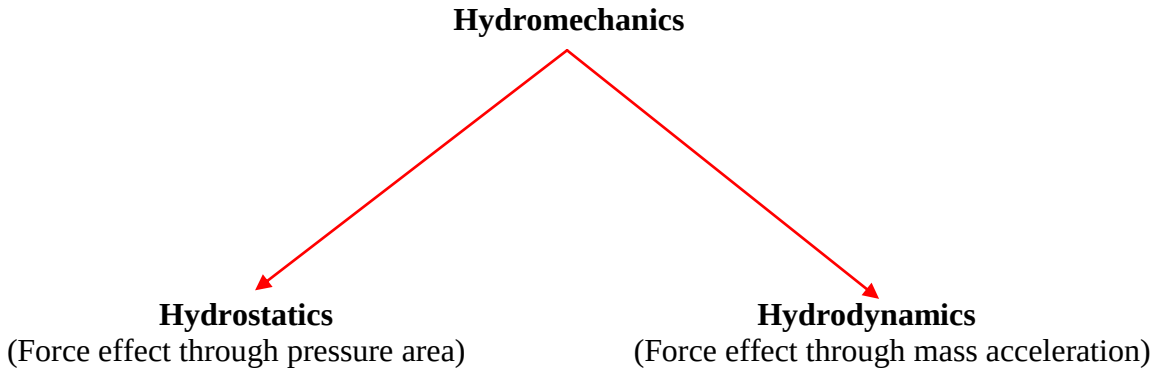
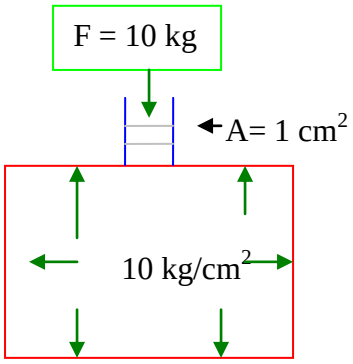
SUB: HYDRAULICS, PNEUMATICS & MECHANICAL
Duration: 74 Sessions = 148 Periods
Sub-discipline: Hydraulics (Lessons: 20 Sessions: 42)
Lesson-I: Fundamentals Session–1: Introduction, Pascal's Law, Bernoulli's Theorem, Advantages of Hydraulic System.

INTRODUCTION:

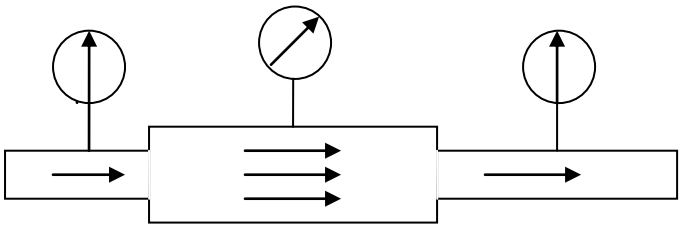
The word hydraulics originates from the Greek. This is made of two words-hydor and aulos. Hydor means water and aulos means pipe i.e. flow of water through pipes. Today the term hydraulic commonly refers to "Power hydraulics" in which fluid is used under controlled pressure to do work. Hydraulic power is used in every branch of industry in a machine tool, missiles, man made satellite, boat, planes, cranes, lifts, track machines etc. So fluid is most versatile means of transmitting power & modifying motions. A fluid is infinitely flexible. It can easily change its shape, it can be divided into parts to do work in different locations, it can move rapidly in one place and slowly in another place. No other medium has the same accuracy, positiveness & power in minimum of volume & weight. It is the science of forces and movements transmitted by means of liquids i.e. generation of forces and motion using hydraulic fluid. A hydraulic system is a means of using a pressurized fluid to transmit power between the place where the power is generated and the point where it is used. It is a part of hydromechanics.



PASCAL'S LAW: It states that when pressure is applied on a confined fluid, it is transmitted undiminished in all directions, and acts with equal force on equal areas, and at right angles to them.



BERNOULLI'S PRINCIPLE: "It states that in a system with constant flow rate, energy is transformed from one part to other, each time the pipe cross-section changes".
Hydraulic fluid in a system possesses two types of energy KINETIC and POTENTIAL kinetic energy is present when the fluid is in motion. Potential energy is a result of the fluid pressure. The total energy of the fluid is the sum of the kinetic and potential energy. Bernoulli's principle states that, "The total energy of the fluid always remains constant."
Therefore, when the flow in a system increases, the pressure must decrease. You may note that when fluid starts to flow through a hydraulic system the pressure drops slightly. When the flow stops, the pressure rises.



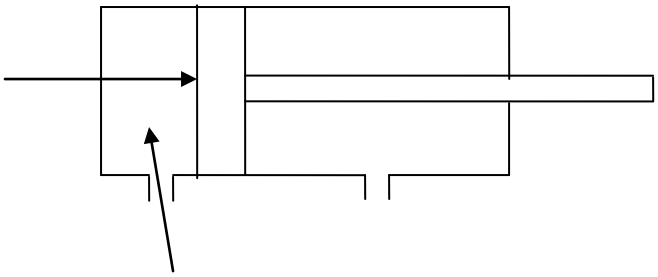
Important Definitions:-

Force: A force is a push or pull that is exerted on an object in order to change its position or direction of movement. To move an object such as a tamping unit, force must be applied to it. Force is commonly expressed in newtons.
Weight: An object or substance has weight as a result of the gravitational force or pull on the object. Weight is always a downward force. In a hydraulic system, the fluid in the reservoir, the hydraulic lines or in any of the components, has weight.
Inertia: An object's resistance to movement is called its inertia. The inertia determines how much is required to start, stop or cause a change in the movement of an object. The greater its mass, the more force required to overcome its inertia.
Specific gravity: The density or mass of a liquid is given as its specific gravity. The specific gravity of a liquid is also its weight compared to the weight of water in the same amount and at the same temperature. The specific gravity of water is 1.0, while the specific gravity of petrochemical base hydraulic fluids is 0.78.
Pressure: Pressure is the amount of force exerted on an object or a substance divided by the area over which the force is exerted. It is usually expressed in N/m^2. Pressure results whenever the flow of a fluid is resisted. The resistance may come from a load on actuator or a restriction (or orifice) in the piping.

The relationship between Force (F), Pressure (P) and Area (A) is expressed as follows:

$F = P \times A$ where, Force is in newton.
Pressure in N/m^2.
Area in m^2.

Area of piston (A)= $0.25m^2$ & Pressure (P)= $200N/m^2$ Then, $F = P \times A = 0.25 \times 200 = 50$ N



Work: Whenever a force or push is exerted through a distance, work is done. Its unit is N-m or joule.

work (W) = force (F) x distance (D)

In a hydraulic system, work = force x piston travel
= pressure x piston area x piston travel

Power: Power is defined as an amount work done in a given amount of time. Its unit is J/s or watt.

Power = work ÷ time

Energy: To do work or use power, energy must be expended. The law of conservation of energy states that "Energy cannot be created or destroyed. It can only be transformed."The types of energy used in hydraulic system are:-

Hydraulic energy- produced by pump.
Kinetic energy- produced when the hydraulic fluid moves a piston.
Potential energy- produced when the piston has raised an object.
Heat energy- produced by friction in the pump, motor, cylinder, hydraulic fluid.

CHARACTERISTICS OF HYDRAULICS:

- **Multiplication of Forces:** If a small force on small area would create a proportionally larger force on a larger area, the only limit to the force, a machine can exert, is the area to which the pressure is applied.
- **Incompressibility:** Hydraulic fluid is incompressible that is why tremendous pressure is achieved.
- **Acceptance of Shape:** The hydraulic fluid accepts the container's shape in which that is contained.
- **Non Diffusion:** Hydraulic fluid can be easily poured from one container to another without diffusing in atmosphere. Gases, however, cannot be placed in open containers because they rapidly diffuse into the atmosphere.

Hydraulic power transmission: Hydraulics can be defined as a means of transmitting power by pushing on a confined liquid. The input component of the system is called a pump and the output is called an actuator. The hydraulic system is not a sorce of power.The power source is prime mover such as an electric motor or an engine which drives the pump. The hydraulic system is versatile which gives it advantages over other methods of transmitting power.

Units of pressure:

1 bar = 1 Kg/cm^2 (approx)
1 bar = 10^5 Pa
1 N/m^2 = 1 Pa
1 KPa = 1000 Pa
1 MPa = 10^6 Pa = 1 N/mm^2

ADVANTAGES OF HYDRAULICS:

1. **Variable Speed:** The actuator of a hydraulic system can be driven at variable speeds by varying the pump delivery or using a flow control valve.

2. **Reversibility:** An actuator can be reversed instantly while in full motion without damage. A four way directional valve or a reversible pump provides the reversing control.

3. **Overload Protection:** The pressure relief valve in hydraulic system protects it from overload damage. When the load exceeds the valve setting, pump delivery is directed to tank.

4. **Self Lubrication:** In most hydraulic components internal lubrication is provided by the fluid**.** Pump elements and other wearing parts slide against each other on a film of fluid.

5. **Cooling:** Circulation of the fluid through lines and around the walls of the reservoir allow the fluid to give up the heat that has been generated in the system.

6. **Sealing:** In many instances the fluid is the only seal against pressure inside the hydraulic component. In DC valve there is no seal between the valves spool and the body to minimize leakage. The close mechanical fit and the viscosity of the oil determine leakage rate.

7. **Easy to Install and Handle:** Hydraulic components can be easily installed and handled due to less weight and size in compare to mechanical system.

8. **Portable:** Hydraulic plant can be used in mobile application.

9. **Compactness:** Hydraulic components can provide high power output with very small weight and size.

10. **Transmission loss:** In hydraulic system power transmission losses are very less in comparison to mechanical transmission.

Hydraulic circuits and their components are depicted in various ways in drawings. Depending on what the picture must convey, it may be a pictorial representation of the components' exteriors, a cutaway showing internal construction, a graphical diagram which shows function or a combination of any of the three. However, the graphical symbol and diagram are most common. Graphical symbols are the shorthand of circuit diagrams, using simple geometric forms which show functions and inter-connections of lines and components. Following is a brief exposition of the most common symbols and how they are used, along with an abbreviated classification of some hydraulic lines and components.

1. Lines- Hydraulic pipes, tubes and fluid passages are drawn as single lines as follows-
(i) A working line (solid line) carries the main stream of flow in the system. It includes the pump inlet line, pressure lines and return lines to tank. ———————

(ii) A pilot line (long dashes) carries fluid that ia used to control the operation of a valve or other component. - - - - - - - - - - - - - -

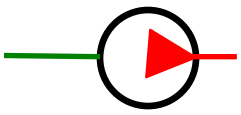
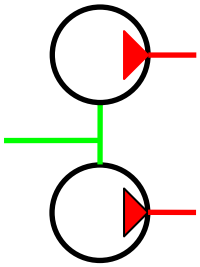
(iii) A drain line (short dashes) carries leakages oil back to the reservoir. - - - - - - - - - - - - - -

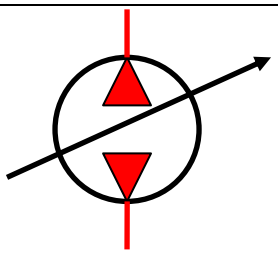
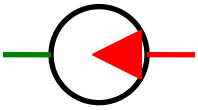
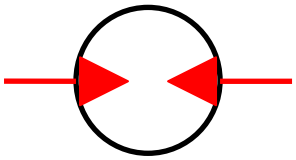
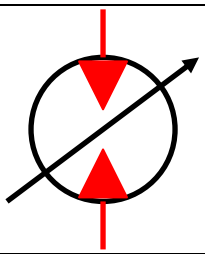
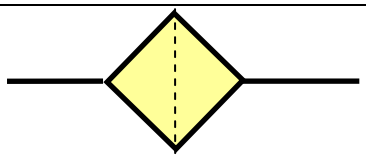
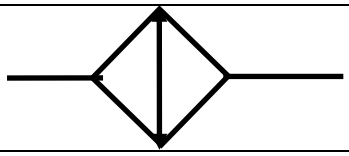
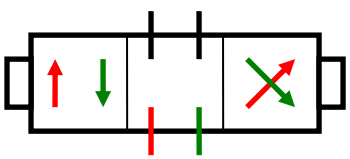
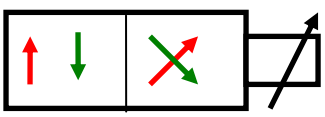
2. Rotating components (pump & motor)- A circle is the basic symbol for rotating components. The triangles are placed in the symbols to show as energy sources (pumps) and or energy receivers (motors). If the component is unidirectional, the symbol has only one triangle. A reversible pump or motor is drawn with two triangles.

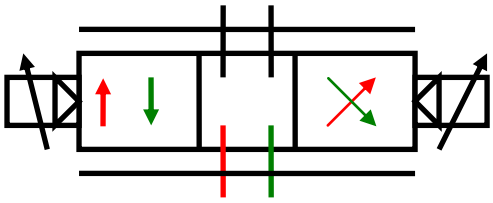
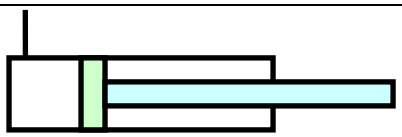
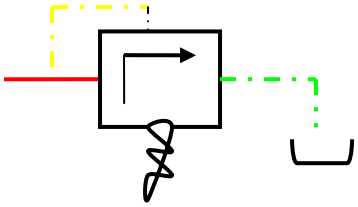
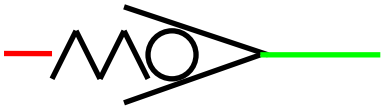
3. Cylinders- A cylinder is drawn as a rectangle with indications of a piston, piston rod and port connections. A single acting cylinder is shown open at the rod end and with only a cap-end port connection. A double acting cylinder appears closed with two ports.

4. Valves- The basic symbol for a valve is square- referred to as a envelope. Arrows are added to the envelope to show flow paths and the direction of flow. Three envelopes in D.C.Valve show the valve has three positions. Port connections are drawn to centre position.

HYDRAULIC SYMBOLS:

	**Single Pump**
	**Double Pump**

	**Variable Pump**
	Return Line **Pressure Line**
	Pilot Line
	**Uni-Directional Motor**
	**Bi-Directional Motor**
	**Variable Motor**
	**Stop Cock**
	**Filter**
	**Cooler**
	**4/3 Way Valve**
	**4/2 Way Valve**

	**Servo Valve or Proportional Valve**
	**Single Acting Cylinder**
	**Double Acting Cylinder**
	**Relief Valve**
	**Check Valve/ Non-Return Valve**

Proper selection and care of hydraulic fluid for a machine will have an important effect on machine performance and on the life of the hydraulic components. Any liquid is essentially incompressible and therefore will transmit power instantaneously in hydraulic system. The most common liquid used in hydraulic system is petroleum based oil. Oil transmits power readily because it is only very slightly compressible, a negligible amount in most systems. The most desirable property of oil is its lubricating ability.

FUNCTIONS:

1. To transmit power from one point to another
2. To lubricate moving parts
3. To cool or dissipate heat
4. To seal clearance between parts/moving parts by forming thin film
5. Cushioning of oscillations caused by pressure jerks.
6. Corrosion protection.
7. Scuff removal.

PROPERTIES:

1.1 Suitable viscosity:-viscosity is measure of fluid's resistance to flow. If a fluid flows easily, its viscosity is low. Fluid flows with difficulty have a high viscosity. Some methods of define viscosity are: absolute viscosity, kinematic viscosity, and relative viscosity and SAE numbers. Kinematic viscosity is the most common way of measuring viscosity. It is measured by the amount of time needed for a fixed volume of oil to flow through a capillary tube. The unit for kinematic viscosity is mm^2/sec or centistokes.

Too high a viscosity increases friction, resulting in –

1. High resistance to flow
2. Increased power consumption due to friction loss
3. High temperature caused by friction
4. Increased pressure drop due to resistance
5. Possibility of sluggish or slow operation
6. Difficulty in separating air from oil in reservoir.

Too low a viscosity resulting in –

1. Internal leakages increases
2. Excessive wear and even seizure may occur under heavy load due to break down of oil film between moving parts
3. Pump efficiency may decrease causing slower operation of the actuator
4. Leakage losses may result in increased temperatures.

1.2 Viscosity Index: - The change in fluid viscosity caused by a change in temperature is referred to as the fluid's viscosity index. Viscosity index is an arbitrary measure of a fluid's resistance to viscosity change with temperature changes. A fluid that has a relatively stable viscosity at temperature extremes has a high viscosity index (VI). A fluid that is very thick when cold and very thin when hot has a low VI.

1.3 Anti-rust and anti-corrosive:- Rusting is the chemical union of steel with oxygen. Corrosion is chemical union between a metal and acid. Corrosion occurs as the acid acts on the metals. Rusting is caused by air bubble in the system. It is usually not possible to keep air and atmosphere born moisture out of hydraulic system. They contaminate the system and promote wear. There are several ways of preventing rust and corrosion. The best way is that hydraulic system may work at proper temperature and pressure. A fluid should be filtered properly.

1.4 Oxidation resistance: - Fluid oxidation is the chemical reaction of the fluid with air which forms new substances or compounds, when hydraulic oil is oxidized, it forms gum, sludge. Some of these soluble compounds are acids which bites the metallic components in the system. It is the most common factor that reduces the fluid life. These contaminants close the orifice, increases wear and tear and causes valves to stick. The best control is through the good maintenance.

1.5 Resistance to foaming: - A small air bubble get entrapped during course of suction and delivery of released oil from circuit. Air also enters through vent hole and mixes with oil and affects the efficiency. Air also causes heating of the oil and hydraulic assemblies. Return pipe should be located well below in the hydraulic tank.

1.6 Low pour point: - Pour point is the lowest temperature at which a fluid will flow. Beyond this it becomes so thick that it won't flow any more. The pour point for hyd. Oil is kept -21^0C.

1.7 High flash point:- Flash point is the temperature at which a liquid gives off vapour in sufficient quantity to ignite momentarily or flash when a flame is applied. A high flash point is desirable because it indicates good resistance to combustion and a low degree of evaporation at normal or working temperatures. The flash point of petroleum base hydraulic oil is 210^0C.

1.8 Demulisification : Small amounts of water get into the hydraulic fluid in the form of water vapour that is carried in with the air that constantly finds its way into the system. When the air is suspended in the fluid, the water vapour also becomes emulisified in the fluid and remains in suspension as a result of the churning conditions that exist in the system. Water fluid emulsions may be thin and slurry, thick and pasty or heavy and gummy depending on the amount of water and the fluid viscosity. Emulsions frequently promote the collection of impurities, which increases friction and wear in the system. Many fluids use chemicals to prevent emulsions from forming. If a fluid (with or without the aid of chemicals) resists the formation of water-fluid emulsions and promotes the breakdown of emulsions, it is said to have 'demulsification.'

Method of identifying hydraulic oil:

One important method of identifying hyd. oil is the specification of viscosity class. The ISO standard and new draft of DIN 51524 explain that the viscosity classes lay down the minimum and maximum viscosity of hyd. oil at 40^0C

ISO VISCOSITY CLASSES	KINEMATIC VISCOSITY (MM^2 /S) AT 40^0 C	
	MIN	MAX
ISO VG 10	9.0	11.0
ISO VG 15	13.5	16.5
ISO VG 22	19.0	24.8
ISO VG 32	28.8	35.2
ISO VG 46	41.4	50.6
ISO VG 68	61.2	74.8
ISO VG 100	90.0	110.0
ISO VG 150	135	165

Qualities of hydraulic fluid:

1. Lowest possible density
2. Minimal compressibility
3. Viscosity not too low
4. Good viscosity temperature characteristics.
5. Good viscosity-pressure characteristics.
6. Good aging stability.
7. Low flammability.
8. Good material compatibility.

HYDRAULIC OIL PARAMETERS: The hydraulic oil parameters are viscosity, water content and purity of oil.

1. Viscosity: The admissible decrease in viscosity is minus 10% of the original value. For eg VG 68 – 10% (6.8) = 61.2 cst at 40^0c.

2. Water content: The water content has to be as low as possible. The maximum admissible concentration of water in the hydraulic oil is 1000 ppm. This corresponds to 0.10% by volume. It means an oil quantity of 1000 litres contains 1 litre of water.

3. Purity of oil: In order to ensure reliable operation maintain a degree of purity according to NAS 1638:7-8, ISO 4406:19/16/13 - 20/17/14.

In order to prevent contamination caused by damages to machines a minimum admissible degree of oil purity is prescribed for hydraulic systems. This degree of purity is achieved and maintained by using suitable filter conceptions and carrying out optimum machine service. The degree of oil purity is stated in so – called oil purity classes.
The most important standards in this field are:

- ISO 4406
- NAS 1638

These classes of oil purity define the quantity of contaminating particles in the system /ml related to a certain particle size.

ISO 4406:1999- The ISO 4406 Standard determines the quantity of particles in accumulative way, i.e.> 4 μm, > 6 μm and > 14 μm (either manually by filtering the fluid through a test membrane, or automatically, by using particle counters) and assigns characteristic numbers to them. The aim of this assignment to particle numbers is to facilitate the assessment of purity of fluids. In 1999, the "old" ISO 4406 standard was revised and the ranges for the particle sizes to be assessed were defined a new. Furthermore, the particle counting method and calibration were changed.

The practical user has to know the following:

Even if the ranges for particles to be assessed have been changed, the purity code will remain unchanged except for some individual cases, during preparation of the "new" ISO 4406 standard attention has been paid to maintain most of the existing regulations on system purity.

	"old" ISO 4406:1987	"new" ISO 4406:1999
Size ranges	> 2 μm > 5 μm > 15 μm	> 4 μm > 6 μm > 14 μm

Old classification		New classification	
NAS 1638	ISO 4406/91	ISO 4406/99	SAE AS 4059/01
Should not be used any longer	> 2μm/>5μm/15μm	>4μm/>6μm/>14μm	>4μm/>6μmμ/>14μm
3	- /12/9	15/12/9	5A/3B/3C
4	- /13/10	16/13/10	6A/4B/4C
5	- /14/11	17/14/11	7A/5B/5C
6	- /15/12	18/15/12	8A/6B/6C
7	- /16/13	19/16/13	9A/7B/7C
8	- /17/14	20/17/14	10A/8B/8C
9	- /18/15	21/18/15	11A/9B/9C
10	- /19/16	22/19/16	12A/10B/10C
11	- /20/17	23/20/17	>12A/11B/11C
12	- /21/18	24/21/18	>12A/12B/12C

Determination of oil purity according to ISO 4406:

Number of particles		ISO code
From 100 ml each	Up to and including 100 ml each	
10,00,000	20,00,000	21
5,00,000	10,00,000	20
2,50,000	5,00,000	19
1,30,000	2,50,000	18
64,000	1,30,000	17
32,000	64,000	16
16,000	32,000	15
8,000	16,000	14
4,000	8,000	13
2,000	4,000	12
1,000	2,000	11
500	1,000	10
250	500	9
130	250	8
64	130	7
32	64	6
16	32	5

ISO marks all particles > 4 μm**,** > 6 μm and > 14 μm.

For e.g. From above table 1,90,000 particles > 4 μm/100 ml lie between 1,30,000-2,50,000 hence the ISO code is 18. Similarly, 58,600 particles > 6 μm/100ml lie between 32,000-64,000 hence the code is 16 and 1525 particles >14 μm/100ml lie between1000-2000 hence the code is 11. Hence the result is represented as ISO 18/16/11.

Oil purity according to NAS 1638:

Range of particle	Maximum number of particles per 100 ml NAS classes										
sizes in µm	2	3	4	5	6	7	8	9	10	11	12
5-15	1000	2000	4000	8000	16000	32000	64000	128000	256000	512000	1024000
15-25	178	356	712	1425	2850	5700	11400	22800	45600	91200	182400
25-50	32	63	126	253	506	1012	20	4050	8100	16200	32400
50-100	6	11	22	45	90	180	360	720	1440	2880	5760
>100	1	2	4	8	16	32	64	128	256	512	1024

The following particle numbers were measured for an oil specimen:		
5-15 µm:	62000 particles	= NAS 8
15-25 µm:	5000 particles	= NAS 7
25-50 µm:	500 particles	= NAS 6
50-100 µm:	10 particle	= NAS 3
>100 µm:	1 particle	= NAS 2

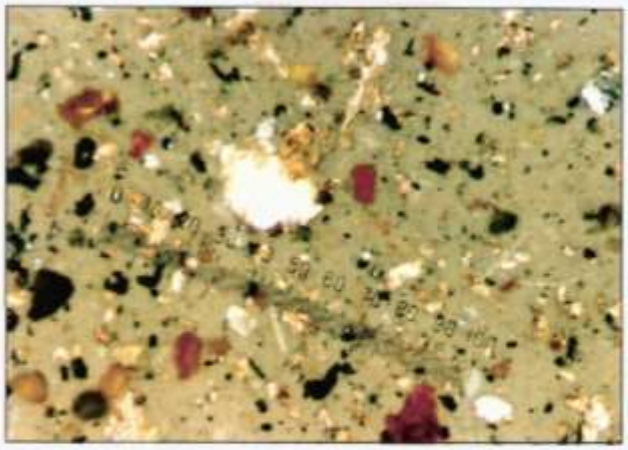
The oil purity according to NAS is always determined by the highest class measured in our example -8. Therefore, the oil purity of the present oil test quantity according to NAS 1638 is NAS 8.

Acid content: The TAN (Total Acid Number) of fresh oil amounts to 0.05 mg KOH/g. The values of used oil should be between 0.05 and 1 mg/KOH/g.

Recommended oil purity

Application	Required oil purity according to ISO 4406 (NAS 1638)	Recommended filter material/filter fineness
Systems consisting of components highly susceptible to dirt and of very high availability. Filling of servo-systems.	< 15/13/10 (3)	H1 SL/ 1µm
Systems consisting of components susceptible to dirt and high availability. Servo valve applications.	< = 17/14/11 (5)	H3 SL/ 3µm
Systems using proportional valves and pressures>160 bar	< = 18/15/12 (6)	H6 SL/ 6µm
Vane pumps, piston pumps, piston motors.	< = 18/16/13 (7)	H10 SL/ 10µm
Modern industrial hydraulics, way-valves, pressure valves.	< = 20/17/13 (8)	H10 SL/ 10µm
Industry hydraulics with high tolerances and low susceptibility to dirt.	< = 21/18/14 (10)	H20 SL/ 20µm

Oil purity classes according to ISO 4406



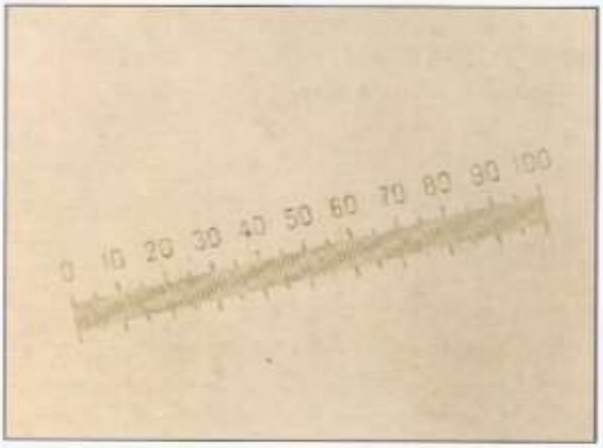
Example:

ISO : 24 / 22 / 17

For particle sizes: > 4µm(c), 6µm(c), 14µm (c)

Result:
Heavily contaminated oil.

oil purity classes according to ISO 4406



Example:

ISO : 17 / 14 / 10

For particle sizes: >4µm(c), 6µm(c), 14µm (c)

Result:
Very high purity of the oil

Types of Hydraulic fluid used in different track machines:

Keeping view for above quality of hydraulic oil, it is found that ISO VG 68 is the most suitable oil for power transmission in Plasser's machines in Indian conditions. Hence oil ISO VG 68 is recommended for using transmission system in track machines.

As per RDSO's letter no.TM/HM/27 dated 07/08.06.2004 and Rly Bd's letter no.90/Track-III/TK/75 Part-III dated30-11-05 following brands of hydraulic oils have been recommended-

1. Indian oil corporation - Servo system HLP-68 (N)
2. Bharat Petroleum Corporation Ltd. - Bharat Hydol HDP-68-SC
3. Balmer lawrie & Co. Ltd. - Protomac HLP-68
4. Hindustan Petroleum Corporation Ltd. - Enklo HLP 68

Note: Oil ISO VG 100/150 is used for lubrication purpose only in track machines (Tamping unit).

Replacement of Hydraulic oil:

Complete hydraulic oil is replaced during POH because it is observed that old hydraulic oil might have completed its useful service life during last 6 years (period between two POH) leading to possibilities of physical and chemical changes besides various other contaminants resulting –

1. Reduction in its effective power transmission
2. Reduction in its lubricating power
3. Reduction in sealing power which increases wear & tear
4. Presence of impurities and moisture promotes oxidation effect of oil causing rusting of high value hydraulic components and ultimate reduction in their service life.

Note: Mixing of new oil with old oil is not recommended as it will reduce the overall performance of hydraulic system.

भारत सरकार - रेल मंत्रालय
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Government of India-Ministry of Railways
Research Designs & Standards Organisation
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TM/HM/Oils

Date: 27-7-2012

I

1. मध्य रेलवे, सीएसटी, मुम्बई–400001 — CST, C R, Mumbai - 400001.
2. फेयरली प्लेस, पूर्व रेलवे, कोलकाता–700001 — Fairlie Place, E R, Kolkata-700001.
3. बड़ौदा हाउस, उत्तर रेलवे, नयी दिल्ली–110001 — Baroda House, N R, New Delhi-110001.
4. उत्तरपूर्व रेलवे, गोरखपुर 273012 — N E R, Gorakhpur-273 012.
5. मालीगांव, उत्तरपूर्व सीमान्त रेलवे, गुवाहाटी–781011 — Maligaon, N F R, Guwahati -781011.
6. पार्क टाउन, दक्षिण रेलवे, चेन्नई–600003 — Park Town, S R, Chennai -600003.
7. रेल निलायम, दक्षिण मध्य रेलवे, सिकन्दराबाद–500 371 — Rail Nilayam, SCR, Secunderabad-500371.
8. गार्डन रीच, दक्षिणपूर्व रेलवे, कोलकाता–700043 — Garden Reach, S E R, Kolkata-700043.
9. चर्चगेट, पश्चिम रेलवे, मुम्बई–400020 — Churchgate, W R, Mumbai-400020
10. उत्तर पश्चिम रेलवे, जयपुर–302001 — N W R, Jaipur-302001.
11. पूर्व मध्य रेलवे, हाजीपुर–844101 — E C R, Hazipur-844101
12. दक्षिण पश्चिम रेलवे, हुबली–580023 — SWR, Hubli-580023
13. उत्तर मध्य रेलवे, इलाहाबाद–211001 — NCR, Allahabad-211001
14. पूर्व तट रेलवे, भुवनेश्वर–751001 — East Coast Rly, Bhubaneshwar-751001
15. पश्चिम मध्य रेलवे, जबलपुर–482001 — WCR, Jabalpur-482 001
16. दक्षिण पूर्व मध्य रेलवे, बिलासपुर–495004 — South East Central Rly, Bilaspur-495004

II- उपमुख्यअभि./सी.पी.ओ.एच.वर्कशाप/उत्तरमध्य रेलवे बेगम सराय इलाहाबाद–211001 — Dy. CE/CPOH workshop/ NCR/begum sarai,Allahabad-211001

Chief Engineer (Track Machines)

Sub: RDSO approved hydraulic oils for 'ON' Track Machines.
Ref: This office letter no. TM/HM/27 dated 27-12-2005

Vide letter referred above a list of certain brands of hydraulic oils was advised to be used for 'ON' track machines.

Now this list have been revised by the M&C directorate of RDSO and the revised list of hydraulic oils which can be used in lieu of Shell tellus-68 is being reproduced as below.

SL. NO.	VENDER	BRAND
1.	Balmer Lawrie & Co. Ltd., (Grease &Lubricants Div.), P-43, Hide Road Extension, Kolkata-700088	PROTOMAC HLP-68
2.	Bharat Petroleum Corporation Ltd, Lube Oil Blending Plant, Wadibunder, Mallet Road, Mumbai - 40009	Mak Hydrol HLP-68
3.	Hindustan Petroleum Corpn. Ltd., HPCL Lube Plants, Mazgaon Haybunder complex,Haybunder Road, Mumbai-400033	Enklo HLP-68
4.	Indian Oil Corporation Ltd., Lube Blending Plant, PirPau, Trombay, Mumbai-400074	Servosystem HLP-68N
5.	Gulf Oil Corporation,Ltd, Lubricants Division, Survey No. 27/1/2, Village Masat, Silvassa Khanveil Road, UT of D & NH,Silvassa-396230	Gulf Harmony AWT- 68 (R))

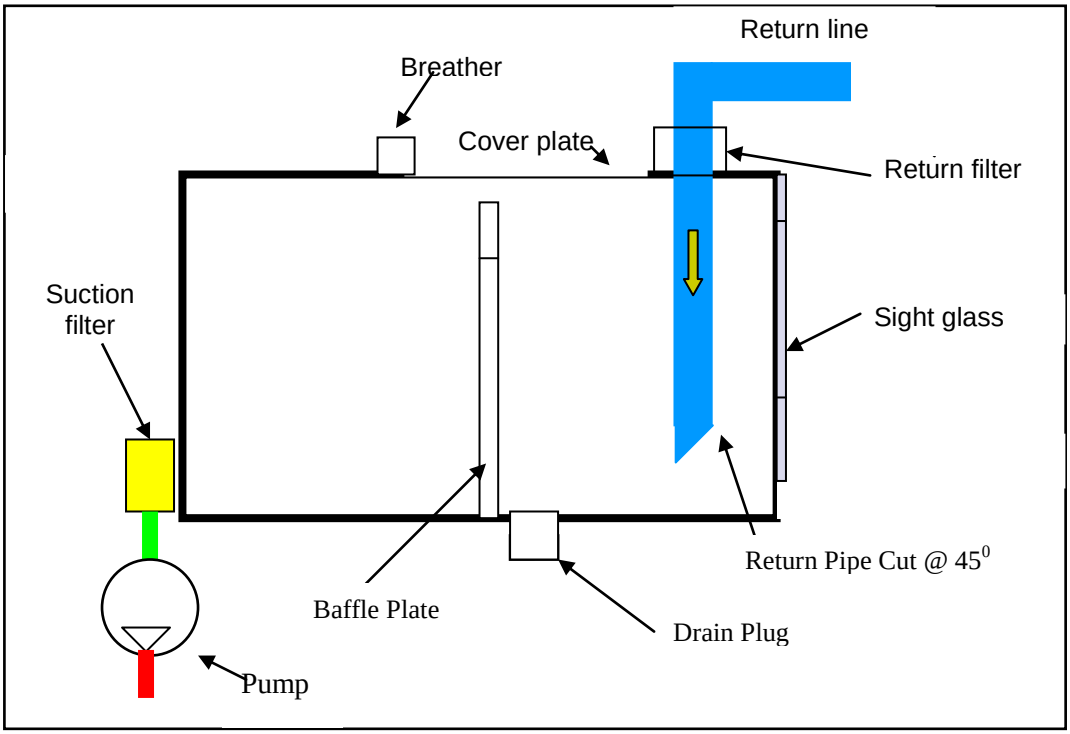
(Anil chaudhary)
Director/Track Machines-III
For DG/TMM

Copy for information: Director/TK (MC),Railway Board,
Rail Bhawan,New Delhi- 110001

(Anil chaudhary)
Director/Track Machines-III
For DG/TMM

FUNCTIONS: The reservoir in the hydraulic system fulfils several task-

1. Acts as intake and storage reservoir for the hydraulic fluid required for the operation of the system.
2. Dissipates heat.
3. Separates air, water and solid materials.
4. Supports a built – in or built – on pump and drive motor and other hydraulic components such as valves, accumulator, filter etc.



PARTS:

- Baffle plate: - It separates pump inlet line and return line. It is usually about 2/3 of the total height of the tank. Lower corner of the plate may be cut away to permit circulation. Thus the baffle plate –

  1. prevents local turbulence
  2. allows foreign material to settle to the bottom.
  3. gives the fluid an opportunity to free of entrapped air.
  4. helps heat dissipation.

- Inlet and Return line:-Most line of the tank terminates below the oil level. The line connections are often sealed. This prevents dirt from entering through these openings. Pumps inlet and return line must be below the oil level otherwise oil may be aerated and foaming may start. Connections above the oil level must be tightly sealed to prevent the entry of air in the system.

- Air breather: - An air breather is installed at the tank to vent air to the atmosphere so screening element of air breather should be cleaned regularly.

- Sight glass: - This is provided to see the oil level in the hydraulic tank and oil is filled accordingly.

- Drain plug: - It is provided at the bottom of the tank to drain oil from tank at the time of cleaning the tank. Generally magnetic drain plug is provided to trap iron particles present in the oil.

- Return filter: - It is provided on the top of the tank. It traps contaminants present in oil which is returned from the hydraulic circuit to tank.

Hydraulic tank for Track machine & its maintenance-

It is a reservoir for media fluid i.e. hydraulic oil having adequate capacity to store sufficient amount of hyd oil normally 1600-1800 lts to feed all hyd units at the time of working. It is designed in such a way so that foaming and aeration in hyd oil is avoided by container.

Normally two types of maintenance are carried out during maintenance-

1. Tank cleaning
2. hyd oil filling in tank

Necessity of tank cleaning-

It is necessary to clean the hyd tank as per schedule (at the time of IOH/POH it is necessary) due to following reason-

1. During the course of service, there are different types of impurities which are mixed with hyd oil (like water, dust, metal particle etc.) and these impurities are collected in the bottom of tank in the form of sludge. Removal of this sludge is necessary because it always makes hyd oil contaminated (foreign particles more than allowed range).
2. Due to wear and tear of mechanical parts, metal chips are used to flow with return oil and in tank. Removal of these particles are required time to time otherwise this will damage costly hyd components when these are recycled in the system.
3. To maintain NAS value of hyd oil (7-12) otherwise foreign particles more than 2-5 microns will stick-up with tank and it will make always hyd oil contaminated.

Precautions & Procedure for tank cleaning-

Following methodology may be adopted for tank cleaning-

1. Unload the used hyd oil from tank to clean empty drums completely by draining or by pumping. Preferably it should be drained out with the help of porta filter and bottom sludge shall be left (minimum 50mm). This sludge mixed oil shall be drained outside.
2. Tank cover shall be opened cautiously without damaging the gasket. Examine the tank and clean leftover residues.

3. Wiping the entire surface of inside tank by cleaning dry and fibreless cloth.
4. Scrapping the sludge deposited in bottom surface of tank and flushing the tank through the drain line.
5. Special care is exercised to clean any leftover metal particles.
6. After this, washing all internal surfaces by caustic soda/detergent powder etc.
7. Re-flushing the tank completing to ensure that no trace of caustic/detergent powder is left otherwise slightest of this will lead to foaming and affect the viscosity of hydraulic oil.
8. Thereafter, other hyd. appliances such as filters and gauges are replaced. Side by side tank breather is also cleaned or replaced on need basis.
9. Final cleaning the tank internally in all respects and allowing it for drying in natural way.
10. The top gasket if damaged, it should be replaced by new one (preferably in single piece).
11. Now clean the cover of tank properly and should be placed on cover with serviceable bolts.
12. Thereafter, fresh clear hyd oil passing through filter media is filled in tank such that it is maintained 4 inch below the top line otherwise induced pressure due to gas formation may lead to distortion/deshaping of hyd. tank.

Note- The entire operation is carried out in sufficient light to ensure that no foreign particle is left inside and tank has become truly dust free.

Oil filling operations after tank cleaning-

1. Suitable pump/ device is to be used for oil filling in the hyd tank.
2. 10 micron filter media shall be used especially while filling old/used oil in tank.
3. Before filling oil dryness and cleanliness of the tank shall be assured.
4. Dummy plug/sensors are to be tightened with use of Teflon tape/sealant loctite before filling oil.
5. Initially, small quantity of oil is poured. Leakage and other observations are watched. Only then further quantity of oil is pumped.
6. After filling about 25% of quantity, all filters and joints are checked minutely. Deficiency observed, if any are rectified before filling balance oil.
7. Oil is filled leaving 4 inch gap from top and inlet cover is closed properly.

