PIPELINE JUNCTION

Fig 44



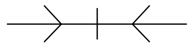
CROSSED PIPELINES

Fig 45



PLUGGED ON EQUIPMENT OR LINES

Fig 46



QUICK-ACTING COUPLING

Hydrolic oil Functions and properties

The primary function of a hydraulic fluid is to convey power. In use, however, there are other important funtions of hydraulic fluid such as protection of the hydraulic machine components. The table below lists the major functions of a hydraulic fluid and the properties of a fluid that affect its ability to perform that function:

Function	Property
Medium for power transfer and control	Non compressible (high bulk modulus) Fast air release Low foaming tendency Low volatility
Medium for heat transfer	Good thermal capacity and conductivity
Sealing Medium	Adequate viscosity and viscosity index Shear stability
Lubricant	Viscosity for flim maintenance Low temperature fluidity Thermal and oxidative stability Hydrolytic stability / water tolerance Cleanliness and filterability Demulsibility Antiwear characteristics Corrosion control
Pump effciency	Proper viscosity to minimize internal leakage High viscosity index

Copyright Free Under CC BY Licence

Special function	Fire resistance Frction modifications Radiation resistance
Environmenal impact	Low toxicity when new or decomposed Biodegradability
Functioning life	Material compatibility

Types of Hydraulic fluids

According to ISO there are three different types of fluids according to their source of availability and purpose of use.

Mineral- Oil based Hydraulic fluids

As these have a mineral oil base, so they are named as Mineral- Oil-Based Hydraulic fluids. This kind of fluids will have high performance at lower cost. These mineral oils are further classified as HH, HL and HM fluids.

Type HH fluids are refined mineral oil fluids which do not have any additives. These fluids are able to transfer power but have less properties of lubrication and unable to withstand high temperature. These types of fluid have a limited usage in industries. Some of the uses are manually used jacks and pumps, low pressure hydraulic system etc.

The HL fluids are refined mineral oils which contain oxidants and rust inhibitors which help the system to be protected from chemical attack and water contamination. These fluids are mainly used in piston pump applications.

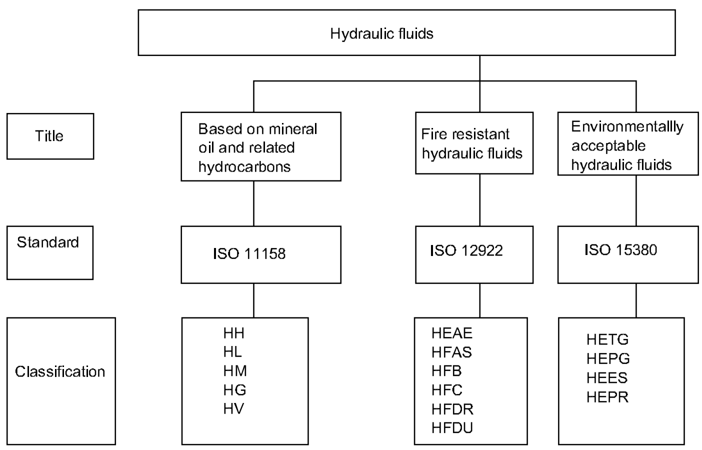
HM is a version of HL- type fluids which have improved anti- wear additives. These fluids use phosphorus, zinc and sulphur components to get their anti-wear properties. These are the fluids mainly used in the high pressure hydraulic system.

Fire Resistant Fluids

These fluids generate less heat when burnt than those of mineral oil based fluids. As the name suggests these fluids are mainly used in industries where there are chances of the hazards, such as foundries, military, die-casting and basic metal industy. These fluids are made of lower BTU (Brithish Thermal Unit) compared to those of mineral oil based fluids, such as water-glycol, phosphate ester and polyol esters. ISO have classified these fluids as HFAE (soluble oils), HFAS (high water-based fluids),HFB(invert emulsions), HFC(water glycols), HFDR(phosphate ester) and HRDU (polyol esters).

Environmental Acceptable Hydraulic Fluids (EAHF)

These fluids are basically used in the application where there is a risk of leakage or spills into the environment, which may cause some damage to the environment. These fluids are not harmful to the aquatic creatures and they are biodegradable. These fluids are used in forestry, lawn equipment, off - shore drilling, dams and maritime industries. The ISO have classified these fluids as HETG (based on natural vegetable oils), HEES (based on synthetic esters), HEPG (polyglycol fluids) and HEPR (polyalphaolefin types).



Copyright Free Under CC BY Licence

Controlling of Contamination

While the fluid is at operating temperature, completely drain the system. paying attention to the reservoir, all lines, cylinders, accumulators, filter housings or any area of fluid accumlation. Also, replace the filters.

With a lint-free rag, clean the reservoir of all sludge and deposits. Make sure the entire reservoir is free of any soft or loosened paint.

Flush the system with a lower viscosity fluid that is similar to the fluid to be used. A Reynolds number between 2,000 and 4,000 should be selected to achieve enough turbulence to remove particles from the lines. Stroke valves frequently to ensure they are thoroughly flushed. The fluid should be filtered and the flushing should continue until reaching one level beyond the system's target cleanliness levels. For example,if the target is ISO 15/13/11, continue to flush the system until ISO 14/12/10 is reached.

Drain the flushing fluid as hot and as quickly as possible. Replace the filters and inspect/ clean the reservoir again.

Fill the system to approximately 75 percent with the fluid to be used. Bleed/vent the pump.If the pump has a pressure relief or bypass, it should be wide open. Run the pump for 15 seconds, then stop and let it sit for 45 seconds. Repeat this procedure a few times to prime the pump.

Run the pump for a minute with the bypass or pressure relief open. Stop the pump and let it sit for a minute. Close the bypass and permit the pump to operate loaded for no more than five minutes. Allow the relief valve to lift to confirm that it is flushed as well. Do not operate the actuators at this time. Stop the pump and let the system sit for about five minutes.

Start the pump and operate the actuators one at a time, allowing fluid to return to the reservoir before moving to the next actuator. After operating the final actuator, shut down the system. Keep an eye on the fluid level in the reservoir. If the level drops below 25 percent, add fluid and fill to 50 percent.

Refill the reservoir to 75 percent and run the system in five- minute intervals. At each shutdown, bleed the air from the system. Pay close attention to the system sounds to determine if the pump is cavitating.

Run the system for 30 minutes to bring it to normal operating temperature. shutdown the system and replace the filters. Inspect the reservoir for obvious signs of cross-contamination. If any indication of cross-contamination is present, drain and flush the system again.

After six hours of operation, shut down the system, replace the filters and sample and test the fluid.

The sampling frequency should be increased until you are confident that the system fluid is stable.

Contamination of oil and its control

Contamination in hydraulic systems can be classified into particle contaminants (Metal particles from wear,dirt ingression) or chemical contaminants (water, air ,heat, etc). Examples of damage from contamination are: accelerated component wear, orifice blockage, formation of rust or other oxidation, depletion of additives, formation of other chemicals, oil degradation.

Types of contamination

Particle contaminants

Particle sizes are generally measured in micrometers or microns. Some examples of microns: Grain of salt 100 microns, human hair 70 microns, lower limit of visibility 40 micron, milled flour 25 micron, average bacteria 2 micron. Note that most damage-causing particles in hydraulic or lubrication systems are smaller than 14 μm micrometers, so they cannot be seen.

Chemical contaminants

Water

The most common chemical contaminant in hydraulic systems is water. The presence of water in hydraulic oil can have wide- ranging effects on system components because of its effect on the physical and chemical properties of hydraulic oil. Rust in tanks, reduced lubrication characteristics resulting in accelerated metal surface wear are some of the most obvious physical results of excessive water, however the effects could be as diverse as the jamming of components due to ice crystals at low temperatures. Chemical effects include additive depletion or deposition, oxidation, unwanted reactions which can result in the formation of acids, alcohols or sludges. Oil becomes cloudy when it's contaminated with water above its saturation level. The saturation level is the amount of water that can dissolve in the oil's molecular chemistry and is typically 200 to 300 ppm at 20° C for mineral hydraulic oil. SKF state that hydraulic oil containing just 0.1% water by volume cuts bearing life in half, while 1% reduces bearing life by 75%

Air

Air in hydraulic system can exist in either a dissolved or entrained (undissolved, or free) state. Dissolved air may not pose a problem, providing it stays in solution. When a liquid contains undissolved air, problems can occur as it passes through system components. There can be pressure changes that compress the air and produce a large amount of heat in small air bubbles. This compressibility of air means that control of the system is lost. Air bubbles and frothing in the oil reservoir can cause major damage to pumps or it can also cause oil to "boil" out of the tank.

Heat

Excessive heat in hydraulic systems can also result in additive depletion or chemical changes to the oil.

Copyright Free Under CC BY Licence

Hydraulics filter

Objectives: At the end of this lesson you shall be able to:
- **explain hydraulic filters**
- **list the types of filters**
- **state the difference between mechanical, absorbent, adsorbent and magnetic filter.**

Filter

Filter is a device which removes solid contaminants from the fluid.

Hydraulic filters are available in several shapes, sizes, micron ratings and construction materials. Hydraulic filters provide in built protection and minimize hydraulic system breakdowns that are quite often caused by contamination.

The life of a filter in a hydraulic system depends primarily on the system pressure, level of contamination and nature of contaminants.

Filters is a very important components used in hydraulic system for the reliable functioning and long service life of the components.

Filter and Strainer are the two terms commonly used.

Use of Hydraulic Filters

One of the main cause of failure or poor functioning of a hydraulic system is contamination of hydraulic oil or fluid. Hydraulic filters are used for handling and removing contamination from hydraulic oil.

