Maintenance of Hydraulic Systems

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1. INTRODUCTION

- In the early years of fluid power systems, **corrective maintenance** was the most common way.

- The attitude was to fix the problem when the system **broke down**. However, with today's highly sophisticated machinery and mass production, the industry can **no longer afford** to operate on this basis.

- The **cost** of downtime is **prohibitive**.

1. INTRODUCTION

- ***The most common causes of hydraulic system breakdown:***
- 1. Clogged or dirty oil filters
- 2. Inadequate supply of oil in the reservoir
- 3. Leaking seals
- 4. Loose inlet lines that cause the pump to take in air
- 5. Incorrect type of oil
- 6. Excessive oil temperature
- 7. Excessive oil pressure

1. INTRODUCTION

- ***Preventive Maintenance***
- **Most of these problems can be eliminated if a planned preventive maintenance program is undertaken, where:**
- Selection of high-quality, properly sized components.
- Proper assembly of the various components. i.e., applying the correct amount of torque to the various tube fittings to prevent leaks while considering not distorting the fitting.
- Parts should be cleaned when assembled and the system should be completely flushed with clean oil before being put into service.
- Easy access to components requiring periodic inspection as filters, strainers, sight gages, drain and fill plugs, flowmeters, and pressure and temperature gages must be provided.

1. INTRODUCTION

- Over **half** of all hydraulic system **problems** have been traced directly to **the oil**.
- Thus, **sampling** and **testing** of the fluid is one of the most important **preventive maintenance** measures that can be undertaken.
- **A hydraulic fluid test kit** may be used **on the spot** to determine whether fluid quality **permits continued use**.
- Tests that can be performed include the determination of **viscosity**, **water content**, and **particulate contamination level**, which requires only about **10 mins.**

1. INTRODUCTION

1. INTRODUCTION

- **Viscosity** is measured using a **Visgage viscosity comparator**.
- **Water content** is determined by the **hot plate method.**
- **Contamination** is evaluated by filtering a measured amount of hydraulic fluid, examining the particles **caught on the filter** under a microscope, and comparing what is seen with a series of photos indicating **contamination levels**

1. INTRODUCTION

- ***Training of Maintenance Personnel and Record Keeping:***
- **It is important for maintenance personnel and machine operators to be trained to recognize early symptoms of potential hydraulic problems, such as:**
- A noisy pump may be due to cavitation caused by a clogged inlet filter or a loose intake fitting allowing air to be taken into the pump.
- If the cavitation noise is due to such an air leak, the oil in the reservoir will be covered with foam.
- Spongy operation of hydraulic actuators is caused by entrained air in the oil.
- A sluggish actuator may be due to fluid having too high viscosity or due to excessive internal leakage through the actuator or one of its control valves.

1. INTRODUCTION

- ***Training of Maintenance Personnel and Record Keeping:***
- **For preventive maintenance techniques, it is necessary to have a good report and records system such as:**
- The types of symptoms encountered, how they were detected, and the date.
- A description of the maintenance repairs performed, which include the replacement of parts, the amount of downtime, and the date.
- Records of dates when oil was tested, added, or changed. Dates of filter changes should also be recorded.

1. INTRODUCTION

- ***Safety and Environmental Issues***
- **Proper maintenance procedures for external oil leaks are also essential.**
- Safety hazards due to oil leaking on the floor and around machinery must be prevented.
- Loose mounting bolts or brackets should be tightened as soon as they are detected to avoid misalignment of the shafts of actuators and pumps, which can result in shaft seal or packing damage.
- A premature external oil leak can occur that will require costly downtime for repair.

1. INTRODUCTION

- ***Safety and Environmental Issues***
- **Environmental rules and regulations have been established concerning the operation of fluid power systems, which deal with the following issues:**
- 1. Developing biodegradable fluids.
- 2. Maintaining and disposing of hydraulic fluids.
- 3. Reducing oil leakage.
- 4. Reducing noise levels.

2. OXIDATION AND CORROSION OF HYDRAULIC FLUIDS

- **Oxidation** is caused by the chemical reaction of oxygen from the air with particles of oil, which can seriously reduce the service life of the hydraulic fluid.

- Most products of **oxidation** are soluble in oil and are **acidic** in nature, which can cause **corrosion** of parts throughout the system.

- The **oxidation products** such as insoluble gums, sludge, and varnish increase the **oil's viscosity**.

2. OXIDATION AND CORROSION OF HYDRAULIC FLUIDS

- **Heat, pressure, contaminants, water,** and **metal surfaces** are parameters that speed up the rate of oxidation **once it begins** but it is **most affected** by **temperature**. The rate of oxidation is very slow below 140°F but doubles for every 20°F temperature rise.

