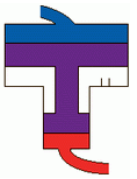
Applications of Hydraulics & Pneumatics

7

By: Alireza Safikhani

Accessories

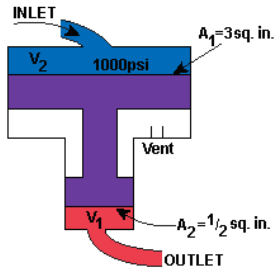
- Pressure Booster & De-booster
- Pressure Switch
- Pressure Gage
- Accumulator
- Heat Exchanger
- Filters
- Sealing & Packing
- Fluid Conductor





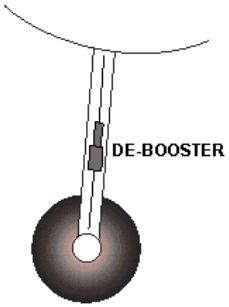

Pressure Boosters & Debooster

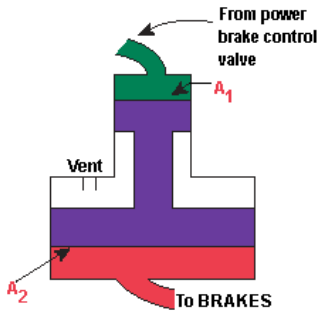
- The function of a pressure booster is to act like a transformer--that is, it raises the pressure of a small circuit connected to the power system.
- The booster is a cylinder made up of two pistons of different surface areas that are connected. The larger surface area (A1) is connected to the inlet side of the hydraulic system, and, the smaller surface area (A2) is connected to the outlet side of the hydraulic system.



Pressure Boosters & De-booster

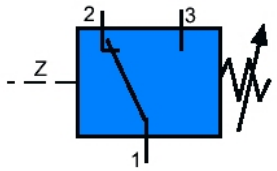
- Pressure de-boosters are used to reduce the pressure in the system to a level that can be used by certain devices (damage Prevention).

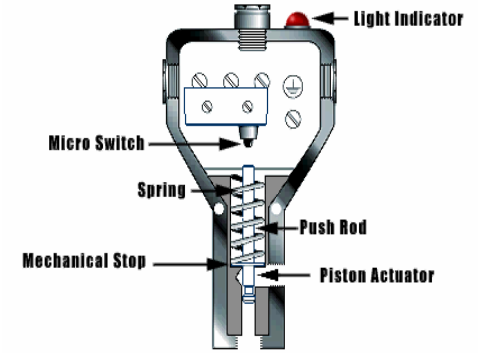




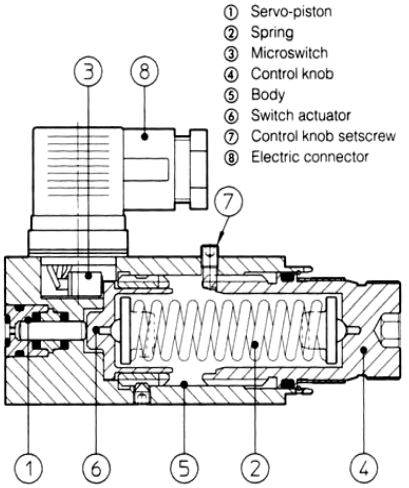
Pressure Switch

- **Pressure switches produce an electrical make/break which is triggered when pressure in the hydraulic circuit reaches a given setting.**





Principle of operation



- Fluid pressure in the circuit operates a piston (1) fitted with adjustable spring bias (2); once the pressure setting is reached, the piston is urged forward so as to actuate a micro switch (3) and make or break its contacts.
- The pressure setting is selected by turning a graduated control knob (4). Clockwise rotation increases the setting pressure.

Industrial Example

Pressure Range

1) 3 to 40 bar

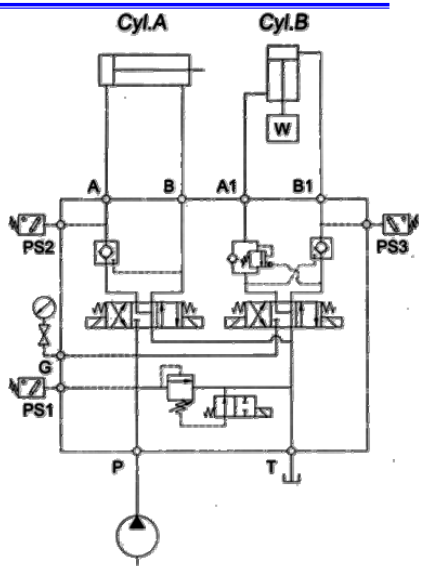
2) 4 to 80 bar

3) 8 to 160 bar

4) 16 to 320 bar

5) 32 to 630 bar

Circuit Example



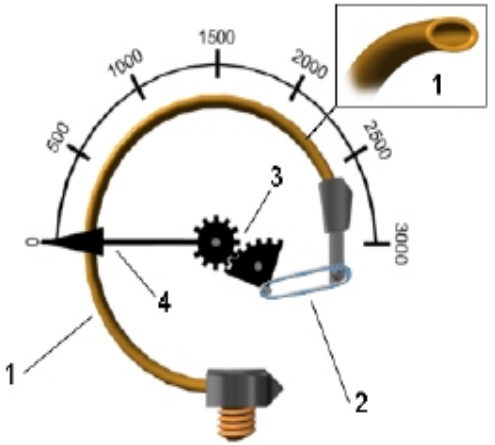
9

Pressure Gage

- used in liquid-powered systems to measure pressure to maintain efficient and safe operating levels. Pressure is measured in psi or bar