Contaminants of hydraulic fluid are broadly defined as any substance that impairs the proper functioning of the fluid.

Contaminants are classified as

- Solids
- Liquids
- Gaseous
- Bacteria
- Organic

Types of Filters

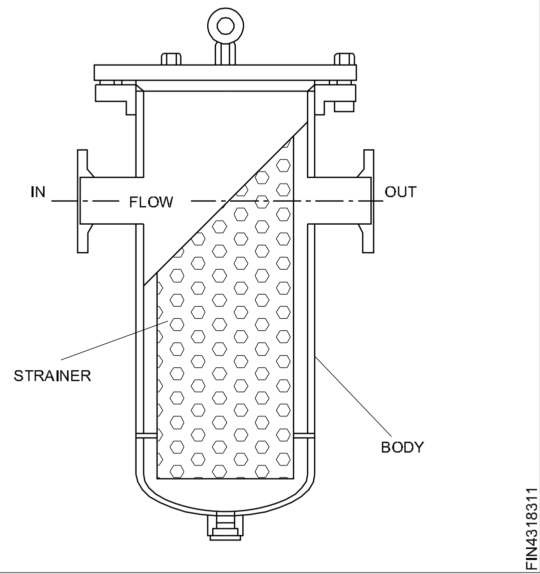
There are four types of filters generally used in hydraulic system.

- Mechanical filter
- Absorbent filter
- Adsorbent filter
- Magnetic filters

Mechanical filter

Mechanical filters contain closely woven metal screens or discs. They generally remove only fairly coarse particles. Mechanical filter is known as strainer in hydraulic system. These filters are located in the suction line of the pump, hydraulic oil is drawn from the reservoir through the filter. (Fig.1)

Fig 1



Grade of Mechanical filter: 60-100μm

μ**m** is the micron which is 1/1000 part of 1 mm.(ie)

1μ**m = .001 mm**

Absorbent filter

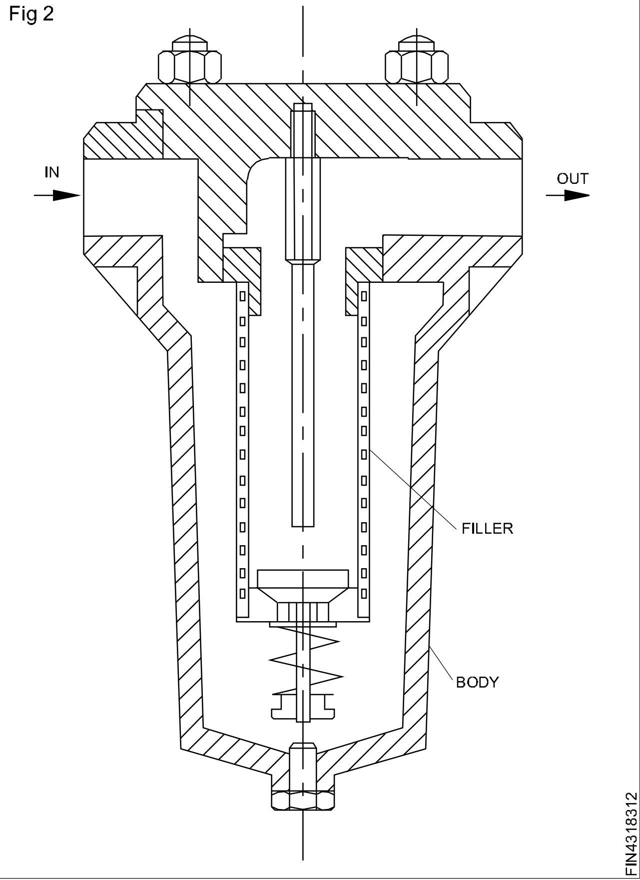
Absorbent filters, such as cotton, wood pulp, yarn, cloth, or resin, remove much smaller particles; some remove water and water-soluble contaminants. The elements often are treated to make them sticky to attract the contaminants found in hydraulic oil.

These filters are installed in the pressure line of a hydraulics system at the pressure port of the pump.

Since this filter is subjected to the maximum operating pressure, it must be of robust design. (Fig.2)

Copyright Free Under CC BY Licence

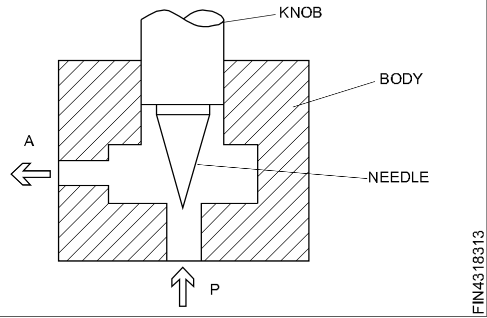
Fig 2



Adsorbent filter

A filter used for trapping various sizes of particulate matter. Adsorbent filters consist of clay, chemically treated paper and desiccant. (Fig.3)

Fig 3



Magnetic filter

Magnetic filters are basically used to remove the ferrous material from oil along with contaminants.

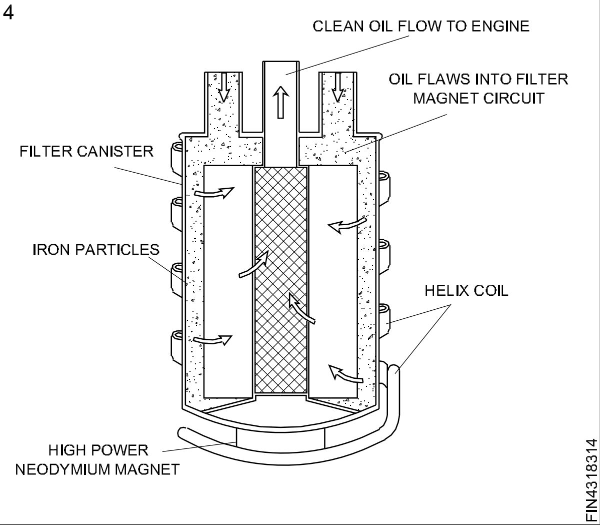
Magnet are geometrically arranged outside or inside the filter which produce a strong magnetic field that help to arrest the ferrous particles from oil.

In most of magnetic filter permanent magnet is used to create magnetic field.

These filters are commonly used in the automotive industry but are also utilized in a number of low-pressure industrial applications.

Filter is wrapped by magnetic ring which transmit a magnetic field through the steel filter bowl in order to trap ferromagnetic debris it is held tightly against the internal surface of the bowl which we can easily separate during servicing. (Fig.4)

Fig 4



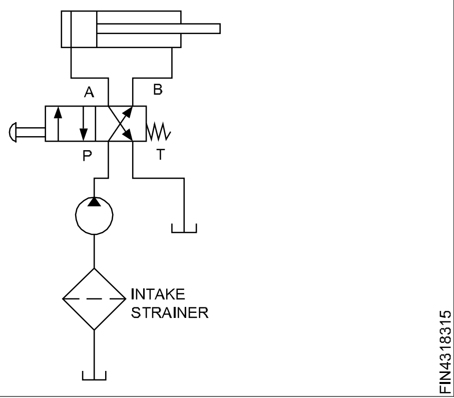
Generally filter can be classified on the basis of their location in hydraulic system:

- Suction stainer
- Pressure line filter
- Return line filter
- Off line filter

Filter types on the basis of location
Suction stainer

Suction filters serve to protect the pump from fluid contamination. They are located in the upstream of pump's inlet port. Inlet strainers are submersed in fluid in the tank. Suction filters have relatively coarse elements, due to cavitations limitations of pumps.(Fig.5)

Fig 5



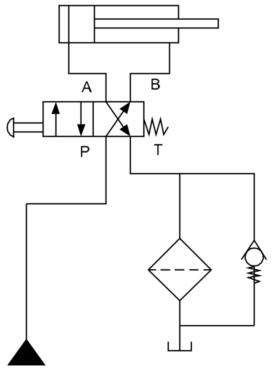
Return line filter

Return line filters may be the best choice if the pump is particularly sensitive to contamination. In most systems, the return filter is the last component through which fluid passes before entering the reservoir. Therefore, it captures wear debris from all of the system's working components and any particles that enter through worn cylinder rod seals before such contaminant can enter the reservoir and be pumped back into the system.

Copyright Free Under CC BY Licence

Because this filter is located immediately upstream from the reservoir, its pressure rating and cost can be relatively low. (Fig.6)

Fig 6

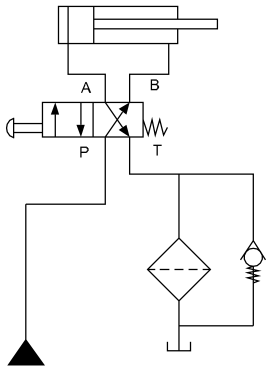


FIN4318316

Pressure line filter

Pressure filters are located downstream from the system pump. They are designed to handle the system pressure and are sized for the specific flow rate in the pressure line where they are located. Pressure filters are especially suited for protecting sensitive components, such as servo valves, because pressure filters are located just downstream from the pump, they also help to protect the entire system from any pump-generated contamination. (Fig.7)

Fig 7

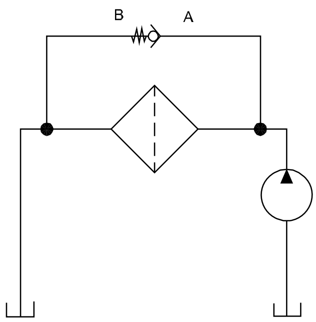


FIN4318317

Off line filter

An off-line filtration circuit includes its own pump and electric motor, a filter and the appropriate connecting hardware. These components are installed off-line as a small subsystem separate from the working lines, or they may be included in a fluid-cooling loop. Fluid is pumped continuously out of the reservoir, through the off-line filter and back to the reservoir (Fig 8).