Note- It is better to use porta filter (electrically operated pump followed 10 micron filter) for oil filling. It shall also be ensured that pumps and their pipe lines are cleaned and free from dust and other contaminations.

Introduction & Importance of filtratrion:

Filters are used to filter the valuable hydraulic oil in order to maintain cleanliness to prolong life of various hydraulic components and assemblies.

About 75% of hydraulic maintenance is caused by contamination of oil. Contamination can cause untold damage to the entire system. The use of a filter is an important stage in keeping dirt/contamination out of the system and hence reducing hydraulic maintenance.

Filter is a device whose primary function is retention, by some porous medium, of insoluble contaminants from a fluid. Porous medium simply refers to a screen of filtering material that allows fluid to flow through it but stops other materials by porous medium. A simple screen or wire strainer is rated in microns for filtering fineness or a mesh number or its nearest sieve number. The higher the mesh or sieve number, the finer the screen. When a filter is specified as so many microns, it usually refers to the filter's nominal rating and its value is in microns such that a 10 micron filter can trap particles having size more than 10 micron. So filters are of great significance in hydraulic systems for the reliable functioning and long service life of component.

Function:

The primary function of filter to reduce the contamination to an acceptable level in order to protect the various components from excessive wear. In this process filter is used to arrest the following-

- Metal abrasion /particles from various hydraulic components like pumps-motors etc.
- Abrasion of rubber pieces/particles coming from hoses and seals.
- Dust and dirt from atmosphere during working.

Evil effects of improper and dirty filters:

Always use clean filter in machines. It is necessary to use correct grade of filter and a contamination indicator is required in order to check the efficiency of the filter. Systems are often flushed using economical filters before commissioning. Always use clean filter in machines. Use of choke and dirty filter will make -

(i) In Suction line- Vacuum/cavitations in pump suction resulting vigorous sound and ultimate damage of pump.
(ii) In pressure line – the function of unit/system will stop or will inefficient.
(iii) In return line back pressure will create resulting problem in normal machine working and bursting of return hoses.

TYPES:

1. **Inlet strainer & filter:-** Strainer is installed on pump inlet lines inside the tank, it is relatively course as filter being constructed of fine mesh wire. A 100 mesh strainer is suitable for thin oil, protects the pump from particles above about 150µ in size. There are also inlet line filters usually mounted outside the tank near pump inlet. A fine filter (unless it is very large) creates more pressure drop that can be tolerated in on inlet line of a pump. The filter must pass the full pump volume within the permitted inlet vacuum for that pump. The filter must provide bypass flow which is still with in that limit where the filter element is blocked. Inlet filters should be used only to

prevent large particles from entering the pump & causing catastrophic failure. Suction filters (Part No.Hy-S 501.360.150) provided in tamping machine has following feature-

(i) It has aluminum cast filter head.
(ii) It is laterally attached to the tank below the oil level.
(iii) Elements can be replaced without draining the oil tank.

2. **Pressure line filter:-** This filter can trap much smaller particles than inlet line filter. Such a filter is used where system components such as valves are less dirt tolerant than the pump. The filter traps fine contaminants from the fluid as it leaves the pump and also protects the system in the event of a catastrophic failure of the pump. Pressure line filters must be able to withstand the operating pressure of the system as well as any pump pulsation. The pressure line filters, in tamping machines, are provided to protect proportional valves (filter part No. Hy-D 501.32.10 ES) and servo valves (DL40.60-3EES).The pressure line filter (Part no.Hy-D501.225.25 and filter cartridge Pt no.Hy-D501.225.25ES) is also provided in the circuit of ZF gearbox.

3. **Return line filter:-** These filters can also trap very small particles before the fluid returns to the tank. Return line filter is necessary in a system with a high performance pump which has very close tolerance & usually cannot be sufficiently protected by an inlet line filter. Full flow return filter should have enough capacity to handle max. return flow without opening the bypass valve (non return valve) the performance of any return line filter depends on magnitude of flow and pressure changes. Advantages and main features of return filters (Part no. Hy-R.501.330.10A) are:
   (i) attached to the tank
   (ii) metal structure
   (iii) contamination warning can be provided
   (iv) simple replacement of cartridges

   The term "full flow" applied to a filter means that all the flow into the filter inlet port pass through the filtering element. In most full flow filters there is a bypass valve preset to open at a given pressure drop to divert flow past the filter element. This prevents the element from being subjected to excessive pressure which could cause collapse. The bypass opens when total flow can no longer pass through the contaminated element without raising the pressure.

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FILTERING MATERIALS:

There are two basic classifications of filtering material viz. (1) Absorbent (2) Adsorbent.

1. **Absorbent filter:** Absorbent filter medium traps particle by mechanical means. Absorbent media are divided into two basic types viz. surface & depth. Surface media is most commonly used for coarse filtration. These are usually used with strainers. These are made of closely woven fabric. Depth media are generally used for finer filtration and are made of a wide range of materials. It has layers of a fabrics or fibers which provide paths for the fluid to flow through. These are usually used with filters. Particles collect on a number of surfaces arranged in layers.
2. **Adsorbent filter:** Such a charcoal & fuller's earth should be avoided in hydraulic system, since they may remove essential additives from the hydraulic fluid.

SOURCES OF CONTAMINATION:

1. **Built-in contamination**: Hydraulic system manufacturers generally are careful to provide internally clean products but, in spite of these efforts, new equipment usually contains some built-in contamination. These contaminants might include burrs, chips, flash, dirt, dust, fibers, sand, moisture, pipe sealants, weld splatter, paints and flushing solutions.

2. **Ingress or environmental contamination** is contamination that is added to the hydraulic system during servicing or maintenance (or from lack of maintenance) or is introduced to the system from the environment surrounding the equipment. Dirt contamination during operation owing to wear, ingress via seals and tank ventilation, filling up or changing hyd. fluid, exchanging components, replacing hoses.
3. **Self-generated contaminations**- This type of contamination is created internally within the system by the moving parts of hydraulic components. These contaminants are produced by wear, corrosion, cavitations and decomposition and oxidation of the system fluid. Every internal moving part within the system can be considering a source of self-generated contamination for the entire system.

CONTAMINANTS CONTROLS: Contaminants can be controlled in following ways –

i. Preventing contamination by keeping the system tight and using proper air and fluid filtration devices and procedures.
ii. Establishing fluid change intervals so the fluid will be replaced before it breaks down. If necessary the fluid can be tested in the laboratory at specific intervals to help establish the frequency of change.
iii. Keeping the reservoir filled properly to take advantage of its heat dissipating characteristics and to prevent moisture from condensing on inside walls.
iv. Repairing all leaks immediately.
v. The filters must provide sufficient dirt holding capacity for an acceptable interval between element changes.

Repair and replacement process-

The filters are to be replaced during POH as well as after completion of scheduled life span as per recommendation. As per extant instructions of Railway Board, only Plasser make (OEM) filter is to be used for track machines. Repair of filter is not carried out except cleaning with petrol or diesel and air blasting due to its sensitivity.

Precautions/procedure for filter replacement-

1. Open the filter body cover.
2. Drain and collect the oil of filter body in bucket.
3. Remove old filters.
4. Examine the filter body.
5. If found ok, place new filter element- ensuring with its correctness (part no. and mesh/micron).
6. Place cover the filter body again.
7. Inspect collected hydraulic oil, if found ok/clean- refill it in tank through filters.

List of filters used on different Track tampers-

Suction Filters

1.HYS.501.360.150ES – CSM-4 nos., UNI-3S- 4 nos., MPT-2 nos., New DUO-3 nos., 09-3X-6 nos., UNI-2S-3 nos.
2.HYS.501.360.200ES- Old DUO-3 nos.
3.HYS.501.90.10ES- CSM-2 nos.(for variable pump)
4.HYS.501.460.150ES- UNI-3S-1 no., MPT-3 nos.
5.HYS.561.160-P-10ES- MPT-1 no., 09-3X-1 no. (for variable pump)

Return Filters

1. HYR.501.330.10ES- CSM-2 nos., UNI-2S-2 nos., UNI-3S-2 nos.,MPT-3 nos., New DUO- 1 no., 09-3X-2 nos.,
2. HYR.501.330.25ES- Old DUO-1 no.

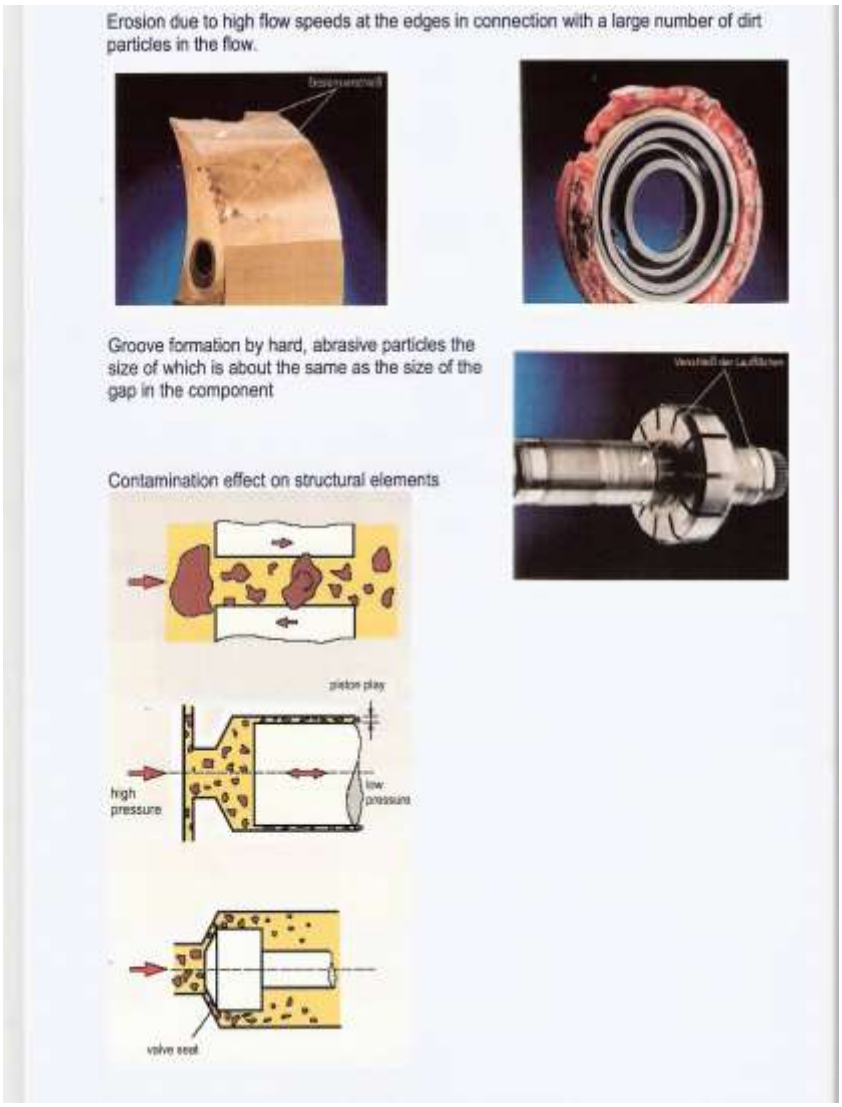
Pressure Filters

1.Proportional filter- HYD.501.32.10ES- CSM-1 no, UNI-2S-1 no., UNI-3S-1no.,MPT-1 no., 09-3X- 4 nos.
2.Servo filter- DL-40.60.3E- CSM-1 no., UNI-3S-2 nos.,MPT-2 nos., 09-3X- 2 nos.
3.Pressure filter for ZF- HYD.501.225.25ES- CSM-1 no., UNI-1 no. 09-3X- 1 no., New DUO- 1 no.
4.Squeezing filter- HYD.501.S.10ES- UNI-3S-2 nos., 09-3X- 2 nos.

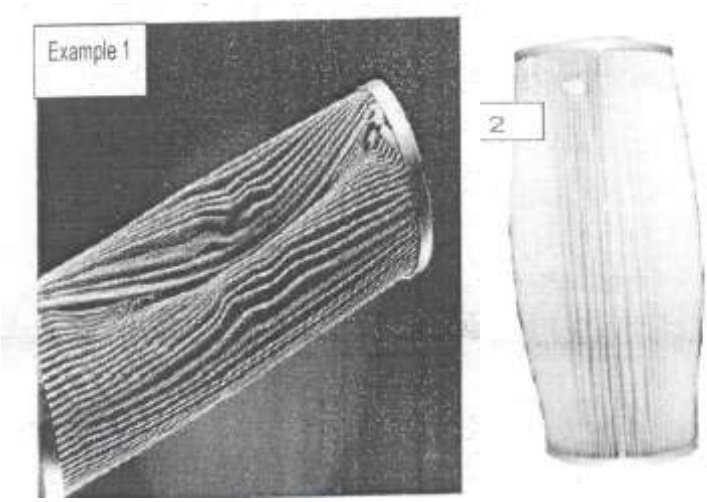
Note :- Always use clean filter in machines otherwise choke/dirty filter will make :-

(i) Vacuum/cavitation in pumps suction line resulting vigorous sound and ultimate damage of pump.
(ii) In pressure line the function of the unit will stop or will inefficient.
(iii) In return line back pressure will create resulting problem in machine working and return pipe bursting.

Damage caused by contamination:



DAMAGE TO FILTER ELEMENT:



Example 1: Too high a differential pressure overloads the filter element = leads to its collapse (too cold oil, contaminated too highly – without bypass)
Measure : check the design, use a filter element resistant to differential pressure.

Example 2: Over loaded filter element due to too high an internal working pressure (e.g. due to oil return, or incorrect filter installation, wrong flow direction.)
Measure : check the system, provide an additional external backing envelope to the element.

Beta Ratio: The beta ratio is also known as filtration ratio, is a measure of the particle capture efficiency of a filter element. It is therefore a performance rating.

$$\beta_x = \frac{\text{Number of particles in upstream}}{\text{Number of particles in downstream}}$$

Where,
x= size of particle in micron
Let no. of particles in upstream=5000, no. of particles in downstream=1000, x=10µ, then

$$\text{Beta Ratio, } \beta_{10} = \frac{5000}{1000} = 5$$

Now, particle capture efficiency of filter $\eta_{10} = (1- 1/\beta) \text{ X } 100 = (1-1/5) \text{ X } 100 = 80\%$.
So the particular filter tested is 80% efficient at removing 10 micron and larger particles.

FUNCTION:

Piping is a general term which embraces the various kinds of conducting lines that carry hyd. oil between components plus the fittings or connectors used between the conductors. Flexible hoses are mostly used in track machines to carry hyd. oil from one point to another. These offer more convenience in making connections and servicing. These are used when the hyd. lines are subjected to movement. Hoses are fabricated in layers of synthetic rubber and braided fabric or wire braids. Wire braided hoses permit high pressure. The inner layer of hose must be compatible with hyd. oil used. The outer layer is usually of rubber to protect braid layer. Low pressure hoses i.e. suction and return line hoses are reinforced with single wire braid while medium and high pressure hoses have double or multiple wire braid.

TYPES:

1. **Suction Hose:** This hose is provided between tank and pump. This is low pressure hose and has single wire braid. Dash no. of hoses used in suction line are 32, 48 and 64.
2. **Pressure Hose:** This hose is provided between pump and actuator. This is medium and high pressure hose and has double wire braid or multiple wire braid. Dash no. of hoses used in pressure line are 4, 6, 8, 10, 12, 16 and 20.
3. **Return Hose:** This hose is provided between actuator and tank. This is low pressure hose and has single wire braid. Dash no. of hoses used in return line are 6, 12, 16, 20, 24 and 32.

Construction of the Hose :

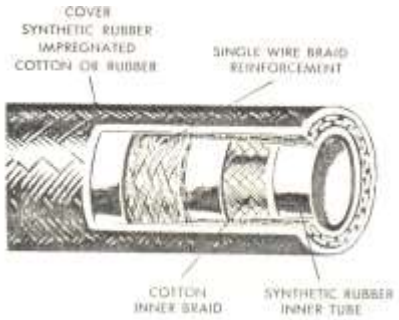
Flexible Hydraulic rubber hose is mainly made of the following three components :-

1. Inner tube which conveys hydraulic fluid at great pressure and temperature without deterioration caused by the chemical properties of the fluid.
2. Reinforcement, either with steel wire or with textile yarn which resists outward fluid pressure in the tube and
3. The rubber outer cover or textile braid impregnated with synthetic rubber solution to protect the hose against external damage from abrasion, oil, weather and temperature conditions.

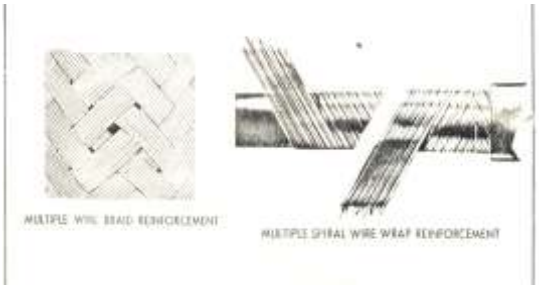
Inner tube can be made with a choice of rubber compounds and the main criteria for selection is its compatibility with fluid to be conveyed and its temperature.
Mainly special grades of synthetic rubber like Nitrile and butyl rubber are selected for inner tubes. Depending upon the chemical properties of the fluids, sometimes other synthetic rubbers can also be used.
In each case, the selected rubber components :-

a. Should be chemically resistant to the fluid to be conveyed.
b. Should have low absorption coefficients.
c. Must not deteriorate or lose flexibility due to the high temperature of fluid.
d. Should resist the internal hydraulic fluid temperature ranging from -40 degrees centigrade to +120 degrees centigrade.
e. Rubber used should have low compression set for better grip of end fittings.
f. Must have very good resistance to fire and should be self extinguishing.

Reinforcement :
Generally two types of reinforcements are provided while manufacturing flexible hydraulic hose. They are classified depending on the type of the material :-



a. Steel wires



b. Textile yarn

In Textile yarn, they are again classified as :-

1. Natural textile yarn – cotton yarn.
2. Synthetic textile yarn – Rayon, Polyester, Nylon and Kevlar

Presently synthetic yarn is being used more widely due to its advantages over cotton yarn. Selection of proper reinforcements for the flexible hose is as critical as the selection of a proper rubber compound for the inner tube of the hose. The function of the reinforcement in the hose is to withstand the system pressure but at the same time it should provide good flexibility. Since these are two contradictory objectives, it is difficult to arrive at an ideal condition theoretically. However, following are the points to be kept in mind while selecting proper reinforcements:-

a. Ultimate breaking strength.
b. Elongation at breakage .

c. Flexing characteristics.
d. Abrasion resistance.
e. Adhesional characteristics of the reinforcements between the inner tube and outer cover.
f. Hygroscopic nature of yarn.
g. Physical property of the reinforcement like : Weight and Diameters.

Outer cover: Outer cover is a synthetic rubber compound in case of a rubber covered hose and is of textile braid impregnated with synthetic rubber solution in case of textile covered hoses. Mainly outer the cover is designed to serve its functions i.e. protecting the reinforcements and the inner tube against external damage. Apart from this function, the outer cover should also have better adhesion characteristics with the reinforcements. Alongwith the above characteristics, following are some of the properties which would give longer life to the hose and hose assemblies:-

(i) Low compression sets
(ii) Better abrasion resistance
(iii) Better oil and weather resistance

Testing of hoses: SAE have elaborately described the testing procedures for various qualification tests. Most of the international hose manufacturers are following SAE standards although other similar international standards like DIN, BS and ISO are also available. Following physical tests are specified by SAE standard-

a. Appearance test
b. Dimensional inspection test
c. Change in length test
d. Proof test
e. Burst test
f. Oil resistance or oil ageing test
g. Leakage test
h. Cold flexibility test
i. Ozone resistance test
j. Impulse test

HOSE SPECIFICATION:

i. EN (European Norm)- EN 853- 1 SN-Single wire braid, 2 SN-Double wire braid
ii. DIN (Deutsch Industry Norm) –DIN 20022-2 Wire braid, DIN 20023- spiral wire
iii. SAE (Society of Automotive Engineers) -100R1 – single wire braid, 100R2 – two wire braid, 100R5 – single wire braid, 100R9 – 4 spiral wire reinforced.

SAE 100R1:
Type A: This hose shall consist of an inner tube of oil resistant synthetic rubber, a single wire braid reinforcement, and an oil and weather resistant synthetic rubber cover. A ply or braid of suitable material may be used over the inner tube and/or over the wire reinforcement to anchor the synthetic rubber to the wire.
Type AT: This hose shall be of the same construction as Type A, except having a cover designed to assemble with fittings which do not require removal of the cover or a portion thereof.
SAE 100R2:
The hose shall consist of an inner tube of oil resistant synthetic rubber, steel wire reinforcement according to hose type as detailed below, and an oil and weather resistant synthetic rubber cover. A ply or braid of suitable material may be used over the inner tube and/or over the wire reinforcement to anchor the synthetic rubber to the wire.
Type A: This hose shall have two braids of wire reinforcement.
Type AT: This hose shall be of the same construction as Type A, except having a cover designed to assemble with fittings which do not require removal of the cover or a portion thereof.
SAE 100R5:
The hose shall consist of an inner tube of oil resistant synthetic rubber and two textile braids separated by a high tensile steel wire braid. All braids are to be impregnated with an oil and mildew resistant synthetic rubber compound.
SAE 100R9:
Type A: This hose shall consist of an inner tube of oil resistant synthetic rubber, 4-spiral plies of wire wrapped in alternating directions, and an oil and weather resistant synthetic rubber cover. A ply or braid of suitable material may be used over the inner tube and/or over the wire reinforcement to anchor the synthetic rubber to the wire.

Type AT: This hose shall be of the same construction as Type A, except having a cover designed to assemble with fittings which do not require removal of the cover or a portion thereof.

Hose Parameters:

i. Dash size- Pipes are represented generally in dash no. E.g. 4, 6, 8, 10, 12, 16, 20, 24, 32, 48, 64.
ii. Inside diameter i.e. Inner dia. of hose=dash no. ÷ 16 (in inches)
iii. Reinforcement over diameter
iv. Maximum working pressure
v. Minimum bend radius
vi. Burst pressure

HIGH PRESSURE SAE 100 R1A

Application : High **Impulse** Pressure Hydraulic oils, air and water
Construction
Tube : Synthetic oil resistant rubber
Reinforcement : 1 high tensile steel wire braid
Cover : Synthetic rubber-abrasion, ozone & weather resistant
Temp. Range : - 40 C to +120 C

HOSE REFERENCE	DASH NO	DN	INSIDE DIAMETER		MEAN OUTER COVER DIAMETER.		MAXIMUM WORKING PRESSURE		MINIMUM BURST PRESSURE		MINIMUM BEND RADIUS	
			inch	mm	inch	mm	psi	bar	psi	bar	inch	mm
PS - 101	- 4	6	1/4	6.4	0.62	15.8	3335	230	11165	770	4.0	102
PS - 102	- 5	8	5/16	7.9	0.69	17.6	3335	230	10150	700	4.5	114
PS - 103	- 6	10	3/8	9.5	0.78	19.9	3045	210	9135	630	5.0	127
PS - 104	- 8	12	1/2	12.7	0.91	23.2	2538	175	8120	560	7.0	178
PS - 105	- 10	16	5/8	15.9	1.03	26.2	2103	145	6090	420	8.0	203
PS - 106	- 12	20	3/4	19.0	1.19	30.3	1813	125	5075	350	9.5	241
PS - 107	- 16	25	1	25.4	1.50	38.1	1450	100	4060	280	12.0	305
PS - 108	- 20	32	1 1/4	31.8	1.81	46.0	1088	75	2538	175	16.5	419
PS - 109	- 24	40	1 1/2	38.1	2.06	52.4	725	50	2030	140	20.0	508
PS - 110	- 32	50	2	50.8	2.62	66.6	609	42	1523	105	25.0	635

HIGH PRESSURE SAE 100 R2A

Application : High **Impulse** Pressure Hydraulic oils, air and water
Construction
Tube : Synthetic oil resistant rubber
Reinforcement : 2 high tensile steel wire braid
Cover : Synthetic rubber-abrasion, ozone & weather resistant
Temp. Range : - 40 C to +120 C

HOSE REFERENCE	DASH NO	DN	INSIDE DIAMETER		MEAN OUTER COVER DIAMETER.		MAXIMUM WORKING PRESSURE		MINIMUM BURST PRESSURE		MINIMUM BEND RADIUS	
			inch	mm	inch	mm	psi	bar	psi	bar	inch	mm
PS - 201	- 4	6	1/4	6.4	0.69	17.5	5800	400	20300	1400	4.0	102
PS - 202	- 5	8	5/16	7.9	0.75	19.0	5075	350	17000	1172	4.5	114
PS - 203	- 6	10	3/8	9.5	0.84	21.3	5075	350	16240	1120	5.0	127
PS - 204	- 8	12	1/2	12.7	0.97	24.6	4350	300	14210	980	7.0	178
PS - 205	- 10	16	5/8	15.9	1.09	27.7	3553	245	11165	770	8.0	203
PS - 206	- 12	20	3/4	19.0	1.25	31.8	3263	225	9135	630	9.5	241
PS - 207	- 16	25	1	25.4	1.56	39.6	2538	175	8120	560	12.0	305
PS - 208	- 20	32	1 1/4	31.8	2.00	50.8	2393	165	6598	455	16.5	419
PS - 209	- 24	40	1 1/2	38.1	2.25	57.2	1958	135	5075	350	20.0	508
PS - 210	- 32	50	2	50.8	2.75	69.9	1378	95	4568	315	25.0	635

SERIES 100 HIGH PRESSURE SAE 100 R1 AT

Application : High pressure hydraulic oils, air and water
Construction
Tube : Synthetic oil resistant rubber
Reinforcement : 1 high tensile steel wire braid
Cover : Synthetic rubber - abrasion, ozone and weather resistant
Temp. Range : - 40 °C to + 120 °C
Impulse Cycles : 150,000

Hose Reference	Dash No	DN	Inside Diameter inch	Inside Diameter mm	Mean Diameter Over Wire inch	Mean Diameter Over Wire mm	Mean Outer Cover Diameter inch	Mean Outer Cover Diameter mm	Maximum Working Pressure psi	Maximum Working Pressure bar	Minimum Burst Pressure psi	Minimum Burst Pressure bar	Minimum Bend Radius inch	Minimum Bend Radius mm
101	- 4	6	1/4	6.4	0.437	11.1	0.528	13.4	2750	190	11000	758	4.0	102
102	- 5	8	5/16	7.9	0.512	13.0	0.591	15.0	2500	172	10000	688	4.5	114
103	- 6	10	3/8	9.5	0.594	15.1	0.685	17.4	2250	155	9000	620	5.0	127
104	- 8	12	1/2	12.7	0.717	18.2	0.807	20.5	2000	138	8000	552	7.0	178
105	- 10	16	5/8	15.9	0.843	21.4	0.933	23.7	1500	103	6000	413	8.0	203
106	- 12	20	3/4	19.0	1.012	25.7	1.091	27.7	1250	86	5000	345	9.5	241
107	- 16	25	1	25.4	1.311	33.3	1.402	35.6	1000	69	4000	276	12.0	305
108	- 20	32	1 1/4	31.8	1.606	40.8	1.811 *	46.0	625	43	2500	172	16.5	419
109	- 24	40	1 1/2	38.1	1.843	46.8	2.063 *	52.4	500	34	2000	138	20.0	508
110	- 32	50	2	50.8	2.370	60.2	2.626 *	66.7	375	26	1500	103	25.0	635
** 111	- 38	60	2 3/8	60.3	2.717	69.0	2.953	75.0	362	25	1450	100	30.0	762
** 112	- 40	64	2 1/2	63.5	2.874	73.0	3.130	79.5	362	25	1450	100	30.0	762
** 113	- 48	76	3	76.2	3.402	86.4	3.720	94.5	290	20	1160	80	36.0	915
** 114	- 56	90	3 1/2	90.0	3.878	98.5	4.154	105.5	220	15	880	60	42.0	1067
** 115	- 64	100	4	101.6	4.331	110.0	4.606	117.0	145	10	580	40	43.5	1105

** Not covered under SAE specification

* SAE 100 R1A dimensions

SERIES DIN HIGH PRESSURE DIN 20022-1SN

Application : High pressure hydraulic oils, air and water
Construction
Tube : Synthetic oil resistant rubber
Reinforcement : 1 high tensile steel wire braid
Cover : Synthetic rubber - abrasion, ozone and weather resistant
Temp. Range : - 40 °C to + 120 °C
Impulse Cycles : 150,000

Hose Reference	Dash No	DN	Inside Diameter inch	Inside Diameter mm	Mean Diameter Over Wire inch	Mean Diameter Over Wire mm	Mean Outer Cover Diameter inch	Mean Outer Cover Diameter mm	Maximum Working Pressure psi	Maximum Working Pressure bar	Minimum Burst Pressure psi	Minimum Burst Pressure bar	Minimum Bend Radius inch	Minimum Bend Radius mm
1 SN 01	- 4	6	1/4	6.4	0.437	11.1	0.528	13.4	3265	225	13060	900	3.9	100
1 SN 02	- 5	8	5/16	7.9	0.512	13.0	0.591	15.0	3120	215	12480	860	4.5	105
1 SN 03	- 6	10	3/8	9.5	0.594	15.1	0.685	17.4	2610	180	10440	720	5.1	130
1 SN 04	- 8	12	1/2	12.7	0.717	18.2	0.807	20.0	2320	160	9280	640	7.1	180
1 SN 05	- 10	16	5/8	15.9	0.843	21.4	0.933	23.7	1890	130	7560	520	7.9	200
1 SN 06	- 12	20	3/4	19.0	1.012	25.7	1.091	27.7	1525	105	6100	420	9.5	240
1 SN 07	- 16	25	1	25.4	1.311	33.3	1.402	35.6	1275	88	5100	352	11.8	300
1 ST 08	- 20	32	1 1/4	31.8	1.606	40.8	1.811 *	46.0	915	63	3660	252	16.5	420 *
1 ST 09	- 24	40	1 1/2	38.1	1.843	46.8	2.063 *	52.4	725	50	2900	200	19.7	500
1 ST 10	- 32	50	2	50.8	2.370	60.2	2.626 *	64.0	580	40	2320	160	24.8	630

* DIN 20022-1ST dimensions

SERIES 200 HIGH PRESSURE SAE 100 R2 AT

Application : High pressure hydraulic oils, air and water
Construction
Tube : Synthetic oil resistant rubber
Reinforcement : 2 high tensile steel wire braids
Cover : Synthetic rubber - abrasion, ozone and weather resistant
Temp. Range : - 40 °C to + 120 °C
Impulse Cycles : 200,000

Hose Reference	Dash No	DN	Inside Diameter inch	Inside Diameter mm	Mean Diameter Over Wire inch	Mean Diameter Over Wire mm	Mean Outer Cover Diameter inch	Mean Outer Cover Diameter mm	Maximum Working Pressure psi	Maximum Working Pressure bar	Minimum Burst Pressure psi	Minimum Burst Pressure bar	Minimum Bend Radius inch	Minimum Bend Radius mm
201	- 4	6	1/4	6.4	0.516	13.1	0.594	15.1	5000	345	20000	1380	4.0	102
202	- 5	8	5/16	7.9	0.583	14.8	0.657	16.7	4250	293	17000	1172	4.5	114
203	- 6	10	3/8	9.5	0.665	16.9	0.752	19.1	4000	276	16000	1103	5.0	127
204	- 8	12	1/2	12.7	0.780	19.8	0.874	22.2	3500	241	14000	965	7.0	178
205	- 10	16	5/8	15.9	0.906	23.0	1.000	25.4	2750	190	11000	758	8.0	203
206	- 12	20	3/4	19.0	1.087	27.6	1.157	29.4	2250	155	9000	620	9.5	241
207	- 16	25	1	25.4	1.374	34.9	1.500	38.1	2000	138	8000	552	12.0	305
208	- 20	32	1 1/4	31.8	1.748	44.4	2.000 *	50.8	1625	112	6500	448	16.5	419
209	- 24	40	1 1/2	38.1	2.000	51.0	2.248 *	57.1	1250	86	5000	345	20.0	508
210	- 32	50	2	50.8	2.500	63.5	2.748 *	69.8	1125	78	4500	310	25.0	635
** 211	- 38	60	2 3/8	60.3	2.815	71.5	2.984	75.8	1015	70	4060	280	30.0	762
212	- 40	64	2 1/2	63.5	3.000	76.2	3.248	82.5	1000	69	4000	276	30.0	762
** 213	- 48	76	3	76.2	3.520	89.4	3.780	96.0	650	45	2600	179	36.0	915
** 214	- 56	90	3 1/2	90.0	3.984	101.2	4.232	107.5	400	28	1600	110	42.0	1067
** 215	- 64	100	4	101.6	4.457	113.2	4.665	118.5	365	25	1460	101	43.5	1105

** Not covered under SAE specification

* SAE 100 R2A dimensions

SERIES DIN HIGH PRESSURE DIN 20022 - 2SN

Application : High pressure hydraulic oils, air and water
Construction
Tube : Synthetic oil resistant rubber
Reinforcement : 2 high tensile steel wire braids
Cover : Synthetic rubber - abrasion, ozone and weather resistant
Temp. Range : - 40 ° C to + 120 °C
Impulse Cycles : 200,000

Hose Reference	Dash No	DN	Inside Diameter inch	Inside Diameter mm	Mean Diameter Over Wire inch	Mean Diameter Over Wire mm	Mean Outer Cover Diameter inch	Mean Outer Cover Diameter mm	Maximum Working Pressure psi	Maximum Working Pressure bar	Minimum Burst Pressure psi	Minimum Burst Pressure bar	Minimum Bend Radius inch	Minimum Bend Radius mm
2 SN 01	- 4	6	1/4	6.4	0.512	13.0	0.594	15.1	5800	400	23200	1600	4.0	100
2 SN 02	- 5	8	5/16	7.9	0.583	14.8	0.657	16.7	5100	350	20400	1400	4.5	115
2 SN 03	- 6	10	3/8	9.5	0.669	17.0	0.752	19.1	4800	330	19200	1320	5.1	130
2 SN 04	- 8	12	1/2	12.7	0.779	19.8	0.874	22.2	4000	276	16000	1103	7.1	180
2 SN 05	- 10	16	5/8	15.9	0.905	23.0	1.000	25.4	3600	250	14400	1000	7.9	200
2 SN 06	- 12	20	3/4	19.0	1.087	27.6	1.157	29.4	3100	215	12400	860	9.4	240
2 SN 07	- 16	25	1	25.4	1.378	35.0	1.500	38.1	2400	165	9600	660	11.8	300
2 ST 08	- 20	32	1 1/4	31.8	1.752	44.5	2.000	* 50.8	1800	125	7200	500	16.5	420
2 ST 09	- 24	40	1 1/2	38.1	2.000	51.0	2.248	* 57.1	1300	90	5200	360	19.7	500
2 ST 10	- 32	50	2	50.8	2.500	63.5	2.748	* 69.8	1160	80	4640	320	24.8	630

*DIN 20022 - 2ST dimensions

SERIES 500 HIGH PRESSURE SAE 100 R5R

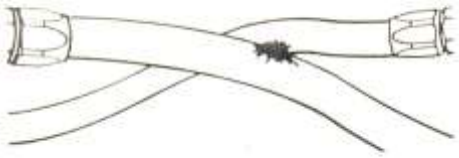
Application : High pressure hydraulic oils, air and water
Construction
Tube : Synthetic oil resistant rubber and one cotton braid
Reinforcement : 1 high tensile steel wire braid
Cover : Synthetic rubber - abrasion, ozone and weather resistant
Temp. Range : - 40 °C to + 120 °C
Impulse Cycles : Upto 7/8 inch - 150,000
1 1/8 inch and above 100,000

Hose Reference	Dash No	DN	Inside Diameter inch	Inside Diameter mm	Mean Outer Cover Diameter inch	Mean Outer Cover Diameter mm	Maximum Working Pressure psi	Maximum Working Pressure bar	Minimum Burst Pressure psi	Minimum Burst Pressure bar	Minimum Bend Radius inch	Minimum Bend Radius mm
501 R	- 5	-	1/4	6.4	0.583	14.8	3000	207	12000	828	3.4	86
502 R	- 6	-	5/16	7.9	0.677	17.2	2250	155	9000	621	4.0	102
503 R	- 8	-	13/32	10.3	0.768	19.5	2000	138	8000	552	4.6	117
504 R	- 10	-	1/2	12.7	0.921	23.4	1750	121	7000	483	5.5	140
505 R	- 12	-	5/8	15.9	1.079	27.4	1500	103	6000	414	6.5	165
506 R	- 16	-	7/8	22.2	1.236	31.4	800	55	3200	221	7.4	187
507 R	- 20	-	1 1/8	28.7	1.500	38.1	625	43	2500	172	9.0	229
508 R	- 24	-	1 3/8	34.9	1.752	44.5	500	34	2000	138	10.5	267
509 R	- 32	-	1 13/16	46.0	2.248	57.1	350	24	1400	97	13.2	337
510 R	- 38	-	2 3/8	60.3	2.874	73.0	350	24	1400	97	21.0	530

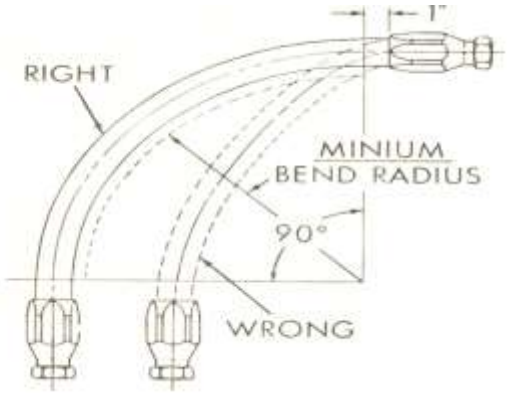
Hose failure due to:

1. Using wrong hose for the job.
2. Improper assembly & installation.
3. External damage.
4. Faulty hose.
5. Faulty equipments

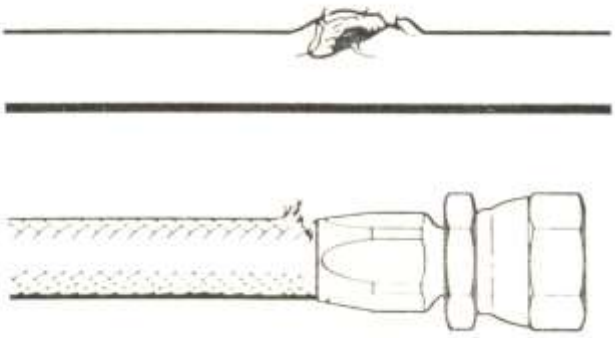
ABRASION



MINIMUM BEND RADIUS



PRESSURE



PRECAUTIONS WHILE MOUNTING HOSES:

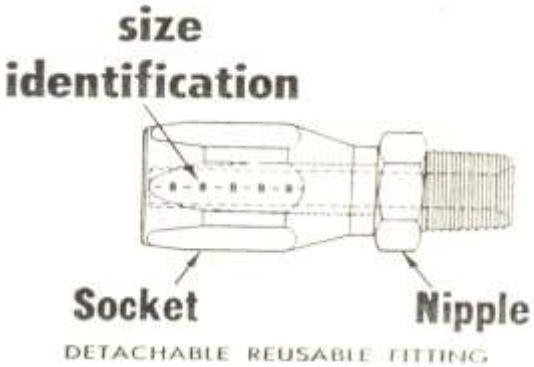
1. The hose should be provided in the end fitting properly.
2. It should be made long enough without tension.
3. It should be avoided to exceed the min bend radius.
4. Twisted hose should not be installed.
5. At vibrated place the hoses should be secured with proper packing.

FITTINGS:

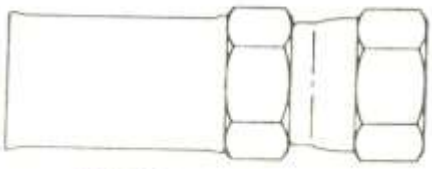
Hose fittings may be either reusable (screw-together, bolt-together, etc.) or non reusable (crimp or swage). It is recommended that hose fittings have a swivel nut or an SAE split flange on each end so that hose assembly does not have to be turned or twisted for proper installation.