- **Additives** can be used to **inhibit oxidation** but due to their **high cost**, they are used only in **necessity** depending on temperature and other environmental conditions.

2. OXIDATION AND CORROSION OF HYDRAULIC FLUIDS

- **Rust** and **corrosion** are two different phenomena, although they both contaminate the system and promote wear

- **Rust** is the chemical reaction between iron or steel and oxygen while **Corrosion** is the chemical reaction between a metal and acid.

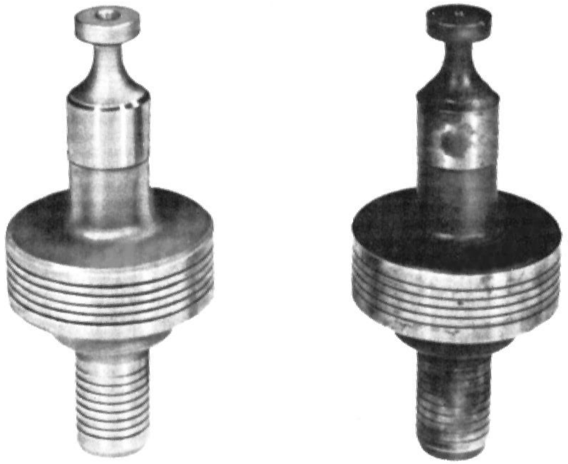
- **Atmospheric air** that enters the reservoir through the breather cap contains **moisture** which is the primary source of **oxygen** in the oil.

- Rust and corrosion can be **resisted** by incorporating **additives** that plate on the metal surfaces to **prevent** chemical reactions.

2. OXIDATION AND CORROSION OF HYDRAULIC FLUIDS

- The result of rusting or corrosion is the **"eating away"** of the metal surfaces of hydraulic components. This can cause **excessive leakage** past the sealing surfaces of the affected parts.

Rust caused by moisture in the oil



Corrosion caused by acid formation in the hydraulic oil

3. FIRE-RESISTANT FLUIDS

- Coal mines, hot-metal processing equipment, aircraft, and marine fluid power systems, are applications that **require** the use of a fire-resistant fluid for **human safety**.
- **Fire-resistant fluid** can be ignited but will not support combustion when the ignition source is removed.
- **Flammability** is defined as the ease of ignition and ability to propagate a flame.

3. FIRE-RESISTANT FLUIDS

- **Flammability of hydraulic fluid can be determined by testing three characteristics:**

- **1. Flash point** - the temperature at which the oil surface gives off sufficient vapors to ignite when a flame is passed over the surface.
- **2. Fire point** - the temperature at which the oil will release sufficient vapor to support combustion continuously for five seconds when a flame is passed over the surface.
- **3. Autogenous ignition temperature (AIT)** - the temperature at which ignition occurs spontaneously.

3. FIRE-RESISTANT FLUIDS

- **There are basically four different types of fire-resistant hydraulic fluids in common use:**

- **1. Water-Glycol Solutions** – this type consists of an actual solution of about 40% water and 60% glycol. These solutions have high viscosity index values, but the viscosity rises as the water evaporates. The operating temperature range runs from -10°F to about 180°F.

- **2. Water-in-Oil Emulsions** - This type consists of about 40% water completely dispersed in a special oil base. The water provides a good coolant property but tends to make the fluid more corrosive. Thus, greater amounts of corrosion inhibitor additives are necessary. The operating temperature range runs from -20°F to about 175°F.

3. FIRE-RESISTANT FLUIDS

- **There are basically four different types of fire-resistant hydraulic fluids in common use:**

- **3. Straight Synthetics** - This type is chemically formulated to inhibit combustion and in general has the highest fire-resistant temperature. Typical fluids in this category are the phosphate esters or chlorinated hydrocarbons. Disadvantages of straight synthetics include low viscosity index, incompatibility with most natural or synthetic rubber seals, and high costs.

- **4. High-Water-Content Fluids** - This type consists of about 90% water and 10% concentrate that consists of fluid additives to improve viscosity, lubricity, and rust protection. Advantages of high-water-content fluids include high fire resistance, outstanding cooling characteristics, and low cost. Maximum operating temperatures should be held to 120°F to minimize evaporation.

4. FOAM-RESISTANT FLUIDS

- When the **return line** to the reservoir is **not submerged** in oil or there is a **small leak** in the suction line, a **large quantity of air** from the atmosphere can be entrained in the oil.

- **Entrainment** of large quantities of air in oil can cause pump damage due to **cavitation** and affect the **stiffness** and **accuracy** of hydraulic actuators.

- The amount of **dissolved air** can be greatly **reduced** by properly designing the reservoir or using premium-grade hydraulic fluids that contain **foam-resistant additives.** These additives are chemical compounds, which break out entrained air to separate quickly the air from the oil while it is in the reservoir.