Fig 8



FIN4318318

Hazard and safety precautions in hydraulic system

Objectives : At the end of this lesson you shall be able to

- **state the safety precaution while working with hydraulic fluids**
- **describe related hazards of hydraulic fluid**

Safety precautions

There are numerous hazards involved, like skin irritation, fires, explosions, environmental damage and a slippery workplace. But hydraulic fluids are required for many machines to function. Therefore it is necessary to follow certain precautions while using these fluids. With proper knowledge of these hazards, working with hydraulic fluid can be safe.

- In order to avoid skin irritations, it is necessary to wash contaminated skin immediately. It is also necessary to keep your clothing clean.
- Wearing masks and gloves while using hydraulic fluids is also helpful.
- To avoid environmental dangers,there is biodegradable hydraulic fluid option,though it is more expensive.
- To avoid fires,materials and fluids soaked in hydraulic fluid should be stored in sealed metal containers and disposed of at proper places.
- To check for leaks, use cardboard.
- Never use hands or fingers to search for hydraulic leaks.
- Maintain a clean work area free of slipping hazards.
- Use chemical resistant gloves, splash goggles and a chemical resistant apron to avoid prolonged or repeated skin or eye contact.
- Never begin work on a hydraulic system until fully trained.

Copyright Free Under CC BY Licence

Related hazards

Health problems while using hydraulic fluids

People can become exposed to the chemicals in hydraulic fluids. The exposure to chemicals may be due to inhalation, ingestion or touch. There are instances of people suffering from skin irritation or weakness in hands while handling hydraulic fluids. There are also cases of intestinal bleeding, pneumonia or death through hydraulic fluid ingestion though no serious hazards are reported with hydraulic fluid inhalation.

Similar to ingestion, fluids can be accidentally injected into the skin as well. This takes place when the high pressure hydraulic system hose is disconnected and toxic fluids are leaked and injected into the skin. If there is a small leak in the hydraulic pipe and someone runs there hand along it, at 2000 psi, they can easily incur an injection of hydraulic fluid and may not even be aware that it happened until gangrene begins to set in.

Fire dangers associated with hydraulic fluids

When working with hydraulic fluid, there is every chance that the hydraulic fluid gets heated to high temperatures. And it is evident that most petroleum - based hydraulic fluids will burn and thereby create explosions and burns.

Environmental problems related to hydraulic fluids

Another hazard of hydraulic fluid is that when the hydraulic hose or pipe leaks, the chemicals of the fluids can either stay on top of the soil or sink into the ground. If the chemicals get mixed in a water body, they will sink to the bottom. In fact in such cases the chemicals can stay there for more than a year. Aquatic life can absorb the toxic hydraulic fluid, leading to illness or death to the animal or anything higher on the food chain. For example, a hawk that eats a fish that has been contaminated by hydraulic fluid that was mixed in water could become ill as well.

Fluid texture problems

Although the slimy texture of hydraulic fluids may not seem like a danger or a problem, a spill can cause a person to slip and fall. Also when there is fluid on the hands of a person, it can cause him to slip while climbing on a machine. It can also cause the operator to lose steering control.

Injuries from loose hydraulic hoses

Due to high pressure with in a hydraulic system, the impact force of a disconnected and flailing hydraulic hose can cause abrasions, temporary unconsciousness, bruise, fractures and laserations. Proper maintenance and good pre - shift equipment inspections can minimise these hazards

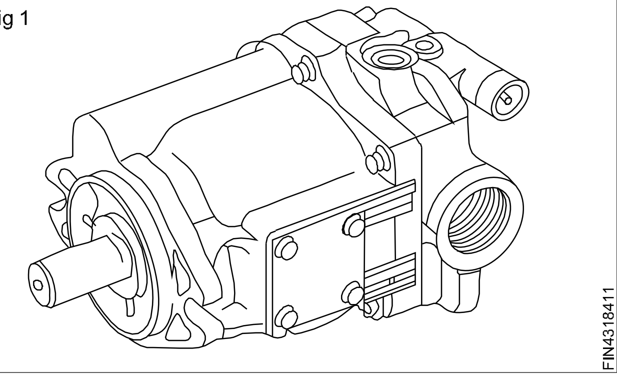
Copyright Free Under CC BY Licence

Hydraulic pumps

Objectives : At the end of this lesson you shall be able to
- **define hydraulic pump**
- **differentiate between positive and non-positive displacement pump**
- **explain working of gear pump**
- **explain the working of vane pump**
- **explain the working of piston pump.**

A hydraulic pump fig.1 is a device which converts mechanical force and motion into hydraulic energy. Many different sources provide mechanical power to the pump. They are electric motors, air motors, engines and manual operation.

Fig 1



Classification of pumps

Pumps are classified as either non-positive or positive displacement. This describes the fundamental division of pumps.

Non-positive displacement pumps

- The non-positive displacement type pump gives continuous discharge.
- The non-positive displacement pump does not provide a good seal against slippage, causing pump output to vary as the system pressure changes.
- The volume of fluid delivered during each cycle will depend on resistance to flow in the system.
- Centrifugal pumps are the Non-positive displacement pumps.(Fig.2)

Positive displacement pumps (Fig. 3)

- A positive displacement pump provides positive internal seal against slippage.
- This type of pump is capable of delivering a definite volume of fluid for each cycle of pump operation.
- Closing the outlet of a positive displacement pump causes an instantaneous increase of pressure. This increase in pressure can stall the equipment or break up of components.
- Gear pump is an example of positive displacement pump.

Fig 2

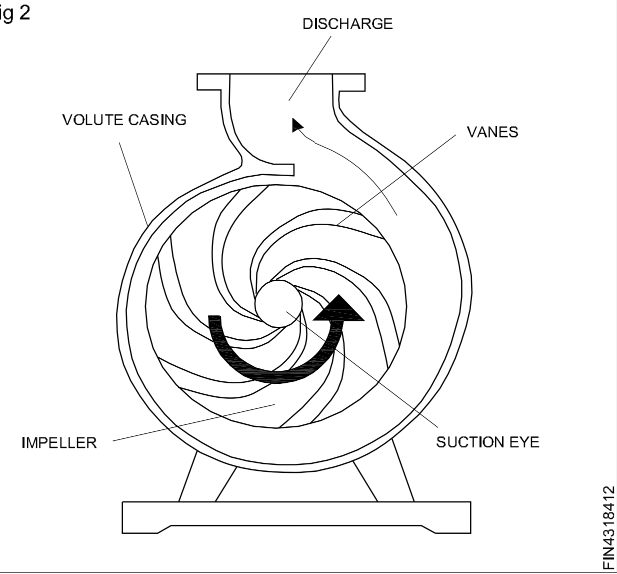
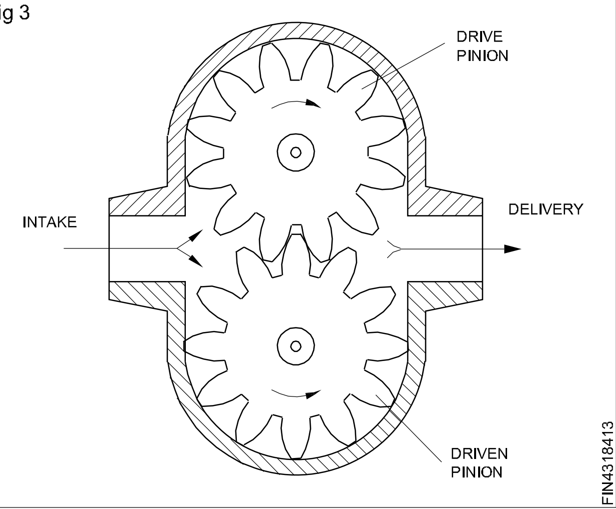


Fig 3



Types of Hydraulic pumps(Fig. 4)

External Gear pump

External gear pump is the most common type rotary pump. In this pump the drive gear is turned by a drive shaft, which engages the power source. The inlet port is connected to the supply line and the outlet is connected to the pressure line. (Fig.5)

As gears rotate the volume of area on the inlet increases, thereby decreasing the pressure and making it possible for the atmospheric pressure exerted on the surface of

Copyright Free Under CC BY Licence

Fig 4

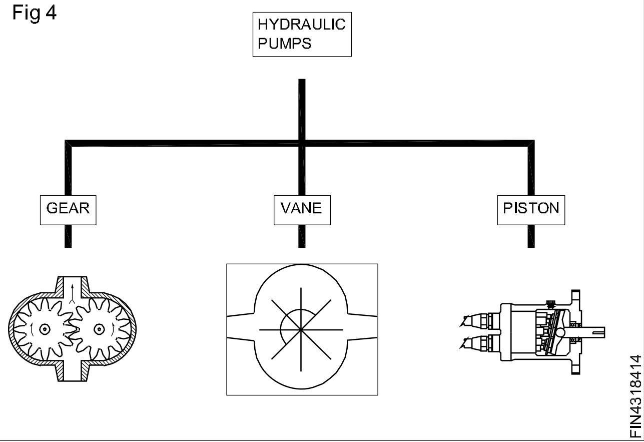
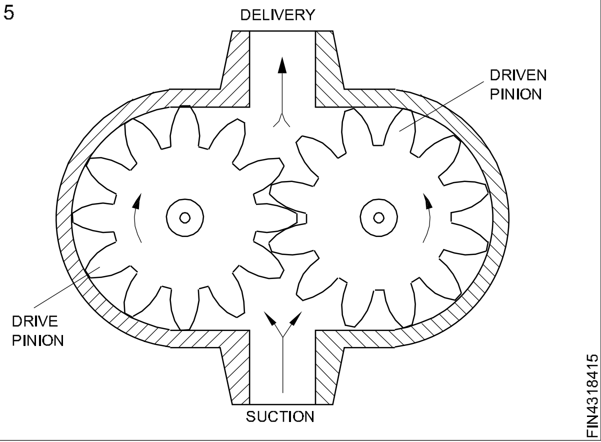