10

Principle of Operation



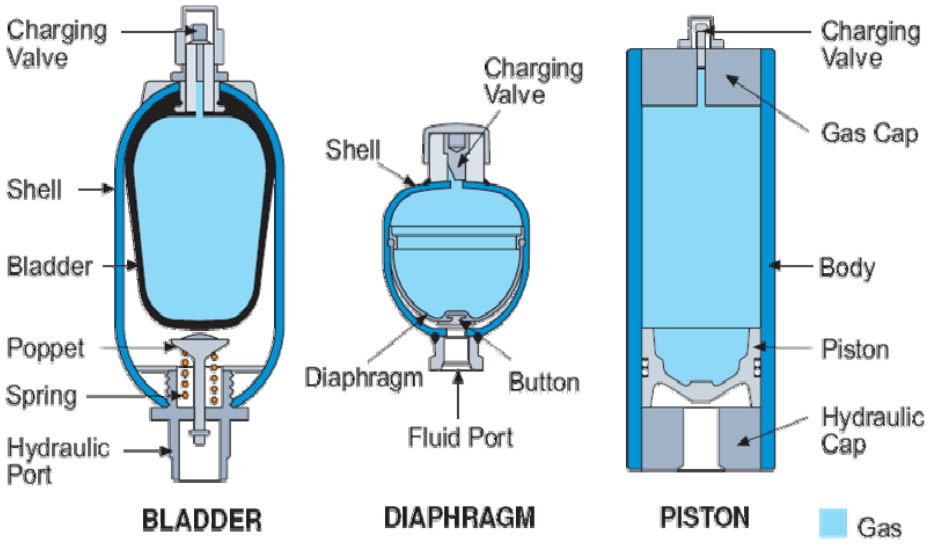
11

Accumulator

- Like an electrical storage battery, a hydraulic accumulator stores potential power, in this case liquid under pressure, for future conversion into useful work.
- Types
- bladder accumulator: the liquid and gas are separated by an elastic bag or bladder.
- diaphragm accumulator: the liquid and gas are separated by a flexible diaphragm.
- piston accumulator: the liquid and gas are separated by a floating piston

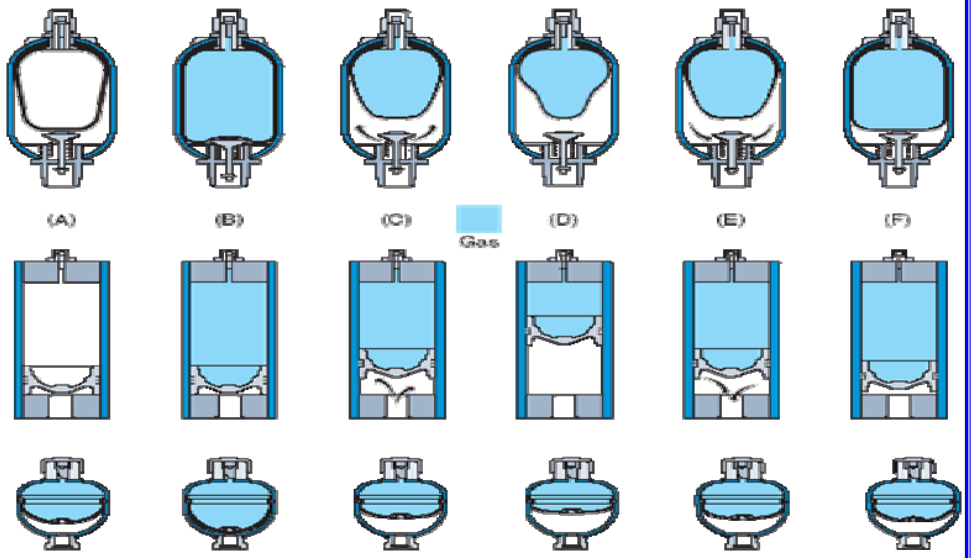
12

Types



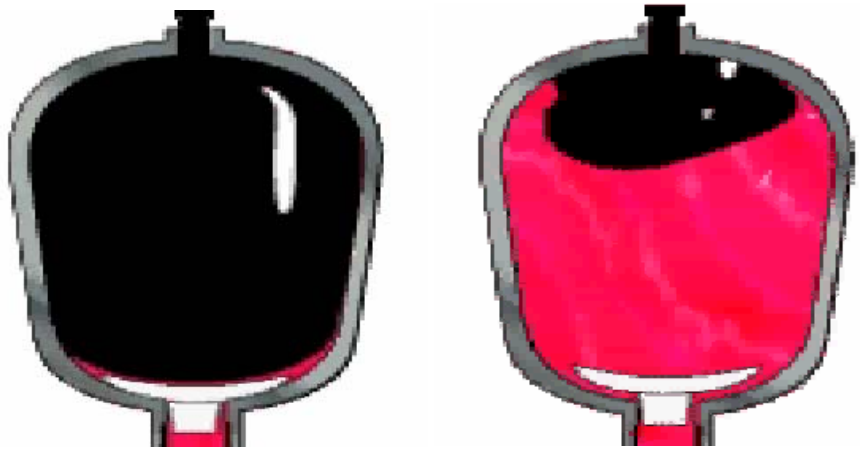
13

Operation



14

Animation

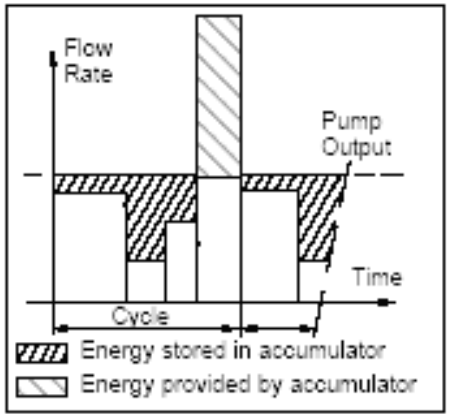


Charging Discharging

15

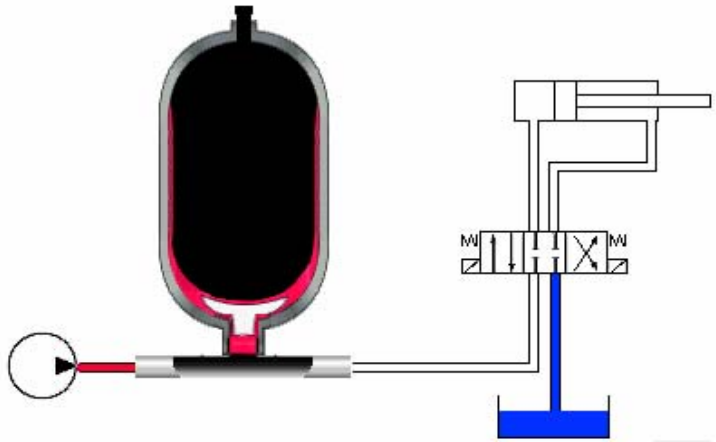
Applications: Reduction of installed power

- **Using an accumulator as an energy storage device effectively reduces the required flow rate capacity of the hydraulic pump. This results in a reduction of the installed power.**