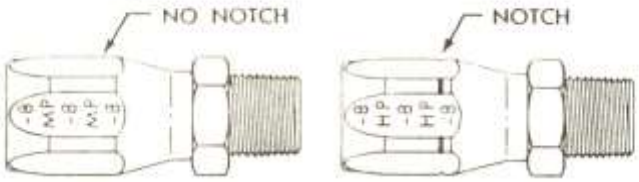
Two types of fittings are manufactured for hoses:

1. Swaged type or crimped type- which is non reusable.
2. Detachable type which has as socket and threaded nipple. This fitting can be used again and again until hose wear out or damages. The socket grips the hose & a nipple is inserted into this hose & screwed into the socket. This gives a firm strong attachment of the hose to the fittings.



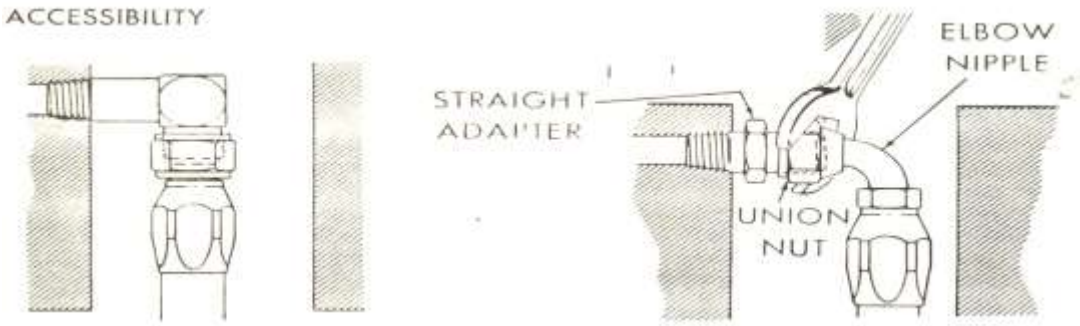
DETACHABLE REUSABLE FITTING


PRESSED-ON FITTING



MEDIUM PRESSURE FITTING

HIGH PRESSURE FITTING
(with notched socket)



ADAPTOR DESIGNATIONS NPTF – JIC :

e. g.: 2021-4-6
Type of adapter –screwed thread- hose connection thread

straight NPTF, outer/ JIC 2021-	bend 45°_ NPTF, outer/ JIC 2023-	45°_NPTF, outer/ NPTF inner 2088	bend 90°_NPTF outer / NPTF inner 2089-
bend 90°_ NPTF outer/ JIC 2024-	bend 90° long_ NPTF outer/ JIC 202411-	bend 90° very long_ NPTF outer/ JIC 202413-	bend 90° extra long_ NPTF outer/ JIC 202414-
T_NPTF outer/ JIC/JIC outer 2028-	T_NPTF outer / NPTF inner/ NPTF inner 2092-	T_NPTF outer/ JIC/JIC inner 2030-	T_NPTF outer / NPTF inner / NPTF inner 2091
hose connection JIC / JIC 2027-	screwed entry JIC / JIC 2041-	screwed entry 45°_JIC / JIC 2042-	screwed entry 90°_JIC / JIC 2043-
connector NPTF outer/NPTF outer 2083-	reducing connection NPTF inner/ NPTF outer 2081-		
blind plug 2082-	cap of the blind plug 210292-	screw of the blind plug 900599-	

PRECAUTIONS WHILE PROVIDING FITTING ON HOSE:-

1. The place of work should be cleaned first.

2. Rubber and wire cuttings should not be left in pipes.
3. Before providing fitting compressed air should be passed through pipes.
4. The other end of the pipe should not be left loose on the ground.
5. After preparing the pipe compressed air should be passed through pipes to remove any foreign material remaining inside.

FUNCTION:

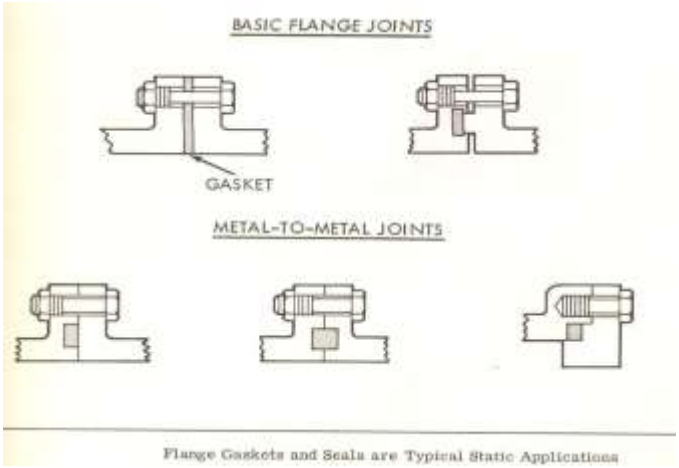
Seals are required to maintain pressure, to prevent fluid loss and to keep out contamination. Excessive leakage any where in a hydraulic circuit reduces efficiency and result in power loss. Mostly hydraulic components are built with operating clearances which allow a certain amount of internal leakage for lubrication purpose. Additional internal leakage occurs when component begins to wear. Internal leakages may cause temperature rise of hydraulic oil.

TYPES:

There are various types of seals used in hydraulic components.

(a)	Positive seals	These prevent even a minute amount of fluid from getting past.
(b)	Non positive seals	These allow a small amount of material leakage, such as the clearance of a spool in its bore to provide a lubricating film.
(C)	Dynamic seals	These are installed between parts which do move relative to one another, thus one of the part must rub against seal. Therefore, these seals are subject to wear.
(d)	Static seals	A seal that is compressed between two rigidly connected parts like flange joints. These do not wear fast and usually remain trouble free.

Static seals:

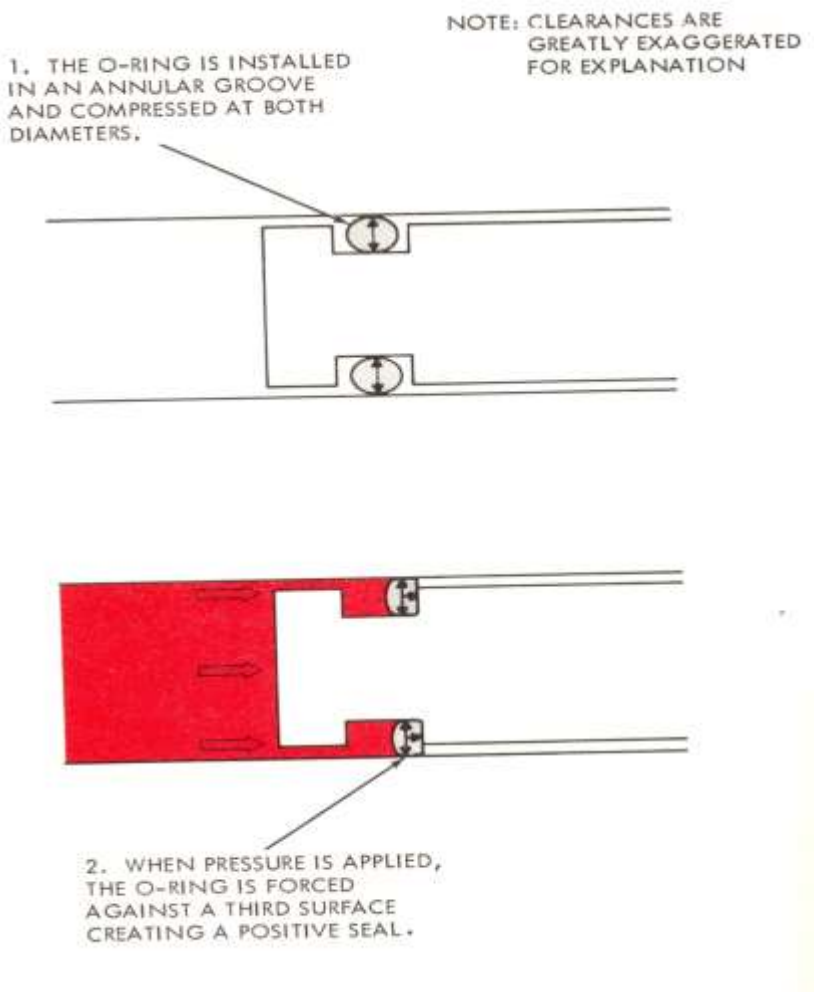


Flange Gaskets and Seals are Typical Static Applications

A seal that is compressed between two rigidly connected parts like flange joints. The seal itself may move somewhat as pressure is alternately applied and released. But the material parts do not move in relation to each other.

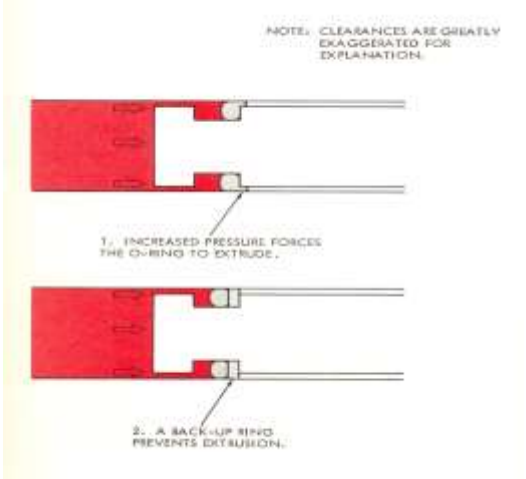
Some examples of static seals are mounting gaskets, pipe thread connections, flange joint seals, compression fitting ferrules and O-rings, static sealing applications are relatively simple. They are essentially non-wearing and usually are trouble free if assembled properly.

O-Ring Seals:



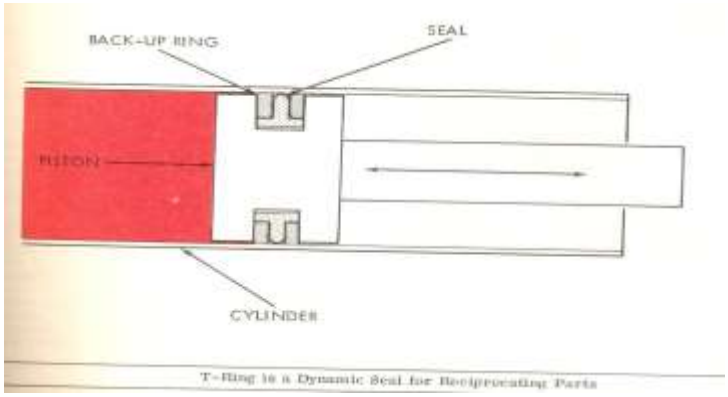
Probably the most common seal in use in modern hydraulic equipment is the O-ring. And O-ring is a molded, synthetic rubber seal which has a round cross-section in the free state. The O-ring is installed in an annular groove machined into one of the mating parts. At installation, it is compressed at both the inside and outside diameters. However, it is a pressure-actuated seal as well as a compression seal. Pressure forces the O-ring against one side of its groove and outward at both diameters. It thus seals positively against two annular surfaces and one flat surface. Increased pressure results in a higher force against the sealing surfaces. The O-ring, therefore, is capable of containing extremely high pressure. O-rings are used principally in static applications. However, they are also found in dynamic applications where there is a short reciprocating motion between the parts. They are not generally suitable for sealing rotating parts or for applications where vibration is a problem.

Backup (Non extrusion) Rings:



At high pressure, the O-ring has a tendency to extrude into the clearance space between the mating parts. This may not be objectionable in a static application. But this extrusion can cause accelerated wear in a dynamic application. It is prevented by installing a stiff backup ring in the O-ring groove opposite the pressure source. If the pressure alternates, backup rings can be used on both sides of the O-rings.

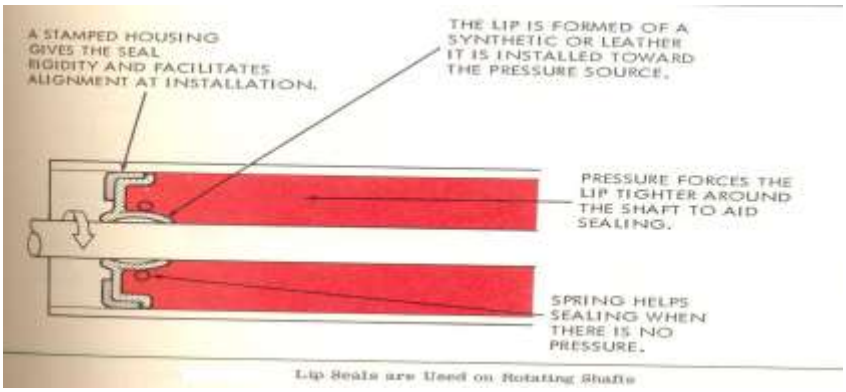
T-Ring Seals:



T-Ring is a Dynamic Seal for Reciprocating Parts

The T-ring seal is used extensively to seal cylinder pistons, piston rods, and other reciprocating parts. It is constructed of synthetic rubber molded in the shape of a "T", and reinforced by backup rings on either side. The sealing edge is rounded and seals very much like an O-ring. Obviously, this seal will not have the O-ring's tendency to roll. The T-ring is not limited to short-stroke applications.

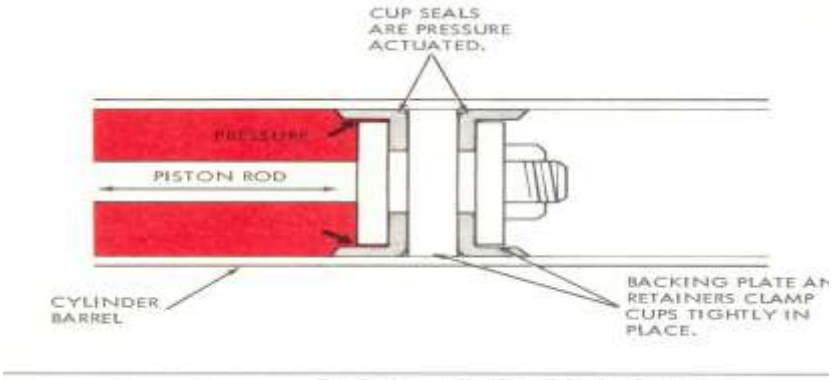
Lip Seals:



Lip Seals are Used on Rotating Shafts

Lip seals are low-pressure dynamic seals, used principally to seal rotating shafts. A typical lip seal is constructed of a stamped housing for support and installation alignment, and synthetic rubber or leather formed into a lip which fits around the shaft. Often there is a spring to hold the lip in contact with the shaft. Lip seals are positive seals. Sealing is aided by pressure up to a point. Pressure on the lip (or vacuum behind the lip) "balloons" it out against the shaft for a tighter seal. High pressure cannot be contained because the lip has no backup. In some applications, the chamber being sealed alternates from pressure to vacuum condition. Double lip seals are available for these applications to prevent air or dirt from getting in and oil from getting out.

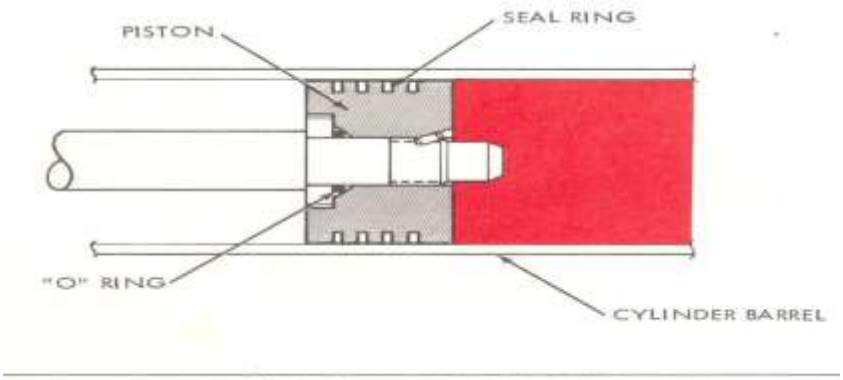
Cup Seals:



Cup Seals are Used on Cylinder Pistons

A cup seal is a positive seal used on many cylinder pistons. It is pressure actuated in both directions. Sealing is accomplished by forcing the cup lip outward against the cylinder barrel. This type of seal is backed up and will handle very high pressures. Cup seals must be clamped tightly in place. The cylinder piston actually is nothing more than the backing plate and retainers that hold the cup seals.

Piston Rings:



Piston Rings are Used for Cylinder Pistons

Piston rings are fabricated from cast iron or steel, highly polished, and sometimes plated. They offer considerably less resistance to motion than leather or synthetic seals. They are most often found on cylinder pistons.
One piston ring does not necessarily form a positive seal. Sealing becomes more positive when several rings are placed side by side. Very high pressures can be handled.

Choice of Seal:

A seal should have effective performance which has become a challenge of the high working pressure and fast cylinder speed. The choice of the seal is guided by following:-

i. Surface finish
ii. Loads
iii. Temperature
iv. Pressure

A seal may be of very good quality, but its surface life does not depend merely on seal material but is greatly influenced by surface finish and method of installation.

SEAL MATERIAL :- PTFE (Poly Tetra Fluoro Ethylene) SEAL

The material did not exhibit any change whatsoever when subjected to practically all known chemicals and its surface was so smooth that hardly any foreign substances remained. Moisture and solar radiation (sunshine) caused neither volumetric change nor disintegration and brittleness. The crystalline change associated with the melting point of the material starts at 327^0C without there being any typical thermoplastic liquefaction. For the above reasons, process technology similar to powder metallurgy is utilized. PTFE powder is compressed into blocks or rods, sintered and then mechanically machined to the required shapes. Based on experience over the last 30 years, the materials industry has developed PTFE types that for certain defined applications can also thermo-plastically processed. The possibility of compounding i.e. matching physical properties to specific applications through the addition of fillers, is an important factor for the use of PTFE in the manufacture of seals and guide elements. In-spite of its remarkable properties, pure unmixed PTFE has limited use for applications where high mechanical loading is required due to its tendency towards cold extrusion (creep)

The influence of filler materials is particularly illustrated by:

- Improvement in the flow strength.
- Reduction of friction and wear.
- Increase in strength.
- Increase in thermal shape stability.
- Increase in hardness.

The most important standard fillers are:

- Glass fibers
- Carbon/Graphite
- Molybdenum disulphide (M_OS_2)
- Bronze
- Polymers
- Pigments

Special characteristics of PTFE:

At low temperatures : Even at -269^0C (boiling point of Helium) PTFE still has residual extensibility, so that it can also be used under extreme conditions, e.g. in space. The temperature-dependent elongation or shrinking that occurs as with other plastics is reduced by the fillers.

At high temperatures: PTFE has exceptional thermal resistances, so that it can be used at temperatures up to 269^0C (dependent on working conditions). Fillers have no influence on the PTFE's own thermal resistance. Most of the fillers are stable up to 400^0C, so that they do not restrict high temperature use.

PRECAUTIONS DURING PROVIDING HYDRAULIC SEALS:

1. A special driver should be used for inserting lip-type shaft seals.
2. Cup seals must be clamped tightly in place.
3. Several piston rings are placed side by side for more positive sealing.
4. The packing is compressed by tightening a flanged follower ring against them.
5. There should be no dent mark on groove where seal is to be provided.
6. Seal of proper size should be used.

7. The operating temperature should always be kept well within the temperature range of the seals being used. At very low temperatures, a seal may become too brittle and at too high temperature, a seal may harden, soften or swell.
8. Seal must be lubricated prior to installation, otherwise the seal will wear quickly and leak.

CAUSES FOR SEAL AND 'O' RING FAILURES:

1	Freedom to roll	Unsatisfactory groove shape and not following the groove completely causes early wear and leakage.
2	Reduced contact area	Due to unsatisfactory design causes single point contact causing early wear and leakage.
3	High temperature	Attacking the rubber material causing early damage.
4	Poor rubbing surface	Unclean surface, scratches on cylinder surfaces cause seals& O-rings to wear very fast.
5	Eccentricity	Cause loading one side only, due to which the seals wear on one side and get damaged.
6	Side loads	Cause loading one side only, due to which the seals wear on one side and get damaged.
7	Excessive stretching	Less in size as such O-ring have to be stretched too much causing early wear and sometimes even breaking.
8	Poor quality of rubber.	Seals wear due to poor quality of rubber and improper hardness.

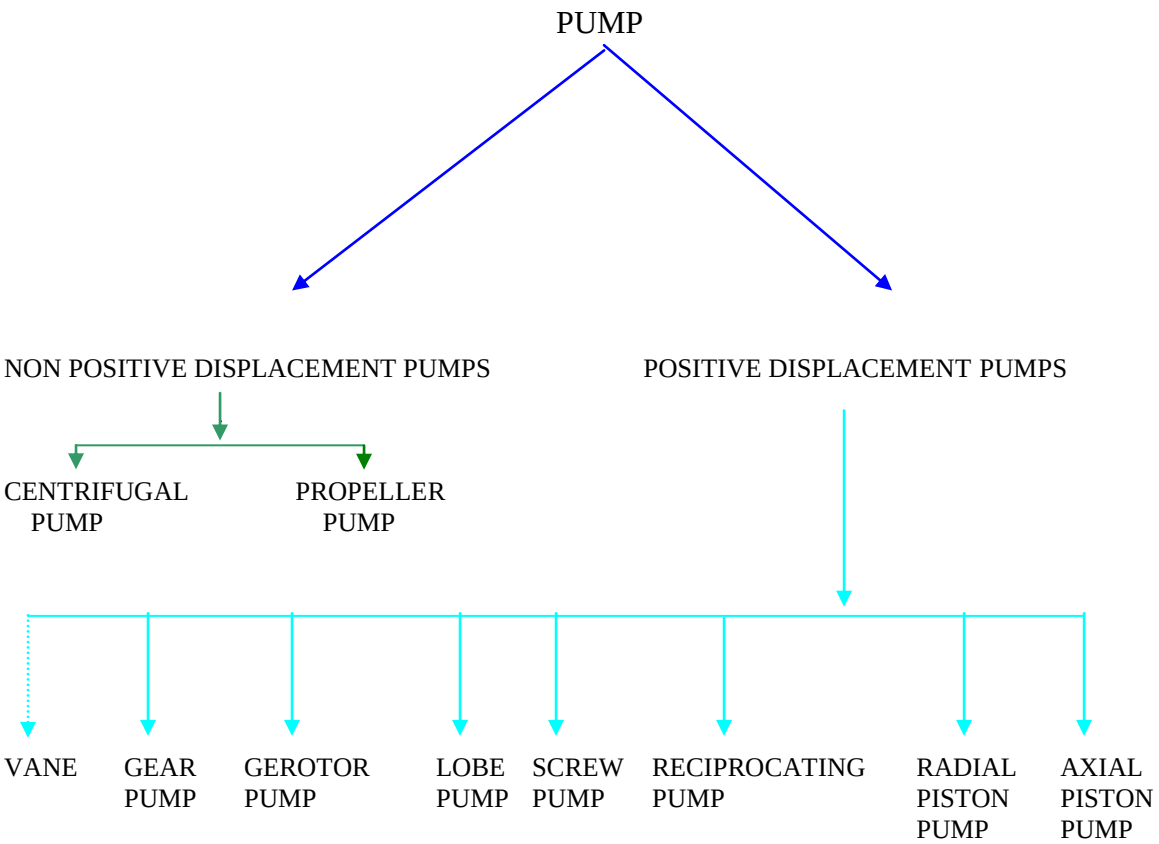
DEFINITION:

Pump is a device which converts mechanical energy into hydraulic energy. Basically pump creates flow from hydraulic tank to system.

FUNCTION:

The hydraulic pump in a hydraulic system converts mechanical energy in a drive unit into hydraulic energy (pressure energy).The pump draws-in hydraulic fluid due to partial vacuum and drives it out into a system of lines. The resistances encountered by the flowing hydraulic fluid cause a pressure to build up in the hydraulic system. Thus the fluid pressure in a hyd. system is not predetermined by the pump. It builds up in accordance with the resistances in extreme cases until a component is damaged. In practice it is prevented by installing a pressure relief valve directly after the pump or in the pump housing at which the max operating pressure recommended for the pump is set.

CLASSIFICATION:



Non positive displacement and positive displacement :

Pumps are broadly classified as either non positive displacement or positive displacement. A non positive displacement pump produces a continuous fluid flow, but since it does not provide a positive internal seal against leakage, its output varies considerably as pressure varies.

Practically all pumps used in power hydraulics system whether on industrial machinery, move vehicles or aircraft are of the positive displacement type. A positive displacement pump

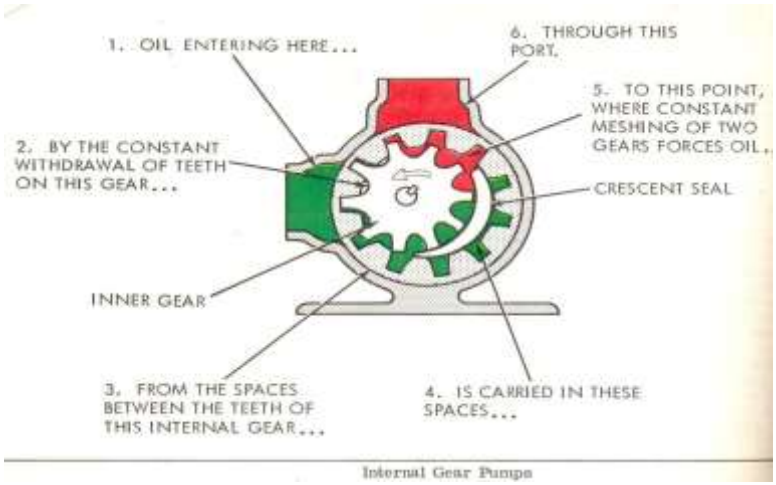
produces a pulsating flow, but since it provides a positive internal seal against slippage its output is relatively unaffected by system pressure variations. In a positive displacement pump, the slippage factior is negligible compared to the pumps volumetric output. Thus, if the outlet of this type of pump were to be blocked, the pressure would instantaneously rise to the point at which the pumps prime mover would stall or the pumps operating mechanism would break.

Fixed and variable displacement pump : Positive displacement pumps have either a fixed or variable displacement. The volume or gpm of a fixed displacement pump can be changed only by changing the speed of the pump because the physical arrangement of the pumping mechanism cannot be changed.The flow of a variable displacement pump can be changed by changing the physical arrangement of the pumping mechanism with a built-in controlling device.

Displacement:

The flow capacity of a pump can be expressed as displacement per revolution or output in GPM. Displacement is the volume of liquid transferred in one revolution. It is equal to the volume of one pumping chamber multiplied by the number of chambers that pass the outlet per revolution. It is expressed in cubic inches per revolutions.

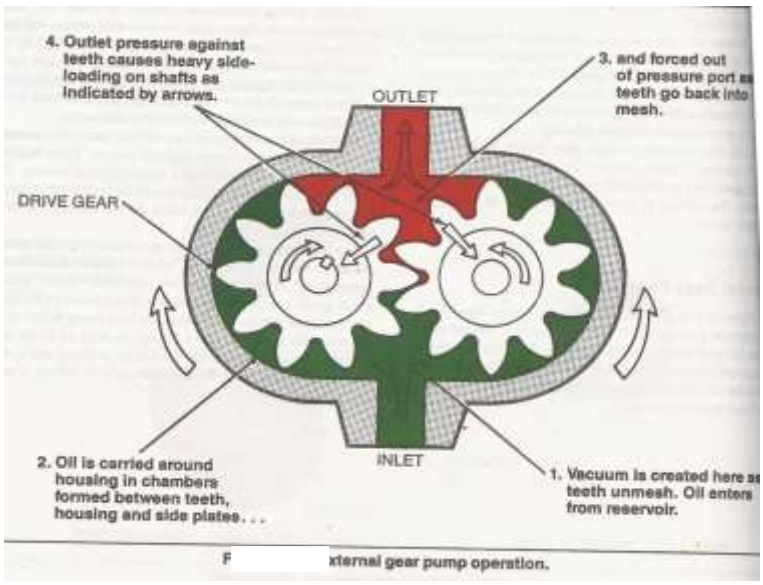
Internal gear pump :



Internal Gear Pumps

The pump consists of a housing in which a pair of gears runs with such low axial and radial play that the unit is practically oil tight. The suction side is connected to tank. The pressure side is connected to hydraulic system. The inner gear is driven in the direction of the arrow and takes external gear along with it in the same direction. A fluid seal is formed between the inner and outer gear teeth by the stationary crescent. The rotary moment causes the gears to separate so that the gear spaces are free. The negative pressure caused by this and the atmospheric pressure on the fluid level in the tank cause fluid to run from the tank to the pump. The fluid fills the gear spaces which form closed chambers within the housing and the crescent. During further moment fluid is pushed to the pressure side. Internal gear pumps used in hydraulic system are usually limited to operating at low pressures, in applications that have slow speeds and small capacities.

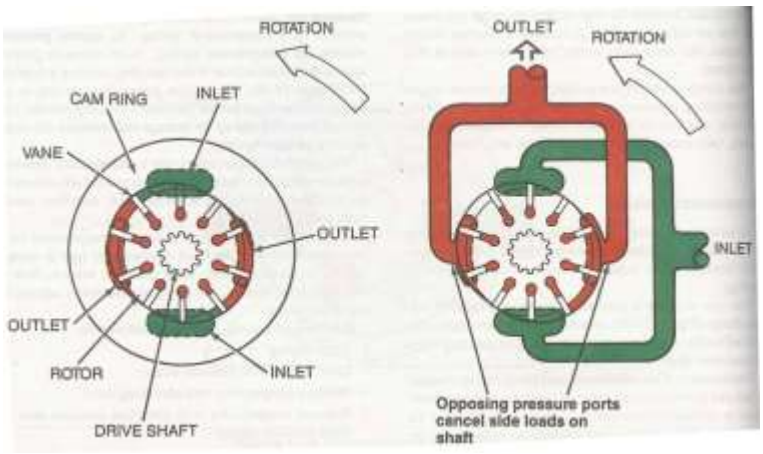
EXTERNAL GEAR PUMP:-



External gear pump operation.

The pump consists of drive gear and a driven gear and closed in closely fitted housing. The gears rotate in opposite direction and mesh at a point in housing between inlet and outlet ports as the teeth of gear separate, fluid is drawn into the inlet chamber, due to partial vacuum the fluid is trapped between the gear teeth and housing and carried through two separate paths around the outlet chamber. As the teeth re-mesh, fluid is forced through the outlet port. Close fit of the gear teeth within the housing is required to provide a seal between inlet and outlet ports, minimizing internal leakage. High pressure at pump outlet imposes an unbalanced load on the gears and bearing supporting them. Most gear pump are fixed displacement pump. Internal leakage increases with wear. However the units are fairly durable and more dirt tolerant than other type.

VANE PUMP:



Basically this pump consists of a cam ring and a splined drive shaft carrying a slotted rotor. In each slot of rotor vane is fitted which is free to slide. Thus following the ring profile as the rotor rotates. The vanes are held against the ring contour by a combination of centrifugal force and system pressure. Since system pressure is not usually present until the pump develops flow, centrifugal force is necessary to eject the vanes when the unit is started. Once the pump is in operation fluid at system pressure is directed to each rotor slot to hold the vanes against the ring contour. The vanes divide the area between the rotor and cam ring into a series of varying size of chambers. The pump inlet is situated in that part of pump where the chambers are expanding in size and the vanes are moving outward from rotor. Fluid is drawn into the pump by the partial vacuum, caused by this expansion. At the pump outlet the

chambers are reducing in size, the vanes moving inwards and the trapped fluid being forced through the outlet port.

Pump Rotation: To determine the rotation of a pump, the operator should facing shaft end. Should the pump be rotating anticlockwise, the rotation is left hand, but if rotating clockwise, is right hand.

When a new pump is installed, the rotation must be checked prior to placing on machine. The label on the pump body should not be accepted as correct. This check is carried out by removing the end cap and noting the direction of the arrow on the cam ring. Whatever direction this arrow depicts, pump rotation will be in the opposite direction.

Change of rotation: The change of rotation of a vane type pump is effected in the following manner-

1. Remove end cap (this contains the delivery port)
2. Withdraw cartridge and reverse pins,
3. Turn cartridge over.
4. Ensure long pin placed in locating hold of end cap. The correct hole is that adjacent to arrow on end cap which denotes the rotation required. It is important to note that arrows on the end cap denote the correct rotation i.e. as viewed from shaft end.
5. Line up porting i.e. outlet opposite outlet.
6. Reassemble pump.

Should the locating pin be placed in the incorrect hole, pump will not operate as cartridge will be 90º removed from correct pumping position. The following illustrates the difference between cartridge positions.

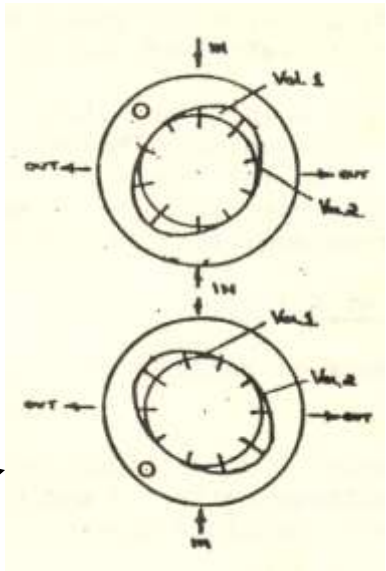
Correct assembly:

Oil entering the pump passes via port plate inlet into volume no.1 is then carried around to volume no.2 by the vanes and passed to system through delivery port plate.

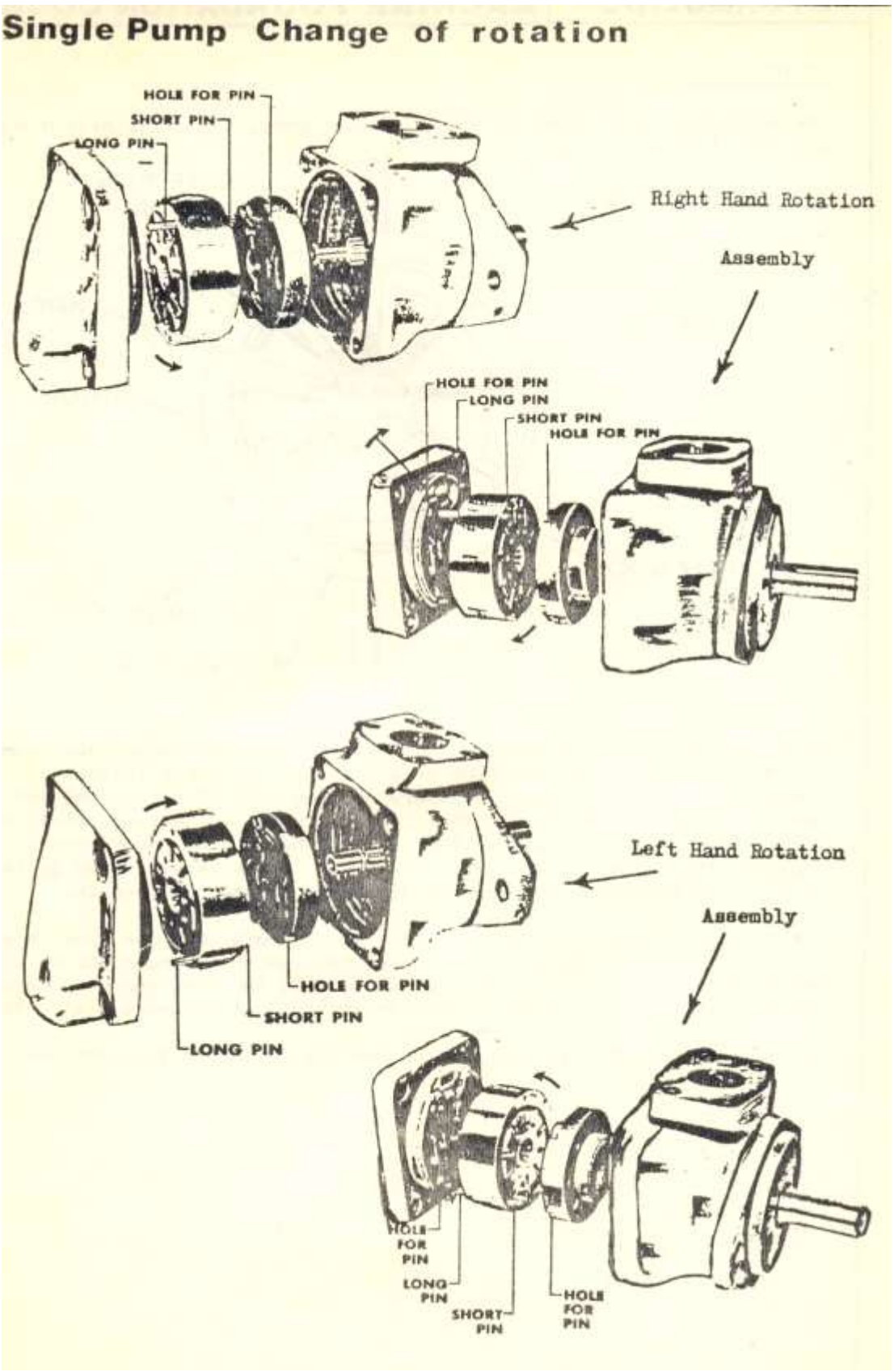
Incorrect assembly:

Oil will enter a reduced volume no.1 but cannot escape via volume no.2 however, if pump should be rotated in the opposite direction, oil will flow to system via delivery port plate, but the volume of oil displaced will be considerably less. If the incorrect method of assembly is used the pump would have to do far more work (assuming the speed of the prime mover could be increased), consequently the life of the pump will be curtailed.

Correct assembly

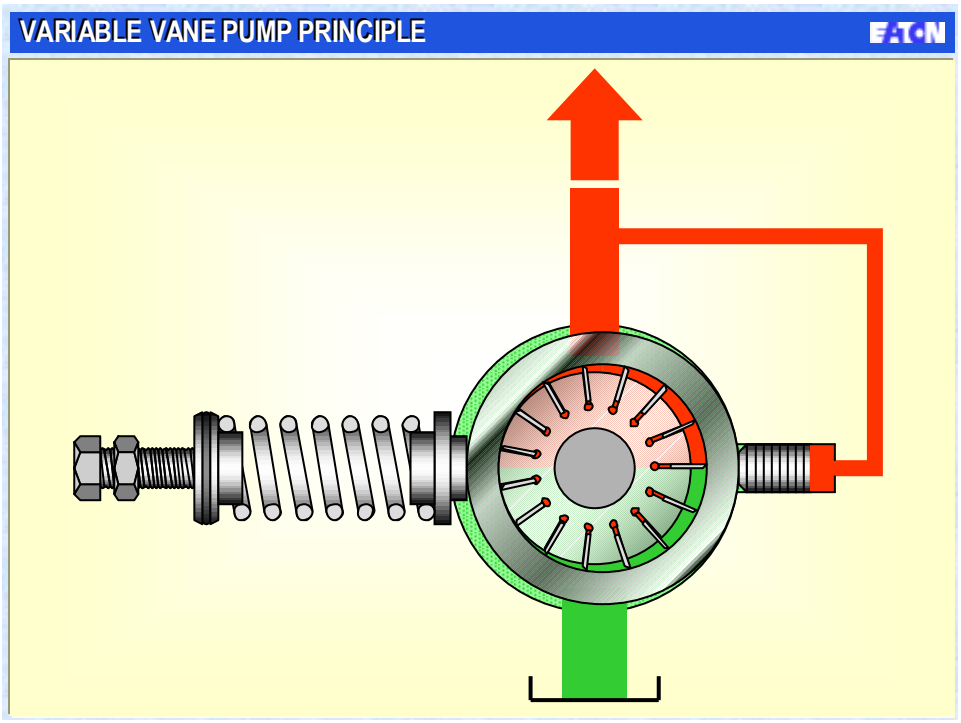


Incorrect assembly


Single Pump Change of rotation
HOLE FOR PIN
SHORT PIN
LONG PIN
Right Hand Rotation
Assembly
HOLE FOR PIN
LONG PIN
SHORT PIN
HOLE FOR PIN
Left Hand Rotation
Assembly
HOLE FOR PIN
SHORT PIN
LONG PIN
HOLE FOR PIN
LONG PIN
SHORT PIN
HOLE FOR PIN

Variable vane pump:

The fluid flow of variable displacement pump varies as the shape of pump chamber is changed. It has a movable cam ring in place of a fixed housing and a means for shifting the cam ring. The cam ring can usually be shifted from an off - centre position (maximum flow) to a centre position (no flow). The cam ring can be adjusted manually, electrically or hydraulically. Variations in flow are achieved by varying the distance between the rotor and ring centre lines. This adjustment is achieved by a mechanism built into the pump. This means however, that due to ring having to move freely, adequate clearances must be provided, resulting in increased slippage. This type of pump therefore, tends to have a lower volumetric efficiency than its fixed volume counter-part. This factor plus the side loading on the bearings in general limit there application to the low pressure range 250 – 1000 psi.