Fig 5



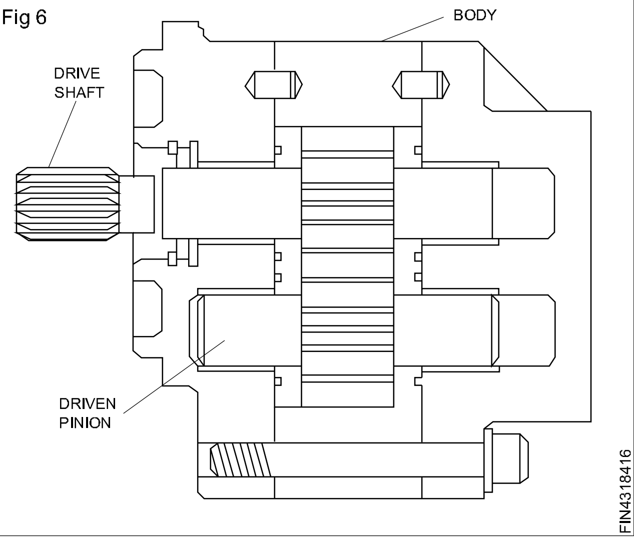
the liquid in the reservoir to push the liquid into the inlet port. This causes liquid to be trapped in the gear space as the gears rotate and to be carried from the inlet port to the discharge port.

This action produces flow of liquid into the system.

A tighter seal against slippage can be accomplished by a metallic contact between the teeth ensures the seal against slippage. (Fig.6)

Important parameters

Fig 6



- Displacements volume 0.2 to 200 Cm^3/rev
- Suitable for pressure up to 300 bar
- Fixed displacement only
- Generally noisy
- Compact and low weight
- Low cost

Gear pump applications

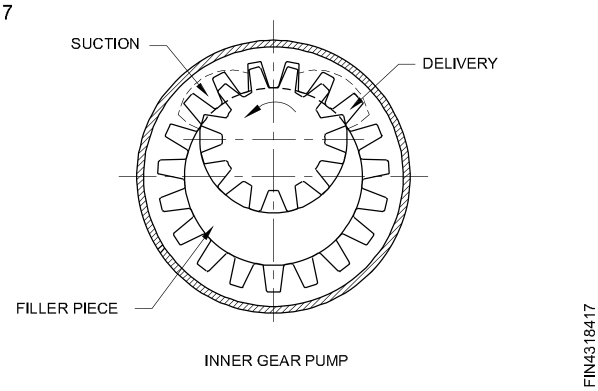
Gear pump is generally used to transfer lubricating oil in industrial & automobile application. Some time it is also used in some hydraulics power application.

Internal gear pump

Two gears are available in internal gear pump. The spur gear is mounted inside a large ring gear (outer gear). The smaller spur gear is in mesh with one side of the larger gear and kept apart by a crescent-shaped separator on the other side. The crescent-shaped separator isolates the inlet port from the outlet port. In the internal gear pump, both gears rotate in the same direction. (Fig.7)

As the gear teeth un-mesh, a partial vacuum is created

Fig 7



on the inlet side. Atmospheric pressure forces liquid into the space created, and with the rotation of the gears, liquid is carried around the periphery of the gears and the crescent-shaped separator until it reaches the outlet port. A continuous flow of liquid is pushed out through the outlet port.

Important parameters

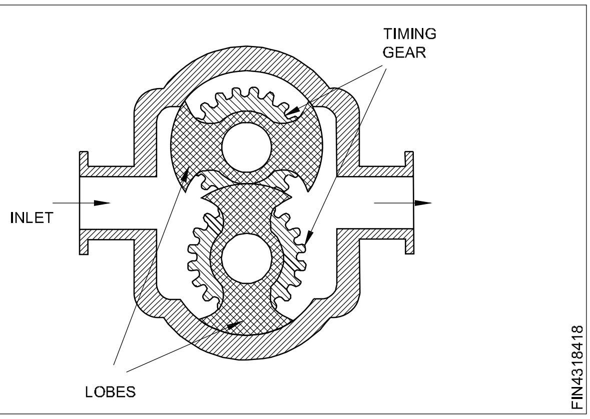
- Internal gear pumps are suitable for pressure up to 3500 psi.
- Working a wide viscosity range up to 2200 cSt, depending on flow rate.
- Generally quiet.
- Internal gear pumps have a high efficiency even at low fluid viscosity.

Copyright Free Under CC BY Licence

Lobe pump

Lobe pump is a multiple rotor type of pump and the rotor utilizes a lobe shaped design. The working is similar to the external gear pump except that unlike gears, the lobes do not directly make contact with each other. The relative motion is synchronized by means of timing gear and therefore the internal contact between the lobes is a sealing contact and not a driving contact. (Fig. 8)

Fig 8



The suction and discharge of the pump is primarily decided by the direction of rotation of the lobes. Let us look into the internal of the pump and its operation.

At the suction side, as the lobes come out of mesh, liquid flows into the pump. The liquid is further carried in the space between the lobe and the casing to the discharge side of the pump. Towards the discharge side the lobes come back into mesh and the liquid is forced out the discharge port.

Since the lobes do not directly mate, lobe pumps are suitable for handling liquid with suspended solids. However this feature reduces its performance especially while handling low viscosity fluids. As the pump has a clean internal surface with few crevices the pump can be used for hygiene related application.

Vane Pump

Vane pump is very common type of pump. The vanes pump having slots in the rotor. When the rotor spins, centrifugal force pushes the vanes out to touch the casing, where they trap and propel fluid. Springs are use to push the vanes outward. When the vanes reach the delivery side they are pushed back into the rotor by the casing. Fluid escapes through a channel or groove of the casing. In this vane pump there is considerable unbalanced force is acting on the drive shaft because high-pressure area is available on outlet side. (Fig.9)

The inlet port is located in that part of the pump where the chambers expand in size so a partial vacuum is formed to allow liquid to flow into the pump. The liquid is trapped between the vanes and is carried to the outlet side of the pump. The chambers at the outlet side contract in size, and this action forces liquid through the outlet port into the system. (Fig.10)

Fig 9

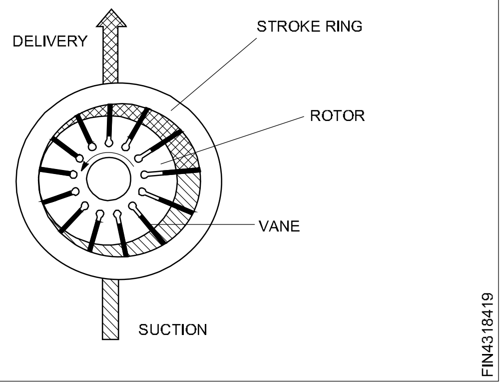
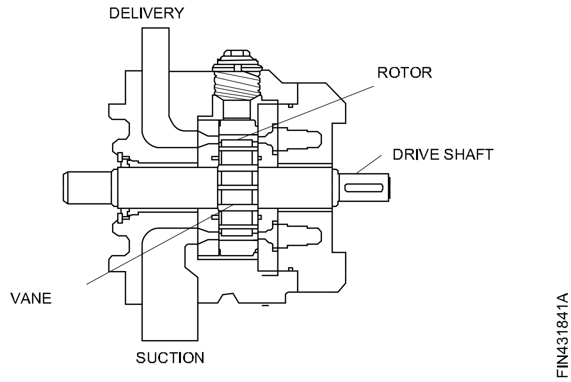


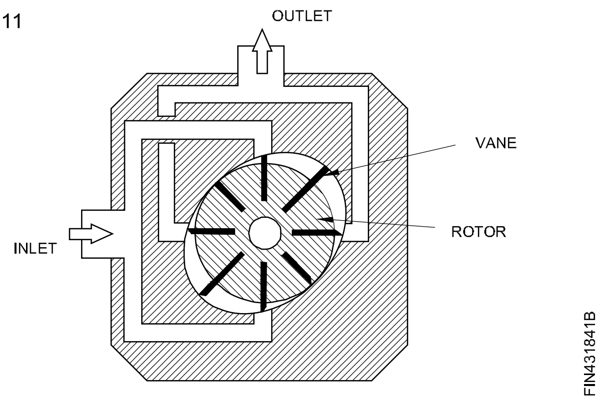
Fig 10



Balance Vane pump

This design results in two pressure cycles per revolution. The two outlet ports are spaced 180° apart so that the pressure forces on the rotor are balanced. These pumps can develop much higher pressures at high rotational speeds. (Fig.11)

Fig 11



Vane pump characteristics

- Typical use for higher flow application.
- Typical pressures upto 160 bar
- Simple multiple assemblies
- Range of pump controls
- Low noise

Vane pump applications

Vane pump is used for higher discharge & low pressure application. It is used to transfer lubricating oil in industry & also used in medium machine tools and presses.