5. FLUID LUBRICATING ABILITY

- Hydraulic fluids must have **good lubricity** to prevent **wear** between the closely fitted working parts such as pump vanes, valve spools, piston rings, and rod bearings.

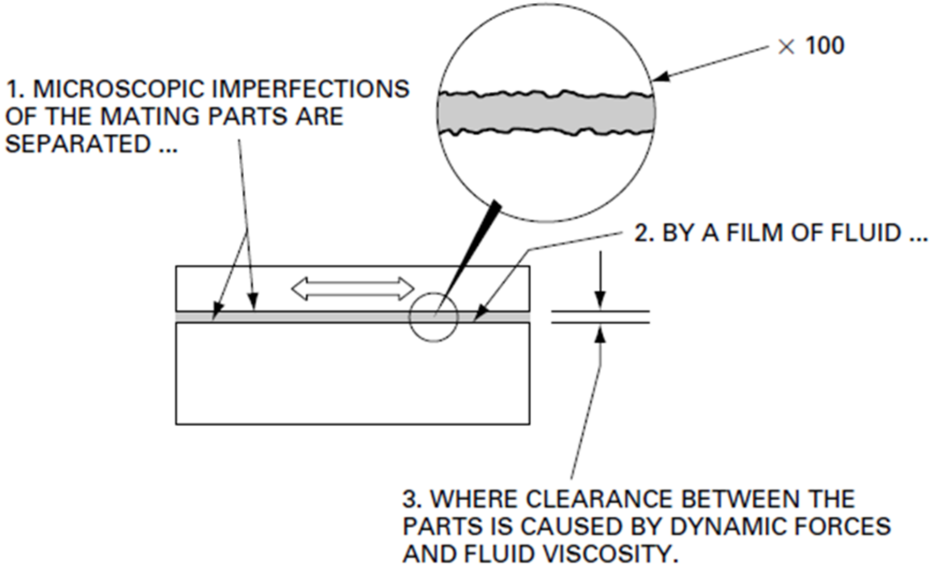
- **Wear** can result in a change in component **dimension**, which can lead to **looseness** and subsequent improper operation and **increase** in maintenance costs.

- **Friction force F** is proportional to the **normal force N** that forces the two surfaces together. The proportionality constant is called the **coefficient of friction (CF)**, where **F = (CF) x N .**

5. FLUID LUBRICATING ABILITY

- Metal-to-metal contact is avoided by a **thin film** of fluids having adequate **viscosity**.

- The coefficient of friction depends on the ability of the fluid to **prevent** metal-to-metal **contact** of the closely fitting moving parts.



6. FLUID NEUTRALIZATION NUMBER

- The **neutralization number** is a measure of the relative **acidity** or **alkalinity** of a hydraulic fluid and is specified by a **pH factor**.

- A fluid having a **small** neutralization number is recommended because high acidity or alkalinity causes **corrosion** of metal parts as well as **deterioration** of seals and packing glands.

- Hydraulic fluids can be **treated** with **additives** to inhibit the formation of acids to keep this number at a **low value** between 0 and 0.1.

7. PETROLEUM-BASED VERSUS FIRE-RESISTANT FLUIDS

- The **petroleum-based fluid** is the most **widely** used type because it dissipates heat well, is compatible with most seal materials, and resists oxidation well for operating temperatures below 150°F.

- It is refined from selected **crude oil** and **additives** are used to meet the requirements of good lubricity, high viscosity index, and oxidation/foam resistance.

- The primary **disadvantage** of a petroleum-based fluid is that it is **flammable.** As a result, a fire-resistant fluid has been developed.

7. PETROLEUM-BASED VERSUS FIRE-RESISTANT FLUIDS

- This greatly **reduces** the danger of **fire;** However, fire-resistant fluids have a **higher density** than petroleum-based fluids, and this may cause **cavitation** problems in the pump due to **excessive vacuum** pressure in the pump **inlet** line unless proper design steps are implemented.

- They also have significantly **lower lubricity, more expensive,** and have **more compatibility problems with seal materials**.

- Therefore, fire-resistant fluids should be **used only** in **hazardous** operating conditions.

8. MAINTAINING AND DISPOSING OF FLUIDS

- It is important to **minimize** the generation of **waste** hydraulic fluids and to **dispose** of them in a way that **does not harm** the environment.

- This can be accomplished by implementing **fluid-control** and **preventive maintenance** programs along with proper **fluid-disposal** procedures.