16

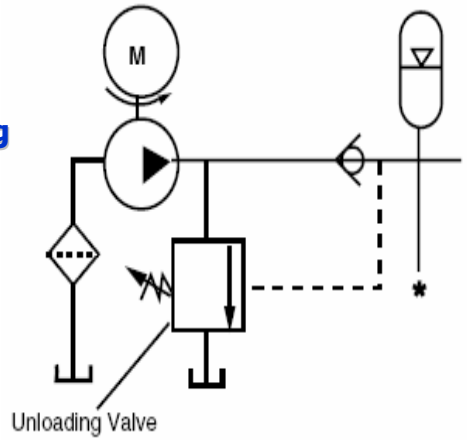
Animation



17

Pump Unloading

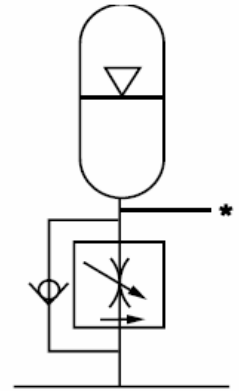
- an unloading valve is used to dump a flow back to tank once an accumulator is charged to the unloading valve setting.
- Once the valve closes, pump/electric motor must therefore generate power to recharge the accumulator to the unloading valve setting



18

Control of Usable Volume

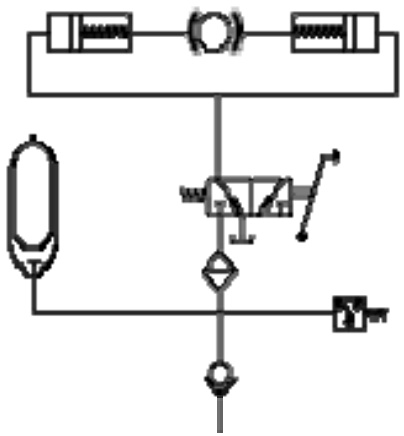
- The usable volume of an accumulator should be discharged at a controlled rate.
- *Safety Note: In any accumulator circuit, a means should be available of automatically unloading the accumulator when the machine is shut down. Such a valve could be located at this point in the circuit.



19

2. Emergency and safety

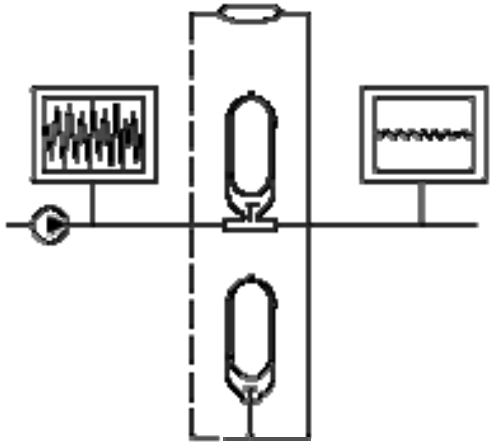
- An accumulator which is kept constantly under pressure allows for instant and/or repetitive operations as required (braking, opening of door, etc.)



20

Dampening of pulsation and reduction of noise

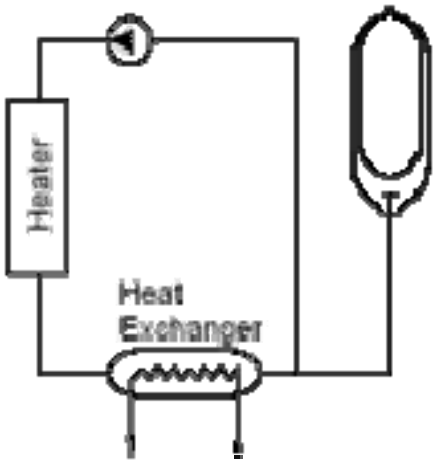
- In order to dampen pressure changes, which are caused by the pulsation of a pump, an accumulator makes it possible, due to the low inertia of its bladder, to improve the precision of operation and to reduce the sound level of the installation



21

Thermal expansion

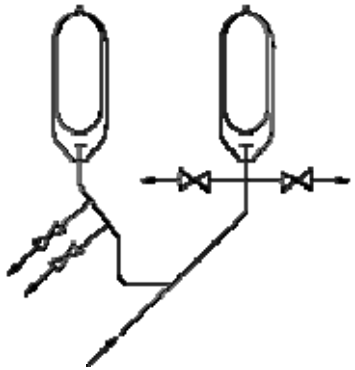
- The pressure differences caused by thermal variation in a closed hydraulic circuit are absorbed by fitting an accumulator



22

Surge control

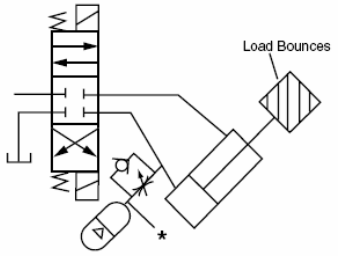
- an accumulator correctly sized and located in the system transforms pressure wave oscillations into liquid mass oscillations which are easily absorbed by the accumulator, bringing the pressure peak level back to acceptable levels.



23

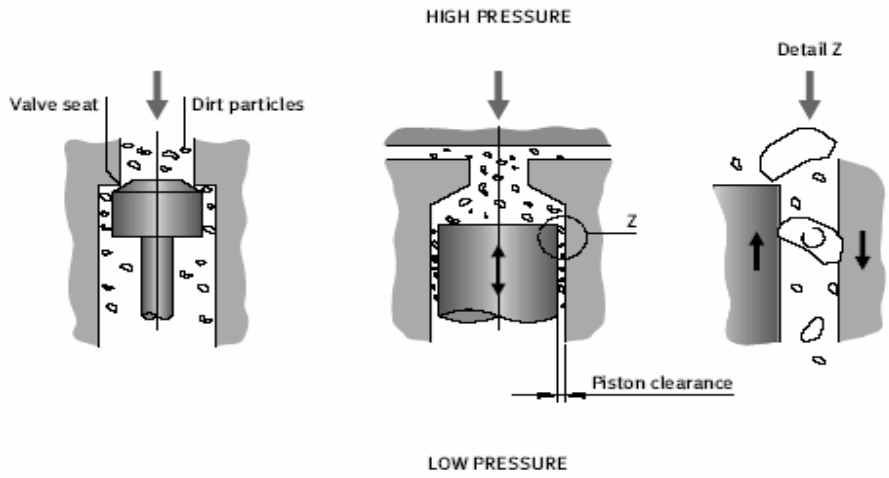
Absorbing Shock

- Shock in a hydraulic system may be developed from the inertia of a load attached to a cylinder or motor. Or, it may be caused by fluid inertia when system flow is suddenly blocked or changed direction as a directional valve is shifted quickly. An accumulator in the circuit will absorb some of the shock and not allow it to be transmitted fully throughout the system.