Copyright Free Under CC BY Licence

Piston pump

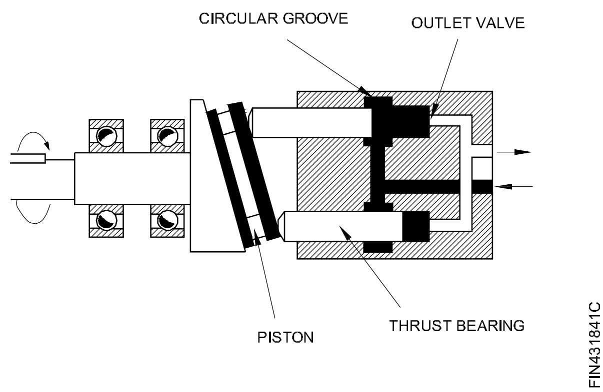
Piston pump is a common pump used for high pressure application. Following three types of pump are come in this category:-

- Axial piston pump
- Bent axis piston pump
- Radial piston pump

Axial piston pump

In the axial piston pump the block and the piston rotates on a shaft in such a way that the piston reciprocates in their cylinders bores, axially. This motion is called axial motion. The pumping action is made possible by a universal joint or a link and a swash plate. (Fig.12)

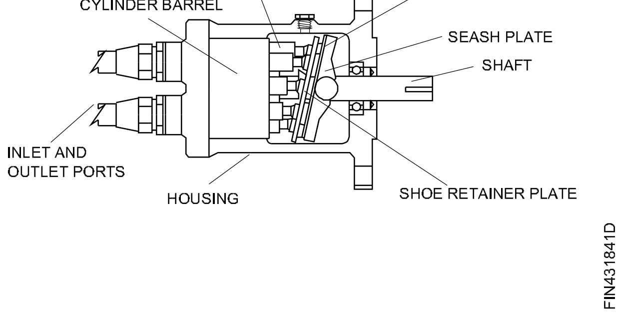
Fig 12



The main parts of the pump are the drive shaft, pistons, cylinder block, and the swash plate. Atmospheric pressure forces liquid in one port; and it is forced out the other port by the reciprocating action of the pistons.

A fill port is located in the top of the cylinder housing. The opening is normally plugged but it can be opened for testing pressure in the housing or case. If a new or repaired pump is installed, this plug must be removed and the housing filled with the recommended fluid. (Fig.13)

Fig 13



As the drive shaft rotates, it rotates the cylinder block and the pistons. The offset position of swash plate in pump block causes the pistons to move back and forth in the cylinder block. The shaft, pistons and cylinder block rotate together.

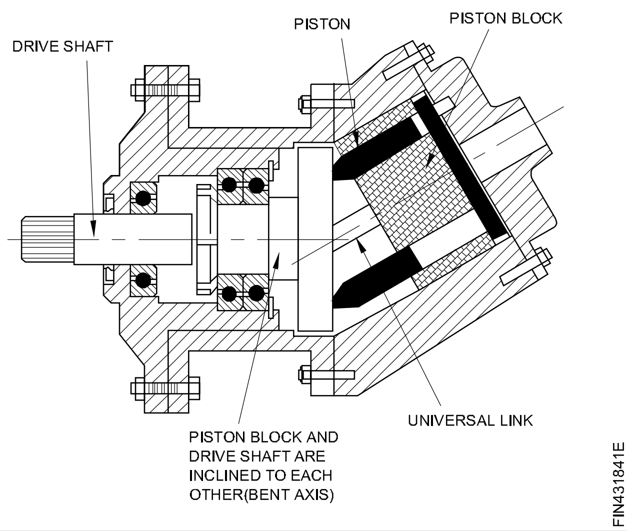
As the pistons reciprocate in the cylinder block, liquid enters through one port and is forced out through the other. This action provides a steady, non-pulsating flow of liquid.

Pumping action depends upon tilt angle of the swash plate. If there is no tilt; there is no pumping action.

Bent axis piston pump

Like the swash plate pump, this pump is also of the axial piston type. There are several pistons those are parallel to each other and reciprocate axially in a piston-block. However unlike the swash plate pump, the drive shaft is inclined at an angle to the piston-block and hence the termed bent axis (Fig 14).

Fig 14



There are several piston housing within slots in the piston-block and they are connected to the drive shaft-flange. A universal link key the piston-block to the drive shaft to maintain alignment and to assure that they rotate together.

As the drive shaft rotates, it transmits drive to the pistons and piston-block. At the suction side, along the direction of rotation between the piston-block and drive shaft-flange distance increases and the piston are pulled out, thus resulting induction. Alternately, the pistons are pushed in as they pass along the discharge port, thus resulting in discharge. This reciprocating of the piston as the drive shaft rotates result in the pumping of the liquid.

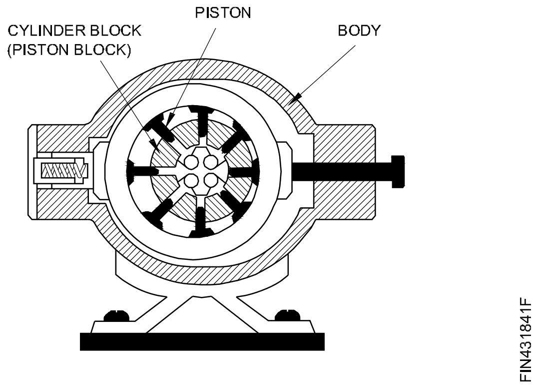
Radial piston pump

A typical picture of a radial piston pump is illustrated. The pump has several pistons those are uniformly

Copyright Free Under CC BY Licence

spaced and housed radially in a cylinder block (Piston-block). The pistons reciprocate in radial direction to the cylinder- block axis and hence the term radial piston pump.(Fig.15)

Fig 15



The drive shaft transmits drive torque to the piston-block by means of a cross-disc coupling. The piston-block rotates around a pintle, which has ducts routed to inlet and outlet connections behind the pump. There are several piston arranged radially inside slots in the piston-block, which against a stroke ring through slipper pads. The piston is connected to the slipper pad by means of a ball and socket joint and the slipper pad is guided in the stoke ring by means of two overlapping rings. The stoke ring is eccentrically located with respect to the piston-block.

When the piston block is rotated, the pistons are forced against the stoke ring by centrifugal force and hydrostatic pressure. Sometime springs are also used for this purpose. Since the stoke ring is eccentric to the piston-block, in one half of the rotation the piston move away from the piston-block. Thus liquid is drawn through inlet port in the pintle into slots in the piston-block. In the other half of the rotation, the piston move into the piston-block, thus forcefully discharge liquid trapped in the slots, into outlet ports in the pintle. If the eccentricity increases the stoke length also increases and it amounts to twice the eccentricity.

Important parameters

Piston pump applications:

Piston pump are commonly used for high pressure and low discharge application.

- Displacements to 750 cm^3/r
- Pressure capabilities to 350/400 bar
- High noise level
- Sensitive to poor inlet conditions & contamination
- High overall efficiency
- Good life expectancy
- Large, bulky units
- High cost.

Piston pump applications

Piston pump are commonly used for high pressure and low discharge application.

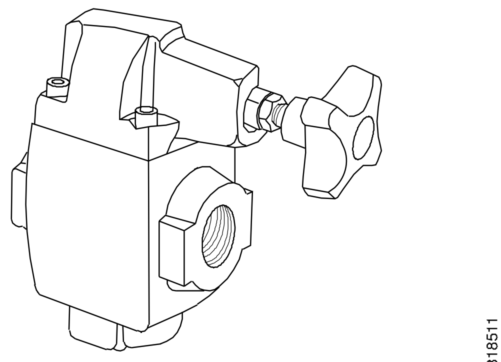
Copyright Free Under CC BY Licence

Pressure relief valve

Objectives: At the end of this lesson you shall be able to
- **identify different parts of a pressure relief valve**
- **explain the functional features of a different parts of a pressure relief valve**
- **explain the constructional features of a pressure relief valve.**

The general outlook of a pressure relief valve is shown in (Fig 1). Knob is the main controlling element from outside.

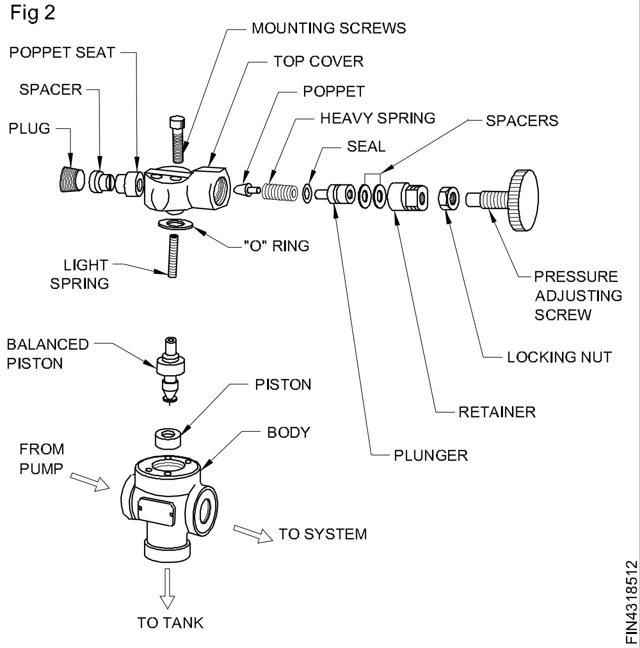
Fig 1



PILOT OPERATED PRESSURE - RELIEF VALVE

The following are main parts (Fig 2) of a pilot operated relief valve:

Fig 2



Body	Poppet
Top cover	Poppet seat
Piston	Heavy spring
Light spring	Adjusting screw
Piston seat	

Body

Body of the valve is a fine grade cast iron. The inside of the casting is accurately machined to accommodate piston, piston seat and tight spring. Body is fixed with top cover by screws. Ports for inlet outlet and drain connections are provided in the body, as threaded holes. The body accommodates the main relieving mechanism.