8. MAINTAINING AND DISPOSING OF FLUIDS

- **The following recommendations should be considered for properly maintaining and disposing of hydraulic fluids:**
- 1. Select the optimum fluid for the application involved.
- 2. Use a well-designed filtration system to reduce contamination and increase the useful life of the fluid.
- 3. Follow proper storage procedures for the unused fluid supply.
- 4. Transporting the fluids from the storage containers to the hydraulic systems should be done carefully.
- 5. Operating fluids should be checked regularly for viscosity, acidity, bulk modulus, specific gravity, water content, colour, additive levels, concentration of metals, and particle contamination.

8. MAINTAINING AND DISPOSING OF FLUIDS

- **The following recommendations should be considered for properly maintaining and disposing of hydraulic fluids:**
- 6. The entire hydraulic system, including pumps, piping, fittings, valves, solenoids, filters, actuators, and reservoirs, should be maintained according to the manufacturer’s specifications.
- 7. Corrective action should be taken to reduce or eliminate leakage from operating hydraulic systems.
- 8. Disposal of fluids must be done properly, because a hydraulic fluid is considered to be a waste material when it is no longer suitable for use in hydraulic systems.

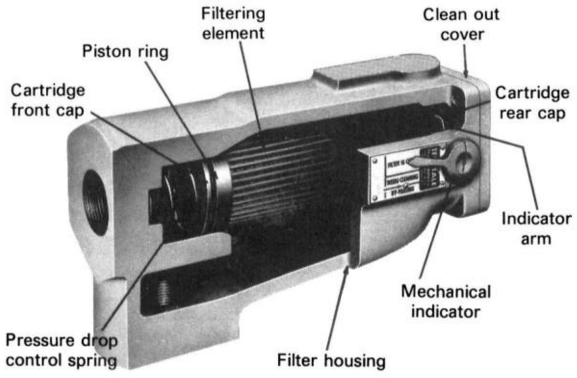
9. FILTERS AND STRAINERS

- The **worst enemy** of a precision-made hydraulic component is the **contamination** of the fluid.

- **Contamination may be in the form of a liquid, gas, or solid and can be caused by any of the following:**
- 1. Built into the system during component maintenance and assembly.
- 2. Generated within the system during operation.
- 3. Introduced into the system from external environment.

9. FILTERS AND STRAINERS

- **Filters** and **Strainers** are devices for **trapping** contaminants.
- Filter's primary function is to **retain insoluble contaminants** from a fluid.
- **Strainers** are constructed of a wire screen that is wrapped around a metal frame which removes only the **larger particles**, Basically, it is a **coarse filter.**



Cutaway view of a Tell-Tale filter

Inlet strainer

9. FILTERS AND STRAINERS

- **Particle sizes** removed by **filters** and **strainers** are measured in micrometers **(or microns)**.
- The **smallest-sized particle** that can normally be removed by a **strainer** is 0.0059 in or approximately **150 µm**, while **filters** can remove particles as small as **1 µm.**
- A **grain of salt** has a diameter of about **100 µm.**
- A **human hair** has a diameter of about **70 µm.**

9. FILTERS AND STRAINERS

- **There are three basic types of filtering methods used in hydraulic systems:**

- **1. Mechanical** - This type of filters normally contains a metal or cloth screen, or a series of metal disks separated by thin spacers, and they can remove only relatively **coarse particles** from the fluid.

9. FILTERS AND STRAINERS

- **There are three basic types of filtering methods used in hydraulic systems:**

- **2. Absorbent** - These filters are porous and permeable materials such as paper, wood pulp, diatomaceous earth, cloth, cellulose, and asbestos. In this type, particles are absorbed as the fluid permeates the material, so they are used for **extremely small particle** filtration.

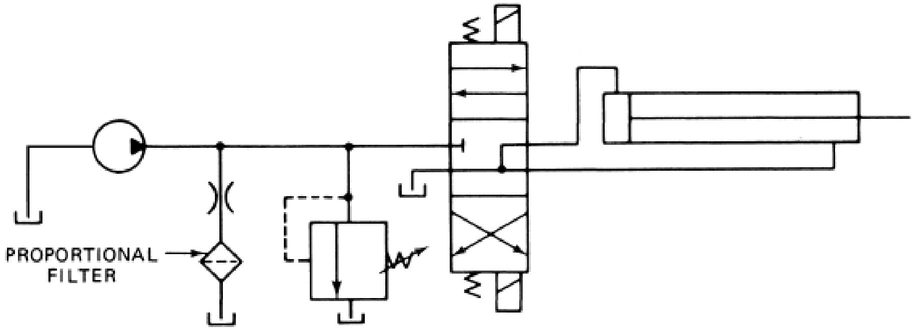
9. FILTERS AND STRAINERS

- **There are three basic types of filtering methods used in hydraulic systems:**

- **3. Adsorbent** - Adsorption is a **surface phenomenon** and refers to the **tendency of particles to cling to the surface** of the filter. Thus, the capacity of such a filter depends on the amount of **surface area** available. Adsorbent materials used include activated clay and chemically treated paper.

