

Chapter 5

HYDRAULIC EQUIPMENT

Basic Hydraulic System Maintenance

This review of hydraulic system maintenance is organized around the basic elements of the hydraulic system: pumps, piping, valves, filtration, the tank, the oil, etc. However, this manual can not take the place of basic training in the fundamentals of hydraulic systems, their maintenance and trouble shooting. Excellent courses are offered by most manufacturers of hydraulic equipment, ranging from hands-on training at their facilities, to in-house training at your plant. Video and slide training are also available. It is recommended that you include basic hydraulic courses in your training curriculum.

Hydraulic Oil¹

Like the blood circulating in our bodies, hydraulic oil is the life-blood of the hydraulic system, and so it must be kept in perfect condition. It has been estimated² that 75% of all system failures are a direct result of contamination.

Foam or air bubbles are indications of aeration of the oil, which may cause cavitation and premature failure of the pumps. If the oil color becomes darker, it may indicate that the oil has been overheated. Clouding may indicate increased water content.

A detailed review of oil contamination and filtration is contained in the paper "Proper System Maintenance to Avoid Contamination and Cavitation," presented at the AEC Press Maintenance Seminar in , in 1991 by Mr. Jack Hayes, Oilgear Corporation (reprinted here with permission, beginning on page 5-14).

Contamination interferes with the four main functions of hydraulic fluids:

- to act as an energy transfer medium
- to lubricate internal moving parts of components
- to act as a heat transfer medium
- to seal small clearances between moving parts.

Contamination may be present in many forms, most commonly as solid particles (particulates), water, and entrained air.

1. Because most extrusion presses currently operate with petroleum oil as the hydraulic fluid, we have chosen to use the terms "oil" and "fluid" interchangeably in this manual. However, please note that, in addition to a few water presses still in service, work is also continuing toward developing a non-flammable hydraulic fluid that is suitable for extrusion presses.

2. Parker Hydraulic Products and Total Systems Engineering, Parker Filter Division, Metamora OH. Catalog 0108, p.179.

Particulate Contamination. Solid particles cause wear related problems and interfere with the lubrication properties of hydraulic fluids. Internal parts such as the gear set of a pump, or a valve spool, will be affected, causing malfunction. Valves for directional or flow control or pressure relief may malfunction; sensitive components such as servo valves may jam or stop completely.

Extremely fine particles, called “silt”, may accumulate in the space between a component’s moving parts, eventually causing a sticking or sluggish action. “Silt” accumulation is the most common cause of frequent solenoid burnouts, inaccurate positioning, and overall wear.

Particles equal to the dynamic clearances of a component (see table page 5-15) interfere with the lubrication process and accelerate abrasive wear. They also contribute to the “wear chain reaction” (see Figures 5-8 and 5-9), where the abrasive action helps to create new particles from component surfaces. This phenomenon accelerates until catastrophic failure may occur. Larger particles restrict or block flow through clearances and orifices, leading to component malfunction, higher operating temperatures, higher pressure drops, and often catastrophic failures.

Damage-causing particles are usually smaller in size than 40 micrometers and are therefore not visible by the naked eye. For reference:

Sizes of Familiar Objects

	Micron	Inches
Grain of Table Salt	100	.0039
Human Hair	70	.0027
Lower Limit of Visibility	40	.00158
White Blood Cells	25	.001
Talcum Powder	10	.00039
Red Blood Cells	8	.0003
Bacteria (average)	2	.000078

The level of cleanliness of a fluid is measured in terms of the number of particles of different size ranges in a specified volume of fluid. Very sensitive optical instruments are used to count the number of particles.

The standard methods for measuring fluid cleanliness have been revised. For more information refer to Oilgear Bulletin 90007-D, page 5-41.

Keep in mind that **new oil is not necessarily clean oil**. Contamination at the refinery or anywhere in the transportation/distribution process may have resulted in contamination. **Most new oil is contaminated. All hydraulic oil should be filtered before being put into service.**

Water Contamination. Water is a common contaminant of hydraulic oil and may cause damage of the following types:

- corrosion of metal surfaces
- accelerated abrasive wear
- bearing fatigue
- fluid additive breakdown
- variation in viscosity

Water may enter the hydraulic system through various means. Drums stored outdoors will accumulate water, which enters when drums are open or filled. It may enter through worn cylinder seals and reservoir openings. Condensation is a constant source – moisture in air condenses on the inside of the reservoir, causing rust and corrosion.

Water also causes the growth of microbes and “slime,” resulting in short fluid life, degraded surface finishes, and inconsistent fluid performance.

Each fluid has a water saturation point, above which it can not dissolve any more water. Any excess water is “free” or emulsified, and may be seen as a “milky” or discoloration of the oil. As little as 0.03% of water may saturate the oil.

Water contamination up to 2% may usually be removed by highly absorbent filter media, which fit into standard filter housings. If contaminated above 2%, special settling or centrifuge treatments may be necessary.

Keeping Contamination Out. Control of contamination is divided into two areas: exclusion and removal. It is necessary to exclude as much contamination as possible from the system by every means possible.

- Reservoir air breathers must have filters; oil-type breathers should have the oil checked and changed often.
- Seals on press cylinders must be well maintained and kept clean to keep dirt out.
- Hoses and manifolds must be capped off during maintenance.
- Flush all systems before putting into service and after component failures.
- Filter all fluid before putting it into service.
- Clean the entire system often – wash it down, remove rags, etc., so as to detect any leaks and avoid any contamination entering the system.

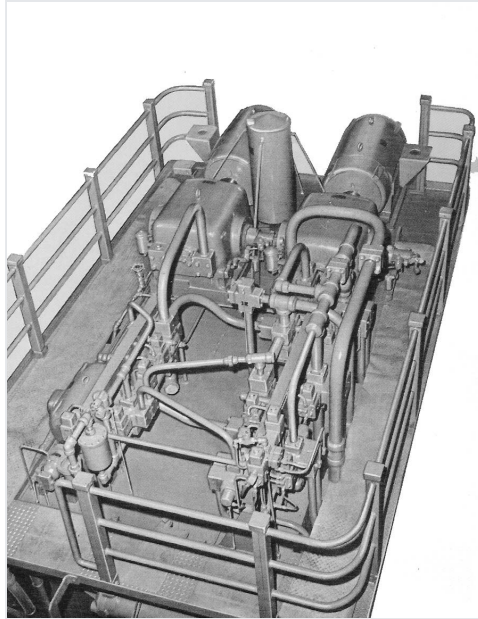


Figure 5-1: Typical tank-mounted hydraulic system from the 1970's

Oil Filtration



Figure 5-2: Filtration by "kidney loop"

Hydraulic oil filtration for extrusion presses is reviewed in detail in the article, "Proper System Maintenance to Avoid Contamination and Cavitation," by Jack Hayes of Oilgear Corporation, beginning on page 5-14 of this chapter as well as in Oilgear Bulletin 90007-D on page 5-41.

Note that an auxiliary filtration loop (“kidney loop”) is preferred (figure 5-2). This is a separate loop that continuously pumps a stream of oil from the system through a filter unit. If possible this loop should be operated continuously, even when the press is stopped, for example for the weekend.



Figure 5-3: Shell and tube heat exchangers

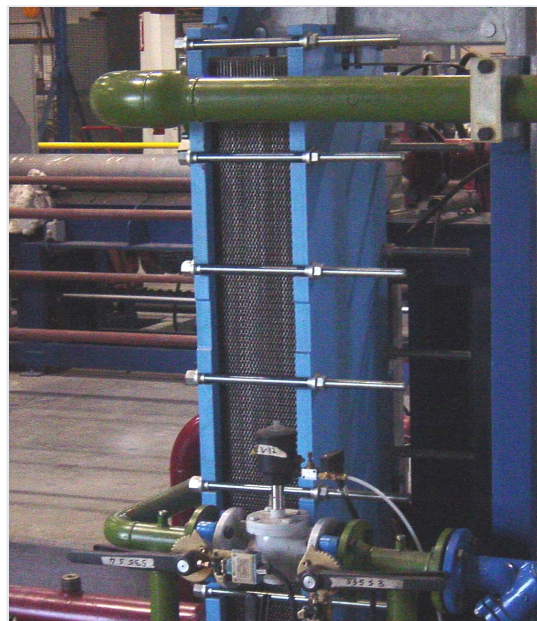


Figure 5-4: Plate & frame type heat exchanger

All filters should be of the indicating or “tell-tale” type, which will give a visual indication when replacement of the element is due. In addition, always drain and clean the cartridge case when changing the filter cartridge.