24

Contamination of the hydraulic fluid



Filters

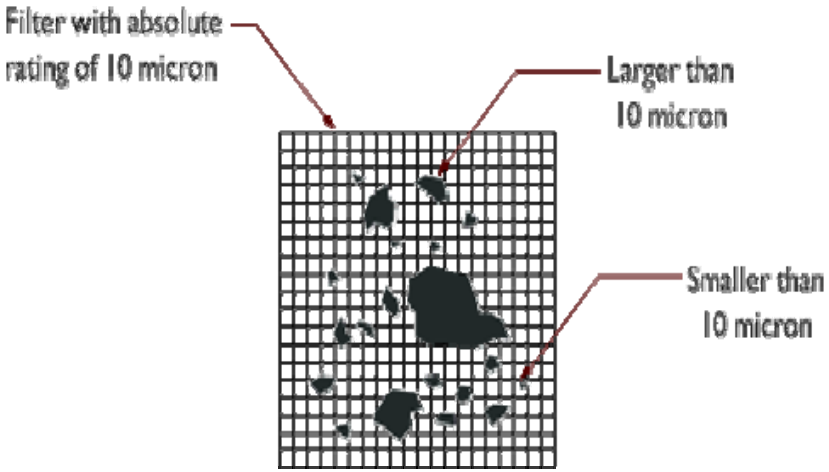
- To keep hydraulic components performing correctly, the hydraulic liquid must be kept as clean as possible.
- Foreign matter and tiny metal particles from normal wear of valves, pumps, and other components are going to enter a system.
- Selection and positioning of the filter is largely based on the sensitivity to dirt of the hydraulic components in use.

Grade of Filtration

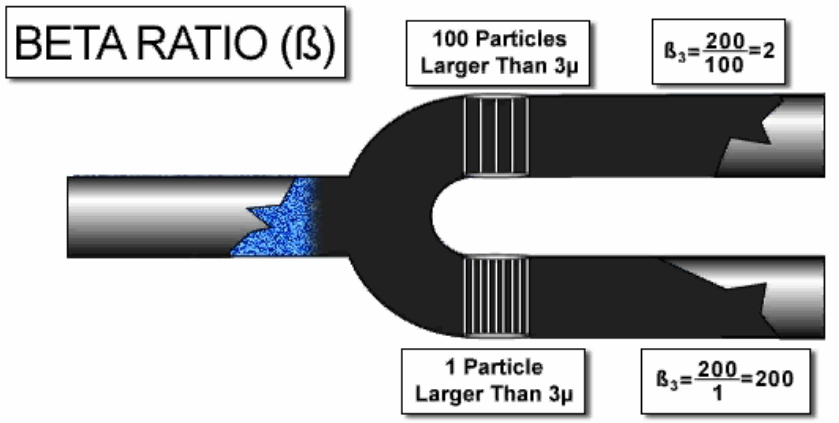
- Dirt particles are measured in µm, the grade of filtration is indicated accordingly.
- Absolute filtration Rating
  - indicates the largest particle able to pass through a filter
- β-value
  - indicates how many times more particles above a specific size are located in the filter intake than in the filter return

Absolute filtration Rating

- indicates the largest particle able to pass through a filter



β-Ratio



ISO 4406

- The level of contamination in a fluid is covered in standards ISO 4406 .
- Two range numbers must be stated.
- The first number is the range of particles in 1 ml larger than 5 microns and the second the range for particles larger than 15 microns.
- For example code 18/13 means the sample contains 1300 to 2500 particles larger than 5 microns and 40 to 80 particles larger than 15 microns.

ISO 4406

Cleanliness Level Correlation Table

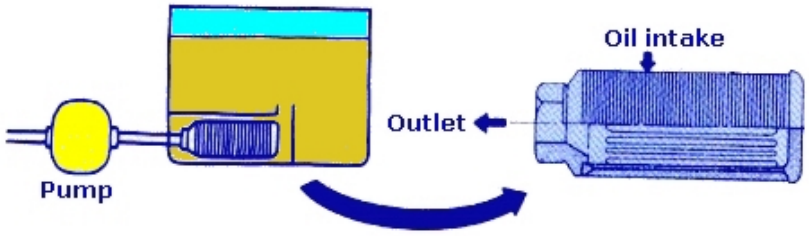
ISO Code	Particles/Millilitre >2 Micrometers	>5 Micrometers	>15 Micrometers	NAS 1638 (1964)	Disavowed SAE Level (1963)
23/21/18	80,000	20,000	2,500	12	–
22/20/18	40,000	10,000	2,500	–	–
22/20/17	40,000	10,000	1,300	11	–
22/20/16	40,000	10,000	640	–	–
21/19/16	20,000	5,000	640	10	–
20/18/15	10,000	2,500	320	9	6
19/17/14	5,000	1,300	160	8	5
18/16/13	2,500	640	80	7	4
17/15/12	1,300	320	40	6	3
16/14/12	640	160	40	–	–
16/14/11	640	160	20	5	2
15/13/10	320	80	10	4	1
14/12/9	160	40	5	3	0
13/11/8	80	20	2.5	2	–
12/10/8	40	10	2.5	–	–
12/10/7	40	10	1.3	1	–
12/10/6	40	10	.64	–	–

Fluid Cleanliness Required for Typical Hydraulic Components

Components	ISO Code
Servo control valves	16/14/11
Proportional valves	17/15/12
Vane and piston pumps/motors	18/16/13
Directional & pressure control valves	18/16/13
Gear pumps/motors	19/17/14
Flow control valves, cylinders	20/18/15
New unused fluid	20/18/15

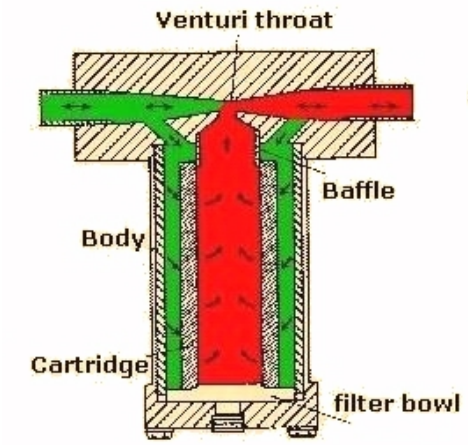
Strainers

- A strainer is the primary filtering system that removes large particles of foreign matter from a hydraulic

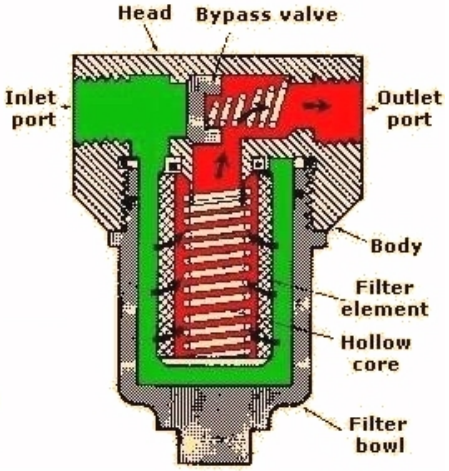


- Strainers are used to pump inlet lines where pressure drops must be kept to a minimum.