9. FILTERS AND STRAINERS

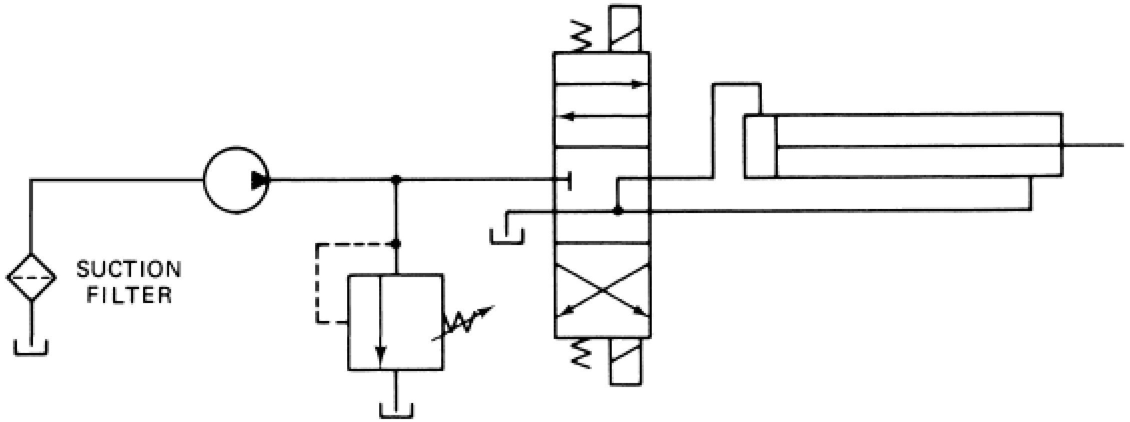
- <u>**Location of Filters in Hydraulic Circuits**</u>
- **Single location for proportional flow (bypass) filters:**
- proportional flow filters are exposed to only a percentage of the total system flow during operation.
- On a recirculating basis the probability of a mixture of the fluid within the system will force all the fluid through the filter, but there is **no positive protection** of any **specific components** within the system, and there is **no way** to know when the filter is **dirty**.



(a) PROPORTIONAL FLOW FILTER IN SEPARATE DRAIN LINE

9. FILTERS AND STRAINERS

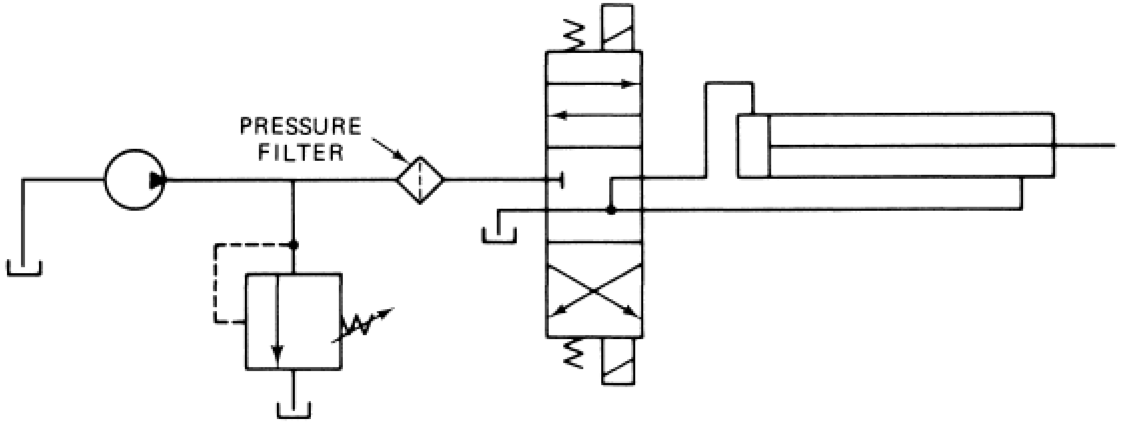
- <u>**Location of Filters in Hydraulic Circuits**</u>
- **Three locations for full-flow filters:**
- Full flow on the suction side of the pump