Some experts recommend an annual cleaning of the oil tank, by first transferring the oil to an auxiliary storage tank; in this case the oil should be passed through filters and water removal media when it is returned to the clean tank. However, other experts say that **periodic tank cleaning is not necessary if the system cleanliness is maintained properly**. Cleaning might actually introduce new contamination if not done properly.

Oil Temperature and Viscosity

Follow the pump manufacturer's recommendations regarding oil temperature, fluid viscosity, and cleanliness levels. Viscosity and viscosity index are the main criteria when selecting oil. Because pumps may operate over a temperature range, select the oil that will give you the proper viscosity for that operating temperature.

Oil temperature must be maintained below a maximum of 140oF (60oC)³. Temperatures above this level lead to deterioration of the oil, loss of lubricating properties, and excessive wear to pumps.

Modern heat exchangers and temperature controllers have increased the reliability of temperature control, but periodic visual verification is needed because of the critical nature of this control.

Most new presses are equipped with plate-type heat exchangers, which are easier to clean and may be easily expanded by adding plates.

Heat exchangers must be checked periodically for oil or water leaks, especially for water getting into the oil. Check for excessive heat, and check that water flow is properly controlled to maintain oil temperature below set point. During periodic shut-downs, flush the exchanger and check for signs of scale or corrosion. Clean or replace the zinc anodes if needed.

High oil temperature may also indicate a hydraulic valve malfunction, such as excessive by-passing over a relief valve or internal by-passing in some component.

Oil Level

Visually check the oil level every day, and refill as needed. Oil level should be checked with the main ram fully returned or retracted; the oil level should be at the high oil level mark as indicated on the sight gauge. It is important to maintain oil level at the high level in order to minimize oil velocities in the reservoir which, in turn, allows contamination to settle and allows entrained air to escape from the oil.

Oil level should be checked with the main ram in the same position each time, as there is a big difference in oil level according to whether the main ram is extended or retracted. Low oil level may result in excessive heat or air in the system.

³. For a VG 46 type fluid, the allowable operating temperature range is 40 to 70oC (115 to 150oF), per Michael Kramer of Bosch Rexroth, AEC Press Maintenance Workshop, Atlanta, 2023.

Oil Sampling and Analysis

Most contaminants in hydraulic oil are invisible to the human eye. Damage-causing particles range from 5 to 40 micrometers in size, but the limit of human visibility is only 40 micrometers. Also, acids, water, and other by-products of oxidation cannot be easily detected by human senses. Therefore, oil sampling and analysis by other means is necessary.

On-site tests are possible by means of a Patch Test Kit, which gives immediate information. However, the range of detail provided is very limited, and the Patch Test Kit should only be used in special circumstances.

Complete laboratory analysis is the preferred method of oil testing. Numerous test labs, especially suppliers of oil and hydraulic equipment, offer these services. Oil samples are gathered, labeled, and sent in, at a frequency ranging from monthly to semi-annually. The test report should be returned within 24 to 48 hours after receipt, and will indicate such information as:

- Spectrochemical analysis of wear metals and additives.
- Particle count over various size ranges, also expressed as an ISO cleanliness code.
- Viscosity at 100oF.
- Water content expressed as a percent of volume.
- Analysis recommendations.

For additional information on oil Sampling and Analysis see pages 5-59 to 5-62 in this chapter.

Air Breather

It is important to maintain sufficient oil in the air breather, of the same grade as the hydraulic oil in the system. Clean the air breather and refill it with oil every month, more often if environmental conditions require it.

Pumps

Most hydraulic pumps used in the extrusion plant are radial- or axial-piston pumps, either bent axis or swashplate type. Follow your pump manufacturer's instructions regarding periodic checks and maintenance.

Obtaining the maximum service life and performance of hydraulic pumps requires the following:

Top quality oil condition. Oil must be filtered, cooled, clean, and free of water as discussed above. Oil condition is the most critical factor in pump life.

No cavitation. Air bubbles entrained in the pump suction collapse violently, causing erosion of metallic surfaces. See page 5-20 for a more detailed review of cavitation.

Proper alignment and rotation. Shaft alignment must be checked with a dial indicator any time the motor or pump has been removed and replaced. Check alignment and rotation before re-coupling. Repack the coupling with grease as needed.

Also, periodically tighten the mounting bolts of the pump and motor, to avoid misalignment, excessive wear, and noise.

Valves



Figure 5-5: Floor-mounted pump layout with three main pumps, three auxiliaries, one spare, “kidney loop” filtration, and plate-type heat exchanger at rear (Photo courtesy of Presezzi Extrusion)

Valves are used to control the flow of the hydraulic fluid to properly sequence the equipment. The most commonly used valves in an extrusion press circuit are: relief valves, check valves, directional control valves, and pre-fill valves.

Relief valves: used to control the hydraulic pressure in a circuit. Several relief valves may be employed in the circuit with different pressure settings; therefore, be careful that each valve is set to the correct pressure, according to the hydraulic schematic. An accurate pressure gage should be used when setting relief valves.

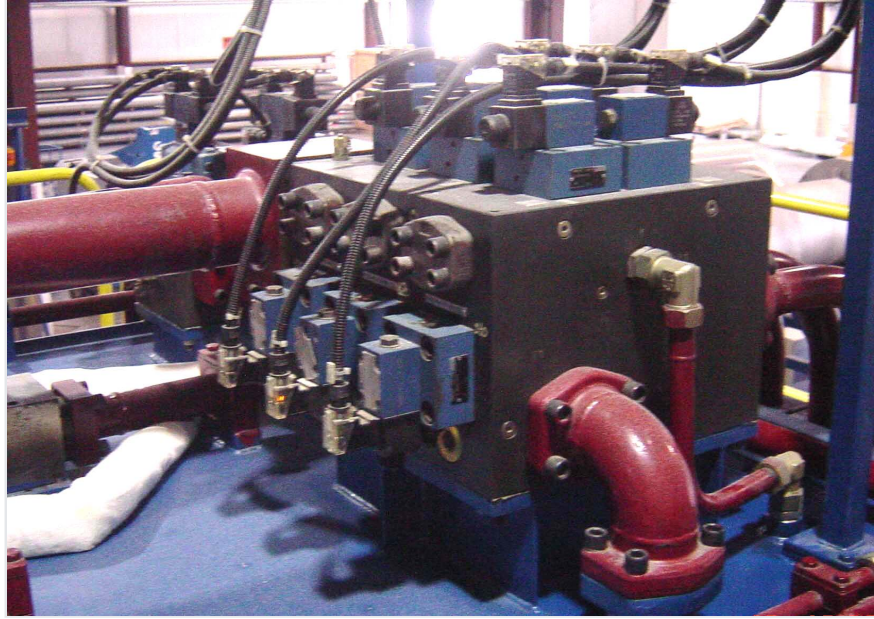


Figure 5-6: Manifold with directional valves

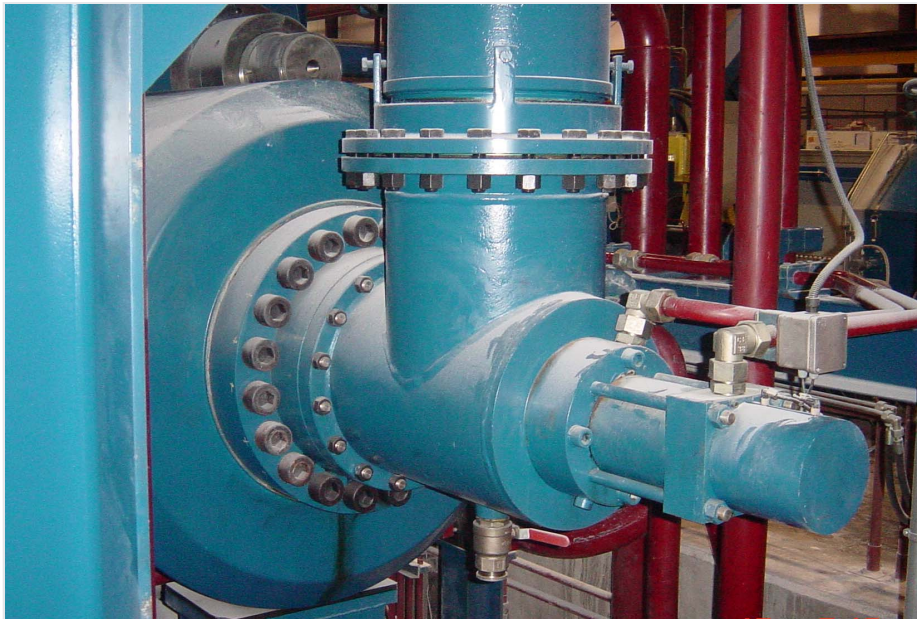


Figure 5-7: Prefill valve (Photo courtesy of Presezzi Extrusion)

Check valves: used to permit flow in one direction only. Note: check valve bonnets are normally fitted with soft steel gaskets, which are good for one disassembly only. When ordering replacements, it is recommended to specify soft copper gaskets instead.