AXIAL PISTON PUMP:

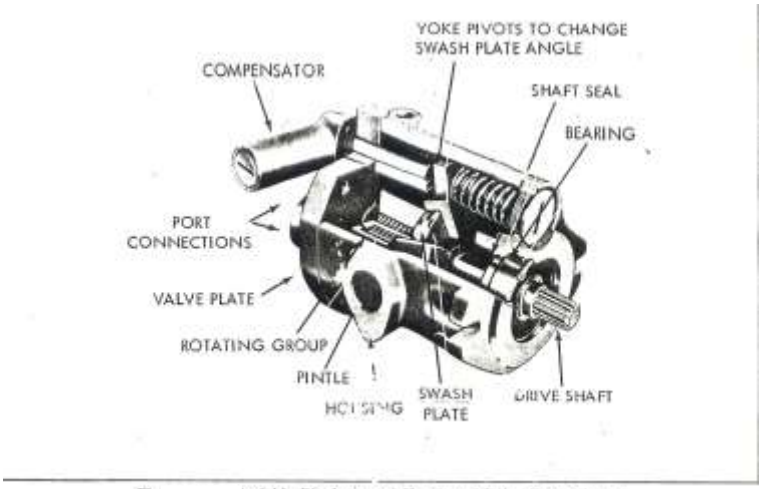


Fig ariable Displacement Variation of Inline Piston Pump

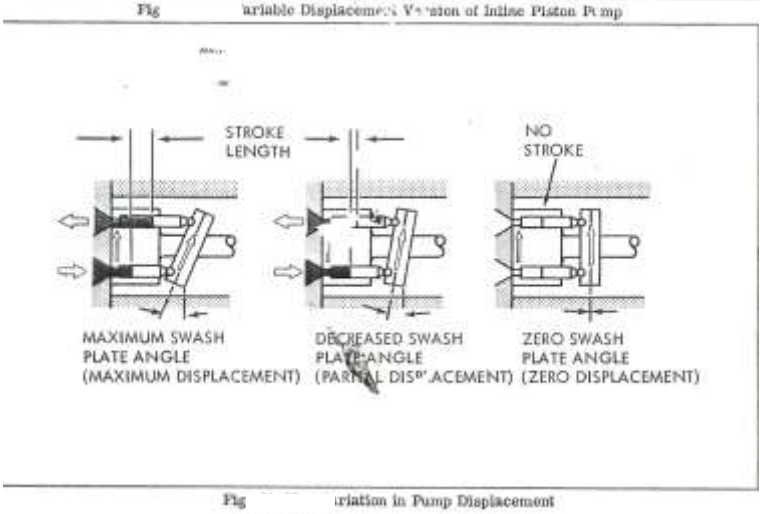
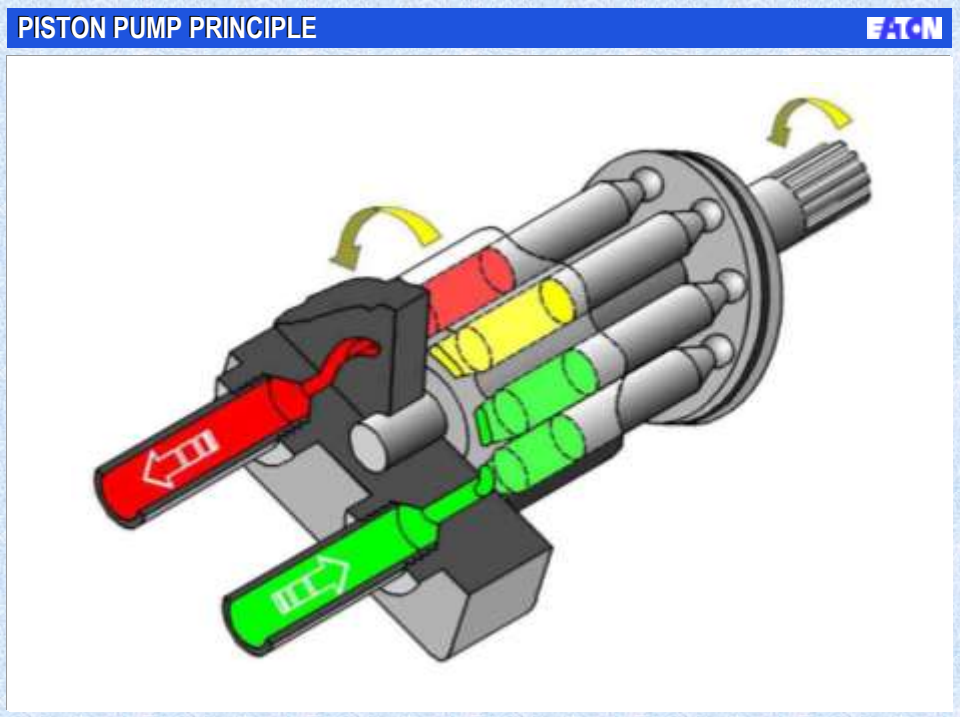


Fig riation in Pump Displacement



The circular arrangement of a piston is located parallel to the drive shaft in a fixed housing. The pistons run in a cylinder barrel which is firmly attached to the drive shaft by means of a key. The piston ends are of ball and socket design and run on slipper pads. These are held on a swiveling swash plate by means of holding discs. On the fixed displacement model the swash plate form a part of the housing and therefore has a fixed swash angle. On the variable displacement model the swash plate is built into the housing and can be swashed to angle of ± 15^0 from centre. The piston travels a stroke relative to the swash angle which determines the pump displacement. When the swash plate is in centre position i.e. vertical to the drive shaft, the piston stroke and thus the pump displacement are zero. Swashing the pump over center changes the direction of flow without changing the direction of rotation. Control of the axial piston pump via inlets in a port plate. At in any one time four of these moving pistons are connected via these inlet ports with the tank side. Further four pistons are connected with the pressure side and displace fluid. A charge pump is mounted on the same shaft of the axial piston pump. This pump draws oil in from the hyd. tank and supplies it to the hydrostatic loop to keep it charged. The charge pump relief valve is set at 30 bar. The either ports of the axial piston pumps are known as low pressure port and high pressure port and denoted by a letter 'A' & 'B'. In either sides pressure relief valve is provided which is set at certain pressure to suit that hydraulic circuit. Such relief valves are called cross relief valves.

PRECAUTIONS FOR INSTALLING HYDRAULIC PUMPS:

1) Clean entire oil from tank, remove scaling paint, dirt etc. flush it with fresh oil.
2) Clean the filter (choked filter may cause cavitation.)
3) Check suction and return lines for air Leakages, loose connection and loose connection in delivery will cause fluid leakage.
4) Sealant tape and shellac with pump should be used while providing fittings on the pump.
5) While assembling direction of rotation should be checked carefully.
6) Suction and delivery ports to be kept in desired directions.
7) All the bolts, O-rings should be properly fitted at proper torque.
8) All blades should be properly fitted. Keeping attention on their direction.
9) All bolts should be properly tightened at a uniform pressure.
10) Oil seal and bearing should be properly fitted.
11) Driving shaft should not be eccentric to the pump shaft.
12) All joints and pipe connection should be preferably applied with hard grease.
13) There should be no seepage form the pipes and pump premises should remain dry.
14) Start the pump at low r.p.m. preferably not more than 1000 r.p.m.
15) Run the pump at this rpm for about 20 min. and then apply pressure to it.
16) Observe the sound if it is taking air the sound is unpleasant and abnormal, at this stage stop the pump and check for air leakage.
17) If suction pipe is getting squeezed it means suction is choked, stop the pump and check filter and suction pipe.
18) After applying pressure if there is no sound, see heating effect on the pump this should be normal.
19) Now the pump is ready for working.
20) Do not start pump immediately after filling the tank a period of at least 12 hrs. so that entrapped air may escape from the oil. Normal recoupment of oil should also be done after working hours.
21) During severe winter the pump must run idle before putting load, for 15-30 min., so that cavitation effect due to high viscosity at lower temperatures is avoided.
22) Max. running temperature of hydraulic fluid for day of working must not cross 80^0 C.

AERATION:

Aeration occurs on account of presence of air in dissolved and free form in the hydraulic oil and renders the oil spongy. Air is always present in small quantity in the oil say up to 10% but this increased inclusion of air in oil reduces its lubricating properties and ultimately reduces the life of the pump.

CAUSES:

The following are the reasons of air inclusion in the oil.

1. Low oil level in the reservoir causes whirl pool at the intake and air is sucked by the pump along with the oil.
2. Restrictions in inlet pipe cause pressure to drop, which helps suction of air into pump.
3. If the return pipe opens above the hydraulic oil level in the reservoir it accompanies foaming in the tank and air inclusion.
4. Turbulent flow (intake and return) also causes air inclusion.
5. If the filter cartridge joint is not perfectly sealed or there is any void in the suction line, the pump sucks air through the same.

6. Leaking pump shaft seal, cylinder rod seals or other leaking unnumbered connections in the intake line cause aeration.

EFFECTS OF AERATION:

Aeration causes lack of lubrication, erodes the end plates of pump and vane tips are also worn out earlier. The vanes bounce and cause irregular ripples on the inner side of the cam ring. Wearing of these fast moving parts create excessive clearance between the end plates and rotor as well as between vanes/blades and cam ring and ultimately the pressure drops. The pump stops functioning properly and can not build up pressure thus the pump reaches a premature death.

CAVITATION:

It is a sort of vacuum created in the hydraulic oil which breaks the fluid into layers or cavities and the fluid does not fill the line perfectly. It can occur equally in pump, motor or cylinder etc.

CAUSES:

The following are the probable causes of cavitations in the pump and other hydraulic equipments:-

1. Filter is clogged.
2. Sharp bend in the suction line.
3. Obstruction in suction line.
4. High viscosity hydraulic oil used in machine.
5. Pump inlet is too high above the oil level in the tank.
6. Tank, if not ventilated properly-oil shrinks in volume as it cools.
7. The load is more than the delivery of the pump.

EFFECTS OF CAVITATION:

The effects in case of cavitations are similar to those occurring in aeration i.e.

i. Erosion of end plates.
ii. Rippled cam ring.
iii. Worn-out vanes tips and loose in slots.
iv. Pitting in the cam ring near inlet port.

TROUBLE SHOOTING:

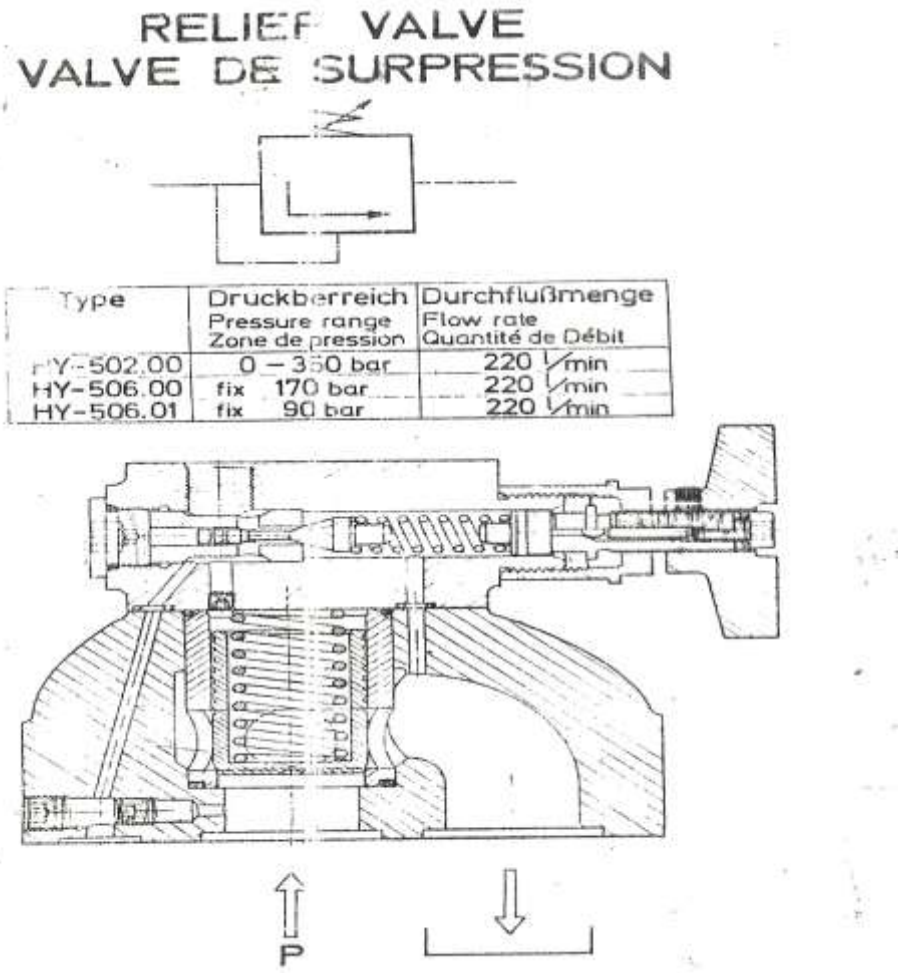
PROBLEM	CAUSES	REMEDIES
1. Pump not delivering oil.	1. Pump driven in wrong direction.	1. We can check the pump rotation by hand priming, pour the oil in intake port and rotate the shaft and see if the oil is coming from outlet or not. If not change the direction by repositioning the cam ring turned by 90^0.
	2. Intake filter or pipe choked.	2. Clean or replace the faulty one.
	3. Oil level too low in the tank.	3. Fill the tank with hydraulic oil.
	4. Pump shaft or rotor broken.	4. Replace the pump shaft or rotor broken.
	5. Air traps in suction line.	5. Check the suction line and replace

2). Pump making noise.	1). Oil level too low.	1). Fill the tank with hydraulic level that more air influence is prevented.
	2). Restricted or partially clogged intake filter or line.	2). Clean or replace the intake filter or line. Suction filter should be changed in time.
	3).Tank is not vented properly.	3).Air breather screening element should be cleaned regularly, so that atmospheric pressure exert effectively on the oil surface in tank and good suction may take place
	4).Viscosity of oil too high.	4).Use proper grade oil. In winter Season oil becomes thick so no free flow takes place, warm up the oil by starting pump for few minutes.
	5).Air leak at pump intake pipe joints.	5).Check for any loose connection or joint and tighten them.
3). Bearing failure.	1). Chips or other contaminants.	1). Replace bearing and check source of contaminants.
	2). Inadequate lubrication.	2). Excessive heating of oil should be avoided.
	3).Pump running too fast.	3). Adjust the R.P.M of prime mover
	4).Excessive or shock loads.	4). Excessive load due to operating pressure may damage bearing so reduce operating pressure.

HYDRAULIC VALVES:

In hydraulic systems, energy is transferred between the pump and the consuming device along appropriate lines. In order to attain the required values – force or torque, velocity or rpm – and to maintain the prescribed operating conditions for the system, valves are installed in the lines as energy control component. These valves control or regulate the pressure and the flow rate. In addition each valve represents a resistance.

RELIEF VALVE:



Function:

It is found in virtually every hydraulic system. It is a normally closed valve connected between the pressure line and the tank. Its purpose is to limit pressure in the system to a preset maximum by diverting some or all of the pump's output to tank when the pressure setting is reached.

Operation:

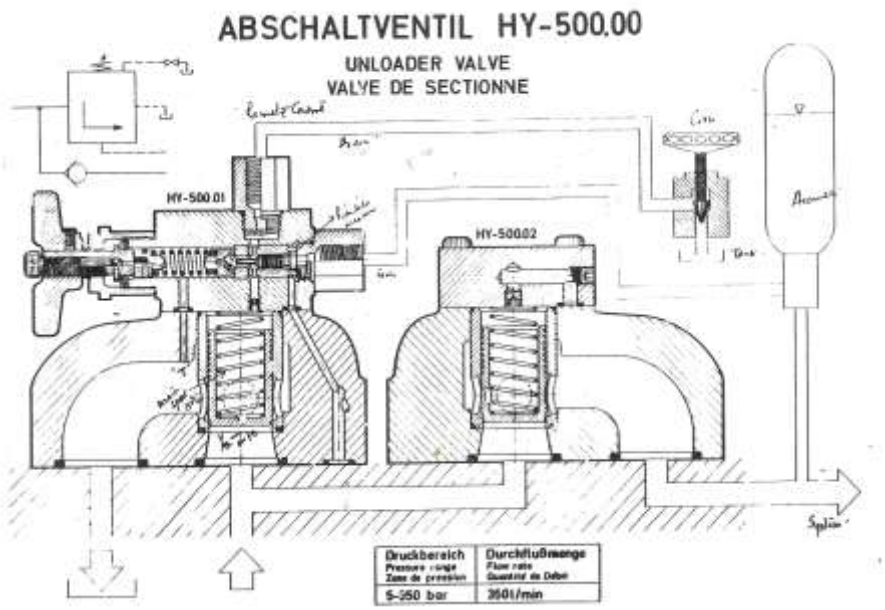
Relief valve consists in two sections (1). Cover section which includes poppet, spring, and adjusting screw & vent connection. (2). Body section which contains the piston, spring& seat. The valve pressure setting is determined by the adjusting screw position which varies the

heavy spring compression. The balanced piston is normally held against the set by the light spring. System pressure is present in lower chamber of piston and also passes to the upper chamber through a pilot line. With system pressure less than the valve setting the pilot poppet is held against its seat by spring force. Pressure in both chambers equalizes and the piston is hydraulically in balance and held against its seat by the light spring.

When system pressure exceeds the heavy spring setting and forces the poppet away from its seat. Fluid then flows through poppet seat to tank port. The pressure in upper chamber is limited by the setting of the heavy spring. When pressure in lower chamber exceeds upper chamber sufficiently, pressure unbalance overcomes the force of the light spring and lifts the piston. Excess fluid then flows past the bottom of the piston to tank. When system pressure drops below the valve setting, the popper reseats. Control flow through pilot line stops and pressures in both chambers are again effectively equalized. The light spring then forces the piston towards the seat when the balanced piston is closed against its seat, the unloading stops. The pump delivery now goes to the system.

Venting: Relief valves can be vented to unload pump delivery to tank in the manner – connect a shutoff valve to the vent port of the main relief valve. This removes pressure at the top of the balanced piston. Pressure in the lower chamber overcomes the light spring, unseats the balanced piston and diverts all the delivery of pump to tank.

UNLOADER VALVE:



Function:

- To control and keep the system working pressure within the predetermined range whenever the pump is producing a flow.
- To divert oil in excess of that required in the system back to tank at nominally zero pressure thus relieving the pump of its load.

Operation:

An unloader valve is used in accumulator charging circuit to (i) limit max. pressure and. (ii) unload the pump when the desired accumulator pressure is reached. In construction, it contains a compound, balance piston relief valve, a check valve to prevent reverse flow from the accumulator & a pressure operated plunger which vents the valve at the selected pressure.

Normally, the relief valve piston is in balance and is held seated by its light spring. Flow is through the check valve to the accumulator/system. When preset pressure has been reached, the relief valve poppet has unseated limiting pressure above piston and on the poppet side of the plunger. Further increase in system pressure acting on the opposite end of the plunger has caused it to force the poppet completely off its seat, in effect, venting the relief valve and unloading the pump. The check valve has closed permitting the accumulator to maintain pressure in the system.

Because of the difference in area between the plunger & poppet seat (approx. 15%), when pressure drops to about 85% of the valve setting, the poppet & piston reseat & the cycle is repeated.

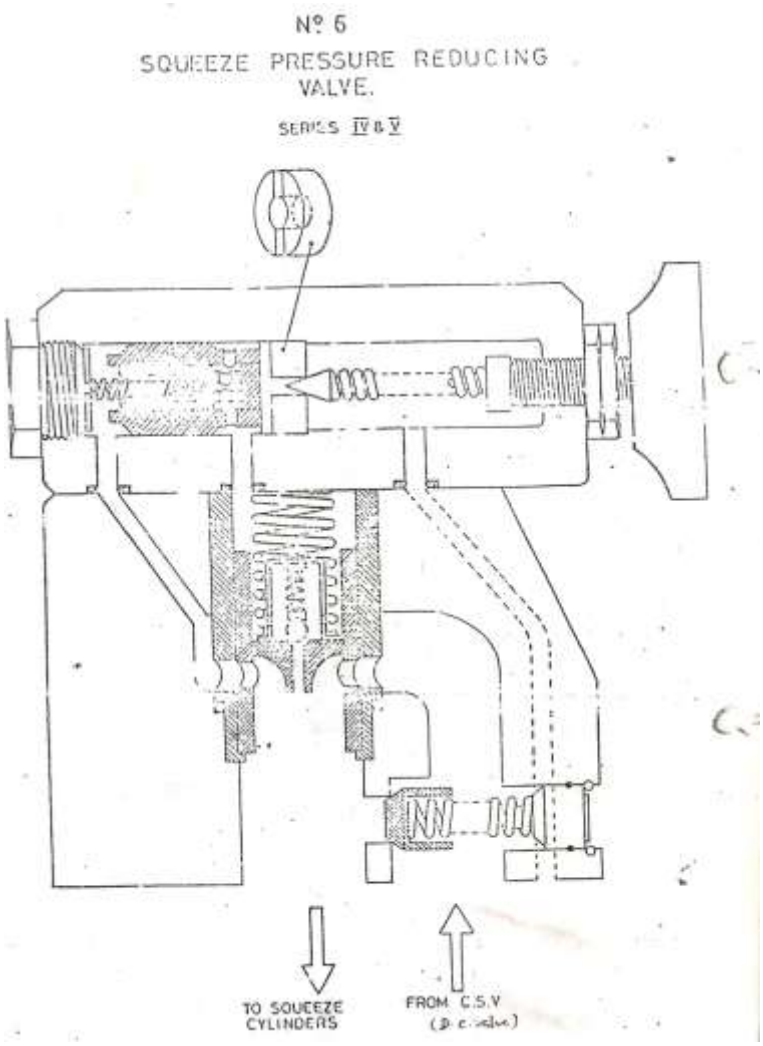
TROUBLE SHOOTING IN UNLOADER VALVE:

Sl.No.	FAULT	REASON	REMEDIES
1	No pressure in the circuit	1. Defective pump	Check the pump and replace if required
		2. Leakage in the system	Check the leakage and rectify the fault
2	Pump O.K. no leakage in the system,still no pressure	1.Choked up orifice of main spool	Clean the orifice.
		2.Secondary stage vent open to tank	Close the vent
		3.Safety valve at Zero setting	Set safety valve as per value written in the circuit.
3	Pressure does not rise to required value even after complete tightening the control knob	1.Worn out pump is not able to push the fluid against set resistance.	Replace the pump.
		2. Leakage in the system	Check the leakage and rectify the fault.
		3. Leakage at seat of ball in control head	Check the seat and ball. If defective replace it.
		4. Safety valve setting lower than unloader valve setting	Set safety valve 10-15 % higher than unloader setting.
4	Unloader does not unload	1. Nil or low nitrogen pressure in the accum-ulator	Check pressure recharge the accumulator
		2. Punctured bladder	Change the bladder.
		3. Leakage in the system	Locate fault and rectify the leakage.
		4. Less delivery from pump than demand of the circuit.	Replace the pump
		5. Partial leakage at ball seat in control head	Replace the ball and seat.
		6. Wrong connection of control head spool from the system.	Correct the connection.
		7. Vent line of unloader connected to return line.	Connect line to drain line.

TROUBLESHOOTING IN RELIEF VALVE:

Sl. No.	FAULT	REASON	REMEDIES
1	No pressure in the circuit	1.Defective pump flow	Check flow with the Meter and replace pump if Required. .
		2.Leakage in the system	Arrest the leakage.
2.	Pump OK & no leakage in sys. still no pressure.	1.Choked up orifice of main spool .	Take out the spool and clear the orifice.
		2.Secondary stage vent open to tank	Close the vent
3.	Pressure does not rise to required value even after complete tightening the control knob.	1.Excessive clearance in pump matching parts due to wear	Replace the pump.
		2. Leakage in the system	Check the leakage & rectify the fault.
		3. Leakage at poppet seat	Check the seat and poppet,if defective Replace it.
		4.Under size valve in relation to flow of pump.	Provide proper size valve.
4.	Valve sticks	1. Valve stressed.	Loosen bolts and tighten uniformly.
		2. Oil temperature too low.	Warm up system by starting hydraulic system.
		3. Piping stressed.	Providing proper bends in piping.
		4. Drain line under pressure.	Install line or separate from return line.

PRESSURE REDUCING VALVE:



Function:

The task of the pressure relief valve is to limit the pressure in the complete system to a given level. The task of the pressure reducing valve, on the other hand, is to reduce the pressure in a particular branch of the circuit to the level required by a special load or consumer.

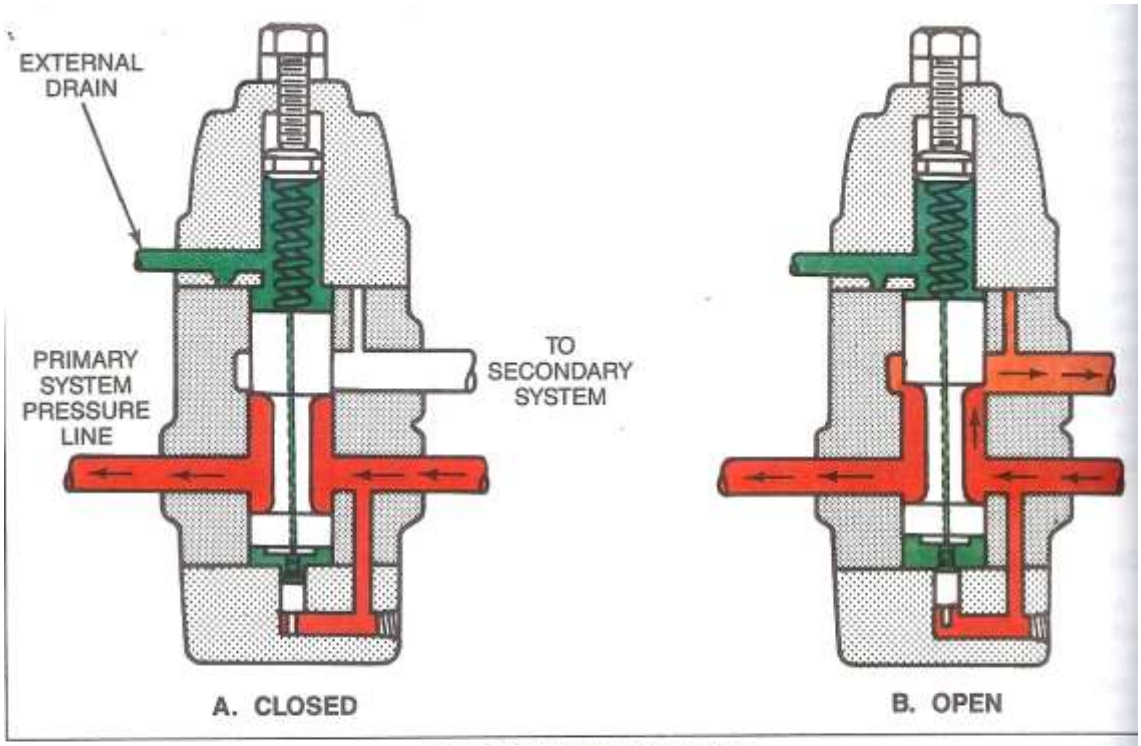
Working:

Pressure reducing valves are normally open pressure controls used to maintain reduced pressure in certain portions of the system. They are actuated by pressure sensed in the branch circuit & tend to close as it reaches the valve setting thus preventing further build-up. This valve is fitted into the squeezing circuit in order that the desired pressure for squeezing in varying conditions may be regulated to suit those conditions.

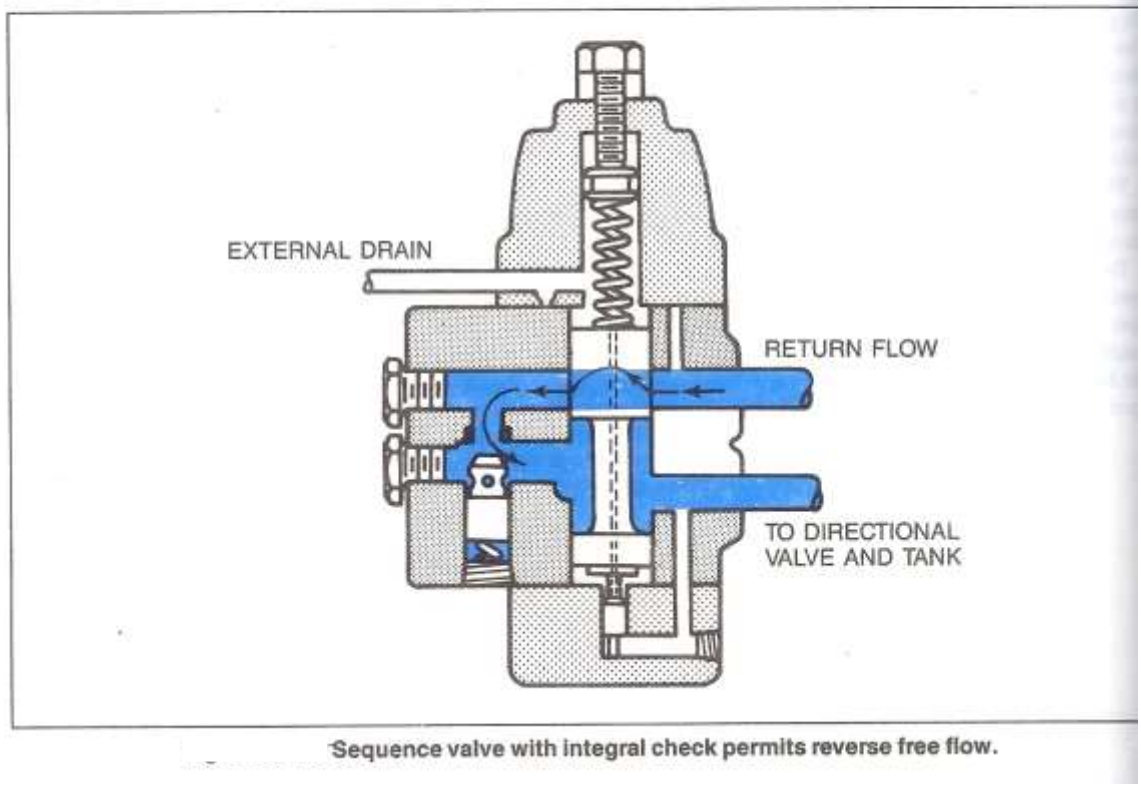
The pilot operated pressure reducing valve has a wider range of adjustment & generally provides more accurate control. The operating pressure is set by an adjustable spring in the pilot stage in the upper body. The spool is hydraulically balanced through an orifice in its centre and the light spring holds it in the wide open position.

When pressure has reached the valve setting and the pilot valve is diverting flow to the drain passage limiting pressure above the spool. Flow through the orifice in the spool creates a pressure difference that moves the spool up against the spring force. The spool partially closes the outlet port to create a pressure drop from the supply to the branch system.

SEQUENCE VALVE:



Sequence valve.



Sequence valve with integral check permits reverse free flow.

A sequence valve is used to cause actions to take place in a system in a definite order, and to maintain a predetermined minimum pressure in the primary line while the secondary operation occurs. Fluid flows freely through the primary passage to operate the first phase

until the pressure setting is reached. A typical application is clamping from the secondary after the work piece is firmly clamped.

To maintain pressure in the primary system, the valve is internally operated. However, the drain connection must be external, since the secondary port is under pressure when the valve sequences. If this pressure were allowed in the drain passage, it would add force and raise the pressure required to open the valve.

TROUBLE SHOOTING:

Sl. No.	Problems	Causes	Remedies
1.	Valve flutters	1. Valve seat defective	Exchange parts
		2. Pilot control defective	Repair pilot control
		3. Oil speed too high	Install valve of greater nominal size
		4. Wrong oil grade	Respect oil recommendations
		5. Dirt in system	Flush system if needed pickle and flush out
		6. Damping defective	Repair valve or change spring
2.	Valve sticks	1. Valve stressed	Loosen bolts and tighten uniformly
		2. Oil temperature too low	Warm up system through pump or install heating
		3. Piping stressed	Incorporate balancing bends
		4. Drain line lacking or under pressure	Install line or separate form return
		5. Dirt in system	Flush system or if needed pickle and flush
		6. Wrong oil grade	Respect oil recommendations
		7. Water condensation in system	Check cooler and check system for condenser effect
		8. Oil gumming	Clean spool and if needed change oil
		9. Body parts wrongly fitted	Observe assembly sequence in service instructions
		10. Wrong seals	Replace seals prescribed
3.	Valve does not function	1. Valve spring broken	Change spring
		2. Valve sticks	Establish cause and repair defect
4.	Valve overheats	1. System temperature too high	Observe maximum pressure
		2. Oil speed too high	Install valve of greater nominal size

FUNCTION:

There are several types of valves in hydraulic system. Some are used to limit and regulate the pressure, while other controls the direction of fluid flow. Directional control valves are used to control fluid flow in hydraulic lines, to start, to stop or change the direction of motion of hydraulic cylinders and motors. Directional control valves can be manually or automatically operated such as by push button, lever, mechanical action, electrical signals, hydraulic power or compressed air. They can be simple check valve, more complicated pilot and solenoid operated valves. Valve body has a precision machined bore in which a very close tolerance spool is suspended on a film of hydraulic fluid. Spool lands and body cavities are designed to divide the bore openings into separate chambers. Ports in the body lead into this chambers so that spool positions determine which ports are opened or closed.

They are classified according to their principal characteristics, such as:-

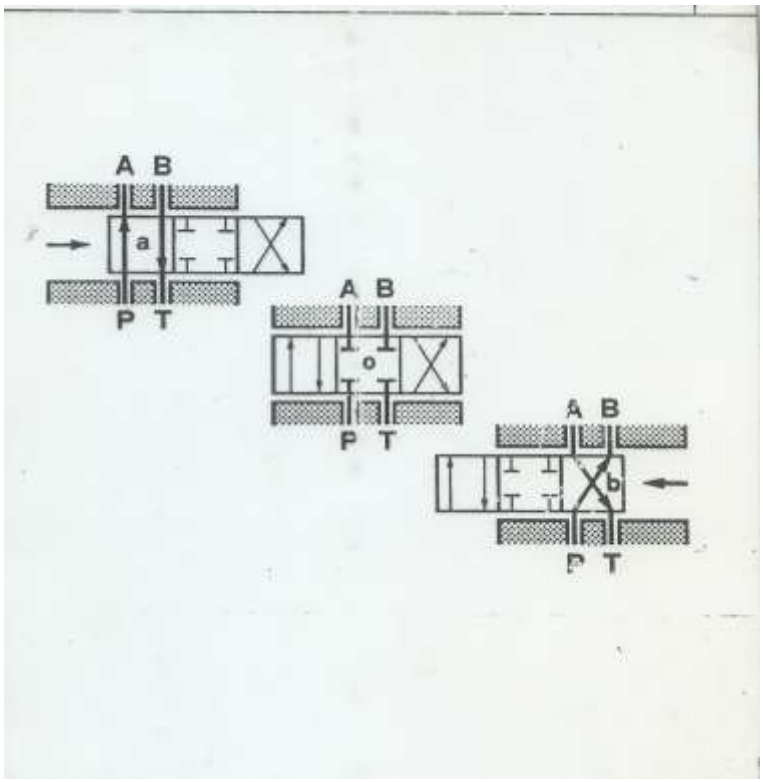
1. Type of internal valving element- poppet (piston or ball), rotary spool and sliding spool.
2. Methods of actuation- cams, plungers, manual lever, mechanical, electric solenoid, hydraulic pressure (pilot operated), compressed air.
3. Number of flow paths- two-way, three-way, four way etc.
4. Size- nominal size of pipe connections to valve or its mounting plate or rated GPM flow.

TYPES:

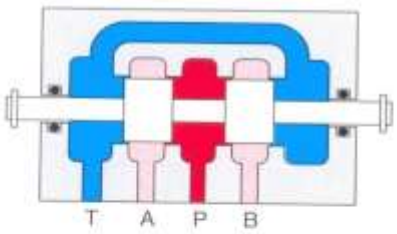
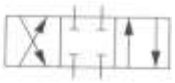
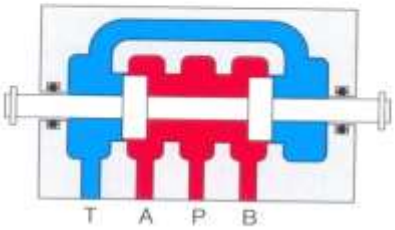
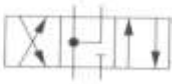
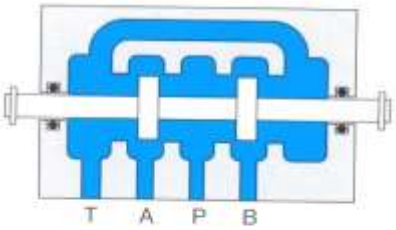
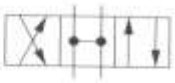
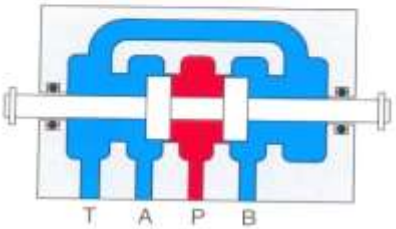
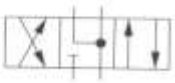
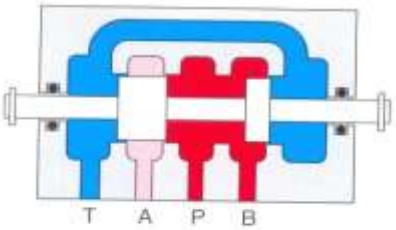
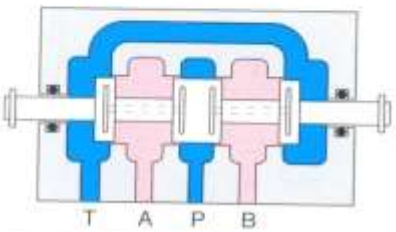
There are three types of D.C. valves:-

1. Spring centered valve.
2. Spring offset valve.
3. Pilot operated valve.

Spring centered valve:



Sliding Spool Types and their symbols (4/3 way valve)

Closed position		
Pressure to A&B port		
Opened position		
Floating position		
Pressure to B port		
Tandem centre		

This valve is provided with spring and centering washer at each end of spool. The spring and washer centre the spool with in the valve body when solenoids are de-energized where it is necessary to stop or hold an actuator at some mid point in its travel, a 3 position valve is used. The third position is achieved by centering springs. Flow conditions in this centre or neutral position are determined by the work requirement of the system.

Spring offset valve:

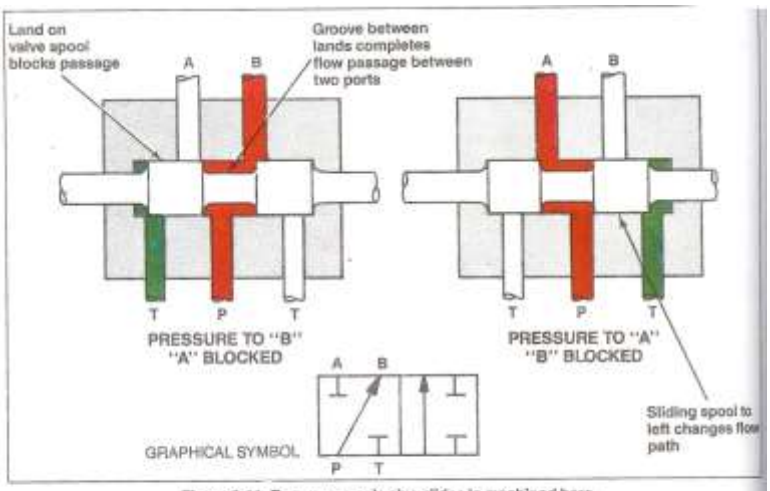


Figure 8-11. Two-way spool valve slides in machined bore.