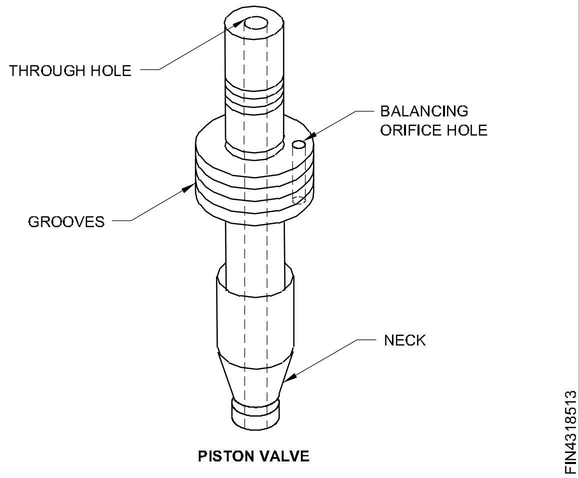
Top cover

The top cover is also a fine grade casting. It is machined inside to accommodate - poppet, heavy spring, adjusting screws, seals and vent plug. The top cover is fixed with the body by means of screws. The top cover houses the pilot operating mechanism, by means of the stated elements.

Piston

It is the main relieving valve element in the body. It is made of wear resistant steel, hardened and ground. The sliding portions of the valve are provided with shallow grooves. These groove retain oil, to give oil film for lubrication. There is a through hole at the center of the valve piston. (Fig 3) There is an orifice hole on a flat side of large diameter. The purpose of through hole is to relieve oil at the time of cracking. The orifice hole fill up the area above piston from the inlet pressure area to balance the piston.

Fig 3



PISTON VALVE

The bottom of the valve is tapered to have a cone seating in closed condition. Piston is accommodated in the body.

Copyright Free Under CC BY Licence

Light spring

The purpose of light spring is to retain the piston down against the seat in a balanced condition. It is accommodated in between the large diameter of the piston and body portion around the upper stem of the piston. This spring is not adjustable one, for its tension.

Piston seat

It is a liner bush tightly fixed in the body. It is made of wear-resistant steel, hardened and ground. The inner side of the bush has a taper to seat the tapered portion of the piston valve.

Poppet

Poppet is a conical member housed in the top cover. Poppet serves as a pilot valve. It is held in position by a heavy spring. It is also made of a wear resistant steel with a fine conical ground surface.

This conical seat will have perfect sealing against oil from pilot port. Poppet is retained by a heavy spring.

Poppet seat

It is a seat for the poppet valve. It has got a conical seat within to match the tapered surface of a poppet. It is a hardened ground and rigidly fixed inside the top-cover by press-fit.

Heavy spring

This spring has to seat the poppet in the pilot port.

This spring is housed in between a plunger and maximum diameter of the poppet. When the force exerted by the oil at pilot port is more, the heavy spring lift off the poppet, to relive oil. The tension of spring is adjustable by means of knob.

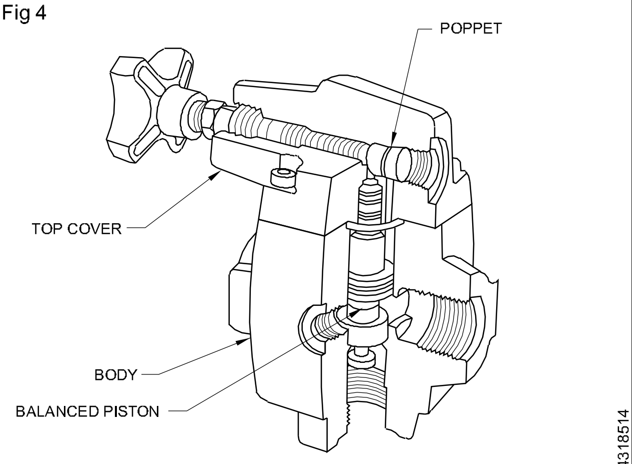
Adjusting screw

Adjustable screw is a fine pitched screw along with knob accommodated in the top cover. The matching thread for this screw is provided by the retainer rigidly fixed in the body, by a locking nut. Spacers are used in initial setting to adjust the tension of spring.

Leakage between the cast bodies and screw end are prevented by suitable seals made of heat and oil resistant rubber. Plug is used to dummy the port.

The complete assembly of all parts in a pilot operated relief valve is shown in Fig 4 by a cross-sectional view.

Fig 4



CROSS - SECTION VIEW OF A PILOT OPERATED PRESSURE RELIEF VALVE

Copyright Free Under CC BY Licence

Tube and pipe assembly

Objective: At the end of this lesson you shall be able to
- **state the various types of tubes and pipes fitting in an hydraulic system**

Tubings in hydraulic system

In any hydraulic system the fluid should pass from one element to the other without breaking. For this purpose tubing is employed. Tubes act as a leakproof carrier for hydraulic fluid from and to the various elements used in the hydraulic circuits.

These pipes/tubes should be capable of withstanding pressure and also temperature. Thus the pipes also act as a area where the fluid dissipates the heat.

Normally the term tube and pipe is always leading to a confusion. What is the exact definition of a tube?

Difference between a tube and pipe

The difference between a pipe and tube is very narrow. Tube walls are usually thin contrary to the pipe walls which are thicker.

Tube generally is seamless in its design, whereas pipe may beveled.

Tubes, because of its thin wall cannot be threaded, whereas pipes can be threaded without affecting the strength.

Both tube and pipe are available in steel, but tubes are available in copper, brass, steel and also in plastic.

Bending of tubes are relatively easier compared to pipes, so tube have better flexibility over the pipes.

A main difference of the tube to a pipe is the inner wall of a tube is smooth, so as to provide a smooth flow of liquid resulting in a LAMINAR flow, which usually is a turbulent flow in a pipe, having not such a smoother inner side.

But generally even now in workplaces, both pipes and tubes are mentioned not precisely.

Tube material

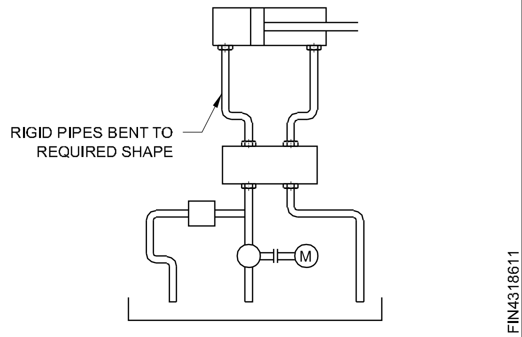
Tubes are usually specified by their outside diameter and the length. Usually the length is made to customer requirement by cutting the tubes. Tubes are available in various materials such as copper, brass, aluminium, carbon steel and stainless steel. All tubes are usually seamless drawn tubes.

Classification of pipe fitting in hydraulics

Tube/pipe fitting in hydraulics is usually classified as

- Rigid connections
- Flexible connection.

Fig 1



Rigid connections

Rigid tubing in done using metallic tubes. The tube is bent to the required length and shape and the various elements of the circuit is connected. (Fig. 1)

This type of connection is done where the circuit only built will not have any change in design or change in the position of the elements in future.

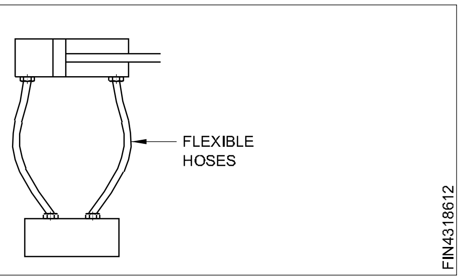
If there is a change then the existing pipes have to be disconnected and new pipes have to be bent fresh.

Flexible connection

This is a system in which the elements are connected with flexible tubes normally called as hoses. Flexible hoses are made of synthetic rubber tube reinforced with one or two braids of high tensile steel wire or with synthetic yarn suitably covered with weather resistant rubber. (Fig. 2)

Flexible hoses are very good in taking up pulsating pressure which is dampened by the hose itself. In case of rigid pipe this would have resulted in vibration ultimately causing breakage or loosening of connector.

Fig 2



Copyright Free Under CC BY Licence

Advantages of using hoses

- Insulates against shock noise and vibration
- Connects stationary parts
- Makes connection easier in congested space
- Makes good temporary connections
- Provides connections and disconnections which are to be frequently changed.

Types of flexible hoses

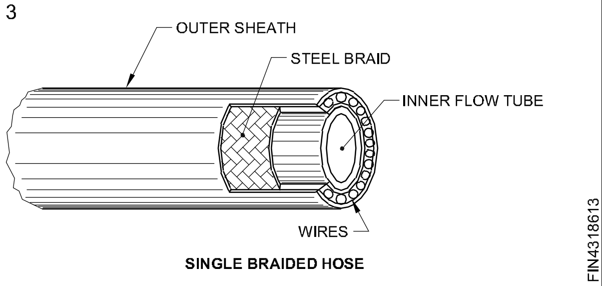
Flexible hoses again are available to cater various pressures and temperature ranges.

Hoses are usually classified according to the:

Type of construction

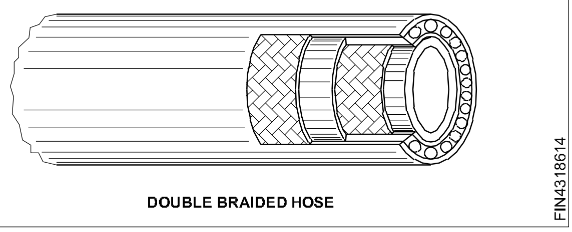
(a) Wire braided-single (Figs. 3 & 4) or double braid

Fig 3



SINGLE BRAIDED HOSE

Fig 4



DOUBLE BRAIDED HOSE

(b) Synthetic yarn braid (Cotton, fibre, asbestos etc).