Directional control valves: used for logic functions by changing the direction of oil flow. Large directional control valves are electric solenoid, pilot operated type. Each pilot head has pilot pressure and pilot drain connections. The pilot pressure provides the force for shifting the valve spool.

When trouble-shooting valve problems, look for the most common system problems: contamination and oil condition. Dirt or foreign matter in the system may hold check and relief valves open or prevent directional valve spools from shifting. Excessive heat in the oil may cause valve bodies to warp and bind the spools, or carbonization of the oil may form gum and cause the spools to stick.

When installing a valve, take care to avoid strain in the valve body. Piping should fit up to the valve body and should not be forced into position. The pipe should be re-bent or welded as necessary. While the valve spool may shift freely when cold, it may bind after the system reaches operating temperature.

Valve spools must move freely in the body (but not loose). Never force a spool into the body. If movement is tight or rough, check for burrs or foreign matter. Small burrs may be removed with a stone, but never stone the spool sealing surface. Tight areas may be eliminated by lapping the spool into the body with lapping compound; flush the valve thoroughly afterwards to remove any lapping compound from the valve.

All valve bolts should be re-tightened monthly to prevent oil leaks. Valve solenoids should be cleaned and checked for broken covers or wires.

Piping

System shock is one of the major causes of pipes leaking. Proper tuning of the press is required to eliminate shock and to prevent damaging the pipe system.

Check daily for leaks at pipe flanges, tube fittings, welds, and manifolds. Check oil connections to cylinders. Look for seepage around valves -- at pipe connections, where mounted to manifolds, and also for leaks within the valve. Bolts should be tightened monthly. Note: oil leaks may be spotted more easily by use of ultraviolet light.

Loose or broken pipe clamps should be repaired immediately. Their function is to minimize strain on pipes and must be tight to accomplish this.

Suction breaks (usually needle valves, noted on the system hydraulic diagram) should be opened before breaking into any piping, in order to avoid unexpected siphoning or draining of hydraulic oil.

New piping: Prior to installation, clean pipes and tank of all contaminants, scale, sand, metal swarf, etc. All welded or bent piping must be pickled, flushed, and lubricated before being placed in service. Use only lint-free wipers for cleaning purposes. Pipe should be seamless steel. Do not use sealing material such as hemp, putty, or sealing tape. Avoid hoses whenever possible. For more information on Piping see page 5-49, Piping Information (Oilgear Bulletin 90011-F) and Resistance of Valves and Fittings to Flow of Fluids, page 5-53.

Pressure Gages

Where gages are used for diagnosis of performance or problems, it is recommended to use quick gage disconnects and removable gages. Permanently installed gages are subject to inaccuracy due to vibration or plugging; it is better to use gages which are known to be accurate.

Reservoir

The top of the oil reservoir should be kept clean at all times. During maintenance, be sure that the reservoir openings are sealed at all times to prevent any contamination from falling in. All bolts should be tightened monthly.

Some experts recommend an annual cleaning of the oil tank, by first transferring the oil to an auxiliary storage tank. In this case the oil should be passed through filters and water removal media when it is returned to the clean tank.

However, if oil system cleanliness is maintained properly there is no reason to clean the reservoir on a regular basis. You could actually introduce more contamination.

It is necessary to clean the reservoir after any major failure of pumps or cylinders.

System Documentation

An accurate diagram of the press hydraulic system is essential for trouble-shooting, and should be studied so that the function of each valve in the system is understood. A table of ISO/CETOP standard Hydraulic Symbols is shown beginning on page 5-34 .

Equally important are manufacturer's bulletins for valves and other components, which give nomenclature and parts numbers for ordering spares and/or replacement parts.

If the above information is not fully available and accessible to maintenance personnel, it is vital to obtain it immediately. Equipment vendors and consultants can assist in gathering the necessary data.

Hydraulic System Preventive Maintenance

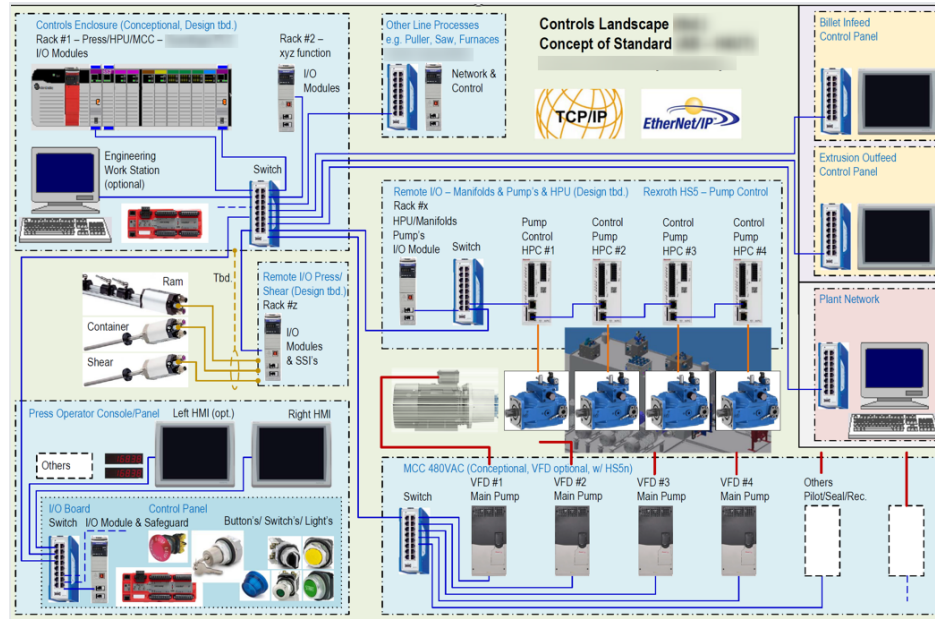
General recommendations for preventive maintenance of extrusion press hydraulic systems are included on charts in Chapter A. Your own experience may vary from these suggested PM frequencies, according to your equipment's particular design and operation, or to local conditions. You should adapt these schedules accordingly.

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Following are selected images and recommendations from presentations by **Jeff Grube** and **Michael Kramer of Bosch Rexroth** about extrusion press hydraulic systems, from the AEC Press Maintenance Workshops, Atlanta, 2015 through 2023.

The press as a system

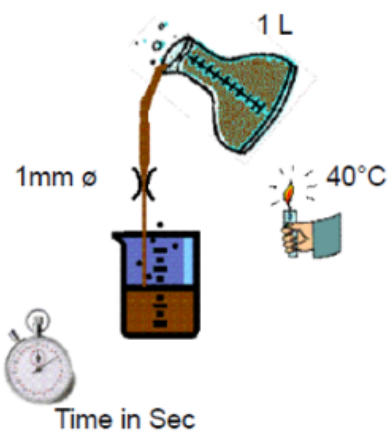
Many parts of the press must work together to form the system, to minimize downtime and optimize performance.