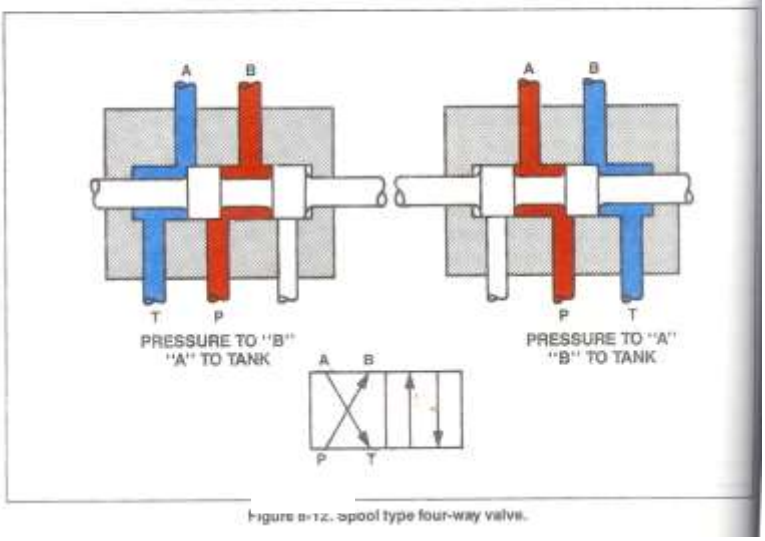
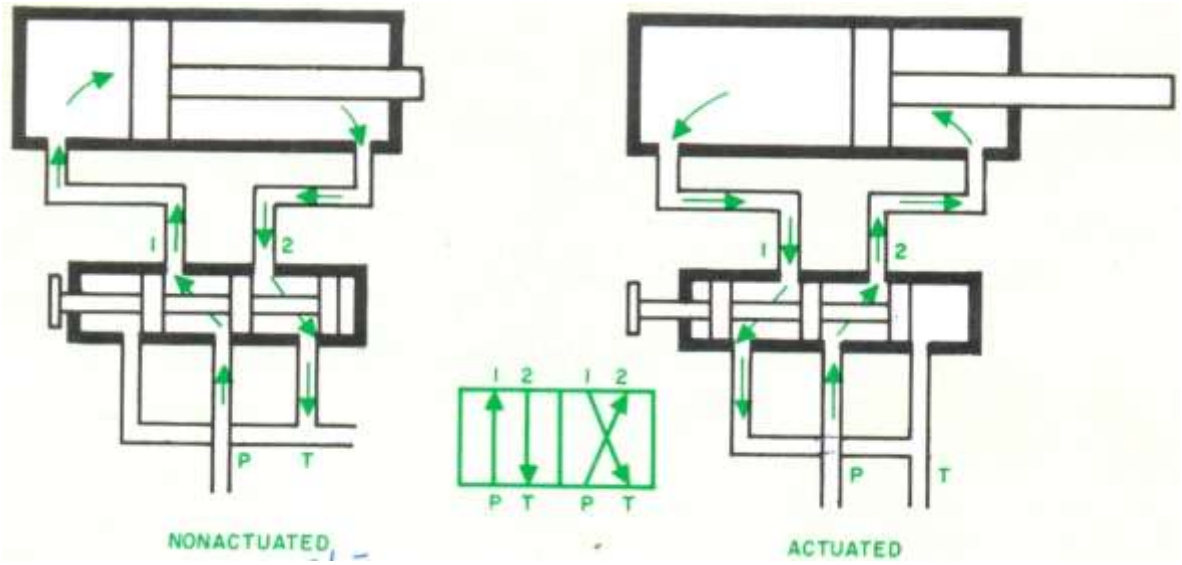


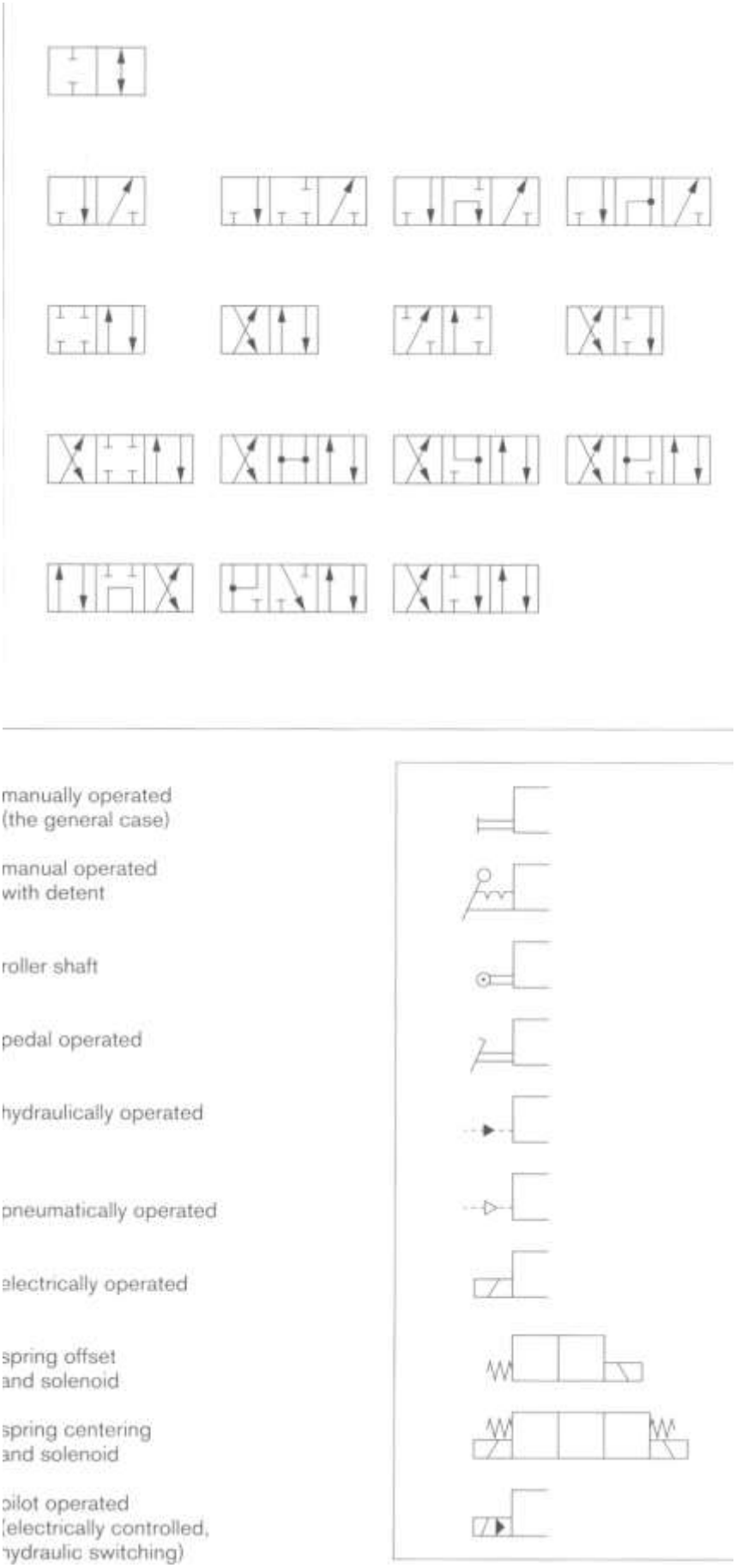
Figure 8-12. Spool type four-way valve.

These valves use one solenoid only. Spring returns the spool to offset position when the solenoid is de-energized.

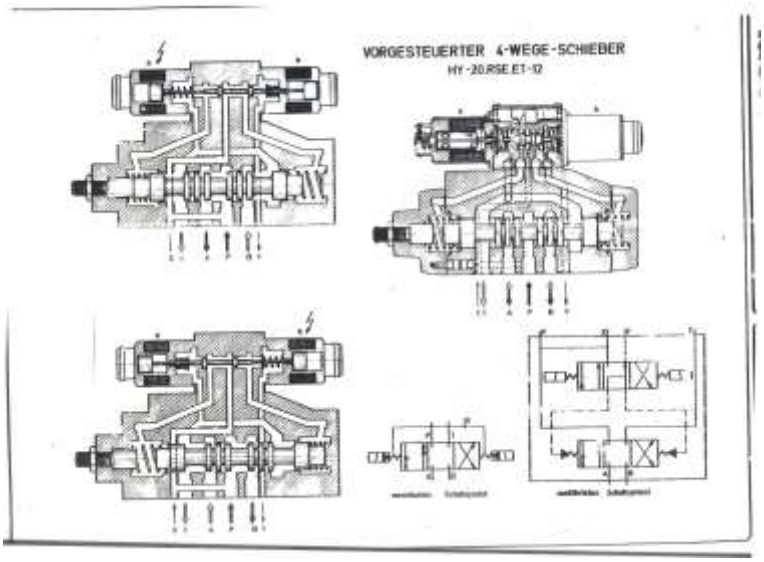
Working of 4/2 way valve



Symbol variety and Control mechanism:

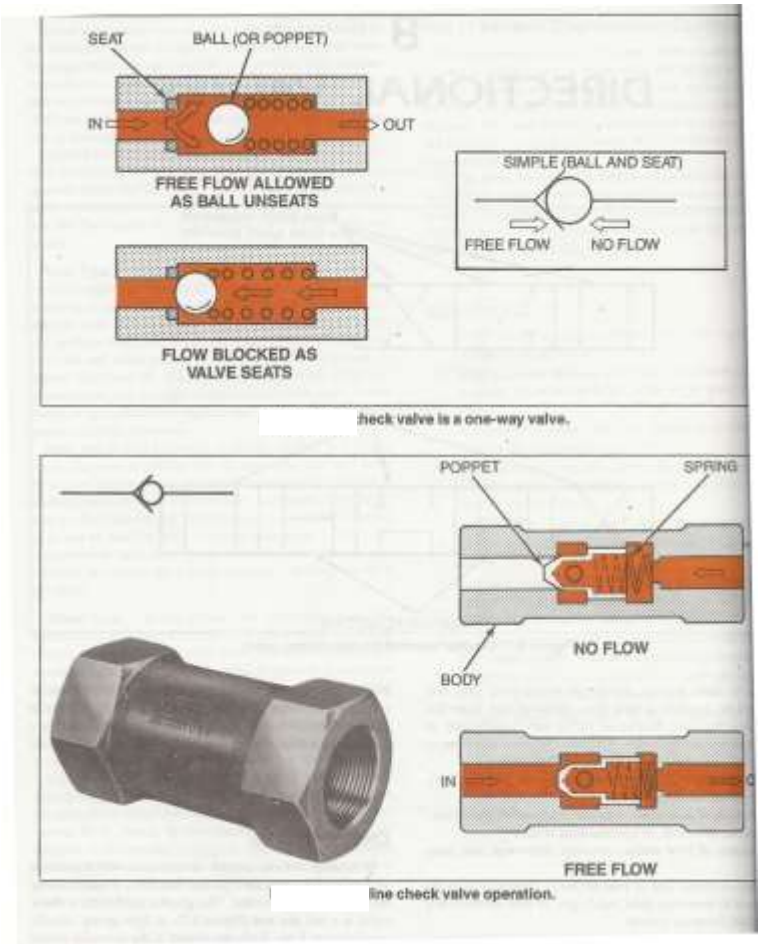


Pilot operated valve:



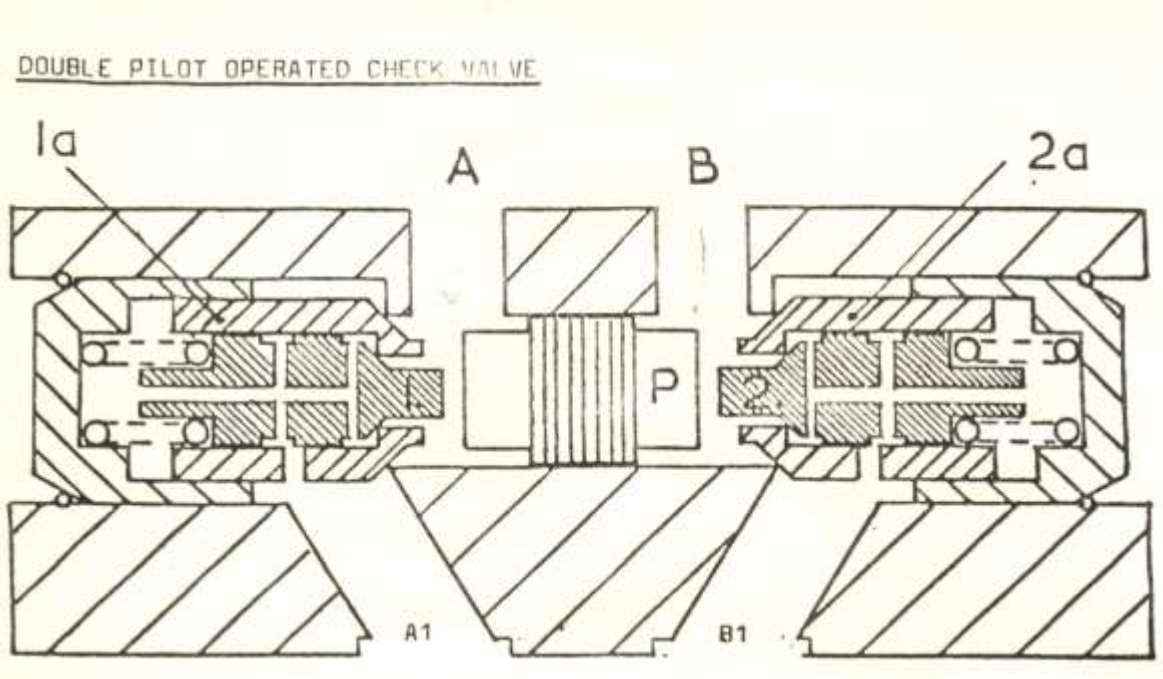
In larger valves much force is required to shift the spool which can not be shifted by 24 V D.C. Therefore pilot operated D.C valve is used. This valve is operated by pilot pressure against either spool end. The pilot oil furnished from a small 4 way valve i.e. is pilot valve which is actuated by solenoids. Thus we may control high flow rates with low solenoid power. Pilot valve or master valve is mounted on top of the larger "slave valve". The normal position of pilot valve is A – B to T.

NON RETURN VALVE (CHECK VALVE):



Non-return valves block the flow in one direction and permit free flow in the other. As there must be leaks in the closed direction, these valves are always of poppet design and are constructed according to the following basic principle.
The sealing element (generally a ball or cone) is pressed against an appropriately shaped seat. The valve is opened by volumetric flow in the flow direction, the sealing element being lifted from the seat.

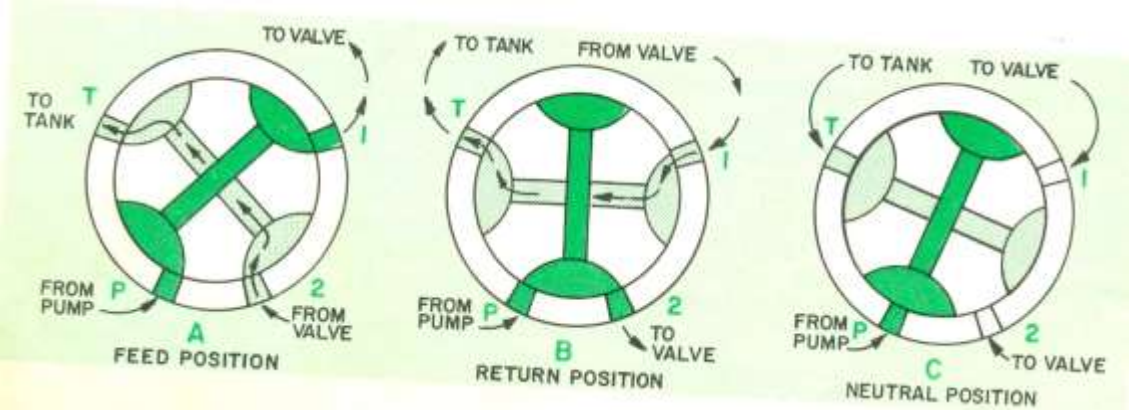
Pilot operated check valve:



Function: Pilot operated check valve is used hold the load in mid position.

Operation: Oil is directed to port A from the D.C.Valve which opens the check valve assembly 1 from its seat, allowing oil to the actuator via port A1. At the same time piston P will be moved to the right unseating check valve assembly 2, so releasing oil to tank from circuit B1 via port B. When the D.C.Valve cuts off the supply to "A", check valve assembly 1 will seat, locking oil in the circuit A1. This hydraulic lock will be felt behind the whole check valve assembly having flowed through a drilling in the check valve 1 & 1a and so assist in keeping them firmly seated. To release oil from circuit A1, a pilot feed of oil from the D.C.Valve is directed to port B, thus moving piston P to the left. The initial movement contacts the inner check valve 1 moving it from its seat to initially relieve pressure locked behind the check valve assembly via the internal drilling of 1. Finally moving the main portion of the non return 1A thus permitting the return flow of oil from the actuator to tank over the seat of the main non return valve.

Rotary spool D.C.Valve: This type of valve is frequently used to supply a flow in or to reciprocate a component (cylinder) or simply to operate a system in one direction, leave it until work is finished and then release i.e. wheel supports on a tamping machine.



LOGIC VALVE (CARTRIDGE VALVE):

Refinements in hydraulic system development have led to greater use of manifold blocks. A manifold block greatly reduces the number of fittings required for the interconnecting lines between components in a system. This eliminates many potential leakage points and reduces fluid waste from leakage. A cartridge valve is inserted into a standardized cavity in a manifold block and held in place with either self-contained screw threads or a cover secured with bolts to complete the cartridge valve design concept.

Cartridge valves are two types: (1) Slip-in cartridge valves and (2) Screw-in cartridge valves.

Advantages of Cartridge valve:

Cartridge valves provide several advantages over conventional line-or subplate-mounted spool-type directional, pressure, and flow control valves. In many applications, the advantages include:-

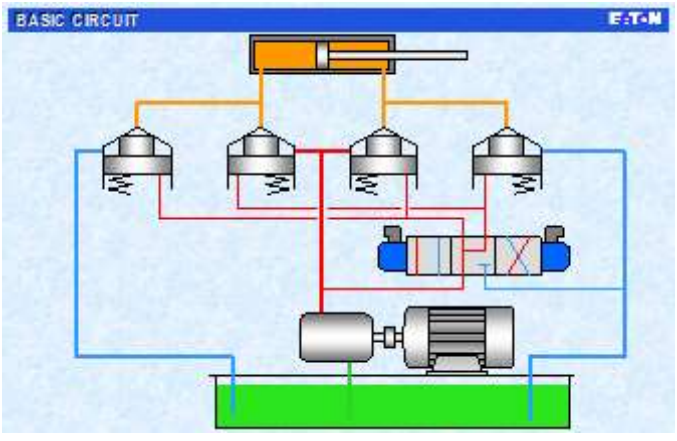
1. Greater system design flexibility.
2. Lower installed cost.
3. Smaller package size.
4. Better performance and control.
5. Improved reliability.
6. Higher pressure capability.
7. More efficient operation.
8. Elimination of external leakage and reduction of internal leakage.
9. Greater contamination tolerance.
10. Faster cycle times.
11. Lower noise levels.

Operation of Slip-in Cartridge Valves:

These valves are used in hook lifting-lowering circuit of Unimat machine. Most Slip-in cartridge valves are poppet type elements that are normally controlled by another valve to provide a complete hydraulic function. These valves are similar to poppet check valves and consist of an insert assembly that slips into a cavity machined into a manifold block. A control cover bolted to the manifold secures the insert within the cavity. The insert includes a sleeve, a poppet, a spring and seals.

The cartridge valve insert can be viewed as the main stage of a two-stage valve. It has two main flow ports, “A” and “B”. Drilled passages in the manifold connect the “A” and “B” ports to other cartridge or to the operating hydraulic system. Similarly, a drilled pilot passage in the manifold connects the control port “X” as desire.

Notice the orifice in the drilled passage between the “X” port and the spring chamber “AP”. The purpose of this orifice is to reduce the speed at which the valve poppet opens and closes. Various orifice sizes are available to optimize or tune cartridge response in relation to that of the entire hydraulic system. The hydraulic system designer can select the orifice size that provides maximum operating speeds with minimum hydraulic shock.



PRECAUTIONS DURING MOUNTING D.C. VALVE:

1. On solenoid operated D.C. valve make sure that the electrical ground is connected to the valve that prevents the possibility of shock hazards developing if a coil were to short out to the frame
2. The number of bends in tubing should be kept to a minimum to prevent excessive turbulence and friction of oil flow. Tubing must not be bent too sharply the recommended radius for bents is three times more than the pipe inside diameter.
3. The selection of valve should be according to the circuit.
4. The normal configuration of valve should be checked. Pour hydraulic oil in P port and check the position of A, B and T port.
5. O – Ring should be checked on the grooves provided between valve and base plate.

TROUBLE SHOOTING:

S.no	Problem	Cause	Remedies
1.	Valve spool stick	1.Dirt in the system	Disassemble, clean and re- assemble
		2.Body parts wrongly fitted	Fit properly
		3.Rusting due to water condensation	Clean or replace if required
		4.Solenoids not operated	Check electrical supply and source
		5.Spool is stressed	Check surface, clean, tighten the bolts. Oil film should be available between valve body and spool. .
2.	Solenoid not functioning	1.Faulty electrical circuit	Check and rectify
		2.No current	Check the electrical wires and supply.
		3.Coil burnt out.	Replace
3.	Leakage in valves	1.Connections not sealed	Check and rectify
		2.Wrong seals	Replace by proper size
		3.Defective valves, cracks in body	Repair or replace
4.	Valve overheats	1.System pressure too high	Reduce pressure setting
		2.Wrong oil grade	Use proper grade oil
		3.Dirt in the system	Flush system and clean the valve
		4.Faulty electric circuit	Check electric circuit
		5.Spool defective	Repair spool

FUNCTION:

- Proportional valves control and vary pressure, flow, direction, acceleration and deceleration.
- They are adjusted electrically are actuated by proportional solenoids.
- Output flow is proportional to the input signal.
- By varying the input signal solenoid adjusts the spool movement to vary the flow through the valve.
- To control the speed of the spool a gradually increasing or decreasing signal (a ramp function) is fed to the control amplifier and thus we get a smooth, shock free movement.
- Used for Tamping unit lifting-lowering and satellite drive.
- Maximum voltage 24V DC, current range-250mA to 750mA
- For Tamping Unit Lowering current-650mA
- For Tamping Unit Lifting current-600mA

Working of Proportional Valve:

D.C conventional valves are 'Yes' or 'No' type valve. These valves are completely 'OFF' or 'ON' type that means either the ports will be completely closed or completely opened and these types of valves are known as finite positioning valves. During operation the movement of actuator is not controllable.

To get a controlled and measured amount of actuation, other types of valves known as proportional valves has been introduced and such valves are known as infinite positioning valves. These valves are also known as direction cum flow control valve. To get measured amount of correction or actuation and accordingly the movement of spool of the valve is proportionate to the current. It means what ever amount of correction or actuation we need. That only will be done. Neither this will be less nor will be more.

In this valve how much amount of current flow through coil, proportional amount of fluid will pass through it. It means its operation is proportional to signal it receives i.e. as movement will be such that it corresponds to the controlling signal. Higher the amounts of signal, higher the actuation. Lower the amount of signal, lower the actuation will be. So we need a proportional movement and proportion actuation.

The amount of movement of the spool in either direction is electrical from an electrical i/p signal. This signal is converted via an electrical amplifier to a current signal to the relevant solenoid the force generated moves the main spool against the main spring. The positional transducer then ascertains the actual position of spool and fills this back as a voltage signal to the amplifier. The input signal and actual values are then compared electrically. From these two values a signal is generated and fed to the solenoid in order to give a defined position to the main spool. The main spool has metering slots cut into it which give a progressive flow characteristic.

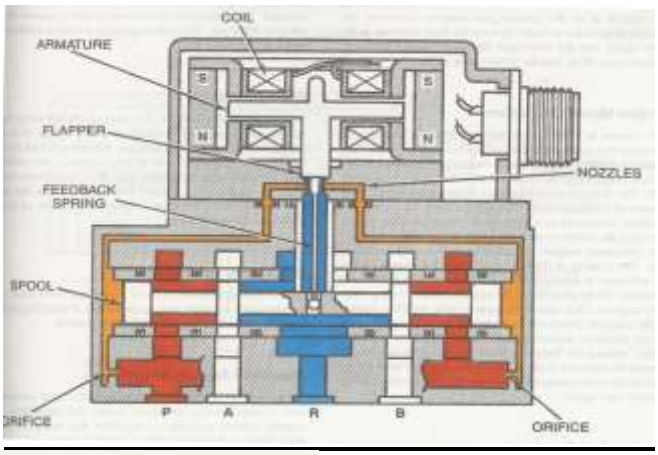
TROUBLESHOOTING OF PROPORTIONAL VALVE:

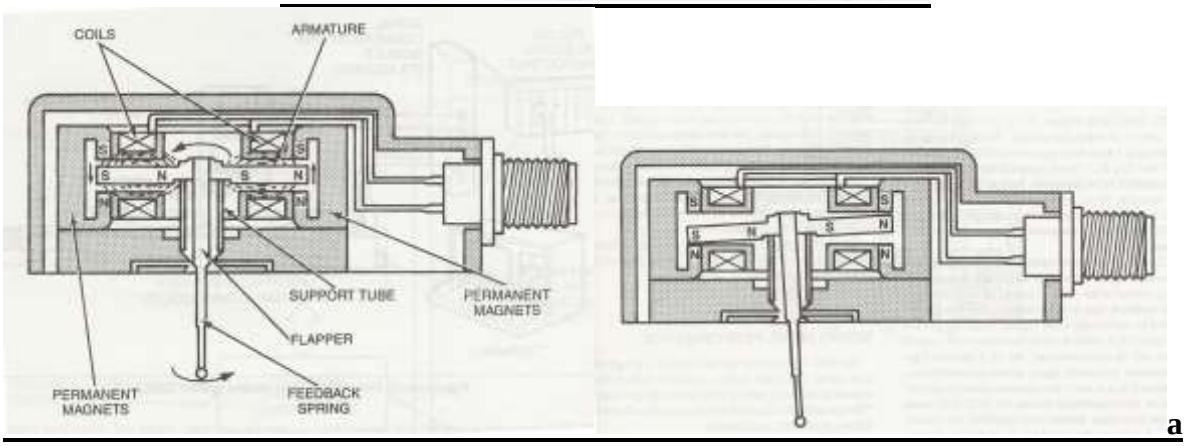
S.No.	Trouble	Causes	Rectification
1.	Spool sticks	a) Spool stressed	Loosen union and tighten uniformly.
		b) Dirt in the system	Clean the valve and flush the system.
		c) Body parts wrongly fitted	Dismantle valve, observe assembly sequence and reassemble.
		d) Wrong seals	Replace seals prescribed.
		e) Oil temperature too high	Check cooling circuit.
		f) Spool defective	Repair or replace.
		g) Return pipe under high pressure	Dismantle the connection and clean. If required lead pipe separately to tank.
2.	Proportional valve does not function.	a) Proportional solenoid defective	Replace.
		b) Electric circuit faulty	Check circuit & PCB.
		c) Proportional filter clogged	Replace.
		d) No current	Check electrical installation.
3.	Proportional valves overheat.	a) Oil temperature too high	Check cooling circuit, reduce pressure setting.
		b) Wrong oil grade	Use recommended oil.
		c) Dirt in the system	Flush system.
		d) Faulty electrical circuit	Check and rectify.
		e) Spool defective	Repair or replace.

FUNCTION:

- Servo valve is a directional valve that may be infinitely positioned to control of both the amount and the direction of the flow. A servo valve coupled with the proper feedback sensing devices provides very accurate control of the position, velocity, or acceleration of an actuator.
- Small input signal causes a large output of hyd. Power.
- A low power control signal can produce output of several hundreds horse-power.
- In airplanes, jet planes servo valves are used for fast response.
- Used in lifting and lining circuit in 09 CSM, 09-3X, Unimat-3X, new Duomatic.
- For track lifting – 2nos and for alignment- 1no servo valve is provided.
- Voltage-3V DC, Current-15mA.
- Contaminated oil is not desirable.
- Maintain the oil cleanliness to NAS-5 class.
- Before installing the servo valves flush the system.
- Filter should be replaced in non-contaminated atmosphere.
- Null should be adjusted properly, if null gets disturbed.

Working of servo valve:





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Servo valve consist of an electrical torque motor, nozzle flexure tube, flapper and sliding spool. In the torque motor there are upper and lower pole plates, permanent magnet and an armature. The armature is supported for limited movement by a flexure tube. The flexure tube acts as a seal between the electromagnetic and hydraulic portion of the valve. The coils surround the armature one on each side. The flapper is rigidly attached to centre of armature. The flapper extends down inside and passes between two nozzle tips and flapper. Flapper motion varies the nozzle openings. The pressurized oil is supplied to each nozzle through a filter and inlet orifices. Differential pressures caused by flapper movement between the

nozzles are applied to the ends of the valve spool. Due to nozzle area difference force develops accordingly more on one side and spool is shifted and 'P' may connect 'A or B' depending upon our requirement. A feed back wire is deflected by spool movement so that feed-back torque is applied to the armature.

Input signal in the torque motor coils causes clockwise or anticlockwise torque on the armature. This torque displaces the flopper between the two nozzles. Thus pressure difference is created due to area difference in nozzle and moves the spool either left or right. The spool displacement causes a force in feed back wire, which opposes the input signal torque. Spool movement continues until the feed-back wire force equals the input signal force. So the spool stops and remains displaced until electrical input changes to a new level. The actual flow from the valve to the load will depend upon the load pressure. In neutral position leakage rate is 0.005 cc/sec.

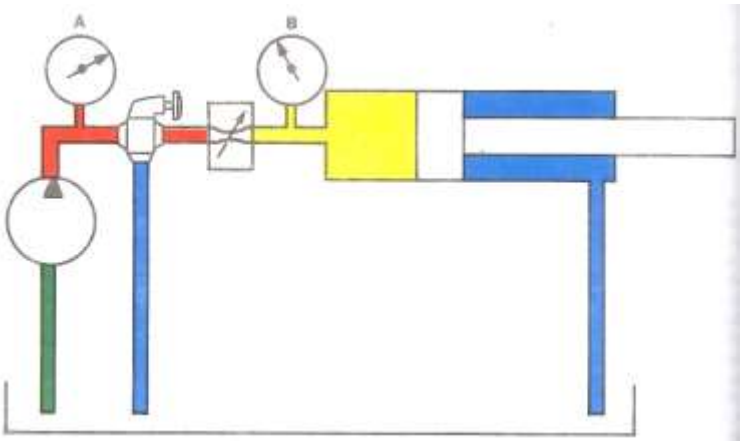
TROUBLESHOOTING IN SERVO VALVE:

Sr. No.	Fault	Causes	Rectification
1.	Servo valve spool sticks.	a) Feed tube dirty	Check system for dirt and clean filter.
		b) Fine filter dirty	Check system for dirt and clean filter
		c) Mechanical return sticks	Valve should be dismantled.
		d) Valve stressed	Loosen unions and tighten uniformly
2.	Servo valve does not function.	a) Electric circuit defective	Check electric circuit.
		b) Rotary magnet system defective	Repair system or replace torque motor.
		c) No differential current	Check electrical installation.
		d) No pressure	Check pump and relief valve.
		e) Oil gummy	Clean valve, flush system and change oil if needed.
		f) Oil temperature too high	Check cooling circuit, check for any line restrictions and reduce pressure setting.
		g) Servo filter clogged	Replace filter.
3.	High null basis (High input current required to maintain the hydraulic cylinder stationary)	a) Incorrect Null adjustment	Readjust the null.
		b) Partially plugged inlet orifice assembly	Clean the inlet.
		c) Partially plugged filter element.	Replace the filters element.
		d) Partially plugged Nozzle	Servicing required.
4.	Out flow obtain from one part only	Plugged inlet orifice	Clean inlet orifice.
5.	Low flow gain (Problem in getting high speed)	Plugged button filter	Replace the filter element.
6.	High threshold (jerky, hunting motion)	Sticky spool	Servicing.
7.	Servo valve overheats.	a) Wrong current	Check current use servo valve tester.
		b) Mechanical return sticks	Needs opening valve.
		c) System pressure too high	Reduce pressure settings.
		d) Wrong oil grade	Respect oil recommendations.
		e) Dirt in system	Flush the system.

FUNCTION: By controlling the rate of flow in a hydraulic circuit, it's possible to control the speed of hydraulic cylinder or motors. A more typical method is to use a flow control valve. By varying the size of opening, one can vary the amount of oil entering the cylinder and thus control its speed. Three factors affect flow rate: pressure, fluid temperature, and orifice size. If any one of these factors is increased, the flow rate increases.

TYPES: Control of flow in hydraulic circuits can be accomplished with a meter-in circuit, a meter-out circuit or a bleed-off circuit.

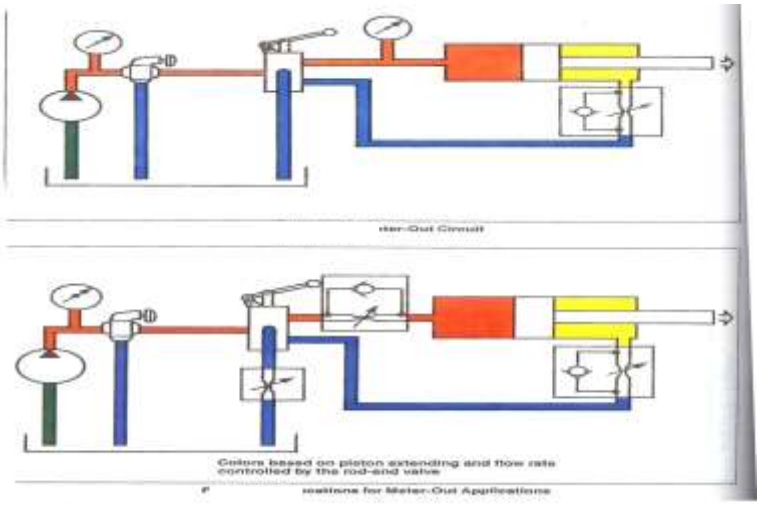
Meter-In circuit:



In meter-in operation, the flow control valve is placed between the pump and actuator. In this way, it controls the amount of fluid going into the actuator. Pump delivery in excess of the metered amount of diverted to tank over the relief valve.

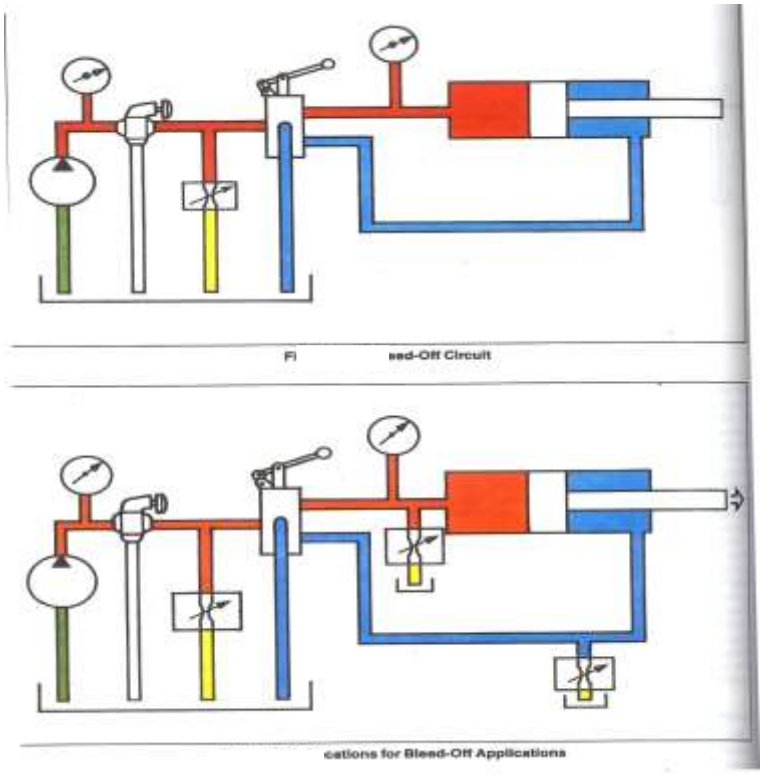
Meter-in circuit can only be used with opposing loads. If the load tends to run away, it would pull the cylinder piston ahead of the oil supply; and since the exhaust flow has a free path back to tank, the meter-in circuit could not prevent the load from running away.

Meter-Out circuit:



The flow control is on the outlet side of the cylinder to control the flow coming out. This is known as a meter-out circuit. If the flow control were closed completely, the oil could not exhaust from the cylinder and it could not move. Regulating the size of the opening controls the flow rate and thus the speed of the cylinder. Although metering into the cylinder is fine with an opposing load, but if the load tends to run away, a better way is to meter out. In fact, a meter-out circuit works if the load pushes or pulls.

Bleed-Off circuit:



The flow control is simply bleed off the main line to control cylinder speed. For instance, with the flow control completely closed, the full flow from the pump would go into the cylinder. However, the moment the flow control is opened up, some bleed off of that pump delivery occurs and the cylinder starts to slow down. Adjusting the size of the opening will bleed off any amount necessary to control how fast the cylinder moves. In the case, unlike the meter-in or meter-out circuits, there is no excess flow going over the relief valve and the pump operates at only the pressure that is needed to move the work load on the cylinder, which saves energy. The bleed-off circuit will not prevent a load from running away. As with meter-in circuit, it can be used with opposing loads only.

TROUBLESHOOTING IN FLOW CONTROL VALVE:

Sr.No.	Fault	Causes	Rectification
1.	Device does not function	a) Device stressed	Loosen bolt and tighten uniformly.
		b) Seat defective	Exchange seat.
		c) Throttle valve defective	Exchange cone.
		d) Non-return valve sticks	Check cone and seat, if needed exchange it.
		e) Fine throttle-valve sticks	Exchange restrictor
		f) Compensator mechanism defective	Disassemble controller and exchange defective parts.
		g) Piston sticks	Check system for dirt, exchange piston.
		h) Spring broken	Exchange spring.
		i) Corrosion on setting mechanism	Clean if needed change.
		j) Wrong choice of device	Install controller of correct nominal size.

INTRODUCTION:

Unlike gases, which are compressible and can be stored for a period of time, hydraulic fluids are usually incompressible. Accumulators provide a way to store these fluids under pressure. Hydraulic fluid enters the accumulator chamber and acts on a piston or bladder area to either rise the weight or compress a spring or a gas. Any tendency for pressure to drop at the accumulator inlet forces fluid back out into the system.

In many hydraulic circuits, the demand of pressurized oil is not constant. The demand of pressurized oil may be temporarily so great that pump cannot supply it alone and one or several motions will be starved of oil and machine will slow down or the system pressure will drop or both. One way is the large pump may be provided to supply the maximum demand need by the system. But it is expensive in both, the initial and running cost. The better way is to use a pump which can supply the average demand of oil and put one or more accumulators in the system. The pump can recharge the accumulator during the idle period.