Normally the flexibility of synthetic yarn braided hoses are more flexible but the operating pressure is a limitation.

Whereas wire braided hoses because of steel wire used is good in withstanding high pressures up to 300 cm^2 but is not as flexible as synthetic yarn braided hose.

Pressure and temperature withstanding capacity

Hoses are used in hydraulic circuits and are subjected to pressure from the oil flowing through it. So hoses are classified according to its pressure withstanding capacity also this is given by the specification standard SAEJ517 as SAE100R1, SAE100R2 etc.

The number R1, R2 indicates the withstanding capacity in pressure and temperature and the construction. This has to be noted while selecting the hoses keeping in mind the maximum pressure produced in the circuit under construction. For actual valves of pressure and temperature the manufacturers catalogue has to be referred.

Type of pipe end fitting

Since hoses are used in various applications and has to mounted to suit a variety of connectors, it is also available with various end fitting. There are many type of end fitting available as required by customer. Some of them shown in the Fig. 5.

Specification of hoses

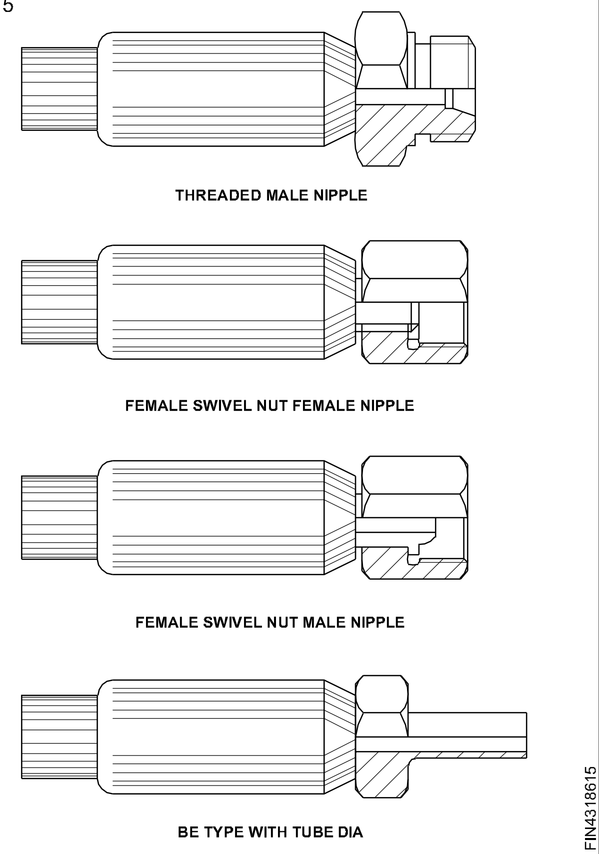
Flexible hoses are specified according to the following informations,

- Internal diameter
- Length between the two end connectors
- Pressure and temp withstanding capacity
- Type of end fitting.

All these can be readily referred from manufacturers catalogue for the specific application. An example is given below.

dia.10 x 1000 x SAE100R2 x both ends female nuts.

Fig 5



Connectors

Connectors are the elements which connects the tube ends to the body of the various hydraulic elements. Connectors also serve various other purposes like change in size of tube, change in direction of flow, restriction of flow etc. Connectors can be grouped according to various parameters.

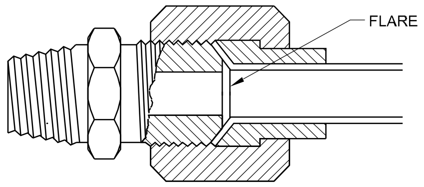
Copyright Free Under CC BY Licence

- According to the type of sealing design.
- According to the shape, size and purpose used for.

According to the type of sealing design

Flared fitting (Fig. 6)

Fig 6



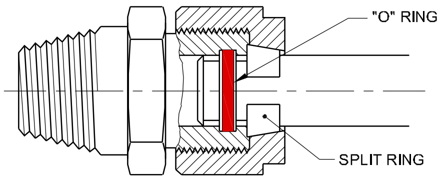
FLARE FITTING

In this, the pipe is flared and fitted to the suitable connector.

'O' ring compression fitting (Fig 7)

In this type of `O' ring seals the pipe outside diameter. The split ring clamps the pipe in position.

Fig 7

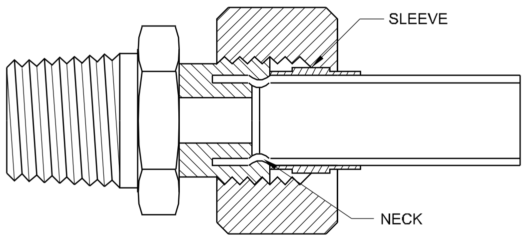


"O" RING COMPRESSION FITTING

Sleeve compression fitting (Fig 8)

In this the pipe is formed the neck seals the path for oil along with the sleeve.

Fig 8

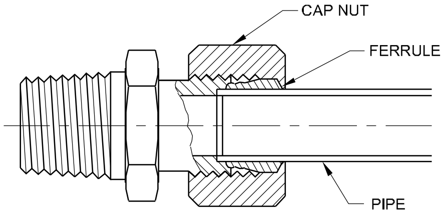


SLEEVE COMPRESSION FITTING

Ferrule compression fitting (Fig 9)

In this, the ferrule is of a special design, ferrule bites into the tube to form a permanent seal.

Fig 9



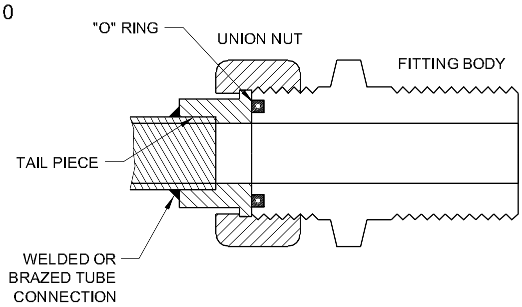
FERRULE COMPRESSION FITTING

O' ring fitting (Fig. 10)

The pipe is welded with a ring with a flat face, this face seals against a 'O' ring.

Various fitting have been illustrated, each of these fittings have the corresponding connectors. The connection will be perfect only when the connection is made according to the manufacturers instructions.

Fig 10



"O" RING FITTING

The selection of the right type of connector depend upon various factors like

- Working pressure of system
- Frequency of assembly and disassembly
- Vibration or shock level in circuit
- Working area.

According to the size, shape and purpose of use

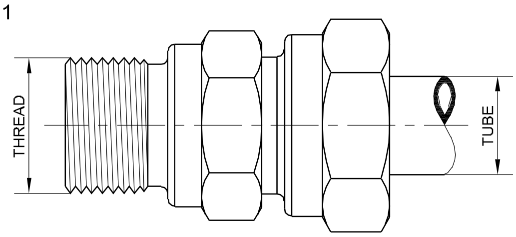
Connectors are used to connect either a tube to the body of a hydraulic element or a tube end to another tube end.

To connect a hydraulic element to a tube end

The connector shown (Fig 11) has threads which is screwed on to the body of the hydraulic element. On the other side a tube is fixed with proper sealing. This sealing is done by various methods as discussed in the previous exercise.

These connectors are available in various size according to the pipe it has to accommodate. The chart shows the pipe size and the threads on the connector.

Fig 11



Copyright Free Under CC BY Licence

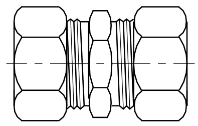
Pipe outsidedia	British standard pipe thread (BSP)	Metric Fine thread
6	R 1/4"	M22 x 1.5
8	R 1/4"	M14 x 1.5
10	R 3/8"	M16 x 1.5
12	R 3/8"	M18 x 1.5
14	R 1/2"	M20 x 1.5
16	R 1/2"	M22 x 1.5
20	R 3/4"	M27 x 2
25	R 1	M33 x 2
30	R 11/4"	M42 x 2
38	R 11/2"	M48 x 2

The various types of connectors in this category to take care of the flow direction of fluid as follows

Straight connector (Fig 12)

To connect tube perpendicular to the body.

Fig 12



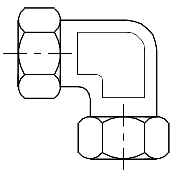
STRAIGHT CONNECTOR

FIN431861C

Elbow connector (Fig 13)

To connect the tube end parallel to the body of the hydraulic elements.

Fig 13



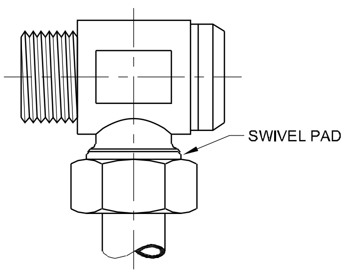
ELBOW CONNECTOR

FIN431861D

Banjo connector (Fig 14)

Banjo connector is similar to a elbow, but has the flexibility to turn 360 degree with the port axis. This helps in easy positioning of the pipe, with hydraulic elements.

Fig 14

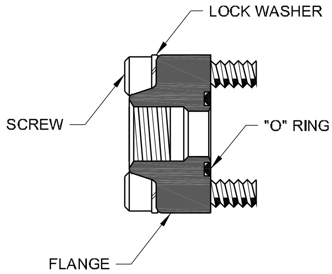


BANJO CONNECTOR

FIN431861E

Flange connection (Fig 15)

Fig 15



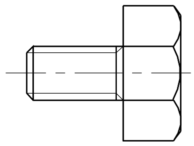
FLANGE CONNECTION

FIN431861F

Big size valves do not have threaded ports. They only have a hole as a port. In these case a flange is mounted on the body and the connector is mounted on the flange. This is also called as flush mounting.