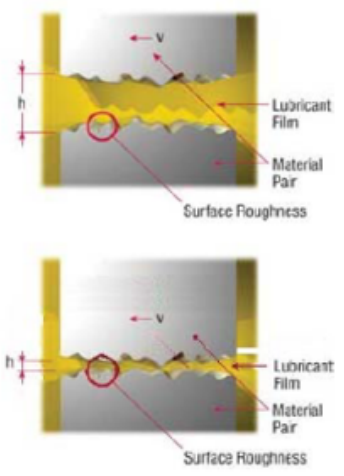
Hydraulic Fluid is the Life Blood of the System.

- Always use high-quality fluid from a reputable source.
- New oil is not clean oil
- Beware the silent killers:
- Temperature
- Water
- Air
- Contamination

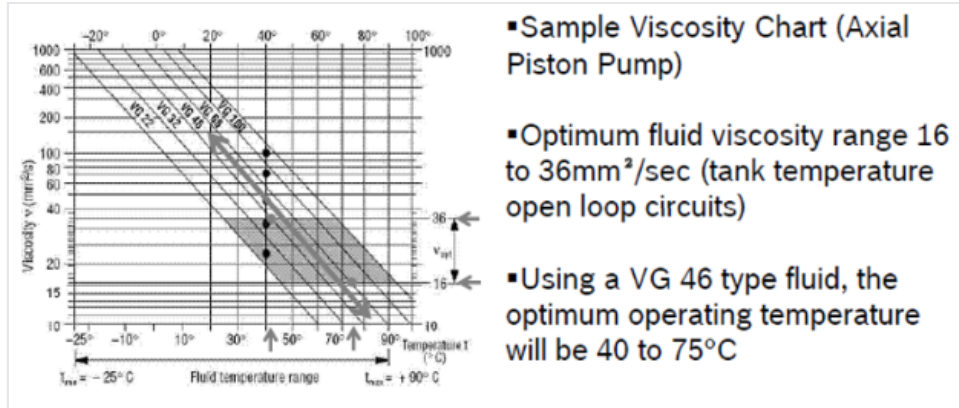
Hydraulic Fluid Temperature



- To get a physical feeling of viscosity and what is meant by a high or low viscosity rating it can be thought of as the following:
- 1 Liter of oil
- Heated to 40°C
- 1 mm ϕ Orifice
- Viscosity Rating can be related to the measured time in seconds to pass through the orifice.



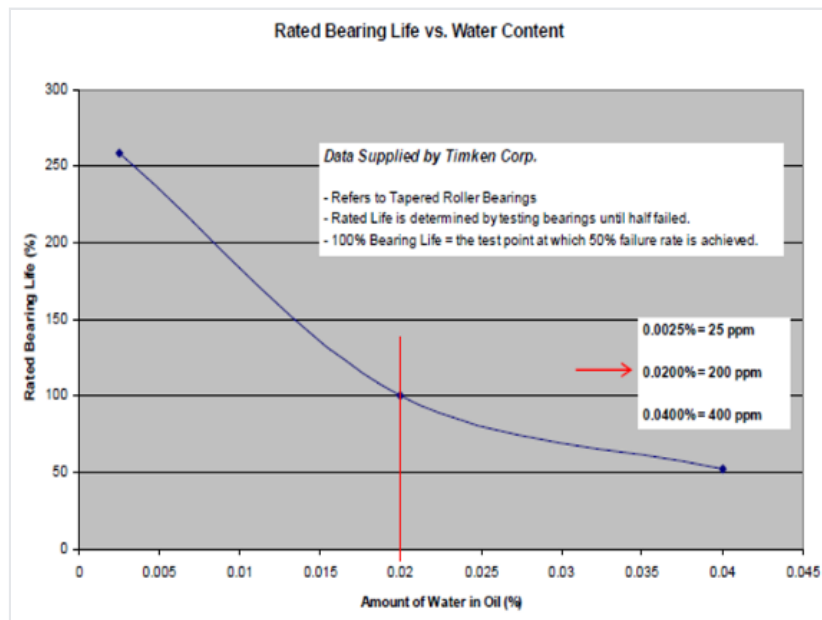
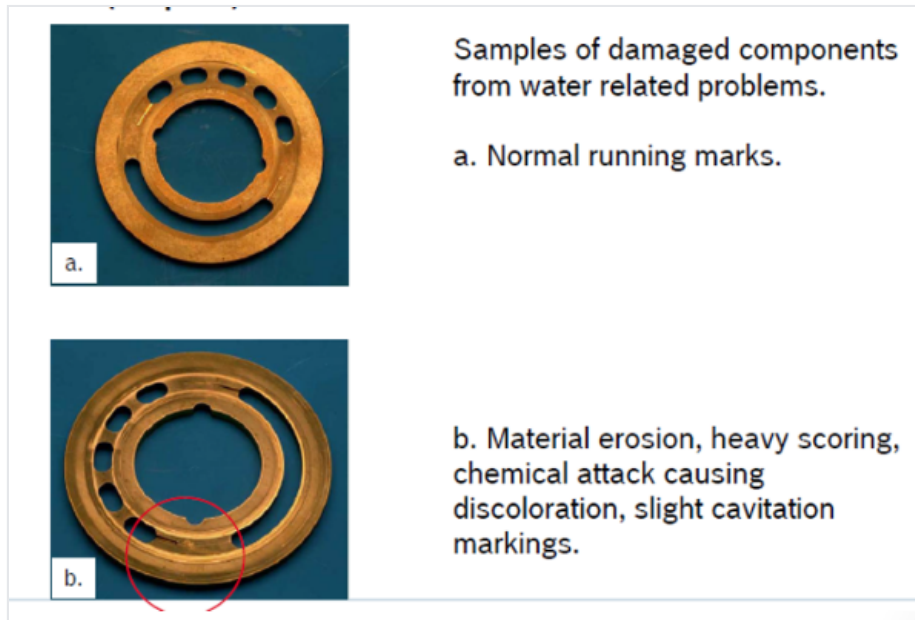
- The viscosity is required to maintain a lubricating film between the internal parts of the component.
- Low fluid viscosity can result in component damage through inadequate lubrication caused by excessive thinning of the oil film.
- As the viscosity becomes lower, physical contact between internal parts will show signs of premature wear.

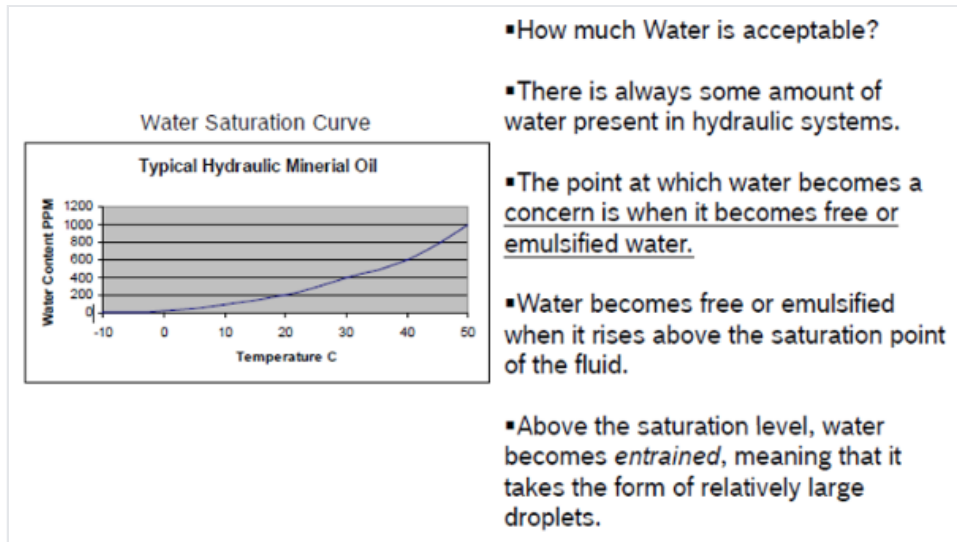


- Among the many requirements of the fluid, including stability against shearing, thermal loads, oxidation, and foaming etc, the **viscosity is the most significant factor** in hydraulic systems.
- Viscosity determines how thick or thin a fluid is at a given temperature, determining the friction between the layers of the fluid.
- Viscosity defined = “the inner friction or resistance to flow”