FUNCTIONS:

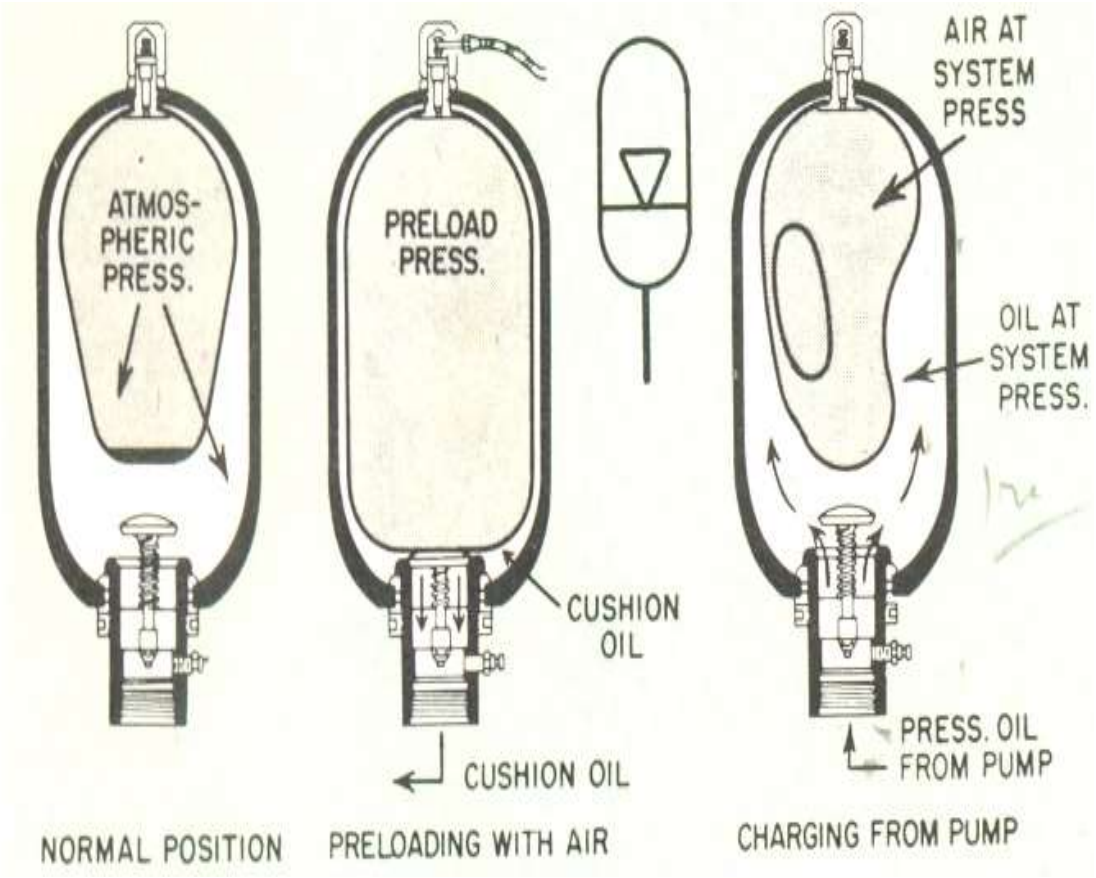
1. It acts as an emergency unit. In case of sudden power loss e.g. pipe or joint failure, pump breakdown etc. the accumulator can provide sufficient energy to complete an operational cycle.
2. As a leakage compensator. Oil reserve for maintaining pressure to compensate leakage losses and to maintain pressure for longer period.
3. As an anti vibration device. It prevents pressure knocks and unpleasant operating noise resulting from system. Rapid valve closer can produce shock waves resulting in over pressurization of pipes, joints, valves, etc. The accumulator can neutralize or reduce the shock.

TYPES:

1. Weight type
2. Spring type
3. Piston type
4. Bladder type
5. Diaphragm type

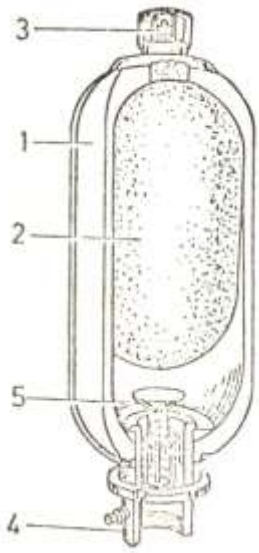
Working of bladder type accumulator:

Operation of an accumulator is automatic. A combination of oil (which is non-compressible) and nitrogen gas (which can both expand and compress) make the accumulator work. When the oil pressures rises, incoming oil compresses the gas. When oil pressure drops, the gas expands forcing out oil. The gas is separated from the oil by bladder. This prevents mixing of the gas and oil and keeps gas out of the hydraulic system. Oil forces the bladder to compress until the resistance of gas is equal to oil pressure. When the hydraulic system needs oil, the compressed gas inside the bladder forces oil to maintain the system flow. The bladder is precharged through the valve core with nitrogen gas. The other end of accumulator contains the oil valve which connects the hydraulic circuit. A rubber sealing ring is provided near at the oil valve to protect the bladder during operation.



Name of parts of bladder accumulator:

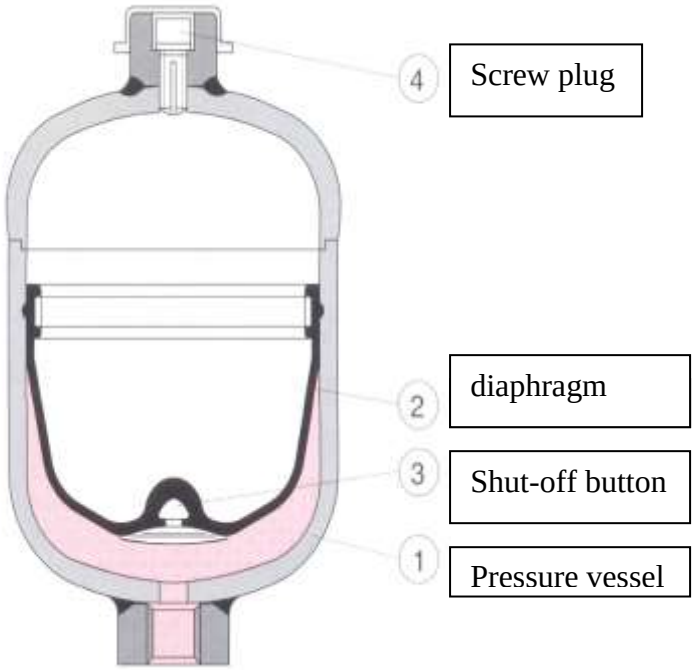
1. Oil reservoir
2. Gas reservoir
3. Gas valve assembly
4. Oil port assembly
5. Non return valve



Working of diaphragm type accumulator:

A diaphragm is clamped between the walls of the pressure vessel and serves as the elastic separator between the hydraulic fluid and the nitrogen. A shut- off button is fixed to the base of the diaphragm. This button serves to block the inlet opening at the connection to the piping when the diaphragm is fully expanded, thus preventing the diaphragm from being forced into the opening when in a pre-charged state. On the gas side, the screw plug facilitates the checking of the nitrogen pressure and the topping- up of the accumulator by means of a filling and checking device.

The Diaphragm accumulator consists of two dome shaped shells held together by threaded or bolted flanges. The diaphragm is clamped between them. The diaphragm has an even thickness and is molded with a single wave or roll to allow it to move more easily. During operation, the diaphragm flexes instead of stretching like the air bladder. It is not, therefore, suitable for high pressure applications.

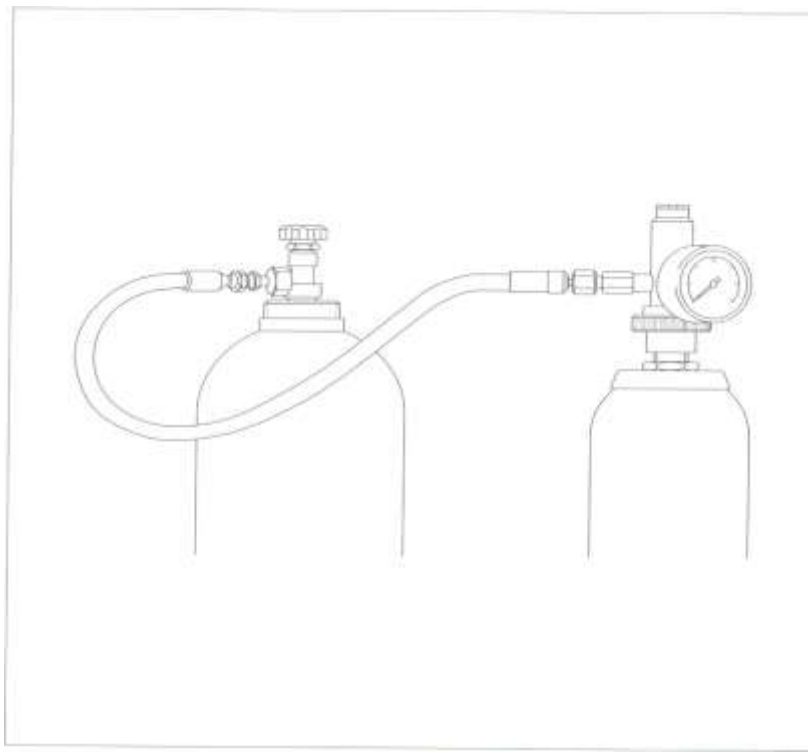


QUICK CHECK FOR NITROGEN PRESSURE:

1. Start the engine so that hydraulic pump supplies pressurized oil to the accumulator.
2. Close the pressurized oil supply to the system.
3. Connect the pressure gauge provided in the circuit (driving cabin) to indicate the hydraulic pressure.
4. Stop the engine immediately and keep on watching the pressure gauge. The gauge needle starts coming down slowly.
5. The pressure gauge needle stops momentarily at a place (pressure) and then immediately comes down to zero.
6. The pressure shown by the gauge needle at this momentary stop over accumulator which should not be less than 80 atmospheres.

CHECKING AND FILLING WITH CHARGING UNIT:

Make sure that Hydraulic pressure is released from the system before attempting to fill or check the Accumulator for Nitrogen.



PROCEDURE:

1. Remove the protecting cap from top of accumulator.
2. Remove the closing nipple from the Accumulator gas valve.
3. Close the venting screw on the charging unit. Turn the handle fully clockwise.
4. Turn the spindle on filler head fully anticlockwise.
5. Connect the filler head to the gas valve and by turning knur clockwise.
6. Connect the charging unit to nitrogen bottle and tighten nut.
7. For checking only nitrogen bottle is not necessary. On new types of charging units a check valve prevents a gas return flow from the accumulator.
8. Turn the spindle on filler head gently clock wise.
9. Read the existing nitrogen pressure in the accumulator on pressure gauge.
10. If a recharging is necessary, open the bottle valve gently until a filling pressure of 90 atm is reading. Shut the bottle valve properly again.
11. Open gently the venting screw on the charging until the required pressure 80 atm is reading on the pressure gauge. Shut the venting screw properly again.
12. Remove the charging unit from the nitrogen bottle.
13. Turn the spindle on filler head fully anticlockwise.
14. Release nitrogen pressure left in the charging unit by opening the venting screw.
15. Disconnect the charging unit from the gas valve on the accumulator.
16. Check the sealing of the gas valve.
17. Fit the closing nipple on to the gas valve and also the protecting cap.

FUNCTIONS:

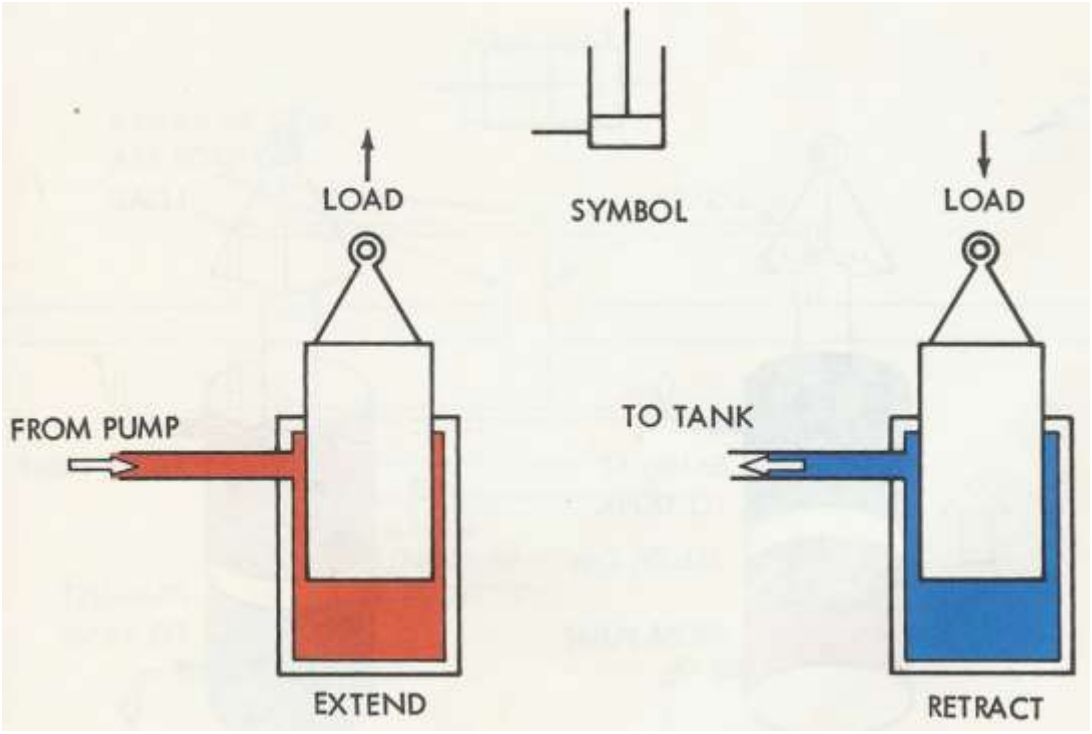
Cylinders are drive components which converts hydraulic power in to mechanical power. They generate linear movement through the pressure on the surface of the movable piston. Cylinders are linear actuators.

Construction:

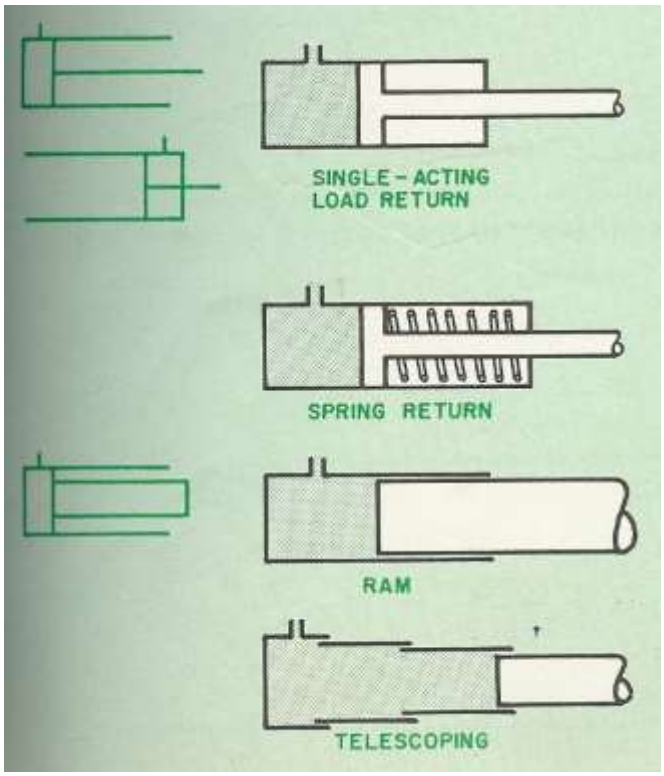
A hydraulic actuator constructed of piston or plunger operating in a cylinder housing or tube by energy laden liquid is known as cylinder. The piston of a cylinder is provided either with seals or piston ring to impart sealing effect with inner surface of the cylinder tube and stands for the efficiency of the cylinder. The efficiency of a cylinder is reduced as soon as the seals/rings start wearing resulting in internal leakage of the fluid. The rod of the piston is also provided with seal and scraper arrangement to stop out flow of liquid form cylinder and wiping out dust etc., from the piston rod.
The cylinder barrel/tube is generally seamless steel tube which has been cold worked and steel piston rod is highly polished usually hard chrome plated to resist puffing and scoring. This piston is generally made out of brass or cast iron.
The seals provided are made out of oil and heat resistant synthetic rubbers like Nitrile, Neoprene and Buna-N. For high temperature working Viton is much suitable. These days polyurethane finds good use in manufacture of seals which are not only heat and oil resistant but wear very slowly which reduces maintenance problem to the minimum.

TYPES:

1. **Ram type:** It is perhaps simplest actuator. It has only one fluid chamber and exerts force in only one direction, most are mounted vertically and retract by the force of gravity on the load. Ram type cylinders are used in elevators jacks and automobile hoists.

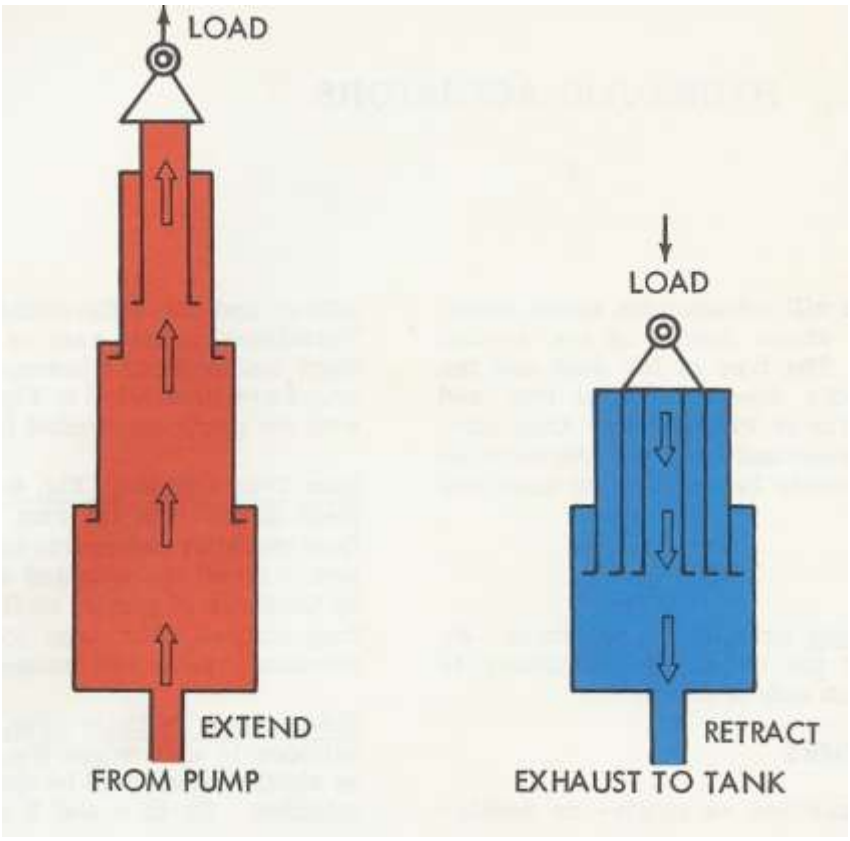


2. **<u>Single acting cylinders</u>:** A single acting cylinder has only one port allowing pressurized oil for its actuation. The return stroke of the piston or plunger is achieved either by gravitational action or spring force releasing the oil back to the tank. The oil flow in single acting cylinder is controlled by reversing directional control valve.

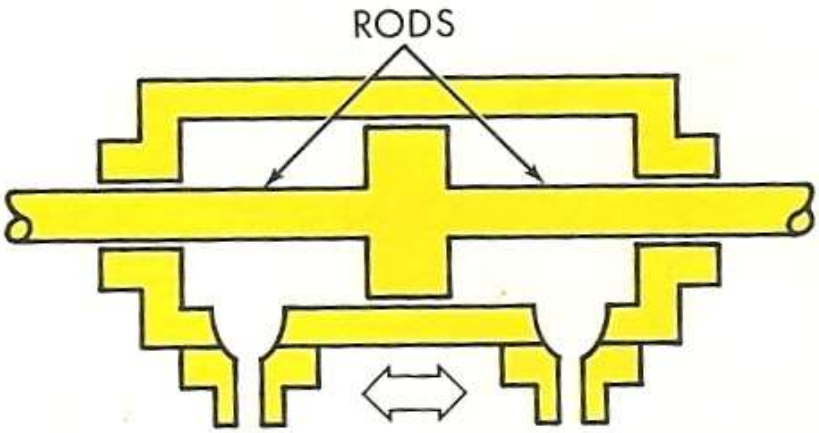


3. **<u>Double acting cylinders</u>:** A doubling acting cylinders has got two ports through which oil flow is controlled by directional control valve (generally solenoid valve) in such a way that if one of the two ports is connected to the in flow of liquid from pump the other is connected for back flow to tank and vice-versa. Such cylinders are called differential cylinders.

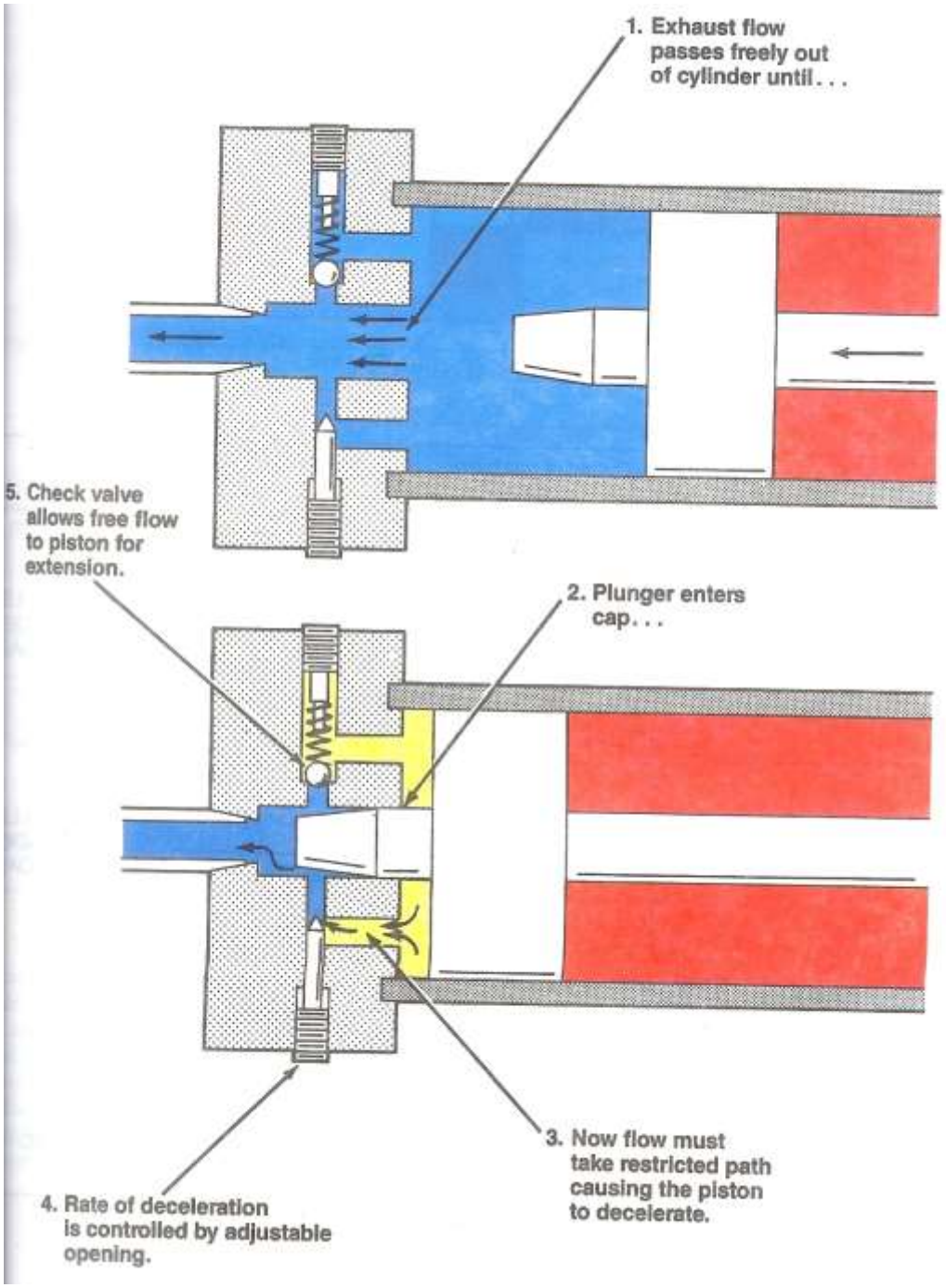
4. **<u>Telescopic cylinders</u>:** A telescopic cylinder is used where collapsed length must be shorter than could be obtained with a standard cylinder upto 4 to 5 sleeves can be used.



5. **<u>Double rod cylinders</u>:** Cylinder has two equal power stroke. Such cylinders are called non-differential cylinder as they have equal areas on either side.



CYLINDER CUSHION:



Cylinder cushion are often provided either or both ends of a cylinder to slow it down near the end of stroke to prevent the piston from hammering. Deceleration begins when the tapered cushion ring or plunger enters the cap and begin to restrict exhaust flow from the barrel to port. During the final fraction of the stroke the exhaust oil must discharge through an adjustable orifice. The cushion feature also includes a check valve to by pass the orifice during its return stroke.

ESSENTIAL PARTS OF A CYLINDER:

1. BARRELS: Barrels are usually seamless tubings, honed to a fine on the inside, bore to be parallel and without longitudinal scratches. Other wise oil will leak from one side to other during working due to high working pressure and frequent bursting of seals will occur.

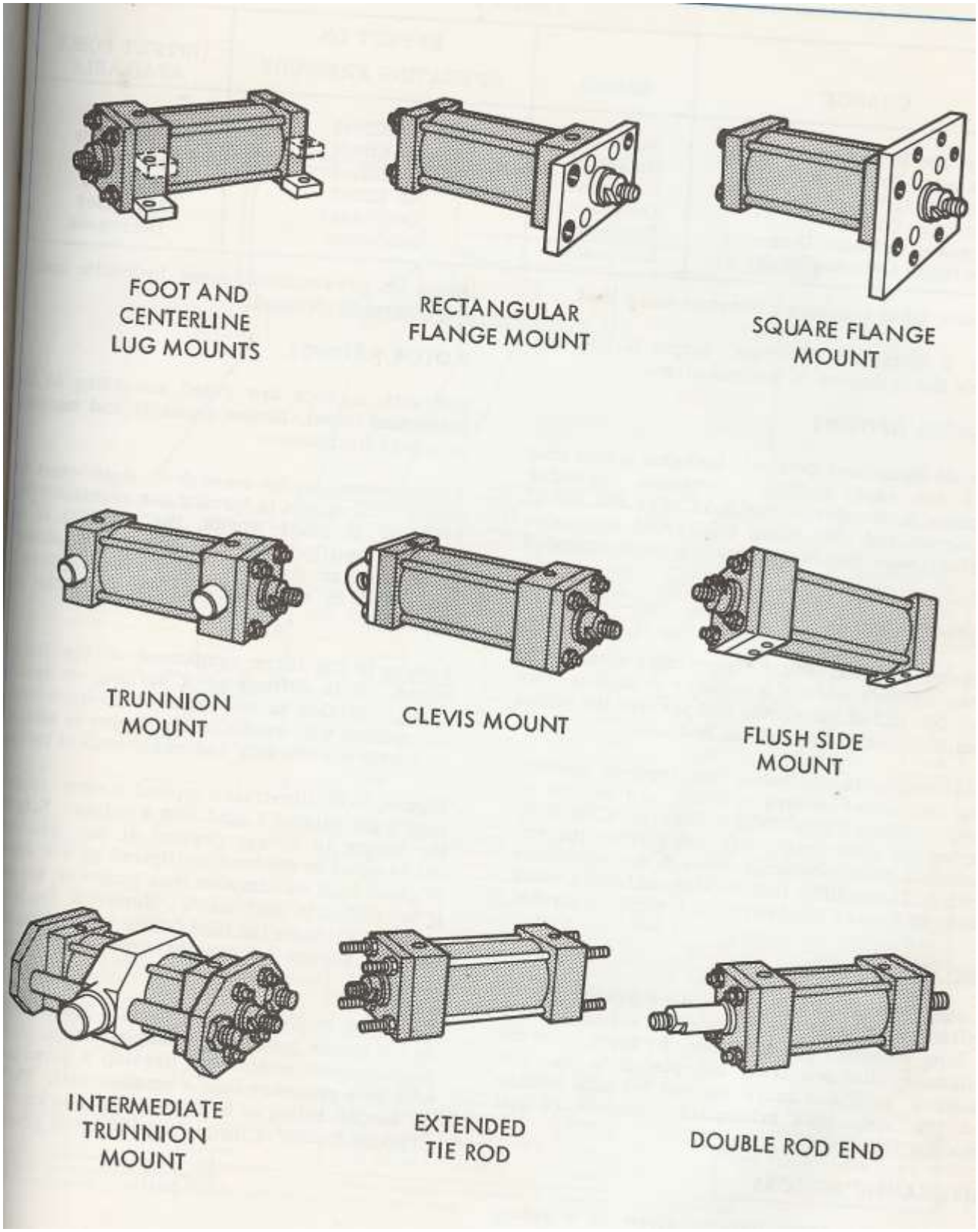
2. PISTON: Piston usually made of cast iron or steel, incorporate seals to reduce leakage between it and cylinder barrel. Step cut automotive type piston rings are used where some leakage can be tolerated.

3. END CAPS: The end caps plug the barrel ends and provide cylinder ports. These are secured with the help of tie bolts.

4. SEALS: Various types of seals are used in the cylinder to prevent leakage and contaminants.

CYLINDER MOUNTINGS:

1. Tie rod
2. Bolt mount
3. Flange trunion
4. Side lug
5. Side tapped
6. Clevis



The main function of a cylinder mount is to provide a means of anchoring the cylinder. There are variety of ways to mount the cylinder including the tie rod, bolt mount, flange, trunnion, side lug and side tapped, and clevis. Rod ends are generally, threaded for attachment directly to the load or to accept a clevis, yoke or similar coupling device.

CYLINDER RATINGS:

The ratings of a cylinder include its size and pressure capability. Main features are-

i. Piston diameter
ii. Piston rod diameter
iii. Stroke length

Cylinder speed, the output force available, and the pressure required for a given load all depend on the piston area, when extending the rod. When retracting the rod, the area of the rod must be subtracted from the piston area.

To find the speed of a cylinder when size and gpm delivery are known, use the following formula:
Speed (Inches Per Minute) =

$$\text{GPM} \times \frac{231}{\text{Effective Piston Area in Sq. In.}}$$

COMMON DEFECTS IN HYDRAULIC CYLINDERS:

1. Leakage:
   - Through gland seals
   - Through cylinder body
   - Internal leakage (Through Piston Seal)
   - Leakage through adapters/ threads.
2. Dent marks / scoring/ scratches on piston rod, Threads loose/ defective.
3. Dent marks / scoring/ scratches on piston, damage of piston and welding defect.
4. Dent marks / scoring/ scratches in barrel (cylinder)
5. Gland bush wear / scoring
6. Defects in yokes / clevis or welded yokes / clevis
7. Defective threads of adapter's housing

STEPS IN OVERHAULING:

1. Inspection/ checking
2. Dismantling
3. Checking and Repair
   (A) Cylinder (Barrel)
   (B) Piston rod assy.
   (C) Gland Bush
   (D) Piston yoke/ clevis
4. Seal Replacement
   (A) Piston seal
   (B) Bush (Gland) Seal
5. Assembling
6. Testing

GUIDELINES FOR OVERHAULING OF CYLINDERS:

- Repaired cylinders shall be dimensionally checked as per drawings / sketch
- Repair cylinders will be hydraulically checked at the pressure of 130 kg / cm2 for internal leakage and smooth operation

- New piston, piston rod and clevis should be as per original except required variations in dimensions as per bore size after honing
- Cylinder barrel is to be honed throughout the bore till the removal of ovality of bore & scratches etc. completely and bore should be a smooth
- Maximum bore dia permitted after service is as under:

Standard dia (mm)	Maximum dia permitted (mm)
125	125.20
100	100.18
80	80.16
63	63.14
50	50.12

In case of major repair when honing in bore is required: Maximum over size bore after honing is permitted 1 mm only (from original bore).

- Piston rod should be made as per original standard dia. (tolerance = 00 to 0.04mm)
- Material of piston rod is EN–24 and duly hardened chromed. Thickness of chrome layer should be 0.075 to 0.10 mm in finish condition
- Piston should be made over size proportionately according to honed over size bore of each cylinder out of MS
- Yoke of piston rod should be provided new as original shape& size out of MS and pin hole should have tolerance of +0.03 to +0.05 mm.
- Bore of clevis / yoke should be repaired according to need
- In the case of hook up down cylinders, locking pin shall be repaired or replaced as per need
- All hydraulic ports thread shall be re-tapped as per original thread and if required it should be repaired. Also these holes should be plugged with metallic dummy
- Repaired cylinders shall be painted with golden yellow enamel paints

DEFINITION:

Hydraulic motor converts the movement (Kinetic energy and pressure – potential energy) of a stream of hydraulic fluid in the continuous rotating force or movement. More specifically the kinetic energy of a fluid is converted into the kinetic energy of a fluid is converted into the kinetic energy of a rotating shaft in a hydraulic motor. The output of the shaft is the point where the motor is connected to the machine or device to be operated. The pressure of the fluid admitted to the motor determines its force or output. Motor's rating is represented in torque, GPM, cubic inches/rev A hydraulic motor converts hydraulic energy into mechanical energy. It is a rotary actuator. In construction it is almost some as hydraulic pump. The gear's, rotor are pushed by pressurized fluid and torque is developed i.e. continuous rotating motion is developed hydraulic motor's are externally drained Hydraulic motors are rated according to displacement (size),torque capacity, speed and maximum pressure limitations.

CLASSIFICATION OF HYDRAULIC MOTORS:

Hydraulic motors can be classified by application into three categories:

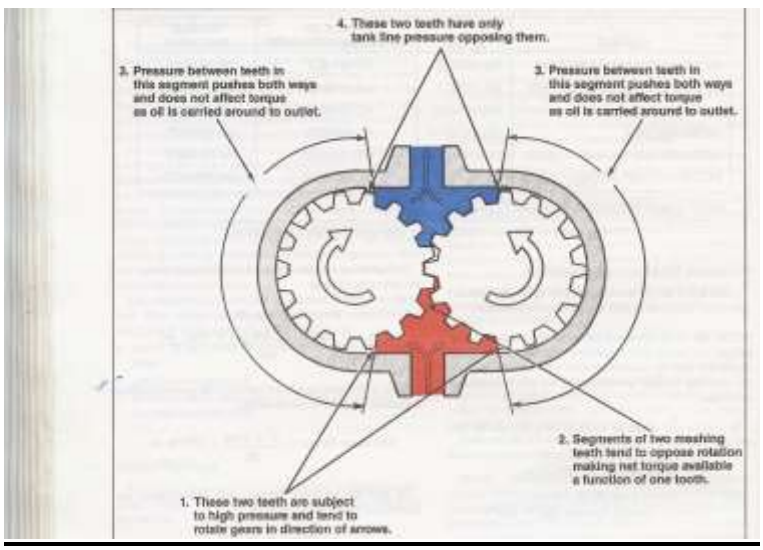
(1) High Speed, Low Torque Motors (HSLT)-in line piston motor , bent-axis motor vane motor and gear motor.
(2) Low speed, High Torque Motors (LSHT)-internal gear motor, vane rolling motor radial piston motor and axial ball piston motor.
(3) Limited Rotation Motors (Torque Actuators)

TYPES OF MOTORS:

1.Gear motors –including external and internal (gerotor and rolator or orbital) motors
2.vane motors—including unbalanced, balanced, fixed, variable and cartridge (high performance) types
3.piston motors-including in-line, bent-axis, and radial motors (fixed, variable and cam type)
4.screw motors-
5.Torque Generators

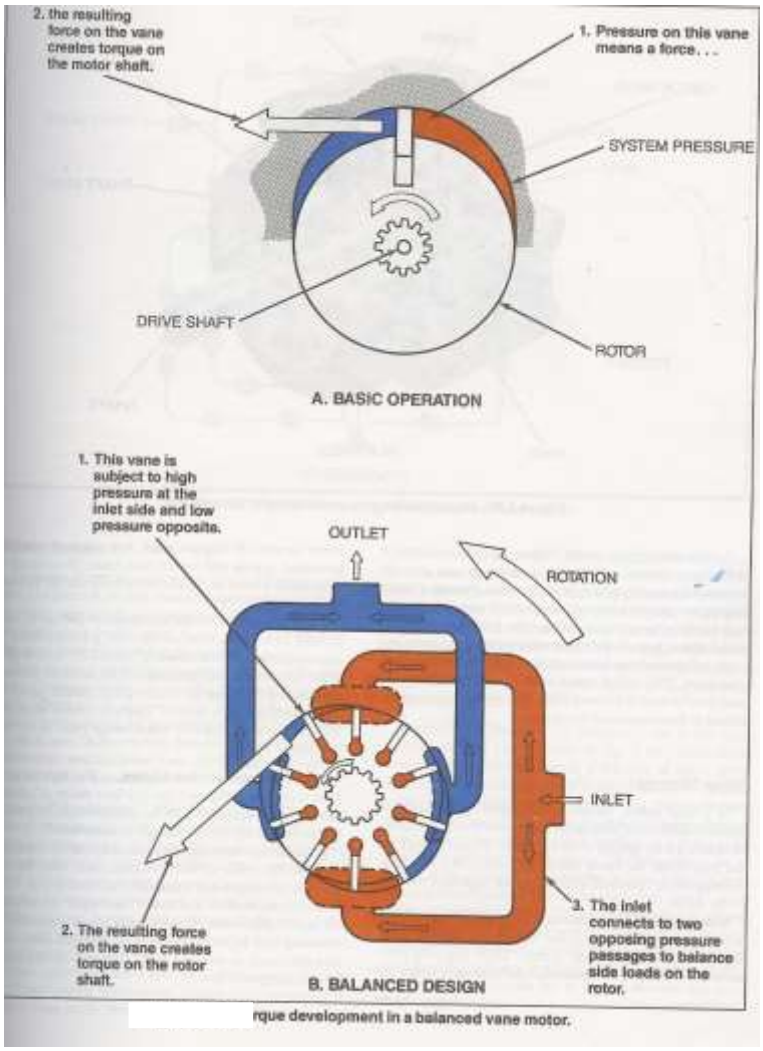
WORKING:

1. **Gear motor:**



A gear motor develops torque through pressure on the surfaces of gear teeth. The two gears mesh and rotate together, one gear coupled to drive shaft. The displacement of a gear motor is fixed and is equal to volume between two teeth multi plied by number of teeth. Generally gear's are not in balance with respect to pressure at the outlet result in high side loads on the shaft and gears as well as the bearings. Gear motor's are simple and more dirt tolerant.

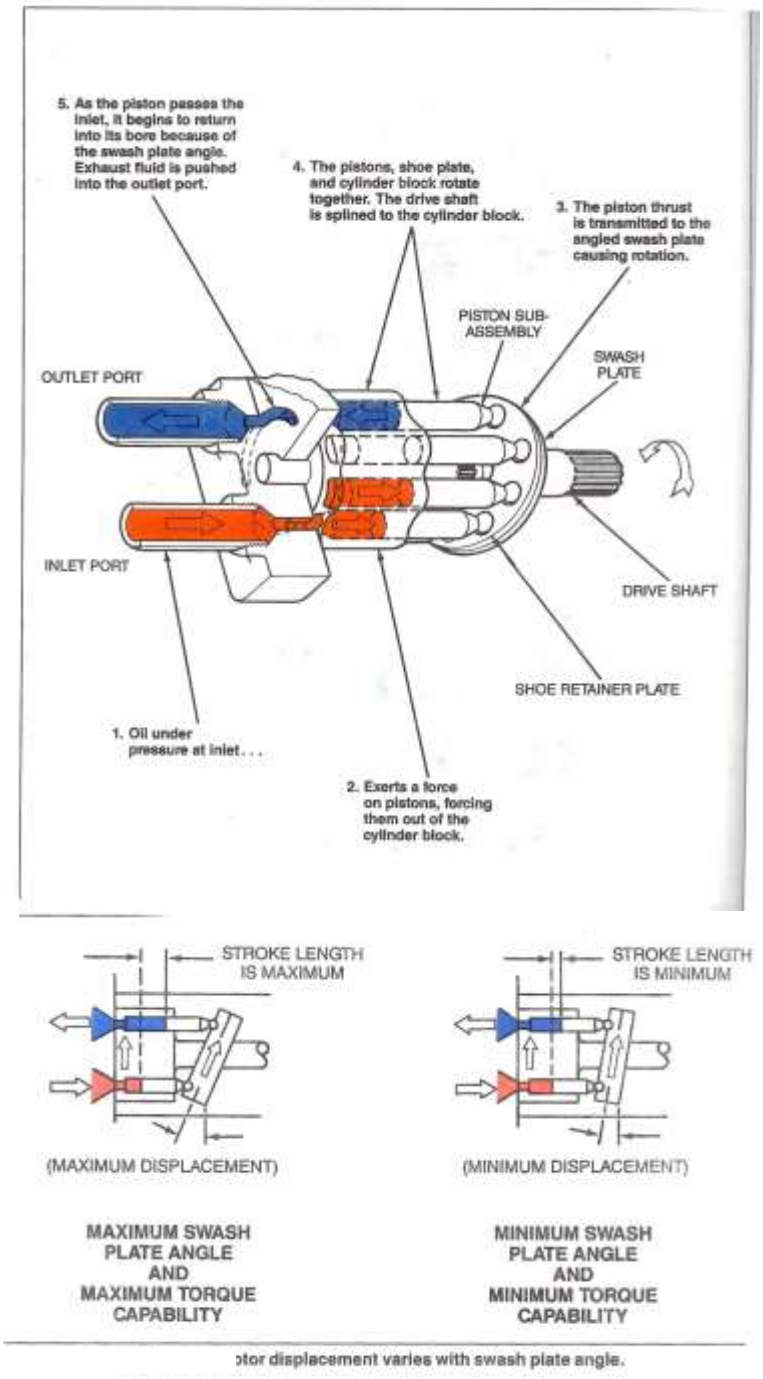
2. **<u>Vane motor</u>:**



rque development in a balanced vane motor.