(b) FULL FLOW FILTER IN SUCTION LINE

9. FILTERS AND STRAINERS

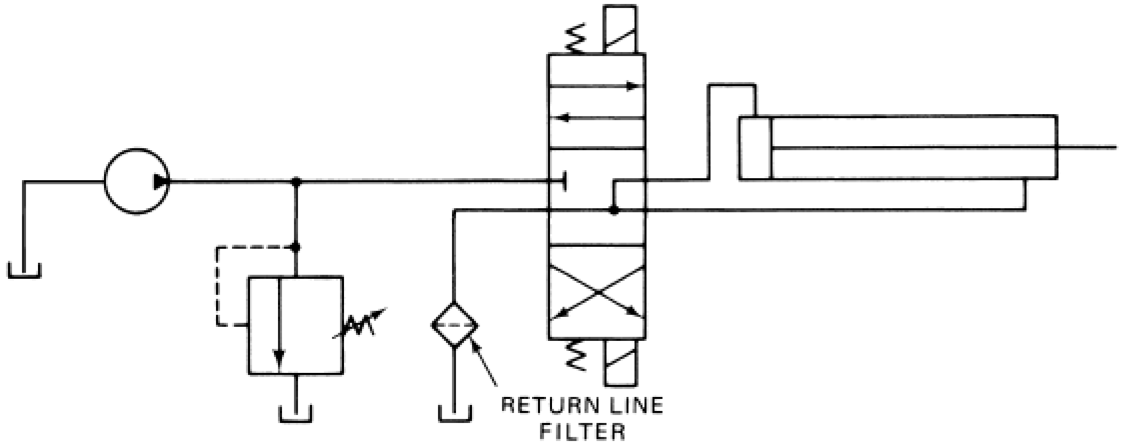
- **Location of Filters in Hydraulic Circuits**
- **Three locations for full-flow filters:**
- Full flow on the pressure side of the pump



(c) FULL FLOW FILTER IN PRESSURE LINE

9. FILTERS AND STRAINERS

- **<u>Location of Filters in Hydraulic Circuits</u>**
- **Three locations for full-flow filters:**
- Full flow in the return line



(d) FULL FLOW FILTER IN RETURN LINE

9. FILTERS AND STRAINERS

- **In general**, there is **no best** single place to put a filter.

- Consider where the dirt **enters** the system and **put the filter/filters** where they do **best**.

- **Good hydraulic systems** have **multiple** filters. There should be a filter in the **pump inlet line** and a high-pressure filter in the **pump discharge line**.

- Placing the **pump discharge filter** between the pump and the pressure relief valve can provide **very good filtration** because oil is flowing through the filter even when the working part of the circuit is **inactive** and the pump discharge is going **directly to the reservoir**.

9. FILTERS AND STRAINERS

- **Flow Capacity of Filters:**
- The **maximum flow rate** that a filter is designed to handle is called **the flow capacity.**
- It is necessary to determine the **maximum flow rate** in the line containing the filter **before** the selection of a filter
- Capacity **equal to** or **greater than** the actual **maximum flow rate** through the filter **should be considered.**
- The flow rate through a filter can **exceed** the pump flow rate.

9. FILTERS AND STRAINERS

Determine the minimum flow capacity of the return line filter of Figure (d). The pump flow rate is 20 gpm and the cylinder piston and rod diameters are 5 in and 3 in, respectively.

Solution Note that during the cylinder retraction stroke, the flow rate through the return line filter exceeds the pump flow rate. Thus, the flow capacity of the filter must equal or exceed the flow rate it receives during the cylinder retraction stroke. The cylinder retraction speed is found first:

$$v_{ret} = \frac{Q_{pump}}{A_p - A_R}$$

where

$$Q_{pump} = 20\,\frac{\text{gal}}{\text{min}} \times \frac{231\ \text{in}^3}{1\ \text{gal}} = 4620\ \text{in}^3/\text{min}$$

$$A_P = \frac{\pi}{4}(5\ \text{in})^2 = 19.63\ \text{in}^2 \text{ and } A_R = \frac{\pi}{4}(3\ \text{in})^2 = 7.07\ \text{in}^2$$

Thus, we have $v_{ret} = \dfrac{4620\ \text{in}^3/\text{min}}{19.63\ \text{in}^2 - 7.07\ \text{in}^2} = 368\ \text{in/min}$

The flow rate through the filter during the cylinder retraction stroke can now be found.

$$Q_{filter} = A_P v_{ret} = 19.63\ \text{in}^2 \times 368\,\frac{\text{in}}{\text{min}} \times \frac{1\ \text{gal}}{231\ \text{in}^3} = 31.3\ \text{gpm}$$

Thus, the filter must have a flow capacity of at least 31.3 gpm rather than the pump flow-rate value of 20 gpm.

10. BETA RATIO OF FILTERS

- **Beta ratio** is a parameter for establishing how well a filter **traps** particles.

$$\text{Beta ratio} = \frac{\text{no. upstream particles of size} > N\mu\text{m}}{\text{no. downstream particles of size} > N\mu\text{m}}$$

- A filter efficiency **(Beta efficiency)** value can be calculated using the following equation:

$$\text{Beta efficiency} = 1 - \frac{1}{\text{Beta ratio}}$$

- A filter with a Beta ratio of 50 would have an efficiency of 98%. The designation "B20 = 50" identifies a particle size of 20 μm and a Beta ratio of 50 for a particular filter, which means that 98% of the particles larger than 20 μm would be trapped by the filter.