- Examples of damaged components from low viscosity:
- Piston OD contacted cylinder barrel bore due to high temperature / low viscosity
- Premature wear is seen in the areas of physical contact between Piston and Barrel
- Excessive friction caused piston to stick in barrel resulting in catastrophic failure pump

Water in Hydraulic Fluid

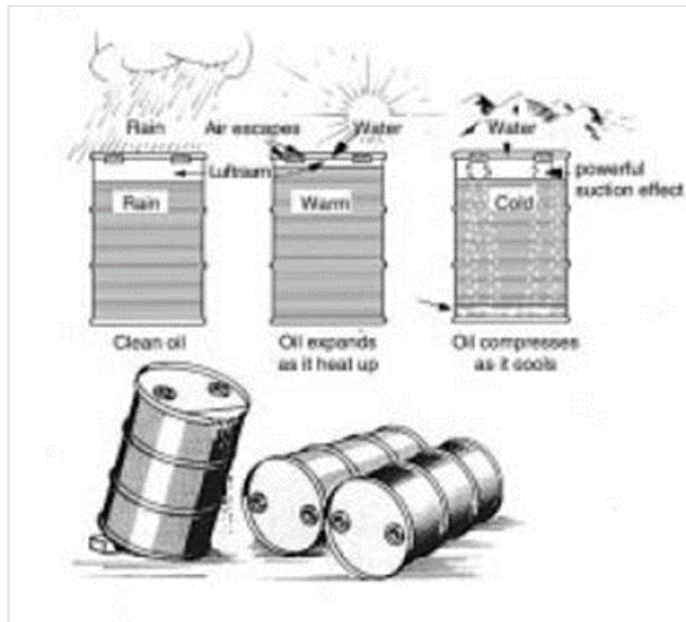




- Water contamination in hydraulic fluid accelerates the aging process of the oil --- resulting in oxidation, additive depletion, reduced lubricant film strength, and corrosion.
- **Cavitation** can also be a symptom of water in the fluid. Because the oxygen content of water vaporizes in the low pressure inlet side of a pump. Vaporization is followed by the subsequent violent collapse of vapor bubbles also known as the “diesel effect”. The result is **cavitation** damage on the interior surfaces of hydraulic components.
- Water in oil-based fluids can be just as destructive as particle contaminants.

Common sources of water entry:

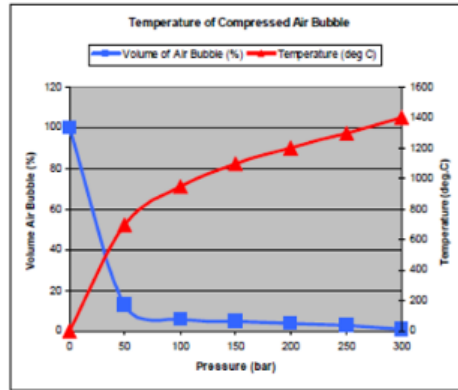
- Condensation from humid air drawn in through breathers.
- Leakages from oil coolers.
- Inadvertently filling with moisture contaminated fluid from drums or storage reservoirs.



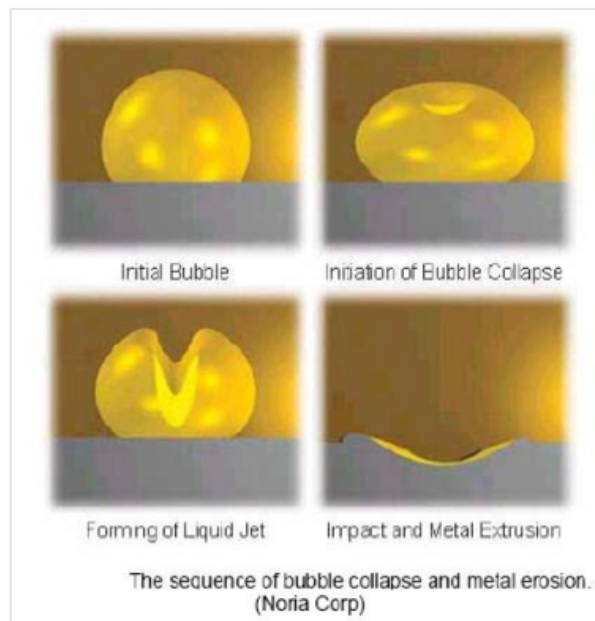
Air in the Hydraulic System

- Hydraulic mineral fluid contains between 6 and 10 percent of dissolved air by volume, Water/Glycols and phosphate esters about 4 percent.
- Free or un-dissolved air is extremely undesirable in a hydraulic system.
- Usually the first signs of un-dissolved air in the system will be seen as damages in pumps.
- As the level of free air increases, it can be heard as a growling noise in pumps and undesirable machine operation in spongy control movement. Usually at this point, serious damage has already occurred at the pump.
- Air is visible in the reservoir as a foam build up. Other indicators could be an increase in system temperature, a rise in contamination, or oil becoming darker.

Tiny fluid "jet" impacts metal surfacesRapid compression ignites small volume of oil in process called "Micro Dieseling"



- Un-dissolved air causes Cavitation or Aeration damages on hydraulic pumps.
- The collapsing air bubbles on the pressure side of the pump creates a tremendous amount of heat 1200°C to 1400°C.
- These temperatures causes serious damage to the pump and surrounding hydraulic fluid.

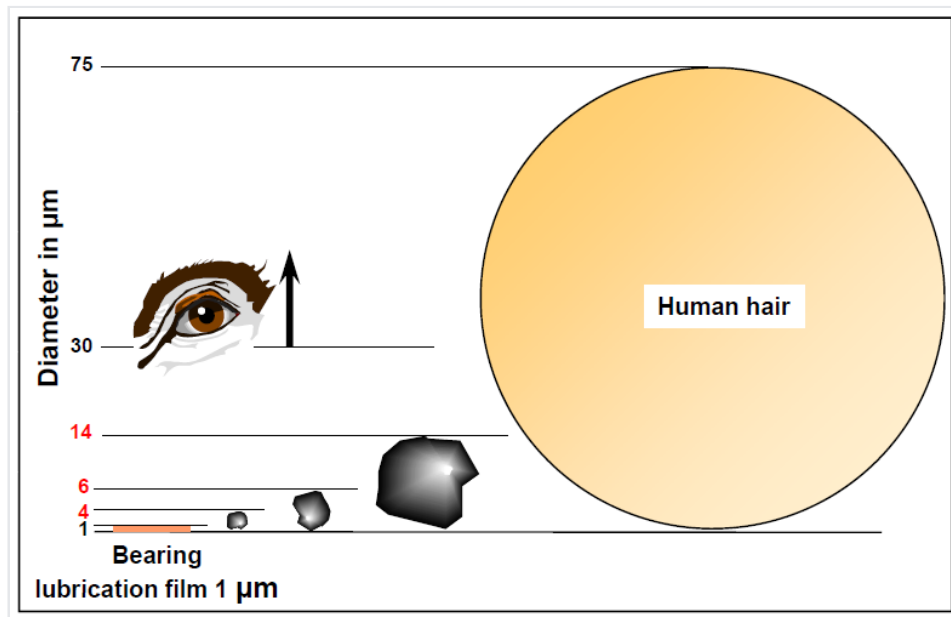


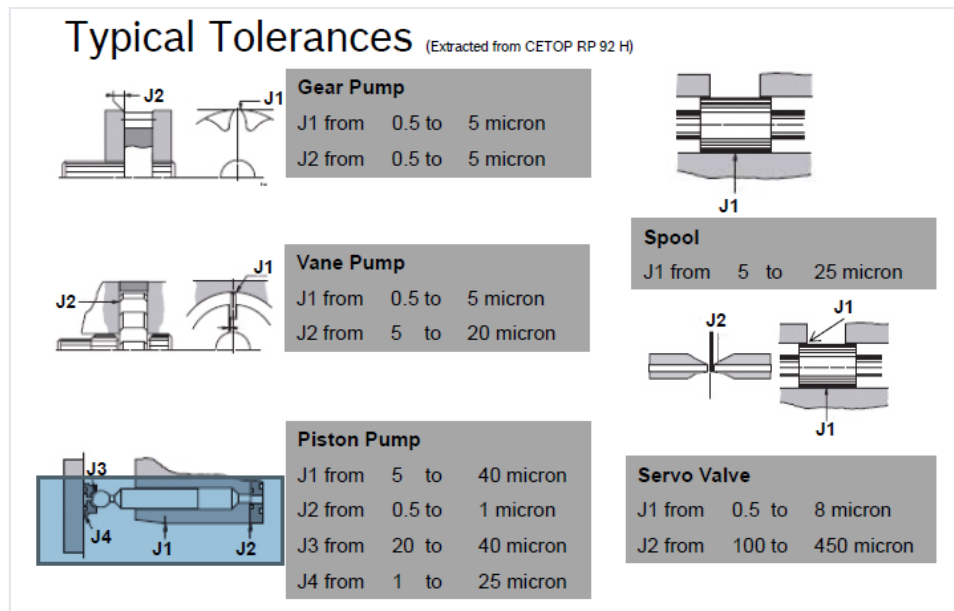


- Cavitation or Aeration damages on hydraulic pumps.
- The oil film surrounding the hot air bubble is prone to severe thermal degradation and oxidization.
- In the most severe cases, hydrocarbon-based fluids will assume a grey or black color.