In vane motor torque is developed by pressure on exposed surface of rectangular vanes, which slides in and out of slots in a rotor to drive shaft. As the rotor turns the vanes follow the surface of cm ring, carrying the fluid from inlet to outlet. In operation pressure under the vanes also holds them in contact with cam ring some devices are used to hold the vanes, may be spring clips or small springs beneath each vane pushing it out.

AXIAL PISTON MOTOR:

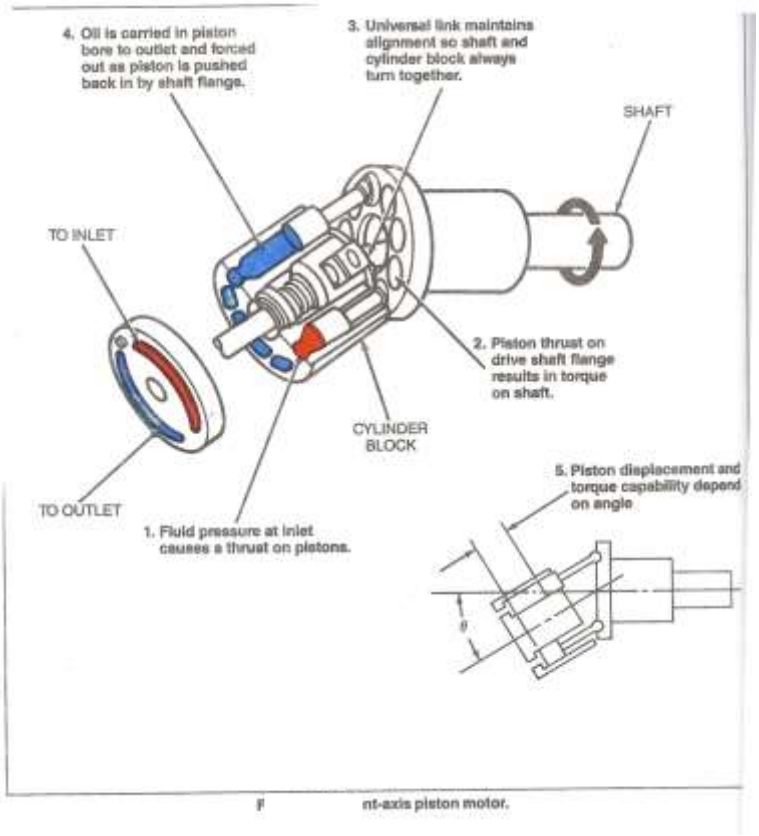


ɔtor displacement varies with swash plate angle.

The axial piston motor is an energy converter with an axial piston arrangement in a barrel shaped body in swash plate-design motor circular arrangement of 9 pistons is located parallel to the drive shaft in a fixed housing. The pistons run in a cylinderal barrel which his firmly fixed to the drive shaft by means of a key. The piston ends or of burn and surface design and run on slipper pads. These are held on a swiveling but not rotating swash plate by means of holding discs. On the fixed displacement model the swash plate forms a part of the housing and therefore has a fixed swash angle which determines the pump displacement. The function of hydraulic motor is the reverse of that of the pump. Energy laden fluid is directed to the hydraulic motor while fluid is being directed at atmospheric pressure from a tank to the pump which then receives a specific amount of energy via the drive motor and the fluid is supplied

to the system as pressure fluid. By charging the direction of the active components of this pressure fluid, hydraulic energy is converted into mechanical energy (as a torque) via the driven shaft . The energy- free fluid is now returned from the hydraulic motor to the tank. On this particular design too, 4 pistons are pressurized 4 are connected to the tank, and 1 is in an intermediate position. The bores in the pistons leading to the ball and socket serve to reduce the high surface pressure in the ball and socket and on the sliding disc that is to say – they serve to provide a hydro-static bearing. For special applications these hydraulics motors can also be equipped with any of the control and regulating devices

BENT AXIS DESIGN MOTOR:



F nt-axis piston motor.

The axial piston motor of bent axis design is an energy converter which converts the energy of the input fluid via a rotary movement into a torque on the driven shaft. The output speed is proportional to the displacement on the so called swept volume, and the torque is proportional to the operating pressure for to be more to the pressure drop between the inlet and outlet. As a rule motors with fixed displacement that is with a fixed swivel angle are used. Variable displacement units are, however, used in some applications.

The rotary group takes from of a complete interchangeable unit and consists of the angled barrel type body with output shaft, supported in the housing by robust bearings.

Pressure oil is supplied via the spherical port plate and those pistons not connected, the hydraulic energy being transmitted to the driven shaft by means of the stroke and output force of 3 pistons are converted into a torque. The now energyless fluid is returned to the tank by means of the return stroke of the 3 pressure unloaded pistons. The seventh piston remains in the crossover position. Due to the spherical design of the port plate torque free bearing of the barrel body is always given, even with maximum loading, the resulting forces in the motor housing being fully absorbed.

MOUNTING PRECAUTION:

1. Motor's rating should be according to the work load.
2. All hydraulic connections must be tight. Loose connections will permit air to be drawn into the system causing noisy and erratic operation or will permit the hydraulic fluid to leak out.
3. Incoming and outgoing ports should be kept in desired direction.
4. All mounting screws should be properly tightened to prevent misalignment of shaft connections.
5. Shaft connecting devices such as keys, collars, etc. must be properly seated to avoid slippage and possible shearing of the shaft.
6. Tubing must not be bent too sharply. The minimum radius for bends is three times the inside diameter of the tube.
7. Sometimes motor is mounted indirectly to work load using pulleys and V-belts or chain or spur gear arrangements. Because of slippage possibilities flat belts must not be used. It is important to check for correct alignment and excessive belt tension. This is necessary to prevent excessive side loads imposed on the drive shaft bearings.

TROUBLE SHOOTING:

PROBLEMS	CAUSES	REMEDIES
1. Motor not running	1. No incoming pressure	1. Check pump and relief valve.
	2. Shaft seizure due to misalignment.	2. Align correctly the shaft with work load.
	3. Shaft seizure due to excessive load.	3. Check load and load capacity of motor.
	4. Too much play in the shaft.	4. Replace bearing.
	5. Oil spill at motor.	5. Check if port plate is in contact.
	6. O-ring on port plate effective.	6. Replace O-ring.
	7. Motor type too small.	7. Replace for larger type.
2. Slow motor operation.	1. Inlet pressure too low.	1. Increase pressure by setting relief valve.
	2. Motor parts defective	2. Replace defective parts.
	3. Oil temperature too high.	3. Check for line restrictions, wrong fluid viscosity and also check cooling circuit.
	4. Outlet pressure too high	4. Check outlet line
	5. Port plate does not make contact.	5. Disassemble motor and repair.

FLUID TEMPERATURE CONTROL:

Every hydraulic system operates most efficiently, when the fluid temperature is held with in a certain limit. There is an ideal temperature at which the resistance to fluid flow is minimum. While the fluid still retains its lubricating and sealing characteristics. Temperature higher than the desired level can reduce the lubricating characteristics of hydraulic fluid. Some fluid may breakdown forming undesirable contaminants. This can lead to plug orifices, piping or valves etc. When the fluid viscosity decreases at high temperature, the lubricating film formed by the fluid may be destroyed. This allows metal to metal contact and the fluid temperature rises.

To control the temperature of hydraulic fluid many circuits use a heat exchanger. This heat exchanger may either heat or cool the hydraulic fluid depending on the requirement of the circuit. Heat exchangers are of three types-heaters, water coolers and air coolers.

WATER COOLERS:

In a typical water cooler, hydraulic fluid is circulated through the unit and around the tubes containing the water. The heat is removed from the hydraulic fluid by the water, which can be regulated thermostatically to maintain a desired temperature. The water is filtered to prevent the cooler from clogging. By circulating hot rather than cold water, this type of temperature control can also be used as a heater.

Water flow requirements are usually equal to between ¼ and 1/3 of the system oil flow. The availability of cooling towers and water recycling reduces the cost, but water taken from these sources usually has a higher temperature than that of municipal systems.

AIR COOLERS:

The fluid is pumped through tubes that are bonded to fins made of aluminum or some other metal that transfers heat to the outside air. The cooler usually has a blower to increase the heat transfer. Air coolers are less efficient than water coolers and tend to be ineffective in areas of high ambient temperatures. The initial installation cost is higher than that of water coolers, but the operational costs are usually less.

MAINTENANCE ASPECT:

For effective cooling hydraulic cooler should be fully functional. Following maintenance steps should be carried out-

1. Cooler fins should be properly cleaned as dust particles sticks to the fins which reduces the cooling effect. Never clean the fins by oil. Use air for cleaning.
2. Cooler fan should run at sufficient speed otherwise heat dissipation does not takes place properly. Pressure setting for running of fan motor should be properly done.
3. Cooler tubing should be properly cleaned so that oil may flow freely. If cooler is getting chocked, the bypass valve opens and oil goes to tank without cooling.
4. Fan blades should be of proper orientation.

Lesson-XVII: Demonstration of Hydraulic Transparent Models **Session-25:** Hydraulic Motors, D.C. Valves, Cylinder, Accumulators Pressure Gauge etc.

Demonstration of internal detail of working of above said components is done and explained.

Lesson-XVII: Demonstration of Hydraulic Transparent Models **Session-26:** Pressure Control Valves, Flow Control Valves, Check Valve, Pilot Operated Check Valve etc.

Demonstration of internal detail of working of above said components is done and explained.

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room
Session-27: Vane Pump & Vane Motor

The said actual models are disassembled. Their internal parts are explained and are reassembled.

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room
Session-28: Axial Piston Pump

The said actual models are disassembled. Their internal parts are explained and are reassembled.

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room
Session-29: Check Valve and POC Valve

The said actual models are disassembled. Their internal parts are explained and are reassembled.

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room
Session-30: D.C. Valves

The said actual models are disassembled. Their internal parts are explained and are reassembled.

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room
Session-31: Proportional Valve

The said actual models are disassembled. Their internal parts are explained and are reassembled.

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room
Session-32: Servo Valve

The said actual models are disassembled. Their internal parts are explained and are reassembled.

SUB-DISCIPLINE: HYDRAULICS (LESSONS: 20 SESSIONS: 42)

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room

Session-33: Relief Valve & Unloader Valve

The said actual models are disassembled. Their internal parts are explained and are reassembled.

Lesson-XVIII: Practical Disassembly & Assembly of Hydraulic Components in Model Room

Session-34: Pressure Reducing Valve and Cylinder

The said actual models are disassembled. Their internal parts are explained and are reassembled.

Lesson-XIX: Hydraulic Circuits Session-35: Constant Pressure Circuit of 3X and CSM

All hydraulic systems depend on Pascal's law , named after Blaise Pascal, who discovered the law. The law states that pressurized fluid within a closed container-such as cylinder or pipe-exerts equal force on all of the container.

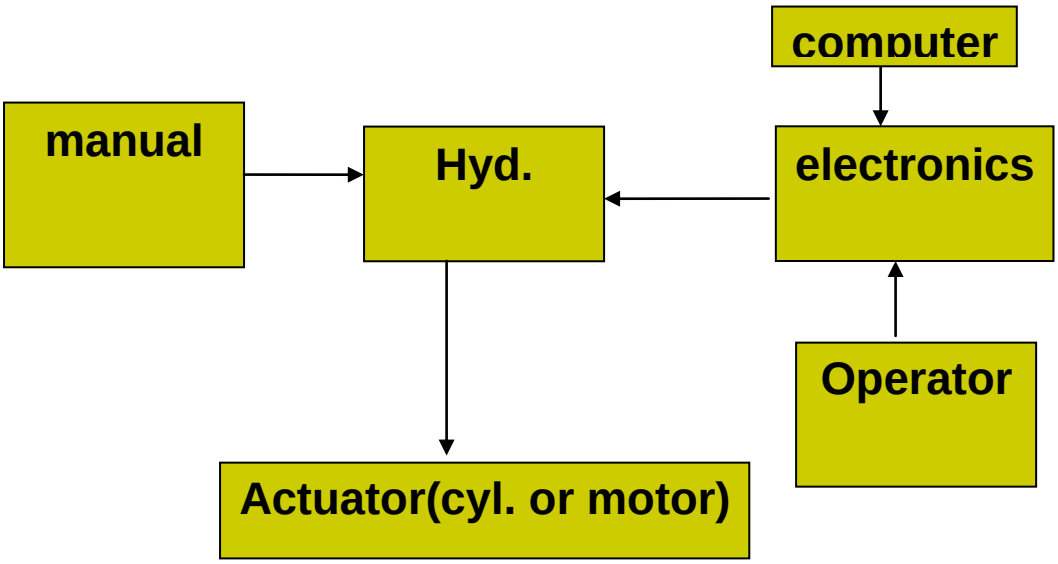
In actual hydraulic systems , Pascal's law defines the basis of the results which are obtained from the system. The intake of the pump is connected to a liquid source, usually called the tank or reservoir. Atmospheric pressure, pressing on the liquid in the reservoir, forces the liquid into the pump .When the pump operates , it forces liquid from the tank into the discharge pipe at a suitable pressure.

The flow of the pressurized liquid discharged by the pump is controlled by valves. Three control functions are used in the most hydraulic systems:(1) control of the liquid pressure,(2) control of the liquid flow rate, and (3)control of the direction of flow of the liquid.

The liquid discharged by the pump in a fluid-power system is directed by valves to a hydraulic motor. A hydraulic motor develops rotary force and motion , using the pressurized liquid as its energy source. Many hydraulic motors are are similar to pumps, except that the motor operates in a reverse manner from the pump. When linear motion is required, a cylinder is fitted with a movable piston, called a hydraulic cylinder, is often used. When the piston is moved by the pressurized fluid, the piston rod imparts a force or moves an object through a desired distance. The pressure of the pressure liquid, multiplied by the piston area, produces an output force, measured in pounds or kg, at the end of the piston rod.

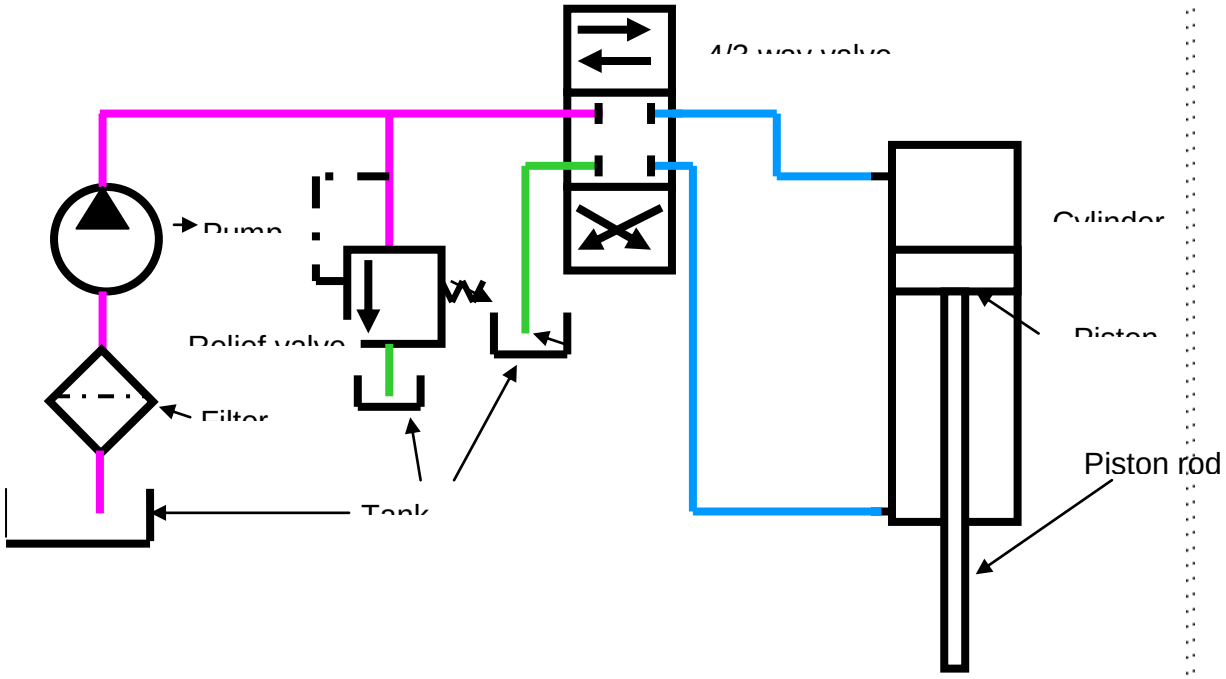
The speed of movement of the piston rod depends on how fast the pressurized fluid enters the cylinder. Flow into the cylinder can be directed to either end, producing either a pushing or pulling force at the piston rod end. A seal around the rod prevents leakage of the liquid.
Directional control of the piston depends on which end of the cylinder the liquid enters. As pressurized liquid enters one end of the cylinder, liquid must be drained from the other end. The drained liquid is passed back to the reservoir**.**

Hyd.transmission



Basic hydraulic circuit:

Hydraulic circuits use a variety of components. These include pressure, flow and directional controls, pumps, motors, pipes, filters, reservoir and accumulators. These components are arranged in various ways to produce a desired output from the circuit.



The constant pressure circuits of the above mentioned machines are discussed in detail in the model room.

Lesson-XIX: Hydraulic Circuits **Session-36:** Constant Pressure Circuit of Duomatic, Unimat and BCM

The constant pressure circuits of the above mentioned machines are discussed in detail in the model room.

Lesson-XIX: Hydraulic Circuits **Session-37:** Closed Loop Circuit of 3X and CSM

The closed loop circuits of the above mentioned machines are discussed in detail in the model room.

Lesson-XIX: Hydraulic Circuits **Session-38:** Closed Loop Circuit of BCM, SBCM & BRM

The closed loop circuits of the above mentioned machines are discussed in detail in the model room.

Lesson-XIX: Hydraulic Circuits **Session-39:** Regenerating Circuit of Tamping Machines

The regenerating circuit of tamping machines is discussed in detail in the model room.

Lesson-XIX: Hydraulic Circuits **Session-40:** Intermittent Circuit of Non-Tampers

The intermittent circuit of non-tamping machines is discussed in detail in the model room.

Lesson-XX: Demonstration of Hydraulic Equipment Sets
Session-41: Demonstration of Hydraulic Circuits Using Fluidsim Software & Work exercises

Different hydraulic circuits are drawn using FluidsimH Software and the circuits are made and verified through the model components of hydraulic equipment set available in the model room.

Lesson-XX: Demonstration of Hydraulic Equipment Sets**Session-42:** Demonstration of Hydraulic Circuits Using FluidsimH Software & Work Exercises

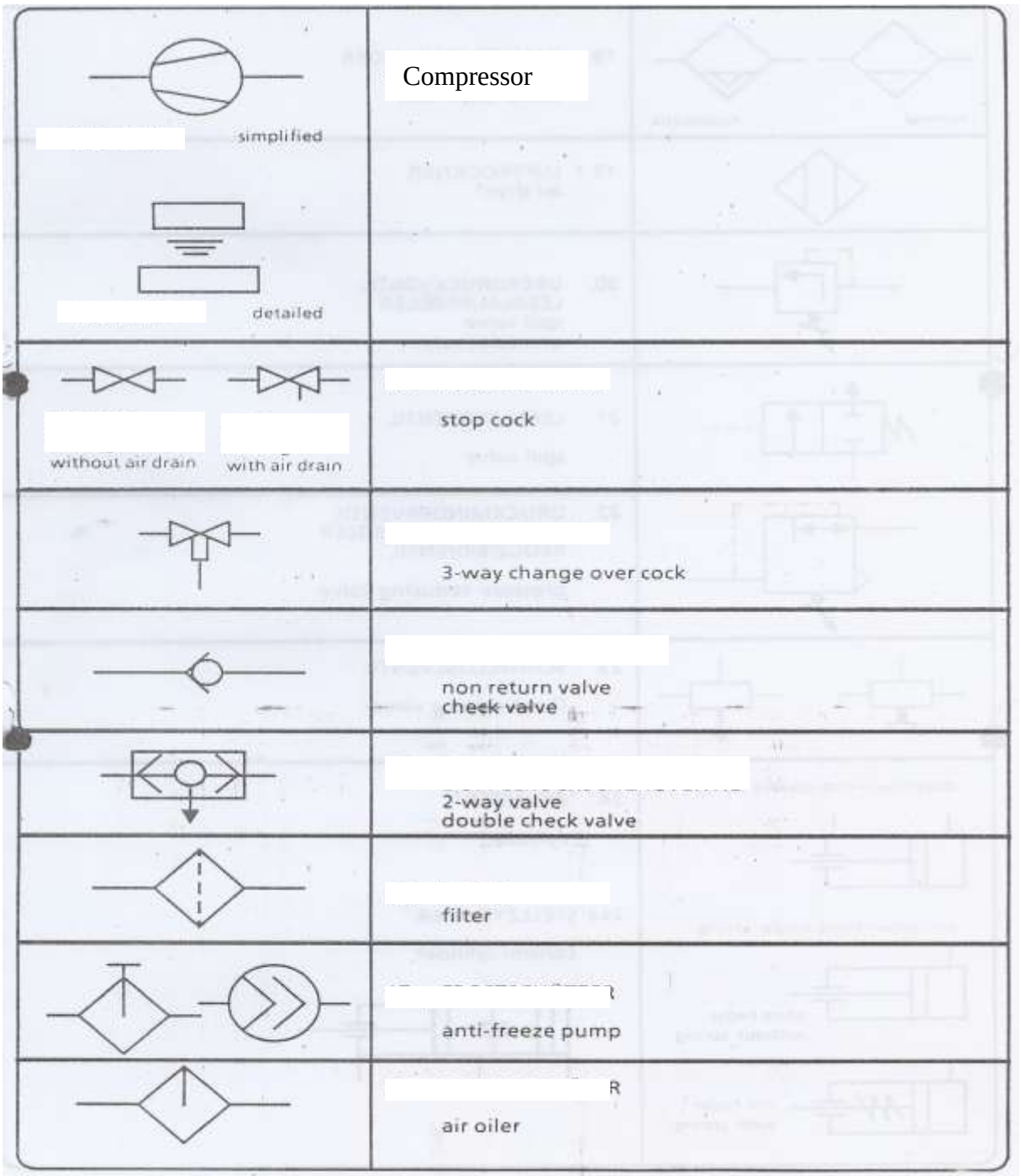
Different hydraulic circuits are drawn using FluidsimH Software and the circuits are made and verified through the model components of hydraulic equipment set available in the model room.

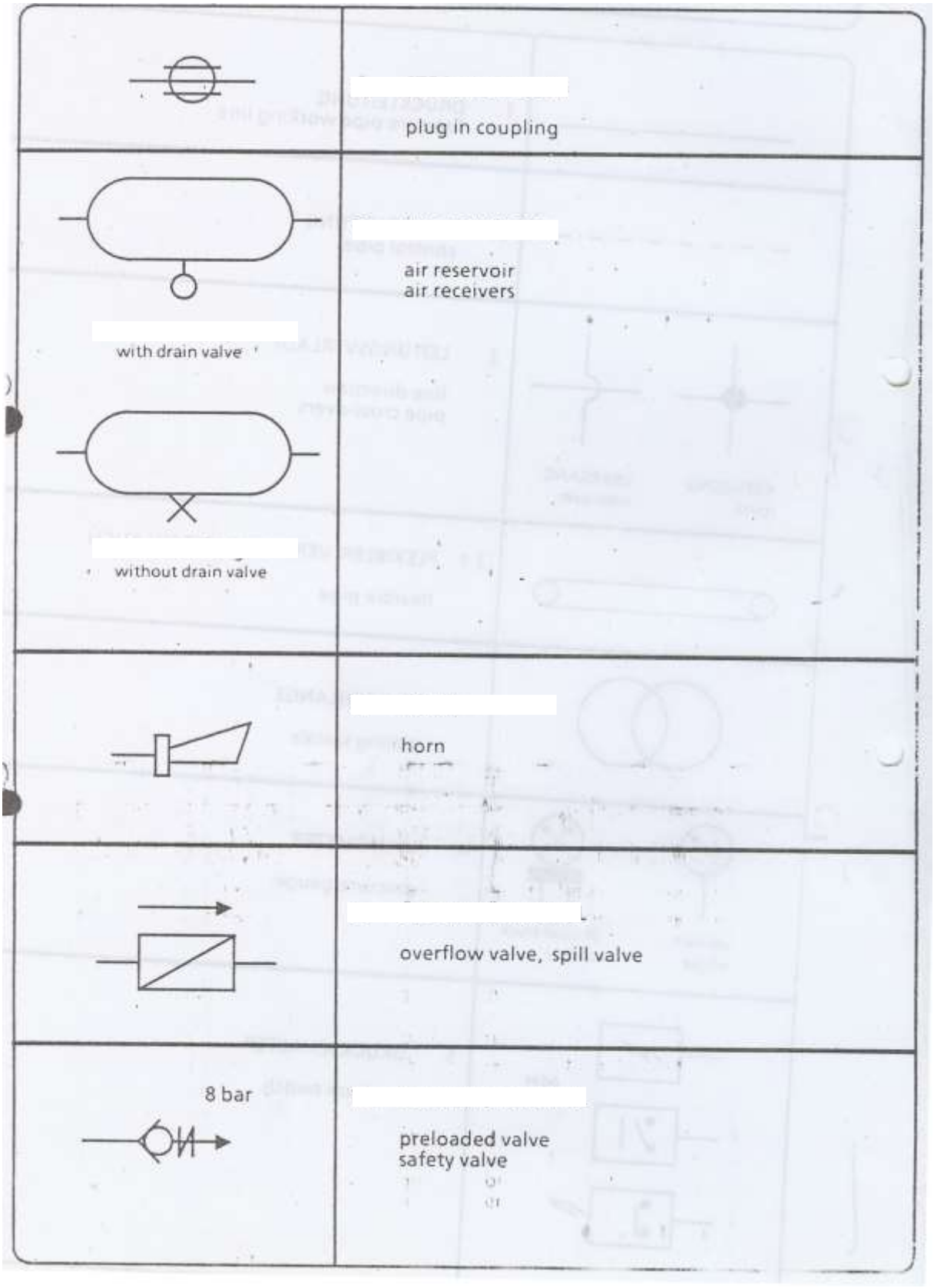
SUB-DISCIPLINE: PNEUMATICS (LESSONS: 05 SESSIONS: 08)

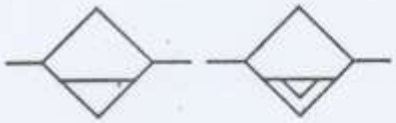
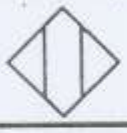
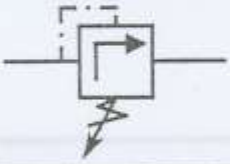
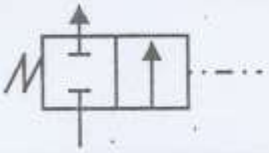
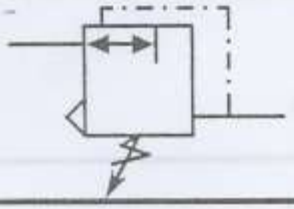
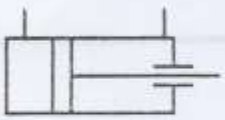
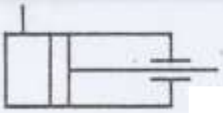
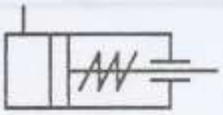
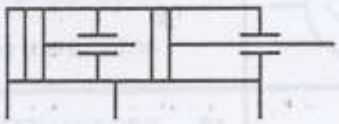
Lesson-I: Pneumatic Symbols**, Session-01:** Pneumatic Symbols And Application Of Air On Track Machines

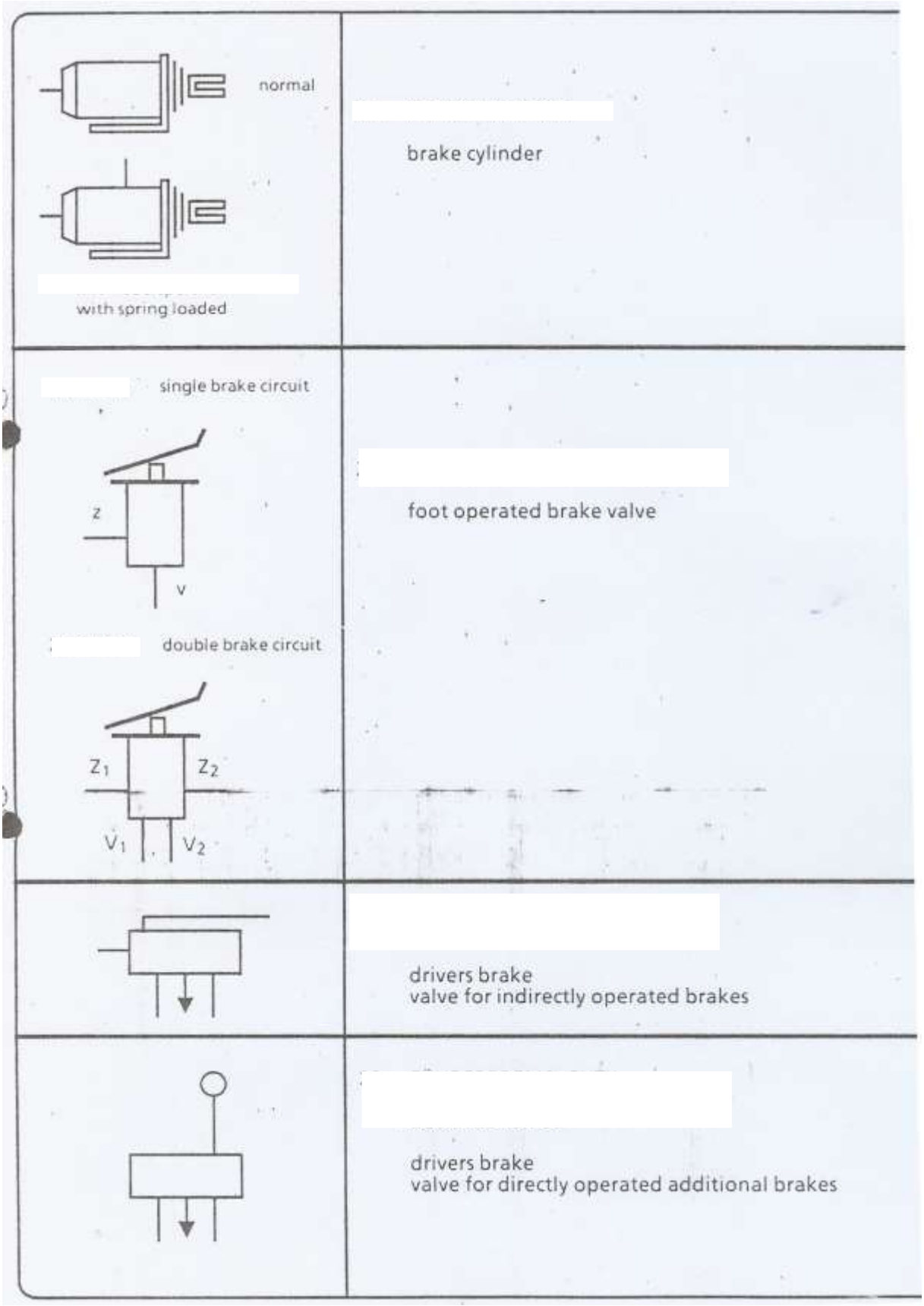
PNEUMATIC SYSTEM:-The word pneumatic has been derived from Greek word. Which refers to flow of air and now a days it includes flow of any gas. In a system under pressure. The pneumatic power is used in industry, workshop and machine to perform various jobs. Broadly speaking the pneumatic power is covered under the heading fluid power. One of which is hydraulic which utilizes water or oil for power transmission and other is pneumatic system that uses gas or compressed air by transmitting the force on track machine we are concerned with the compressed air for pneumatic system. The most common source of pneumatic is compressor which is responsibly for developing compressed air and its utilization for various purposes on machine.

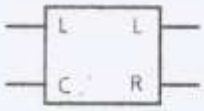
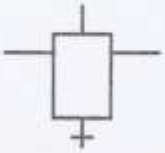
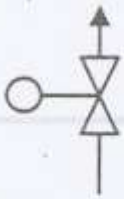
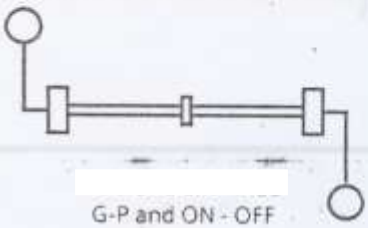
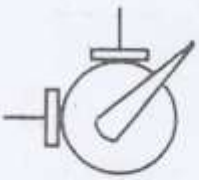
PNEUMATIC SYMBOLS:

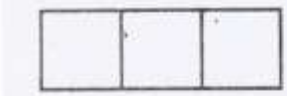



plug in coupling
air reservoir
air receivers
with drain valve
without drain valve
horn
overflow valve, spill valve
8 bar
preloaded valve
safety valve

	water separator
	air dryer
	unloader valve
	spill valve
	pressure reducing valve
	Quick release valve
double acting   	cylinder control cylinder 

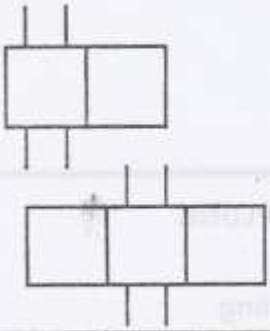

normal
with spring loaded
brake cylinder
single brake circuit
z
v
foot operated brake valve
double brake circuit
Z1
Z2
V1
V2
drivers brake
valve for indirectly operated brakes
drivers brake
valve for directly operated additional brakes

	control valve (KE-valve)
	drip collector
	brake line - house coupling
	Emergency brake valve
	change over linkage
	engine acceleration valve (throttle valve)
 without centralisation	valves

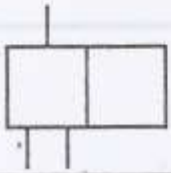


valves

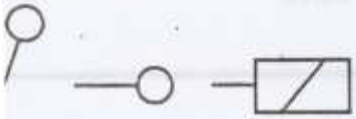
vith centralisation



4-way-valve

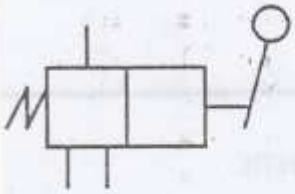


3-way-valve



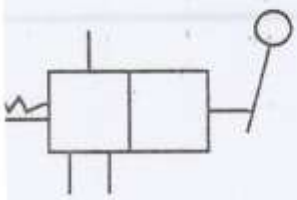
actuating symbols

er cam solenoid



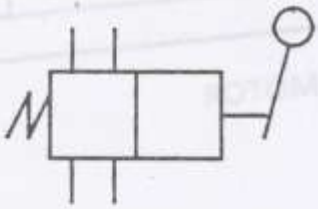
3-way-valve

centralisation by spring

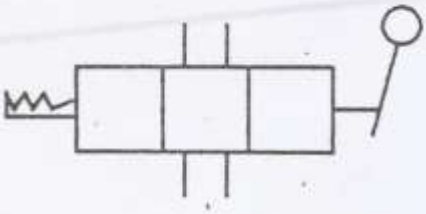


ith mechanical rest position

4-way-valve

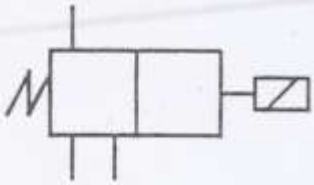


centralisation by spring

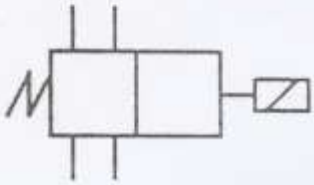


with mechanical rest position

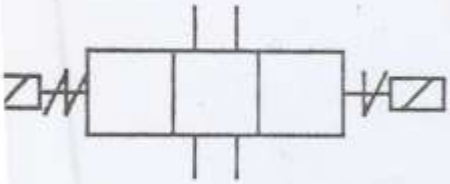
solenoid valve



3-ways



4-ways



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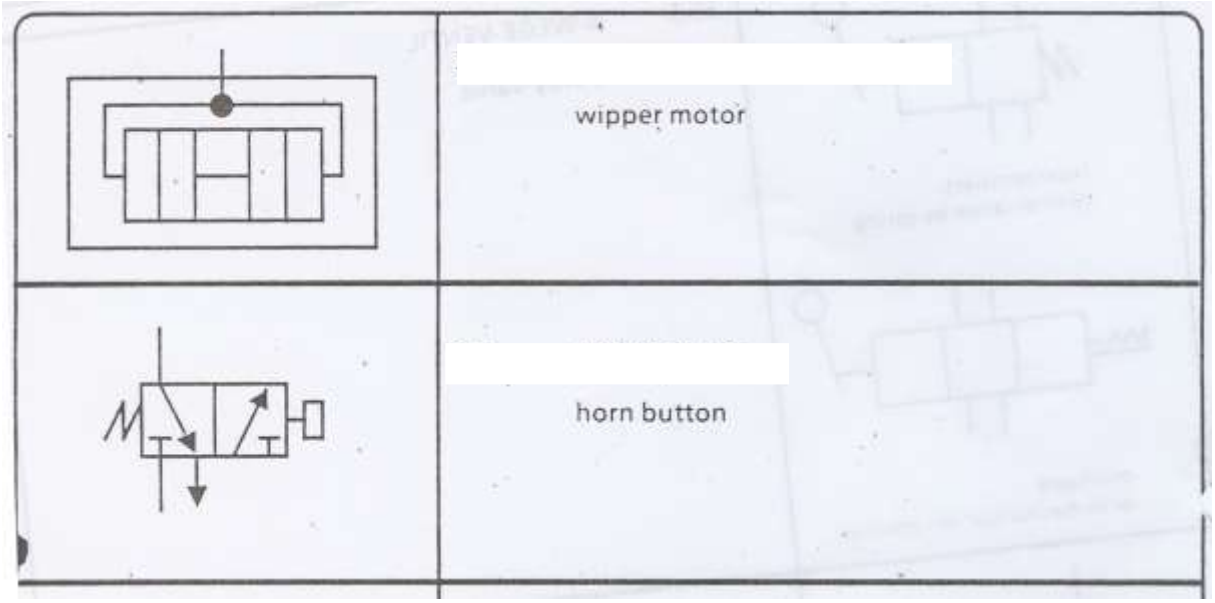
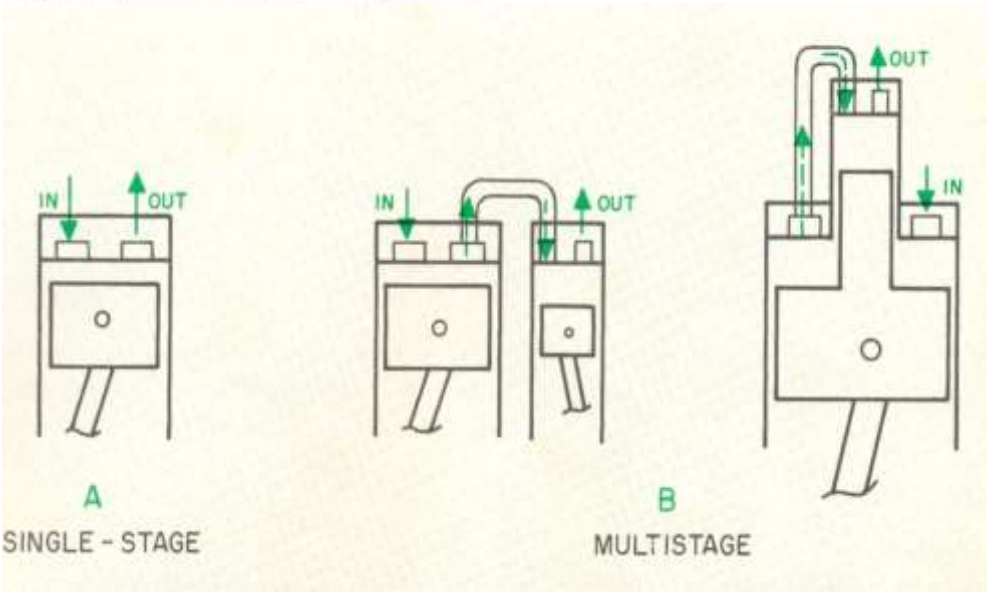


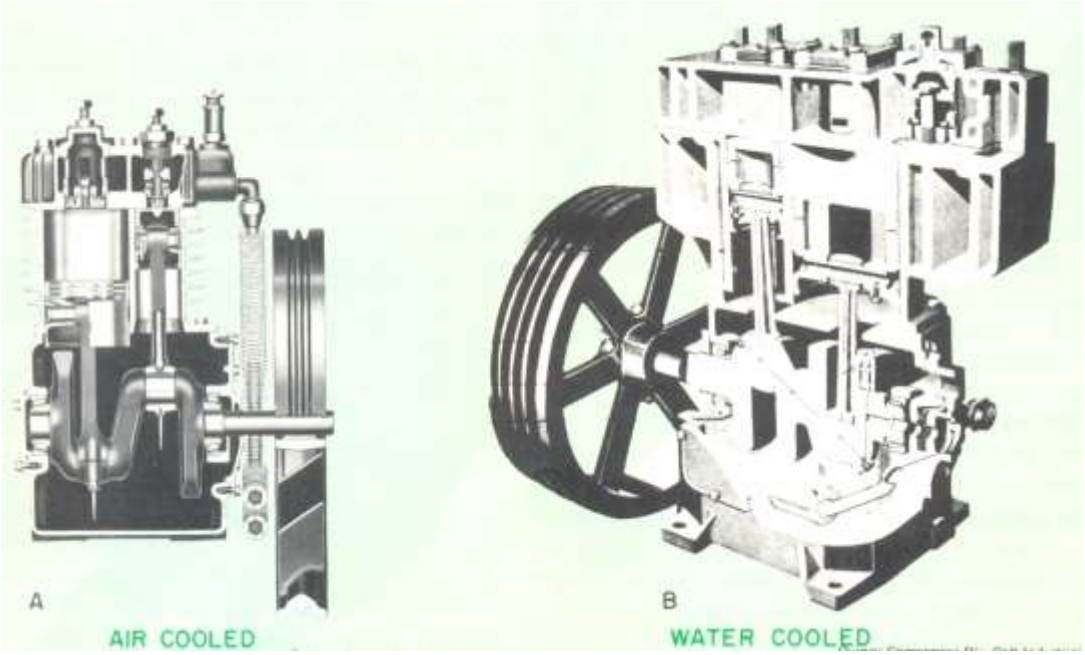
APPLICATION OF PNEUMATIC POWER:-

1. Application of brakes.
2. Locking & unlocking of tamping unit, lifting unit, bogies.
3. Lifting and lowering of different bogies.
4. Clapper cylinder.
5. Pneumatic horn.
6. Lubricating system.
7. Application of datum.
8. Wiper.
9. Tightening of leveling chord / lining chord.
10. Filling the diesel tank.
11. Spray painting.
12. Engaging / disengage pinion to satellite gear.
13. Engaging / disengage the dog clutch
    for work drive in CSM /UNIMAT.
14. Engine rpm acceleration/deceleration

AIR COMPRESSOR: Compressor is a machine which converts air at atmospheric pressure into high pressure by changing its volume. There are two types of compressor

Single-stage and multistage compressors.