Filters

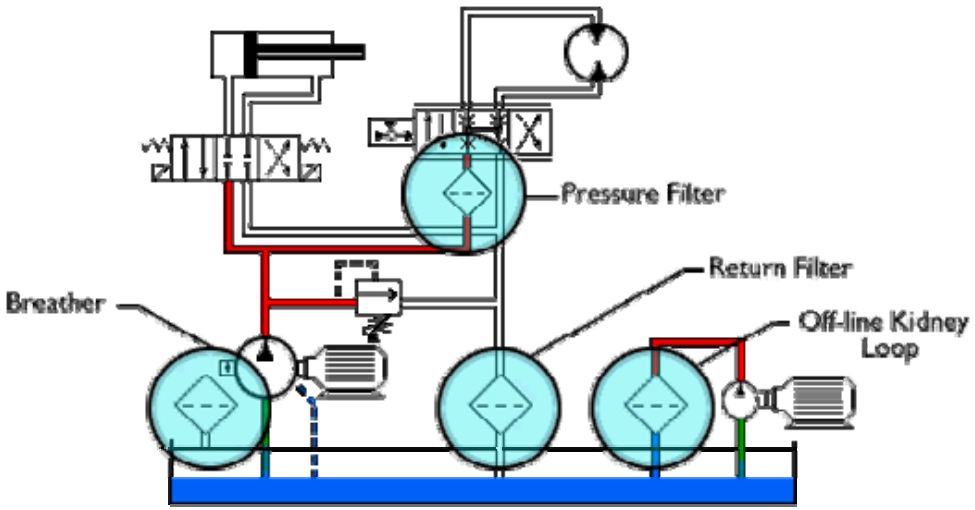


- Partial-Flow Filters

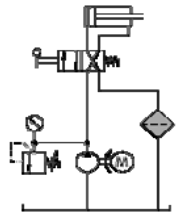
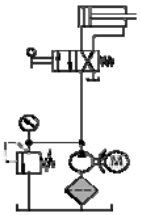
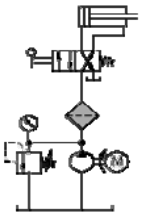
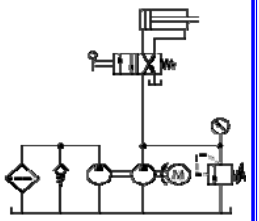


- Full-Flow Filters

Placement



Placement

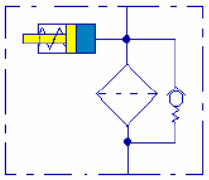
	Filtering of the main flow			By-pass flow filtering
	Return flow filter	Pump inlet filter	Pressure line filter	
Circuit diagram				
Advantages	economical simple maintenance	protects pump from contamination	smaller pore size possible for valves sensitive to dirt	smaller filter possible as an additional filter
Disadvantages	contamination can only be checked having passed through the hydraulic components	difficult access, inlet problems with fine pored filters. Results: cavitation	expensive	lower dirt-filtering capacity
Remarks	frequently used	can also be used ahead of the pump as a coarse filter	requires a pressure-tight housing and contamination indicator	only part of the delivery is filtered

Pressure Drop

- **Pressure filter:**
  - **Δp ~ 1 to 1.5 bar at operating temperature**
- **Return line filter:**
  - **Δp ~ 0.5 bar at operating temperature**
- **Intake filter:**
  - **Δp ~ 0.05 to 0.1 bar at operating temperature**

Contamination indicator

- It is important that the effectiveness of the filter can be checked by a contamination indicator.
- The contamination of a filter is measured by the drop in pressure. As the contamination increases, the pressure ahead of the filter rises. This pressure acts on a spring-loaded piston. As the pressure increases, the piston is pushed against the spring.



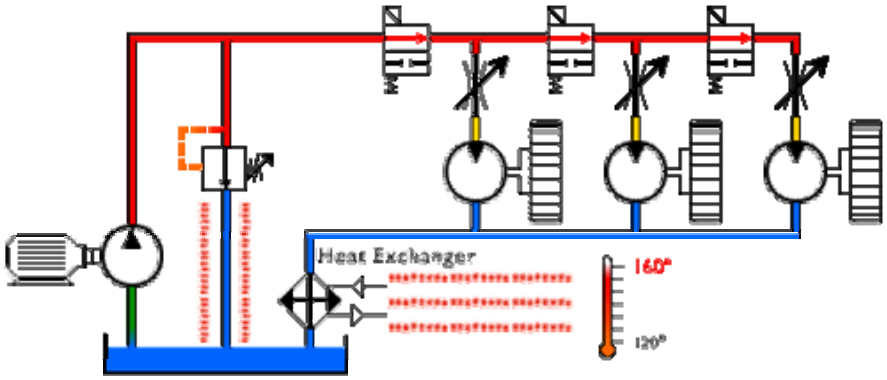
37

Heat Exchanger

- friction causes energy losses when the hydraulic fluid flows through the lines and components.
- This causes the hydraulic fluid to heat up. To a certain extent, this heat is given off to the environment via the oil reservoir, the lines and other components
- Operating temperature should not exceed 50 – 60 °C. Where there is a high temperature, the viscosity of the oil falls by an unacceptable amount, leading to premature ageing. It also shortens the service life of seals

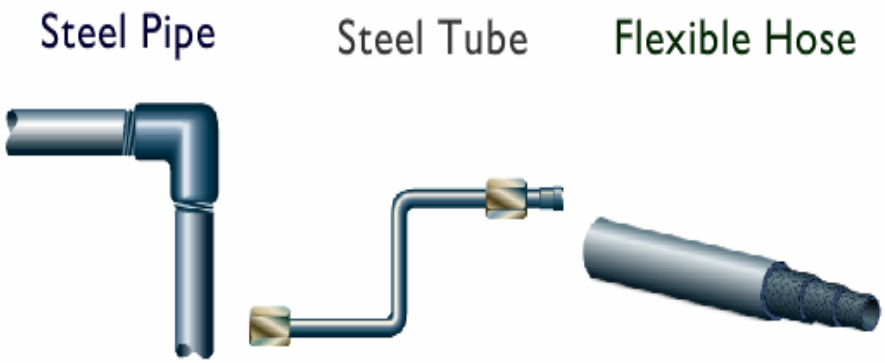
38

Types



39

Fluid Conductor



40

Pipes

- **Pipes are specified by their nominal bore diameter**
- **Pipes are still commonly made to imperial sizes (British Standard Pipe) and 1 inch BSP means it has a 1-inch nominal bore.**
- **Metric pipes are often just inch sizes converted to mm so that a 1-inch pipe becomes a 25 mm pipe and a 2-inch becomes a 50 mm pipe.**
- **Tubes are specified by their outside diameter and they are made to standard sizes. Sizes in fractions of an inch are still available but metric is becoming more popular such as 15 mm, 16 mm and so on.**