Solids Contamination





The most dangerous contaminants are particles that bridge the dynamic clearance in components, typically between 2 and 20 μm in size.

- Control Valves = 5 to 25 μm
- Servo Valves = 2.5 to 8 μm

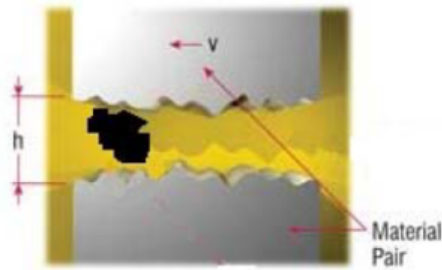
This is not to say larger and smaller particles are not serious.

- Larger particles if left unattended will result into a snowball effect. These larger particles break down into smaller particles that end up matching the component critical tolerances.
- Smaller particles will collect and cause what is known as “silting” on components that are sitting in a stand by mode.

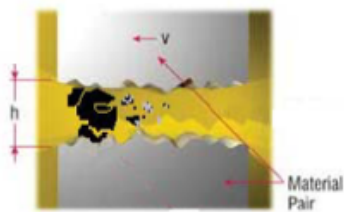
If not attended to, contamination will cause premature component wear throughout the hydraulic system and will not be isolated to single components.

As contaminants wear the internal tolerances of components the efficiency, internal leakages, and response times will all diminish, causing undesirable machine performance and reliability.

The most dangerous contaminants are particles that bridge the dynamic clearance in components, typically between 2 and 20 μm in size.

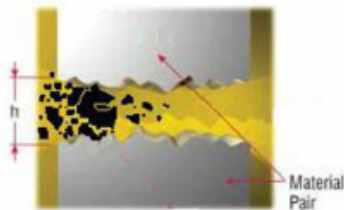


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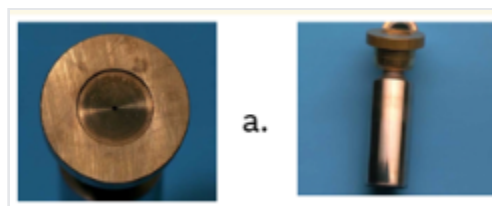
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▪ Larger particles if left unattended will result into a snowball effect. These larger particles break down into a smaller particles that end up matching the component critical tolerances.

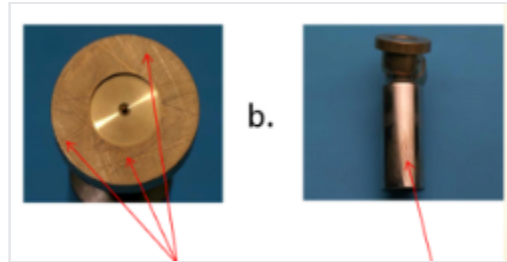


- Smaller particles will collect and cause what is known as "silting" on components that are sitting in a stand by mode.

Contamination examples: Normal running wear Scoring on dynamic sealing surface of the piston shoe. Material on the piston wall is damaged from cylinder to piston. Breakdown of lubrication film, contamination damage and thermal discoloration.



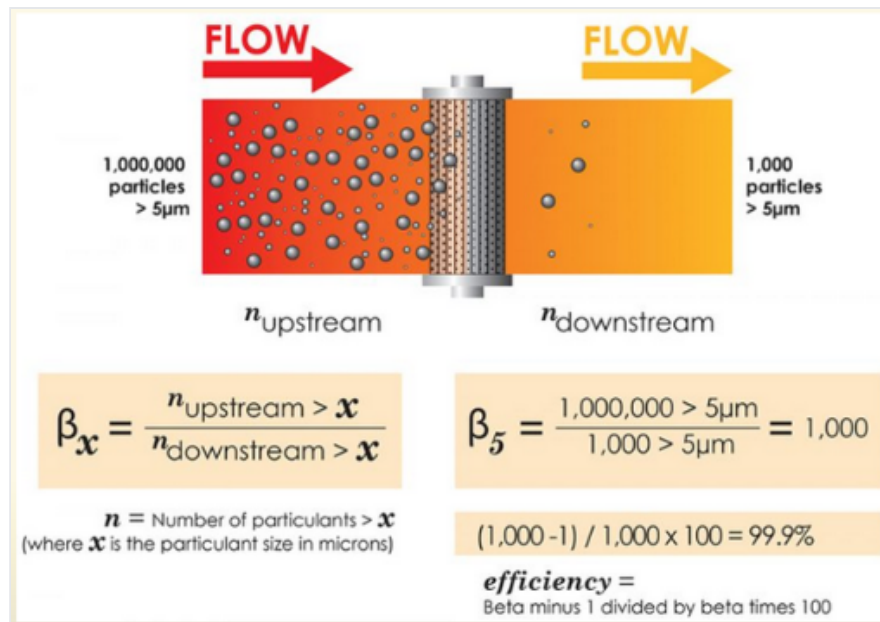
a.



- Cleanliness levels are defined by three numbers divided by slashes, Example: ISO Code = 22/18/13
- These numbers correspond to 4, 6, and 14 micron particles, in that order
- Each number refers to an ISO Range Code, which is determined by the number of particles for that size (4, 6, & 14μm) and larger present in 1 ml of fluid
- Example:
 - # particles larger than 4μm = 22,340
 - # particles larger than 6μ = 1940
 - # particles larger than 14μ = 43
 - = ISO Code 22/18/13
- Note: Each **range is double the range below**
- One code change = 2x as dirty

**Guidelines for
Determining, Achieving, and Maintaining
Target Cleanliness Levels with High Performance Filtration
(Beta Ratio ≥200)**

Most Sensitive System Component	Low/Medium Pressure Under 2000 psi (moderate conditions)		High Pressure 2000 to 2999 psi (or low/medium pressure plus severe conditions) (1)		Very High Pressure 3000 psi and Over (or high pressure plus severe conditions) (1)	
	Target ISO Levels	Filter Micron Rating	Target ISO Levels	Filter Micron Rating	Target ISO Levels	Filter Micron Rating
Pumps						
Fixed Gear or Fixed Vane	20/18/15	20	19/17/14	10	18/16/13	5
Fixed Piston	19/17/14	10	18/16/13	5	17/15/12	3
Variable Vane	18/16/13	5	17/15/12	3	N/A	N/A
Variable Piston	18/16/13	5	17/15/12	3	16/14/11	3 ₍₂₎
Valves						
Check Valve	20/18/15	20	20/18/15	20	19/17/14	10
Directional (solenoid)	20/18/15	20	19/17/14	10	18/16/13	5
Standard Flow Control	20/18/15	20	19/17/14	10	18/16/13	5
Cartridge Valve	19/17/14	10	18/16/13	5	17/15/12	3
Proportional Valve	17/15/12	3	17/15/12	3	16/14/11	3 ₍₂₎
Servo Valve	16/14/11	3 ₍₂₎	16/14/11	3 ₍₂₎	15/13/10	3 ₍₂₎