Plug (Fig 16)

Fig 16



PLUG

FIN431861G

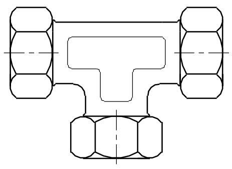
A plug is used to block any port of the hydraulic element.

To connect a tube end to another tube end

'T' connector (Fig 17)

Used to connect three pipe ends at a junction.

Fig 17



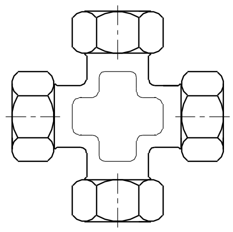
TEE CONNECTOR

FIN431861H

4 way connector (Fig 18)

Connect 4 pipe ends at a junction.

Fig 18



4 WAY CONNECTOR

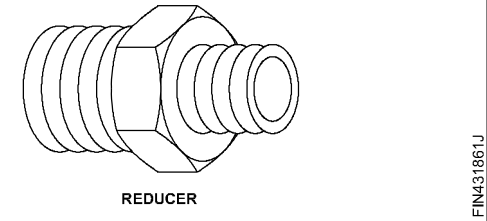
FIN431861I

Copyright Free Under CC BY Licence

Reducer (Fig 19)

Connect two pipe ends of different size.

Fig 19



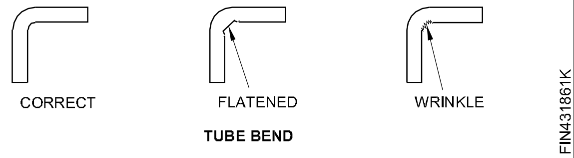
Do's and don'ts in tube/hose fitting:

Life of tube/hose fitting depends very much on how the fitting has been designed and installed.

In case of the rigid connections the following has to be observed:

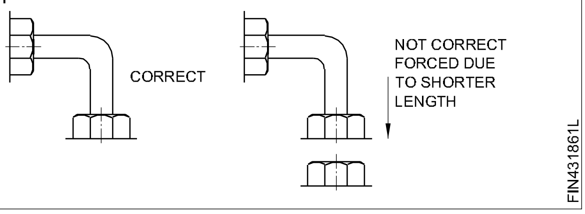
Tubes should be bent such that the bend has no flats or wrinkle at the bent corners. (Fig. 20)

Fig 20



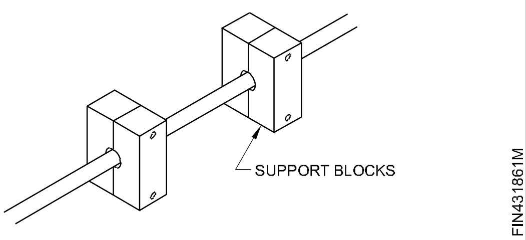
Tubes should be installed and removed without springing, bending or damaging the tubing. (Fig 21)

Fig 21



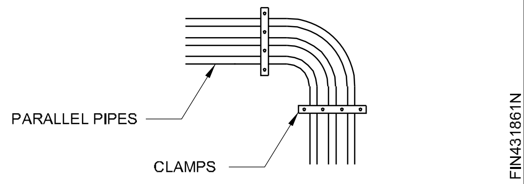
Support for tubes along the length if more than 1 meter long. (Fig 22)

Fig 22



- Use minimum number of connectors.
- Use minimum number of bends in tubing.
- Design pipe lines in a neat and straight way to make fixing and maintenance easy. (Fig 23)
- Use tubes and connectors according to the working pressure of the circuitry.
- Make sure tubes are kept clean and clear from chips dust etc. that enables to deduct apparent oil leakages.

Fig 23



Points to note while using flexible hose connections

- Flexible hoses are costly. Use of them has to be justified.
- Remember that the hose will change in length from +2% to +4% when pressurised. Provide slack or bend in the hose to compensate for any change in length which might occur. (Figs 24 and 26)

Fig 24

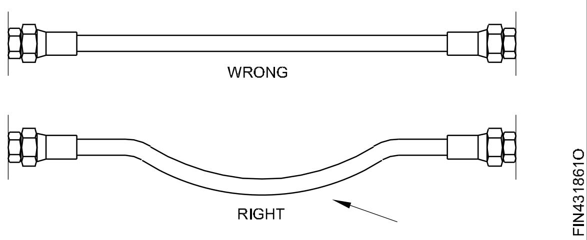
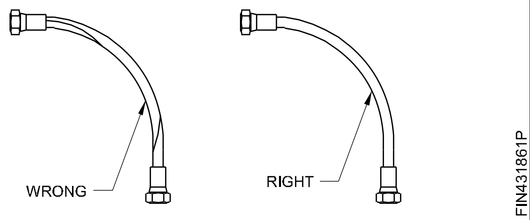
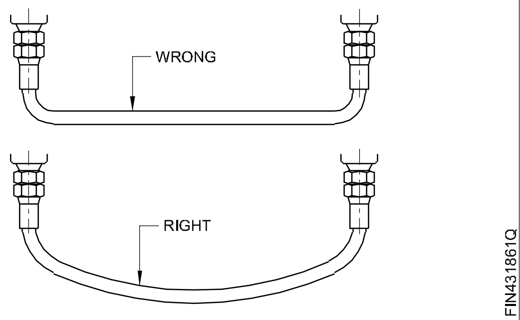


Fig 25



- If high operating pressures are applied to a twisted hose, the hose may fail or the attaching nut becomes loose.
- Keep the bend radii of the hose as large as possible to avoid collapsing of line and restriction of flow. (Figs 26 and Fig. 25)

Fig 26



- When hose lines pass close to a hot exhaust manifold protect the hose with a fire proof boot or metal baffle. (Fig. 27)
- Use elbows and adapters to ensure easier, cleaner installation for quick inspection and maintenance. (Fig. 29)

Copyright Free Under CC BY Licence

- When a hose assembly is to be subjected to considerable flexing or vibration remember that the metal hose fittings are not part of the flexible portion.(Figs 28, 29, 30)

Fig 27

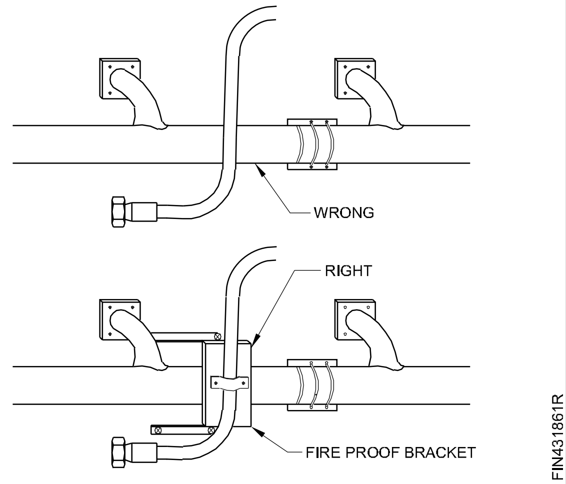


Fig 28

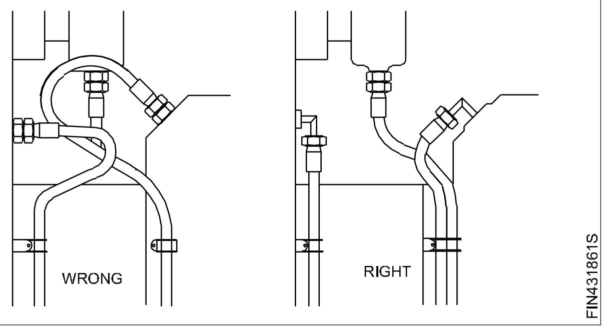


Fig 29

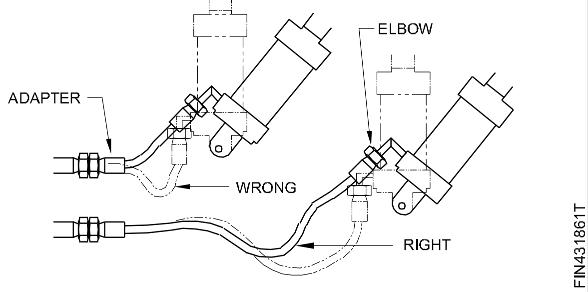
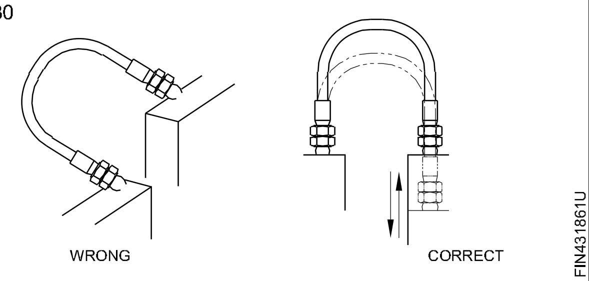
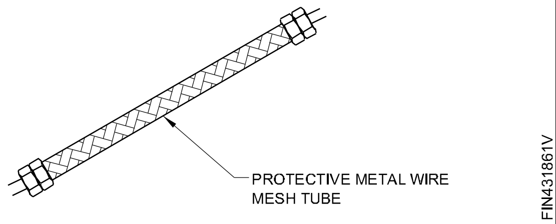


Fig 30



- Hose must be bent in the same plane as the motion of the part to which the hose is connected. (Figs 28, 29 and 30)
- Use metal wire mesh to cover the tube in areas where the hoses may come in contact with hot chips etc. (Fig. 31)

Fig 31



Copyright Free Under CC BY Licence