11. FLUID CLEANLINESS LEVELS

- **The fluid's cleanliness level** is measured by counting the **particles per unit volume** for **specific particle sizes** and comparing the results to a required cleanliness level for the proper selection of the filtration system.
- The following table shows a **cleanliness level standard** accepted by the ISO **(International Standards Organization).**
- The table shows the **ISO code number** that is used to represent either the number of particles per milliliter of fluid of size greater than **5 micrometers** or greater than **15 micrometers**.

11. FLUID CLEANLINESS LEVELS

Code No.	No. of Particles per Milliliter	Code No.	No. of Particles per Milliliter
30	10,000,000	14	160
29	5,000,000	13	80
28	2,500,000	12	40
27	1,300,000	11	20
26	640,000	10	10
25	320,000	9	5
24	160,000	8	2.5
23	80,000	7	1.3
22	40,000	6	0.64
21	20,000	5	0.32
20	10,000	4	0.16
19	5,000	3	0.08
18	2,500	2	0.04
17	1,300	1	0.02
16	640	0.9	0.01
15	320	0.8	0.005

11. FLUID CLEANLINESS LEVELS

- The code is used as **two numbers separated by a slash.**
- The **left number** indicates particle sizes greater than **5 micrometers** that lead to sticking or sluggish action of the component such as a solenoid-actuated valve.
- The **right number** indicates particle sizes greater than **15 micrometers** that contribute to **wear problems** in components such as a hydraulic cylinder or pump.
- A code designation of **"ISO 18/15"** indicates that per milliliter of fluid, there are **2500** particles of size greater than **5 micrometers** and **320** particles of size greater than **15 micrometers**.

11. FLUID CLEANLINESS LEVELS

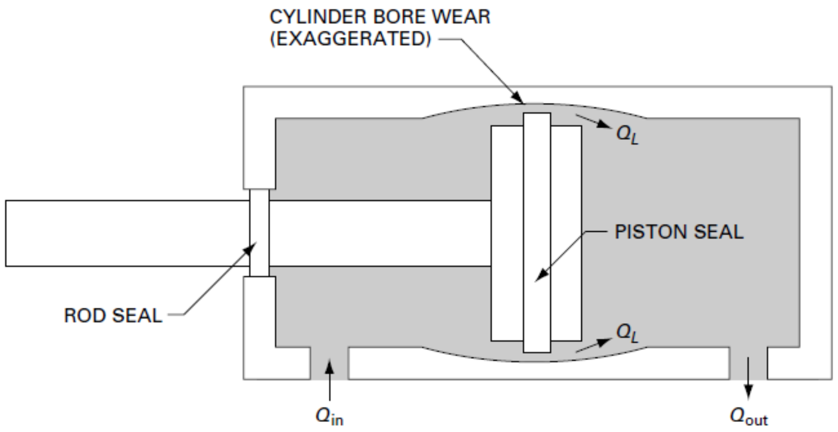
- The following table shows **typical ISO code cleanliness levels** required for various hydraulic components.

Component	ISO Code
Servo Valves	14/11
Vane and Piston Pumps/Motors	16/13
Directional and Pressure Control Valves	16/13
Gear Pumps/Motors	17/14
Flow Control Valves and Cylinders	18/15

12. WEAR OF MOVING PARTS DUE TO SOLID-PARTICLE CONTAMINATION OF THE FLUID

- Solid contaminants **prevent** the hydraulic fluid from providing proper **lubrication** of moving internal parts of hydraulic components such as pumps, hydraulic motors, valves, and actuators.

- Most of the hydraulic system **breakdowns** are due to **wear** of moving parts caused by excessive contamination.



Hydraulic cylinder with a bore that is worn due to solid-particle contamination of the fluid.

13. PROBLEMS CAUSED BY GASES IN HYDRAULIC FLUIDS

- **Gases can be present in a hydraulic fluid in three ways:**
- **1. Free Air** - exists in a free pocket located at some high point of a hydraulic system and causes **spongy and unstable operation** of hydraulic actuators.
- **2. Entrained Gas** – is created in **two** ways, **Air bubbles** created when the flowing hydraulic fluid sweeps air out of a free pocket, and **bubbles of hydraulic fluid vapor** occur when the pressure drops below the vapor pressure of the hydraulic fluid, and both can cause **spongy and unstable operation** of hydraulic actuators as well as **cavitation** in pumps and valves.
- **3. Dissolved Air** - creates no problem in hydraulic systems as long as the air remains **dissolved**, but if it comes out of solution, it forms bubbles in the hydraulic fluid and thus becomes **entrained air.**