Filter Maintenance

- Service when indicator pops out or at least at a set time interval
- Cut old filters apart to learn what is swimming in the system
- Use high quality, name brand, proven filters
- Replace breather elements at regular intervals
- Close openings/protect openings to prevent introduction of contaminants into the system, such as:
 - Missing breathers
 - Reservoir access covers
 - Removal of components or piping
 - Maintain integrity of cylinder seals

Oil Sampling Procedures

Useful Sampling Tips in less than 5 Minutes

- Start slow and build the program
- Perform risk analysis to determine sample frequency
- Send a sample of new oil to the lab prior to starting the program so that a base line chemistry can be referenced
- Trend results so change in status can be detected easily

- Use transfer carts with appropriate filtration for fill ups
- Eliminate tramp oil from repairs and filter carts

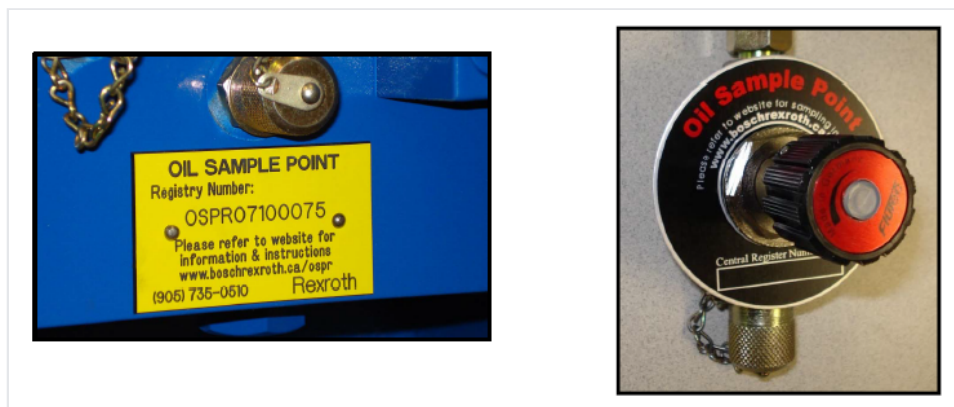
The Goals and benefits of oil sampling

- Provide a holistic view of component health in a hydraulic system
- Provide a holistic view of fluid health in a hydraulic system
- Ensure all parameters of the fluid are in-line with manufacturers recommendations
- The goal is to identify and correct a problem prior to becoming a functional failure

Select a lab service

- ISO Certified
- Visit- relationship build
- Turnaround times- lab location
- Interpretation assistance
- Report clarity

Select a sample location



- Reservoir (from the drain valve): A: This point is not representative or repeatable
- Reservoir (through the breather): A: This point is more representative but difficult to repeat due to different sampling height possibilities. Consideration should be given to the damage caused by removing the breather
- Supply Line (after filter): A: This point will provide a repeatable sample but little information regarding the cleanliness of the oil
- Supply Line (after the Pump before filter): A: Provides a representative and repeatable sample

- Return Line (before the filters): A: This point will provide a repeatable sample and is representative of the system

Clearly label the sample location once determined for consistency and trending purposes.

Purchase sample kits

- Refer to ISO 3722 for bottle cleanliness guidelines
- Most bottles available fall into the “clean” category. “Clean” bottles have less than 100 particles greater than 10 microns/ml
- “Super clean” bottles have less than 10 particles greater than 10 microns/ml

Status

Rexroth Fluid Laboratory
400 Pine Street, Suite 100
Portland, ME 04101
Phone: 207-755-0510
Fax: 207-755-0511
Email: rexroth@fluidlab.com

CUSTOMER INFORMATION
Company: Rexroth
Address: 400 Pine Street, Suite 100
Portland, ME 04101
Phone: 207-755-0510
Fax: 207-755-0511
Email: rexroth@fluidlab.com

SYSTEM INFORMATION
Unit: Rexroth
Capacity: 2000 Ltr
Type: Hydraulic
Pressure: 30 MPa
Temp: 120 F

FLUID INFORMATION
Sample Type: Hydraulic Oil
Manufacturer: SAE
Grade: ISO VG 46
Sample Date: 4/6/14
Lab Date: 4/6/14
Lab Time: 10:00 AM

STATUS
Normal

COMMENTS / RECOMMENDATIONS

PARTICLE COUNT (Particles per ml)

Size (microns)	Count	ISO Code
> 4	114,500	20/18/13
> 6	1,810	20/18/13
> 10	1,810	20/18/13
> 15	1,810	20/18/13
> 20	1,810	20/18/13
> 25	1,810	20/18/13
> 30	1,810	20/18/13
> 40	1,810	20/18/13
> 50	1,810	20/18/13
> 60	1,810	20/18/13
> 70	1,810	20/18/13
> 80	1,810	20/18/13
> 90	1,810	20/18/13
> 100	1,810	20/18/13

WATER CONTENT

Sample	Water (ppm)	ISO Code
1000	0.02	0.02
1001	0.02	0.02
1002	0.02	0.02
1003	0.02	0.02
1004	0.02	0.02
1005	0.02	0.02
1006	0.02	0.02
1007	0.02	0.02
1008	0.02	0.02
1009	0.02	0.02
1010	0.02	0.02

VISCOSITY

Sample	Viscosity (cSt)	ISO Code
1000	43.5	43.5
1001	43.5	43.5
1002	43.5	43.5
1003	43.5	43.5
1004	43.5	43.5
1005	43.5	43.5
1006	43.5	43.5
1007	43.5	43.5
1008	43.5	43.5
1009	43.5	43.5
1010	43.5	43.5

TAN

Sample	TAN	ISO Code
1000	0.01	0.01
1001	0.01	0.01
1002	0.01	0.01
1003	0.01	0.01
1004	0.01	0.01
1005	0.01	0.01
1006	0.01	0.01
1007	0.01	0.01
1008	0.01	0.01
1009	0.01	0.01
1010	0.01	0.01

SPECTROSCOPIC ANALYSIS

Sample	Fe	Cu	Co	Ni	Al	P	Si	Ca	Mg	Na	K	Li	B	Br	Cl	S	O
1000	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1001	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1002	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1003	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1004	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1005	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1006	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1007	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1008	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1009	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1010	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

PATCH TEST

Sample Comments:

ISO Code: 4/6/14

A Typical Oil Analysis Report

- Provides a quick diagnosis (Normal, Caution or Critical) based on the overall result of the analysis and target

Comments / Recommendations

- Provides a specific description of the results. If there is a deficiency in the results lab may provide recommendations for corrective measures

Particle Count

- The particle count test provides the quantity and size (in micron) of all solid contaminants in the fluid

- The particle count makes up the ISO Cleanliness Code and is compared to the target code

ISO Cleanliness Code

- ISO 4406:99 is the current and most commonly used cleanliness code. It is assigned on the basis of the number of particles per unit volume greater than 4, 6 and 14 microns

Water Content

- All hydraulic systems contain water, however the amount of water needs to be monitored and controlled in order to prevent severe damage to components
- Generally speaking for mineral oils <500ppm of water is acceptable

Viscosity

- Measured at a temperature of 40C – the time it takes for a given volume of oil to flow through a calibrated capillary tube under gravity
- A tolerance of +/- 15% (compared to new oil) is used as a limit for flagging a caution

TAN- Total Acid Number

- TAN measures the corrosive acidic by-products of oxidation
- Oxidation, can result in the increase of fluid viscosity, varnishing, or gumming substances
- Once the reaction begins a catalytic effect takes place

Spectrographic Analysis

- Defines and measures levels of additives
- Defines and measures levels of wear metal contaminants
- Comparisons based on new oil specifications from oil manufacturers

Understanding the Spectrographic Analysis:

Fluid Additives may cause presence of these elements:

- Detergents: Magnesium (Mg) Calcium (Ca) Barium (Ba)
- Anti-wear agents: Zinc (Zn) Molybdenum (Mo) Phosphorous (P)

Wear Metal Sources may cause traces of the following metals sources:

- Titanium (Ti) - Bearings, Plating
- Chromium (Cr) Rings, Roller/Taper, Bearings, Rods, Plating