41

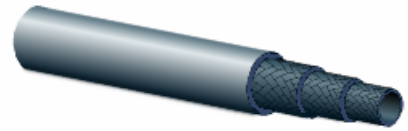
Velocity in Conductor

- **Pressure lines:**
  - **» up to 50 bar operating pressure: 4.0 m/s**
  - **» up to 100 bar operating pressure: 4.5 m/s**
  - **» up to 150 bar operating pressure: 5.0 m/s**
  - **» up to 200 bar operating pressure: 5.5 m/s**
  - **» up to 300 bar operating pressure: 6.0 m/s**
- **Suction lines: 1.5 m/s**
- **Return lines: 2.0 m/s**

42

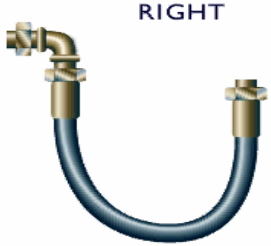
Hose

- System Pressure
- Pressure Pulses
- Velocity
- Fluid Compatability
- Environmental Conditions



Proper Hose Installation

RIGHT



WRONG

43

Hose

PRESSURE RATING

- Safety Factor of 4 to 1
- Reinforcement gives pressure ratings
- Natural & synthetic reinforcements used

Braided Bound

SIZES

- Depends on volume and velocity
- Designated by I.D. (Inside Diameter)
- Sizes designated in 16th's of an inch
- Size (-8) = 8/16" or 1/2" I.D.

Spiral Bound

LIFE

- Various substances deteriorate rubber
- Must be replaced every few years

44

Pipes

- Best performance & cost
- Welding is required
- Costly flushing at start-up

Pipes

NOMINAL SIZE	PIPE O.D.	INSIDE DIAMETER SCHED. 40	SCHED. 80	SCHED. 160	DOUBLE EXTRA HEAVY
1/8	.405	.269	.215	--	--
1/4	.540	.364	.302	--	--
3/8	.675	.493	.423	--	--
1/2	.840	.622	.546	.466	.252
3/4	1.050	.824	.742	.614	.434
1	1.315	1.049	.957	.815	.599
1 1/4	1.660	1.380	1.278	1.160	.896
1 1/2	1.900	1.610	1.500	1.338	1.100
2	2.375	2.067	1.939	1.689	1.503
2 1/2	2.875	2.469	2.323	2.125	1.771
3	3.500	3.068	2.900	2.624	--
3 1/2	4.000	3.548	3.364	--	--
4	4.500	4.026	3.826	3.438	--
5	5.563	5.047	4.813	4.313	4.063

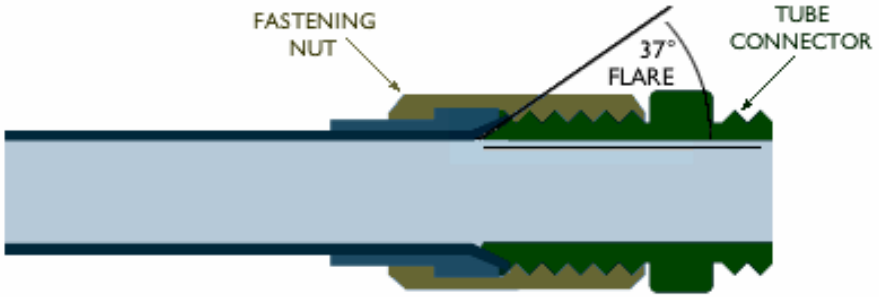
Tube

- Used when rigid lines are required
- Easier to assemble and form then pipe
- No welding required