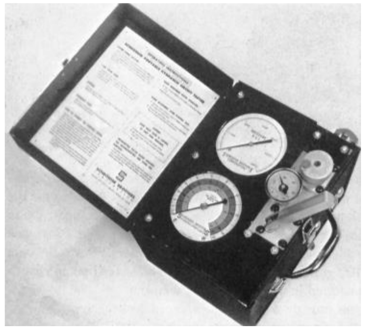
14. TROUBLESHOOTING HYDRAULIC SYSTEMS

- **There are parameters any hydraulic system depends on and should be monitored and measured frequently, the three main parameters are:**

- 1. Flow.
- 2. Pressure.
- 3. Temperature.

Flow-pressure test kit

In-line flowmeter



Portable hydraulic circuit tester

14. TROUBLESHOOTING HYDRAULIC SYSTEMS

- The use of **flowmeters** can tell if the pump is producing proper flow and indicate whether a particular actuator is receiving the expected flow rate or not.

- **Pressure-measurement** devices can provide a good indication of leakage problems and faulty components such as pumps, flow control valves, pressure relief valves, strainers, and actuators. and can also detect pressure drops in pipelines.

- **Temperature** should frequently be **monitored** because it affects the **viscosity** of the oil which affects leakage, pressure drops, and lubrication.

14. TROUBLESHOOTING HYDRAULIC SYSTEMS

- Common hydraulic system **operating problems** and the corresponding probable **causes** that should be investigated during **troubleshooting:**

1. Noisy pump

a. Air entering pump inlet
b. Misalignment of pump and drive unit
c. Excessive oil viscosity
d. Dirty inlet strainer
e. Chattering relief valve
f. Damaged pump
g. Excessive pump speed
h. Loose or damaged inlet line

14. TROUBLESHOOTING HYDRAULIC SYSTEMS

- Common hydraulic system **operating problems** and the corresponding probable **causes** that should be investigated during **troubleshooting:**

2. Low or erratic pressure

- **a.** Air in the fluid
- **b.** Pressure relief valve set too low
- **c.** Pressure relief valve not properly seated
- **d.** Leak in hydraulic line
- **e.** Defective or worn pump
- **f.** Defective or worn actuator

14. TROUBLESHOOTING HYDRAULIC SYSTEMS

- Common hydraulic system **operating problems** and the corresponding probable **causes** that should be investigated during **troubleshooting:**

3. No pressure

a. Pump turning in wrong direction
b. Ruptured hydraulic line
c. Low oil level in reservoir
d. Pressure relief valve stuck open
e. Broken pump shaft
f. Full pump flow bypassed to tank due to faulty valve or actuator

14. TROUBLESHOOTING HYDRAULIC SYSTEMS

- Common hydraulic system **operating problems** and the corresponding probable **causes** that should be investigated during **troubleshooting:**

4. Actuator fails to move

a. Faulty pump
b. Directional control valve fails to shift
c. System pressure too low
d. Defective actuator
e. Pressure relief valve stuck open
f. Actuator load is excessive
g. Check valve in backwards

14. TROUBLESHOOTING HYDRAULIC SYSTEMS

- Common hydraulic system **operating problems** and the corresponding probable **causes** that should be investigated during **troubleshooting:**

5. Slow or erratic motion of actuator

a. Air in system
b. Viscosity of fluid too high
c. Worn or damaged pump
d. Pump speed too low
e. Excessive leakage through actuators or valves
f. Faulty or dirty flow control valves
g. Blocked air breather in reservoir
h. Low fluid level in reservoir
i. Faulty check valve
j. Defective pressure relief valve

14. TROUBLESHOOTING HYDRAULIC SYSTEMS

- Common hydraulic system **operating problems** and the corresponding probable **causes** that should be investigated during **troubleshooting:**

6. Overheating of hydraulic fluid

- **a.** Heat exchanger turned off or faulty
- **b.** Undersized components or piping
- **c.** Incorrect fluid
- **d.** Continuous operation of pressure relief valve
- **e.** Overloaded system
- **f.** Dirty fluid
- **g.** Reservoir too small
- **h.** Inadequate supply of oil in reservoir
- **i.** Excessive pump speed
- **j.** Clogged or inadequate-sized air breather

15. SAFETY CONSIDERATIONS

- **The Occupational Safety and Health Administration** (OSHA) safety standards at the industry location where **hydraulic equipment** is operated:
- 1. Workplace standards.
- 2. Machines and equipment standards.
- 3. Materials standards.
- 4. Employee standards.
- 5. Power source standards.
- 6. Process standards.
- 7. Administrative regulations.

THANK YOU