1). Reciprocating Compressor.

2). Rotary compressor.

Compressor can be driven by an electric motor or by a diesel/ petrol engine, which serves as a prime mover to the pneumatic power unit.

Reciprocating compressor:-A reciprocating compressor can be single or multiple piston compressors. The more the number of piston in a compressor. the more powerful a compressor is. The multi piston cylinder block of a compressor has crank shaft having same number of crank connection has the number of piston and cylinder in it. The crank shaft is connected to the prime mover .With each cylinder. there are two ports known as inlet and exhaust port depending on their functions. The compressor unit is provided with a sump for storing the oil in it for lubricating and cooling of various components of compressor assembly.

When the crank shaft of compressor rotates and the piston of air compressor takes an inward stroke, atmospheric pressure being higher than the pressure in the compressor cylinder, the flow of air takes place through the inlet port when the crank rotates further and piston moves forward stroke, the inlet valve closes and exhaust port opens thus sending the compressed air to the system/ air container (air tank). The compressor reduces the volume of air thereby increasing its pressure.

If the compressor is a multi stage, one piston sends compressed air to another cylinder and thus to tank. The capacity of a compressor is depending upon the number of cylinder in it. The term single or multistage depends upon the no. of stages or steps that a reciprocating compressor uses to compress air to its final pressure. Single stage compressors are more economical for a pressure below 100 psi but for higher operating pressure multistage compressors are more beneficial.

The capacity of a compressor is defined as volume of air displaced per minute. In FPS (Foot pound system) is denoted by CFM (Cubic ft min) and in M.K.S is LPM (Liter per min).

COOLING COIL:-

As the compressed air has get its temperature risen due to compression, the temperature has to be brought down. This is done by cooling coil which is a helical copper tube by which the cooling coil comes in contact with atmospheric air and therefore the compressed air inside the cooling coil cools down.

PRESSURE VALVES:

Pressure control valves are elements which predominantly influence the pressure or are controlled by the magnitude of the pressure. They are divided into the three groups:

1. Pressure regulating valve
2. Pressure limiting valve
3. Pressure sequence valve

PRESSURE REGULATING VALVE:

The role of this valve is to maintain constant pressure even with fluctuating supply. The input pressure must be greater than the required output pressure.

PRESSURE LIMITING VALVE:

The pressure limiting valves are used mainly as safety valves (pressure relief valves). They

prevent the maximum permissible pressure in a system from being exceeded. If the maximum pressure has been reached at the valve inlet, the valve outlet is opened and the excess air pressure exhausts to atmosphere. The valve remains open until it is closed by the built-in spring after reaching the preset system pressure.

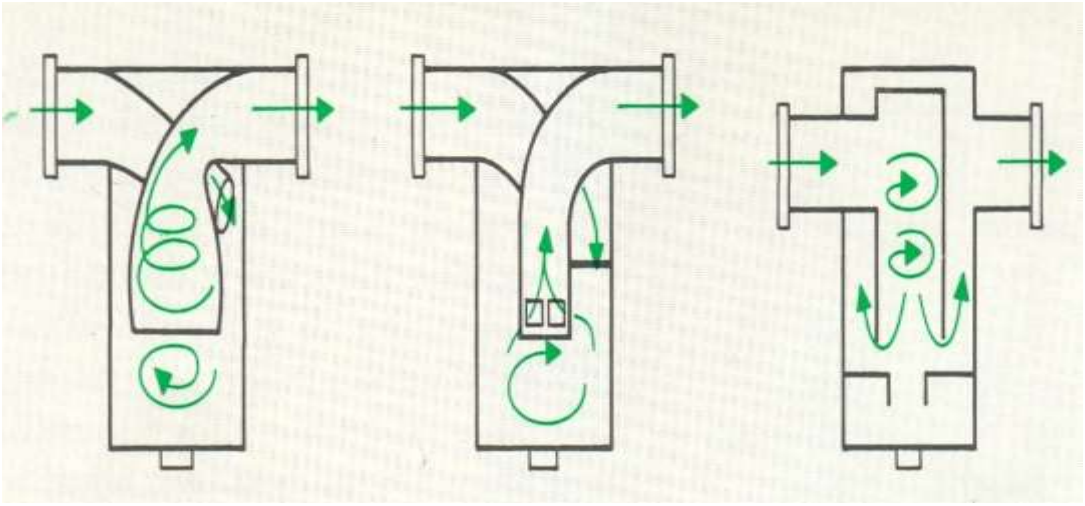
AIR DRYER:-

Condensate (water) enters into the air network through the air intake of the compressor. The accumulation of condensate depends largely on the relative air humidity. The relative air humidity is dependent on the air temperature & the weather condition.

The service life of pneumatic system is considerably reduced if excessive moisture is carried through the air system to the components. Therefore it is important to fit the necessary air drying equipment to reduce the moisture content to a level which suits the application & the components used.

Drying of the compressed air is a achieved by leading the air flow from compressor through a desiccant granulate (Means of adsorption). The granules are of reticulate molecular structure, thus achieving an active surface being large enough to absorb the moisture out of the air. The drying agent is a granular material (gel) consisting almost of silicon dioxide.

WATER SEPERATOR:



The presence of moisture results in the following types of after effects on the pneumatic components and the system is badly affected.

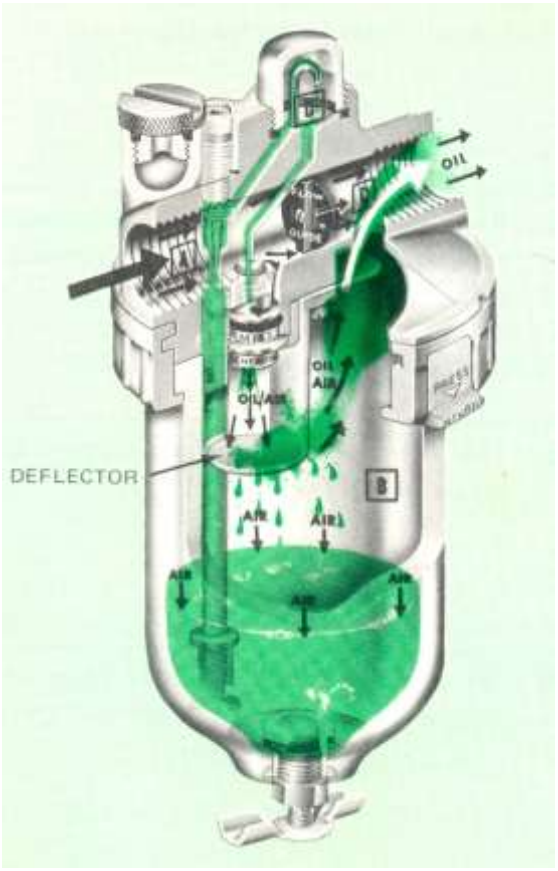
1. Rusting & corrosion.
2. Formation of emulsion.
3. Reduction in lubricating property of oil.
4. Choking of small orifices, valves and system.

So it is imperative that the moisture from the air is removed to avoid crippling of the system.

The first step in process of compressed air after pressure regulation is its filtration or removal of moisture contents which is harmful not only that it may result in rusting but also it may form emulsion with lubricating oil which will block the pneumatic assemblies. The air under pressure enters through inlet of a specially designed water separator having provision for baffle and quite zone. The water droplets are thrown from air stream by virtue of their centrifugal force when they strike the deflector with louvers at the entrance. The water collected at the bottom of quite zone is drained out through the drain tap provided at the bottom or by removing the transparent bowl container.

AIR OILER:

There are certain pneumatic tools and equipments which require lubricated air to reduce wear and corrosion and there are certain other components which do not tolerate oil in the air stream. The importance of lubrication can be well imagined as it not only decreases friction but also prevent corrosion of pneumatic assemblies and simultaneously increases the efficiency.There are two types:



1. <u>OIL FOG LUBRICATOR</u>:

It has a transparent bowl which is filled with oil according to consumption. It has a siphon tube dipping in it which open upon a needle valve. When the air under pressure passes through the venturi section, it is atomized and causes the follow of oil in the form of oil fog (1 drop/10 cu. ft/min) which lubricates the parts through which it passes.

2. <u>CONSTANT DENSITY LUBRICATOR</u>:

It is very simple in construction. A transparent bowl serves as an oil container in which dips the lower end of the siphon pipe having filter attached to its bottom. Air under pressure enters from inlet pore to the container and keeps the oil under constant pressure (regulated by pressure regulator).

<u>D.C. VALVES</u>:

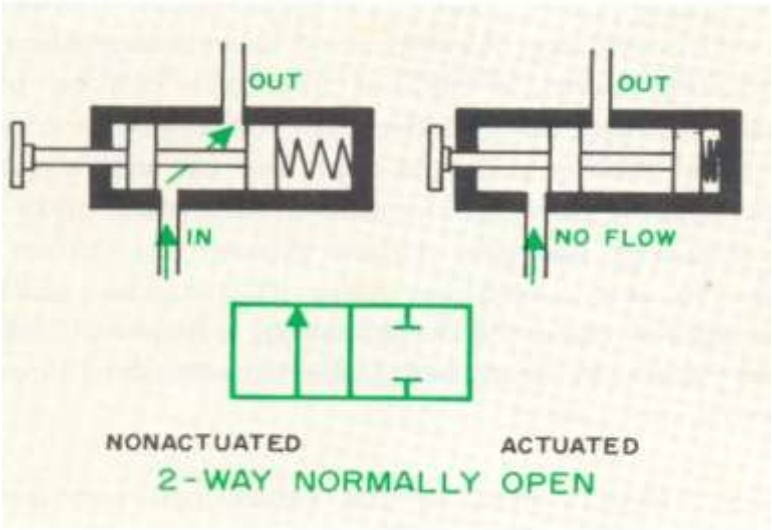
Direction control valves used in pneumatic system are similar to those used in hydraulics. Their primary function is to direct flow of air from one place to another in the system. DC valves are devices which influence the path taken by an air stream. Normally this involves one or all of the following:

- Opening the passage of air and directing it to particular air lines.
- Canceling air signals as required by blocking their passage.
- Relieving the air to atmosphere via an exhaust port.
-

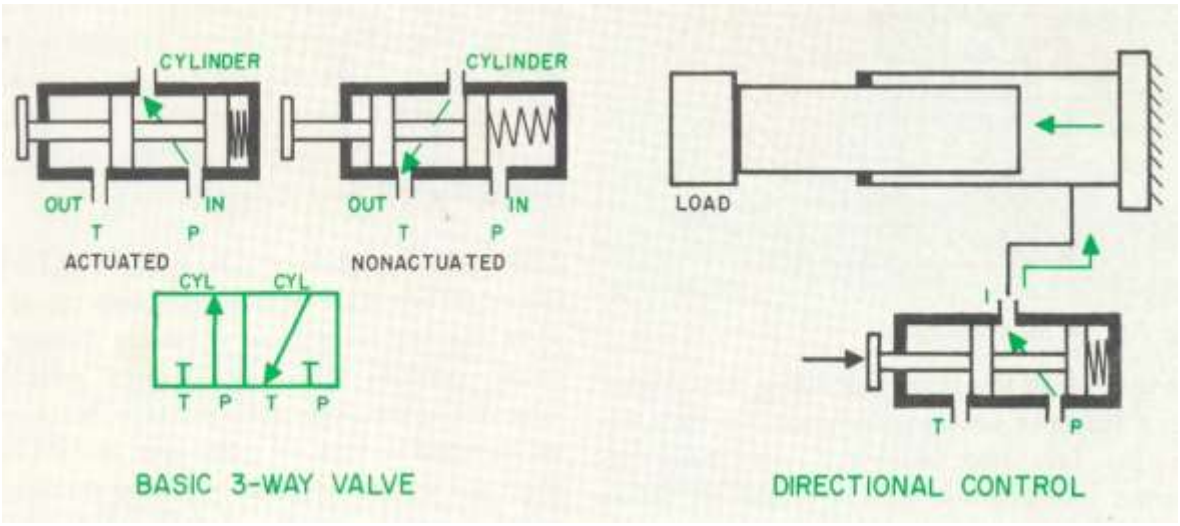
DC valve is characterized by its number of controlled connections or ways, the number of

switching positions and the method of actuation.

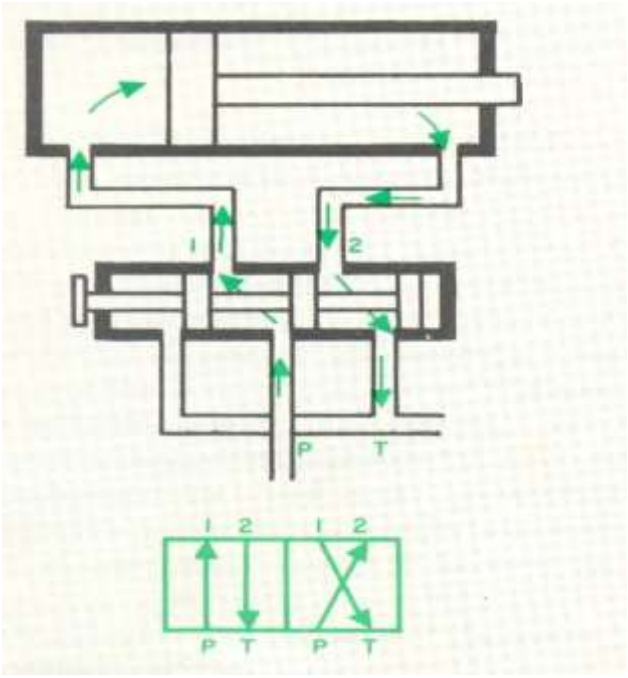
2-way, 2 position valve:



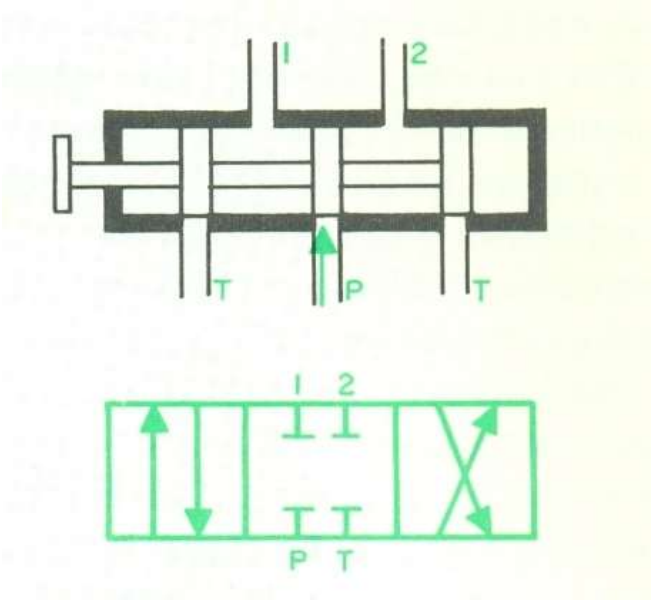
3 way, 2 position valve:



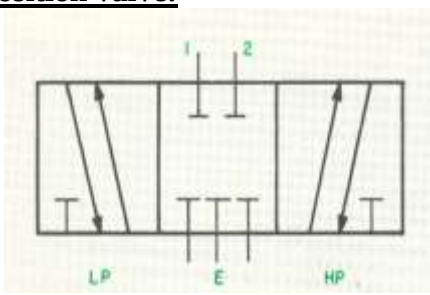
4 way, 2 position valve:



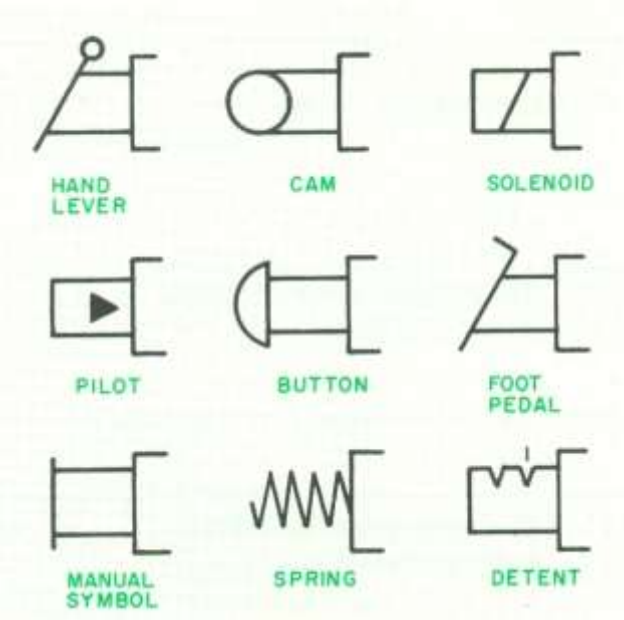
4 way, 3 position valve:



5 way, 3 position valve:



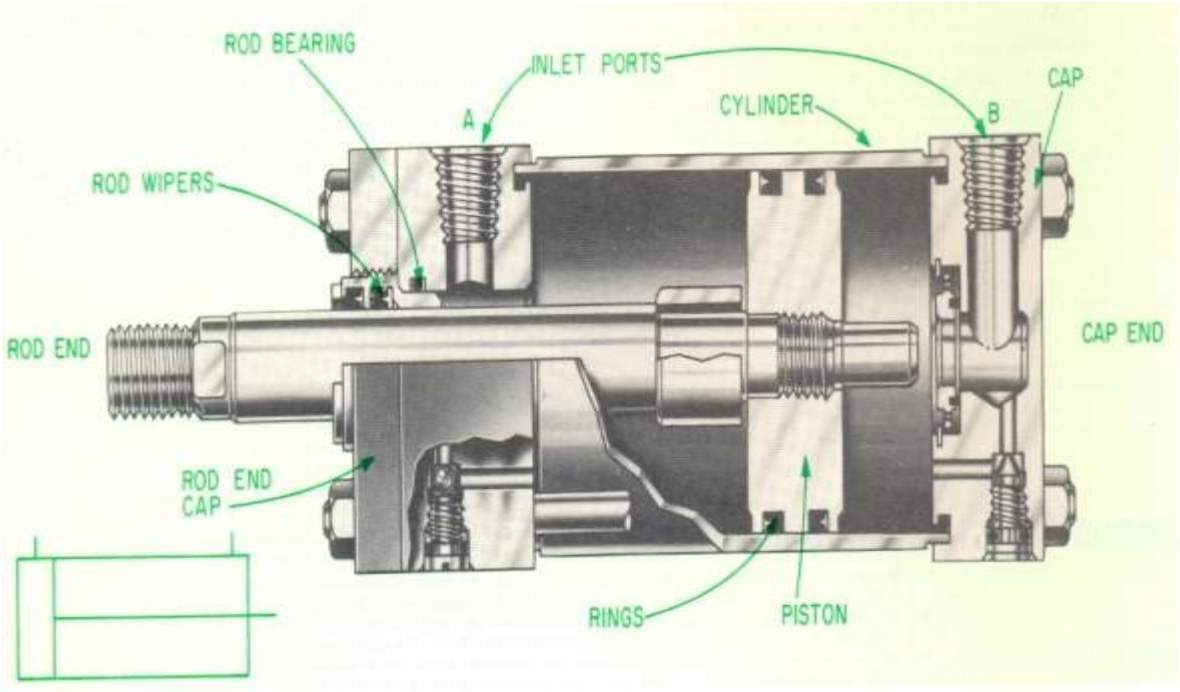
Schematic symbols for actuating D. C. Valves:



AIR RECEIVER/CONTAINER:

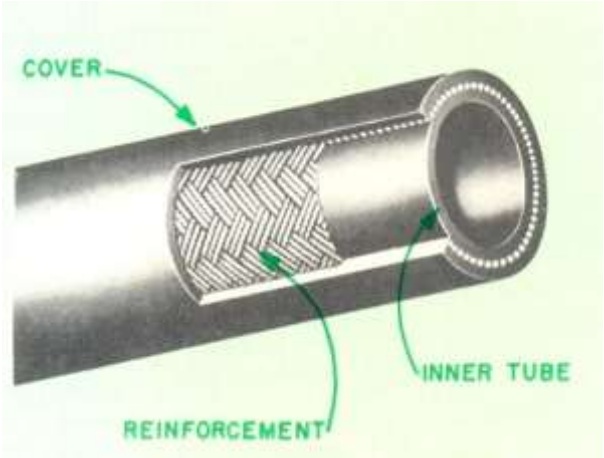
Before discussing an air receiver, let us be clear in mind that unlike liquids (which are virtually imcompressible) is readily co9mpressible. That is why a large quantity of air can be stored in a comparatively smaller vessel or container. The more the air in a container, the higher is the pressure and stronger should be the container to with stand that pressure.

CYLINDERS:



A pneumatic cylinder converse compressed air pressure into mechanical linear force. When the compressed air enters on of the ports of the cylinder, it transmits movements to the piston and its rods and becomes mechanical force to do some work. The flow rate of the pneumatic power determines the piston speed and output in horse power.

PIPING, HOSES AND FITTINGS:



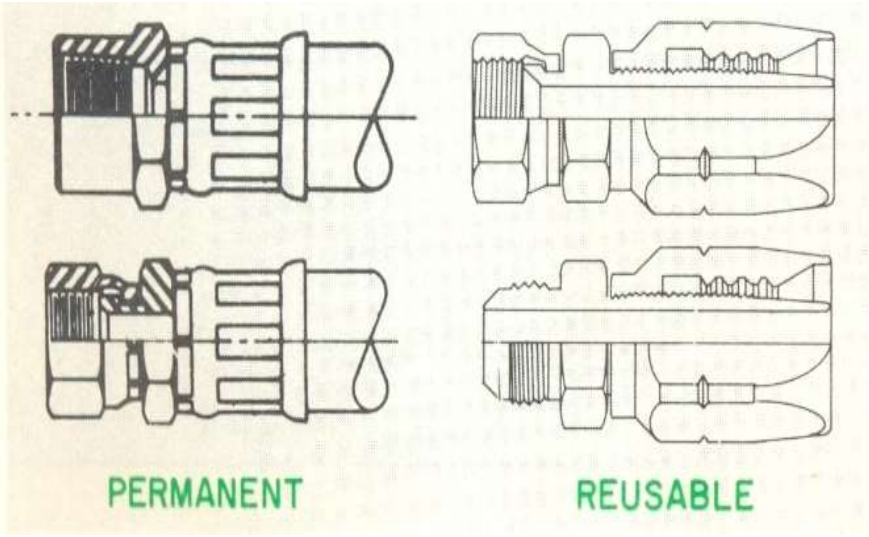
Piping is an important part of pneumatic system. It is not only to transmit the pneumatic power to various components, but also to keep it clean and free from contaminants. The pipes utilized on the machines should be flexible and strong enough to withstand the working pressure of the system.

As a thumb rule, the testing pressure of a pipe should be double that of working pressure and bursting pressure double that of the testing pressure.

The working pneumatic pressure on track machine varies between 6.5 – 7.0 kg/cm^2.

The inside diameter of pneumatic pipe is 6.3 mm and 12.6 mm are used for general transmission and brake system of the machine.

Fitting:

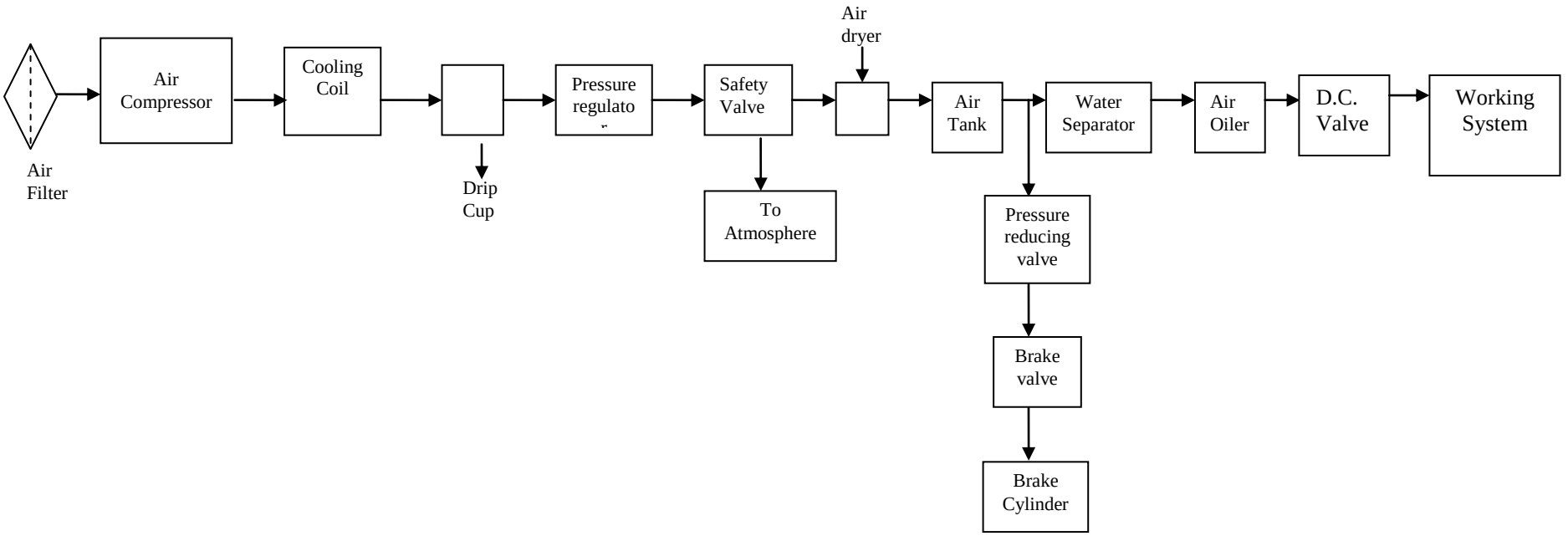


Lesson-III: Pneumatic Circuits, Session-05: Pneumatic Brake Circuits

Air compressor, run by engine crankshaft, supplies compressed air to brakes and working pneumatic system. Pneumatic pressure, in the above, is regulated by means of pressure regulator. Due to compression of air in air compressor, temperature & pressure of air increases. The compressed air is made to flow through cooling coil, which is helical copper tube, where air cools down. This then passes through the drip trays for separating the moisture of the compressed air. The excess air pressure is controlled by safety valve through which excess air is released to atmosphere. The main stream of air flows to air dryer which dehumidifies the air by means of a granulate. After which air flows to air-reservoirs. Upon filling up of one reservoir, pressurized air opens the overflow valve, which is set at 3.8 bar & then the air fills up the other tank.

(a) For Braking System: From air tank, air reaches the pressure reducing valve where pressure is reduced to approx 4 bar (brake pressure). A dual pressure gauge is provided which shows both the pneumatic working pressure (7 bar) by white pointer & brake pressure (4 bar) by red pointer. On operation of brake valve this pneumatic brake pressure moves the brake cylinders, which is a spring loaded single acting cylinder for application of brake.

(b) For Pneumatic working System: From air tank, air passes through water separator which is provided in the outlet line of air reservoir. This removes the moisture from the air. Now dry air passes to air oiler where lubricating oil is filled for lubrication of air. Lubricated air then flows to solenoid operated D.C. valves & actuators for working pneumatic system.



PNEUMATIC WORKING AND BRAKING SYSTEM – FLOW CHART

Brief description and checks to be carried out :

1. **Pneumatic:** Check to make sure it is connected properly. The connection to the pneumatic power may be ascertained by reading the pneumatic pressure in the pressure gauge. In case of low pressure the lines and the brake system should be checked for leakages.
2. For **new or recently overhauled circuit** : It is possible in a to find components with blockages in the flow path which should also be checked.
3. Check **Connections**: of all control valves for their proper connection.
4. **Air Filter**: Should be cleaned/replaced periodically as per schedule.
5. **Air compressor:** Lube oil level should be checked. Compressor fins should be cleaned by compressed air.
6. **Cooling Coil:** This should be checked for leakages. Cooling coil may get punctured.It may leak at the ferrules & joints. Repair or replace accordingly.
7. **Drip Cup:** This should be regularly emptied out by opening the drain valve protect the air dryer from contamination & should be closed after completion of drain.
8. **Pressure Regulator:** If required pressure is not proper, check the lines & pressure regulator. If lines are OK, then readjust the pressure regulator. If pressure is still not proper,then dismantle the pressure regulator. Clean it, check visually the parts & replace if required.
9. **Safety Valve:** If pressure is not proper, check the lines &. If lines are OK, then readjust the safety valve. If pressure is still not proper, then dismantle the safety valve. Clean it, check visually the parts & replace if required.
10. **Air Dryer:** The preliminary filter to the air dryer should be checked regularly for free passage & replaced if required. To avoid damage to the pneumatic components the air dryer has to be checked periodically. The filter cartridges (90187-65) and the granule cartridges (432 406 9202) have to be replaced every 500hrs of operation, at the least, however once a year.
11. **Air Tank:** Air tanks should be drained after the days work or stoppage for a longer period of time. These should be done by actuating the drainage valve.
12. **Water Separator:** Water separator should be functional. If manually operated water separator is provided, it should be drained out regularly particularly when humidity in atmosphere is high.
13. **Air Oiler:** This should be functional. Top up with lubricating oil daily/as per schedule.
14. **D. C. Valve:** Contamination or improper lubrication are the most common cause for valves sticking and become inoperative. Any internal/external leakage shall be attended. This should be checked and preventive measures taken.
15. **Pressure Reducing Valve:** It reduces the pressure to 4 bar approx. for application of brakes. Since its function is based on spring loading pressure hence spring physical condition should be checked regularly.
16. **Dual Pressure Gauge:** Check pressure on Dual air pressure gauge. System pressure should be 7 bar & brake pressure should be 4 bar.
17. **Brake Valve:** It is most critical and costly equipment of the circuit and its function is also critical, hence it should be checked regularly for its internal and external leakages, springs and back pressure disc.
18. **Brake Cylinder:** It is the most important component of the brake circuit which converts pneumatic energy to mechanical power for operating brake levers and shoes for ultimate braking. It is a single acting cylinder and safety item hence its components like barrels, seal etc. should be always in good condition. Since we have no effective checks of rubber items at sites hence seals should always be used of reputed brand. Barrels should be free from dents, corrosion etc. otherwise internal leakage will start. Machine working in coastal areas are affected mostly by corrosion because presence of salty atmosphere hence cylinder should be checked frequently and changed if needed.

19.**Pneumatic Hoses: Since** Pneumatic hoses are simply synthetic yarn braided and no wire is used hence it is prone to damage early due to mechanical damages, atmospheric effects etc. hence it should checked regularly. Any bursting of hose will cause total failure of brake. Its ends clamping should also be tightened well and checked regularly. Heavy handed operation should not be done for application of brake otherwise brake hose may burst or it may slipped off from end connection.

20.**Brake shoe:** Check physical condition of the brake shoe and its fixation. Gap between wheel and brake shoe shall be maintained 3-5 mm. Any deficiencies in shoe profile if observed it should be replaced by new one:

(i) Change worn brakes shoes at any points for minimum thickness of 13mm.

(ii)Avoid sudden and full braking otherwise chances of hose slipping/bursting which will result total failure of braking. In case of emergency only full brake can be applied but gradually.

Brake Test:

The driver should see the impression of brake shoe on wheel tread, whether equal or not & whether the vehicle is pulling a side or not.

The brake system must be in absolutely reliable service condition. Before beginning any open line travel and after a machine stand still of more than 2 hrs during a longer open line travel, a full brake test must be carried out. **During the brake test the appropriate braking and brake releasing has to be checked.** The brakes' air tightness of the brake cylinders and the compressed air pipes have to be observed. During the brake test the hand brake (parking brake) must be released. If there is a risk, the machine might break away, it must be secured by brake shoes. The brake test may be carried out, when the air pressure in the tank amounts to at least 6 bar. The main air pipe (brake pipe) must be under a pressure of 4 bar max.

Brake Test of the Direct Acting Pneumatic Brake:

This brake acts on the machine only and not on the hauled coaches. Keep the handle of the brake valve in release position until the brake cylinder pressure has decreased to "0". check, whether all brake blocks have been released. Subsequently, operate the brake valve to braking position, pressure in the brake cylinders must increase to 3.8 bar. By hammer strokes on one brake block of each bogie check, whether all brake blocks of the machine fit closely.

Again keep the brake valve lever in release position until the pressure in the brake cylinders will have decreased to "0" & observe, whether all brake blocks have lifted off the wheels.

Hand Brake:

Action of the hand brakes of the machine has to be checked (brake blocks have to fit closely). The hand wheels must be easy to turn.

Emergency Brake:

If emergency brake system is available on machine, it should be used in emergencies only. After any operation of the emergency brake the hinged lid of the emergency brake valve must be closed again.

Check of Brake Linings and Brake Block Play:

Brake Linings: Brake linings have to be changed at the latest, when their thickness of 35mm (new) has diminished to 5mm (worn). Grooves in the brake linings are indicators of brake lining thickness. If the grooves are no longer visible, the remaining thickness of the brake lining is below 10mm. It will soon become necessary to change the brake linings. The thickness of the brake linings must in no place be below 5mm.

Brake Play: During the cycle of service of a brake block its play has to be re-adjusted for at least one time. Usually the brake play (distance between the brake block bottom and the wheel tread) is approximately 5mm. In principle, the brake block play has to be re-adjusted, when:

1.The warning lamp indicating brake block wear lights up
2.The brake blocks are replaced
3.The wheel profile had been re-worked.

How to adjust the brake block play:

(i) Secure the machine against breaking away (skid-pans)
(ii) Release the parking brake
(iii) Release the brake cylinders (ZERO brake pressure)
(iv) When assembling new brake blocks, first shift the turnbuckles so that the brake blocks will
move backwards and make room for the new ones.
(v) Adjust the brake play by using for this purpose the turnbuckles.
(vi) Secure the turnbuckles from unintended shifting.

Problem	Causes	Remedies
Insufficient air volume	1. System demands exceed delivery.	1. Check compressor for discharge capacity.
		2. Check the number of pneumatic components in the system.
		3. Check for leaks in the piping.
	2. System leakage excessive.	1. Check all fittings and pipes.
		2. Check and repair all leaking joints.
		3. Check all actuators for leaks.
	3. Clogged intake filters.	1. Clean the intake filters.
		2.Check the compressor intake valves.
		3. Check the size of intake pipe.
Low air pressure	1. System demands exceed delivery.	1. Check the compressor discharge pressure.
		2. Check the reservoir safety valve.
		3. Check the system regulator valve.
		4. Check the system leaks.
	2. System leakage excessive.	1. Check the compressor discharge pressure.
		2. Check the reservoir safety valve.
		3. Check the system regulator valve.
		4. Check the system leaks.
	3. Low compressor discharge pressure.	1. Check for clogged intake lines.
		2. Check for worn intake valves.
		3. Check for worn discharge valves.
Oil in the system	1. Oil coming from the compressor.	1. Check the compressor piston rings.
		2. Check the compressor discharge valves.
		3.Check the compressor intake valves.
	2. Malfunctioning air lubricator.	1. Check the lubricator adjustment. 2. Check the oil viscosity.
Moisture in the system.	1. System demands exceed delivery.	1. Check compressor capacity.
		2. Check the air consumption of the components.
	2.Moisture carryover.	1. Check the moisture separator.
		2. Check the system drain i.e. drip cup.
		3. Check the location of the intake filter.

SUB-DISCIPLINE: PNEUMATICS (LESSONS: 05 SESSIONS: 08)

Lesson-V: Demonstration of Pneumatic Equipment Sets, **Session-07:** Demonstration of Pneumatic Circuits Using FluidsimP Software & Working Exercises

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Different pneumatic circuits are drawn and the circuits are made and verified through the model components of pneumatic equipment set available in the model room.

Lesson-V: Demonstration of Pneumatic Equipment Sets, **Session-08:** Demonstration of Pneumatic Circuits Using FluidsimP Software & Working Exercises

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Different pneumatic circuits are drawn and the circuits are made and verified through the model components of pneumatic equipment set available in the model room.