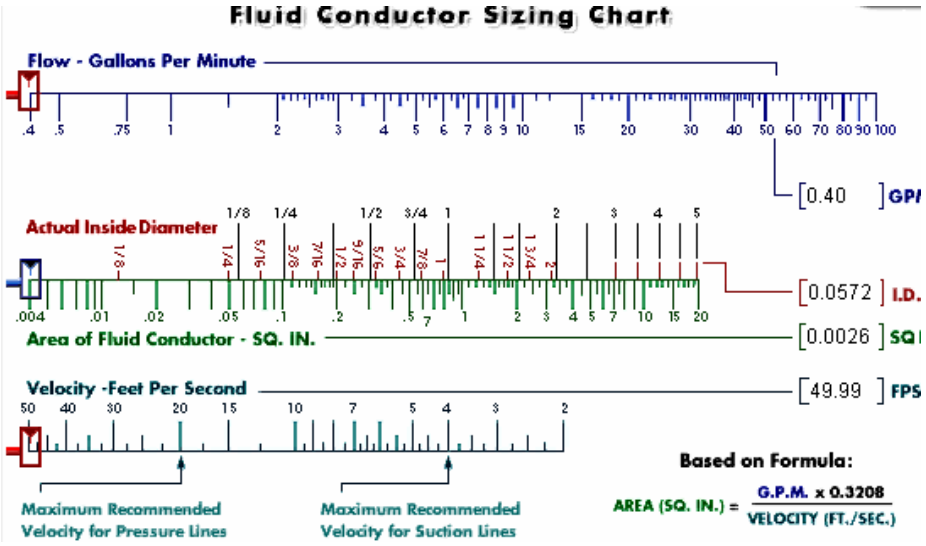
REQUIREMENTS

- Large enough to carry required flow
- Strong enough to withstand pressure

Tube



Sizing

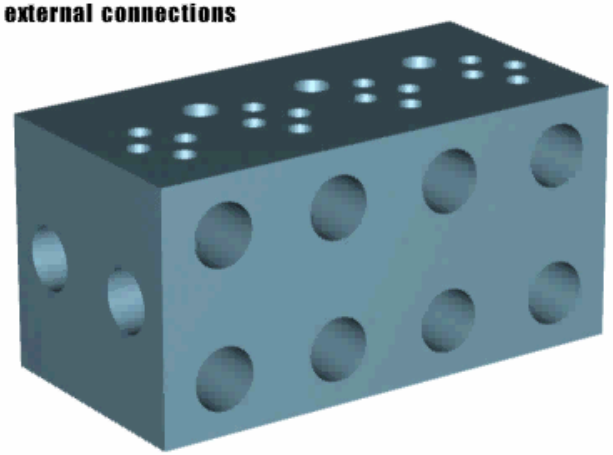


49

Manifold

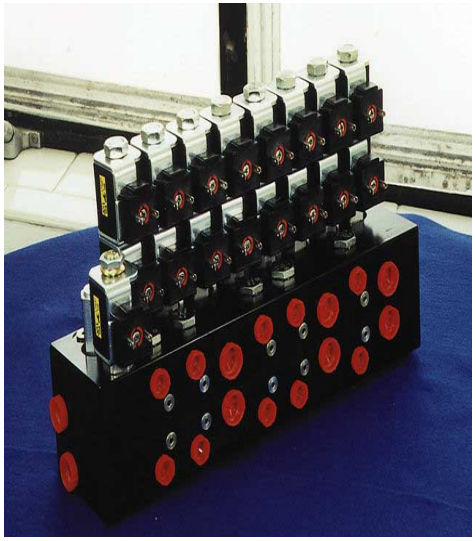
Modular Manifold

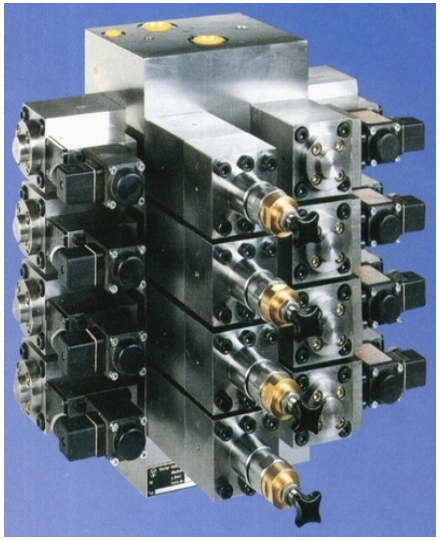
- Reduces the number of external connections



50

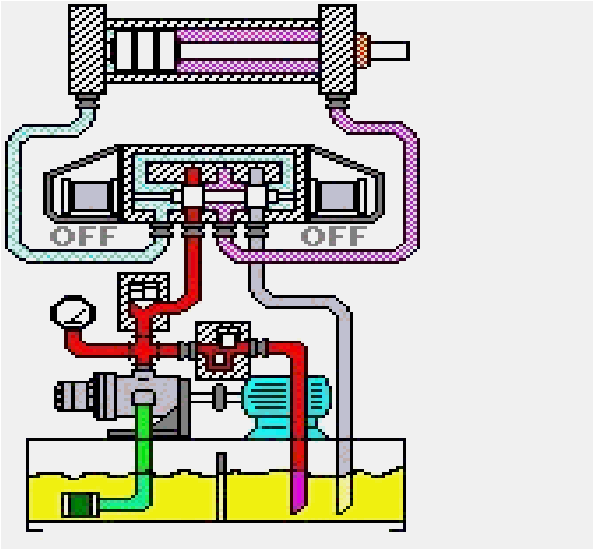
Manifold Assembly





51

Power Pack



52

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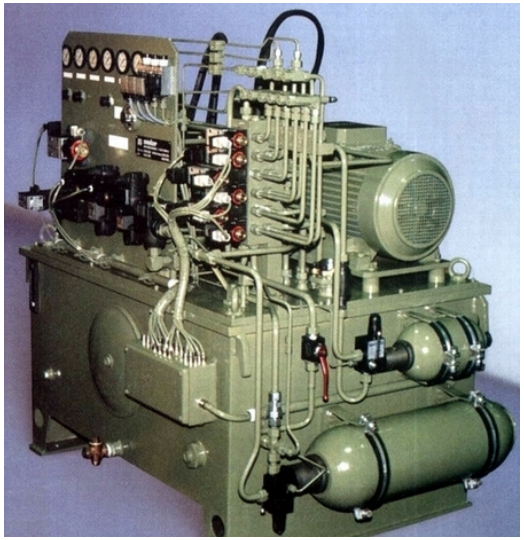

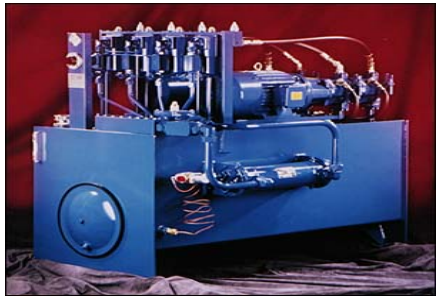

53

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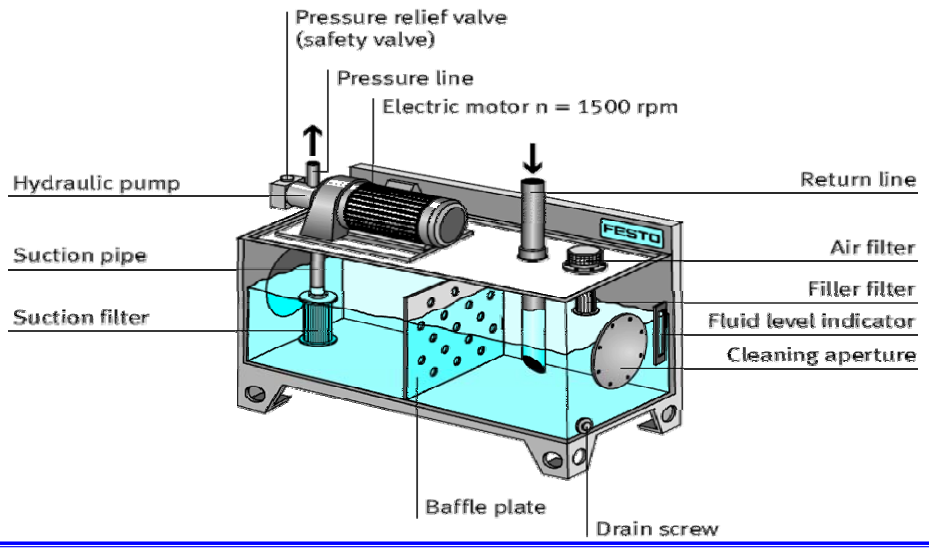
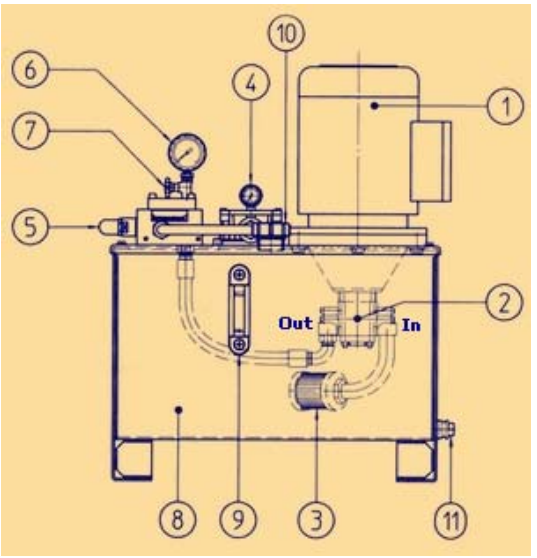


54

Standard Components

- (1) Electric motor coupled
- (2) Hydraulic pump
- (3) Intake submersed filter
- (4) Suction filter
- (5) Pressure relief valve
- (6) Pressure gage
- (7) Shut off valve
- (8) Reservoir
- (9) Visual oil level
- (10) Filling plug
- (11) Drain plug

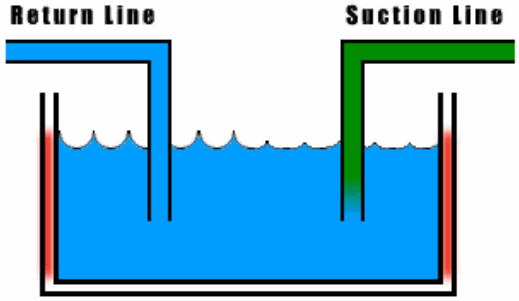


55

Power Pack

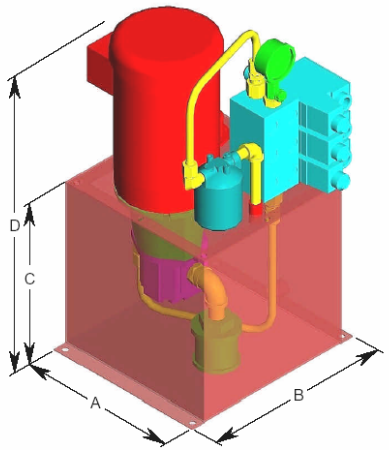
Reservoir

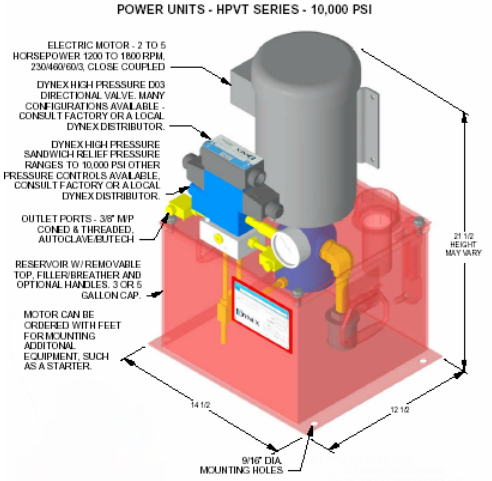
- Cools Hydraulic Fluid



56

Power Pack





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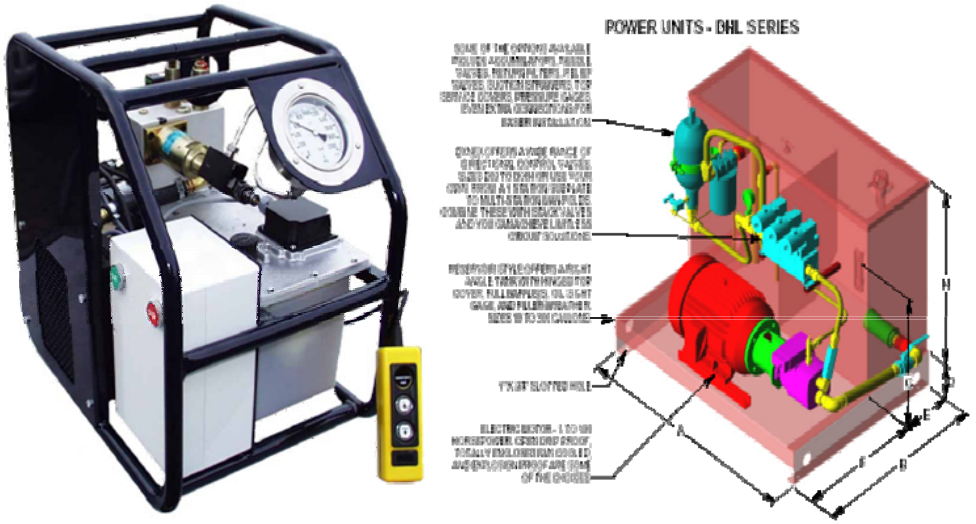

Hydraulic Fluid

- **In principle, any liquid can be used to transfer pressure energy. However, as in hydraulic installations, other characteristics are also required of hydraulic fluids, the number of suitable fluids is considerably restricted.**
- **Types**
  - **1. Petroleum-based or mineral-based fluids: The properties of a mineral-based fluid depend on the additives used, the quality of the original crude oil and the refining process.**
  - **2. Water-based fluids are used for fire-resistance due to their high-water content.**
  - **3. Synthetic fluids are man-made lubricants and many offer excellent lubrication characteristics in high-pressure and high- temperature systems.**
- Hydraulic fluids with a mineral oil base – also known as hydraulic oils – fulfill most normal requirements

Tasks for hydraulic fluids

- **pressure transfer,**
- **lubrication of the moving parts of devices,**
- **cooling, i.e. diversion of the heat produced by energy conversion (pressure losses),**
- **cushioning of oscillations caused by pressure jerks,**
- **corrosion protection,**
- **scuff removal,**
- **signal transmission.**

Hydraulic oils

- **In DIN 51524 and 51525 hydraulic oils are divided according to their characteristics and composition into three classes:**
  - **Hydraulic oil HL**
  - **Hydraulic oil HLP**
  - **Hydraulic oil HV.**
- ***The designations for these oils are composed of the letter H for hydraulic oil and an additional letter for the additives. The code letter is supplemented by a viscosity code defined in DIN 51517 (ISO viscosity classes).***

Hydraulic oils

Designation	Special characteristics	Areas of application
HL	Increased corrosion protection and ageing stability	Systems in which high thermal demands are made or corrosion through immersion in water is possible.
HLP	Increased wearing protection	Like HL oil, also for use in systems where variable high friction occurs owing to design or operating factors.
HV	Improved viscosity-temperature characteristics	Like HLP oil, for use in widely fluctuating and low ambient temperatures.

Example

- Hydraulic oil HLP 68
  - H hydraulic oil
  - L with additives to increase corrosion protection and/ or ageing stability
  - P with additives to reduce and/or increase load carrying, ability
  - 68 Viscosity code as defined in DIN 51517