- Iron (Fe) Cylinders, Gears, Rings, Bearings, Housings, Rust
- Nickel (Ni) Valves, Shafts, Gears, Rings
- Copper (Cu) Bearings, Bushings, Bronze, Thrust-Washers, Friction Plates, Oil Coolers
- Silver (Ag) Bearings, Bushings, Plating
- Aluminum (Al) Pistons, Bearings, Pumps, Thrust-Washers, Dirt
- Lead (Pb) Bearing Overlays, Grease, Paint
- Tin (Sn) Bearings, Bushings, Plating, Solder, Coolers

Corrective Action Suggestions

Exceeding Cleanliness Target

- Monitor system for possible ingress areas (remember if oil is getting out dirt can get in)
- Check condition of filters (indicator status, PM status, and element micron rating)
- Offline filtration may be utilized as a temporary solution

High Water Content

- Find the source of ingestion
- Depending on the severity are three options available for corrective action. Before considering any of these options the source of water has to be located and corrected
- Replace the fluid- ensure proper flush and cleaning of the plumbing and reservoir
- De-watering equipment (Hydac FAM)- dehydration
- On a smaller scale aqua-micron filters can be used

Viscosity and Total Acid Number (TAN)

- Determine if the change has been gradual or sudden
- If sudden, investigation is required (ie: source of excessive heat)
- It may be possible to drain and top up - the fluid manufacturer should be consulted

Spectrographic Analysis

- For additive issues it may be possible to drain and top up then add additives - contact the fluid manufacturer
- In some cases the wear metal may be generated from the machine in particulate form
- It is possible to filter the element out provided micron rating of the filter is small enough

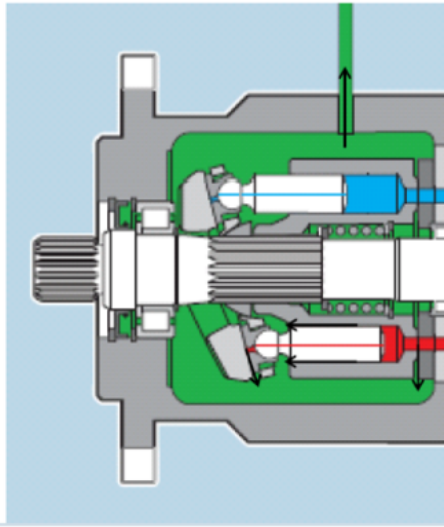
- Important to determine which component is wearing, one test that may be useful is "Analytical Ferrography"
- Ferrography is a particle identification test, which examines both metallic and non-metallic particles
- In some cases the wear metal may be generated from the machine in a dissolved form or from the environment
- One source that can cause this is leaching (chemical reaction usually occurring in areas of high heat or pressure. Occurs during a break-in period but will stabilize)
- Another source may be from a recent repair. Anti-seize compounds (i.e. copper cote), are applied to mechanical parts during repairs, which inevitably find their way into the oil. This would get dissolved in the oil in small quantities, and would present no problems

Pumps

The image shows a software interface for a Rexroth hydraulic system. At the top left is the 'rexroth A Bosch Company' logo. To the right are three buttons: 'PLC OK', 'PLC Not OK', and a close button 'X'. Below the logo, the text 'Select Pump:' is followed by a dropdown menu currently set to 'Pump #1'. Underneath this is a 'Pump Reference Point' button with a red square icon. Below that are three rows of data: 'Valve 1 Command:' with a value of '1.97' and unit '[%]', 'Pump 1 Feedback:' with a value of '1.97' and unit '[%]', and 'Pump 1 Pressure:' with a value of '2500' and unit '[psi]'. A 'Details:' section contains a text box stating 'Pump #1 slip test active.'. At the bottom are three buttons: 'Cancel', 'Start Test', and 'Save'.

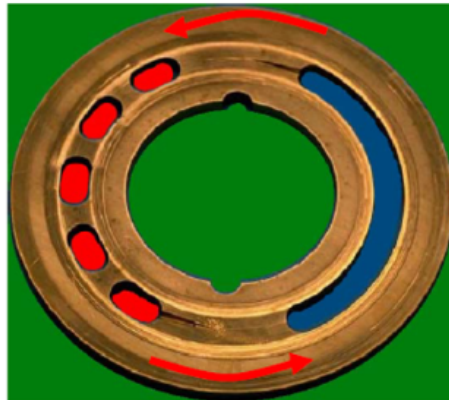
Parameter	Value	Unit
Valve 1 Command	1.97	[%]
Pump 1 Feedback	1.97	[%]
Pump 1 Pressure	2500	[psi]

Intended Leakages



- ΔP up to 350bar
- Speed 10m/s (36km/h)
- Stroke up to 100mm
- With Low Friction

Unintended Leakages



- Cross Port Leakages
- Leakage backward from the pressure port to the inlet
- Reduces the overall output of the pump but is not measured coming out the case drain line.

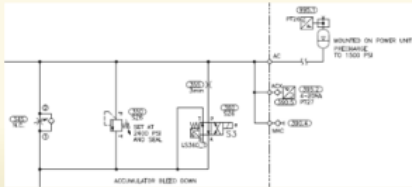
- Pumps are the “heart” of the hydraulic system.
- Perform slip tests – be consistent
- Monitor case drain flow



Accumulators

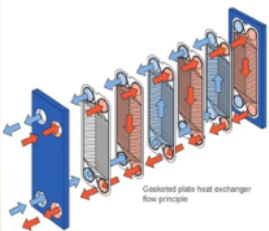


- Typically on pilot system
- Safety bleed-down circuit required
- Nitrogen charging gas
- Periodically verify precharge



Cooling

Plate-Frame water/oil



Consistent plate heat exchanger flow principle

Air/oil





Shell & Tube water/oil

- Keep coolers clean internally
- Filter water if necessary
- Effects on viscosity
- Overheating damages oil

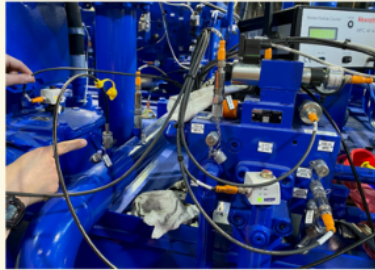
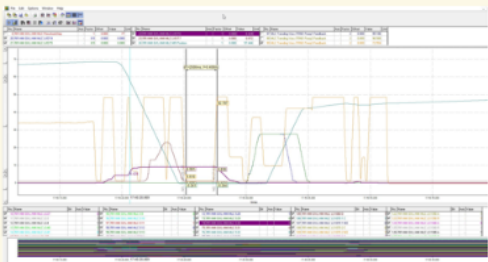
Piping



- Properly sized
- Properly clamped
- Hoses replaced on regular intervals
- Poor system control can stress piping and joints
- Replace when fatigued
- Non-welded options have many benefits



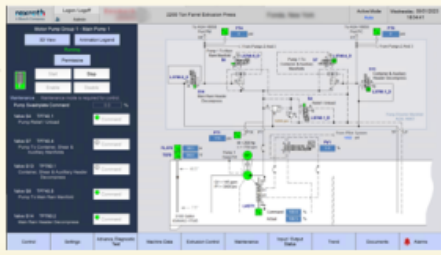

Sensors

- Gages/test points/transducers
- Operational Instrumentation
- Data Acquisition (troubleshooting, shock analysis, dead cycle reduction)
- IR Thermography, IR Thermometer

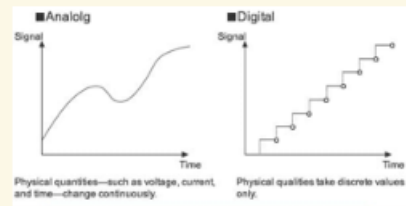
Control Systems

- Modern electronics typically work or do not work—rarely intermittent, or function but poorly
- Temperature and Environment are main problem—change filters on fans and A/C units
- Obsolescence is an issue—best to plan ahead
- Spares provide 2 benefits:
 - Swap for troubleshooting
 - Provide backup for repair time or upgrades



Control Systems – Analog/Digital

- Modern controls are digital, so they are unaffected by noise, poor connections or wire length that can plague older analog systems
- Machine function can be changed unexpectedly by inexperienced “tweakers” making adjustments
- Closed-loop systems are very repeatable, while open-loop systems produce different results with varying temperatures, contamination levels and component wear



Control Systems - Connectivity



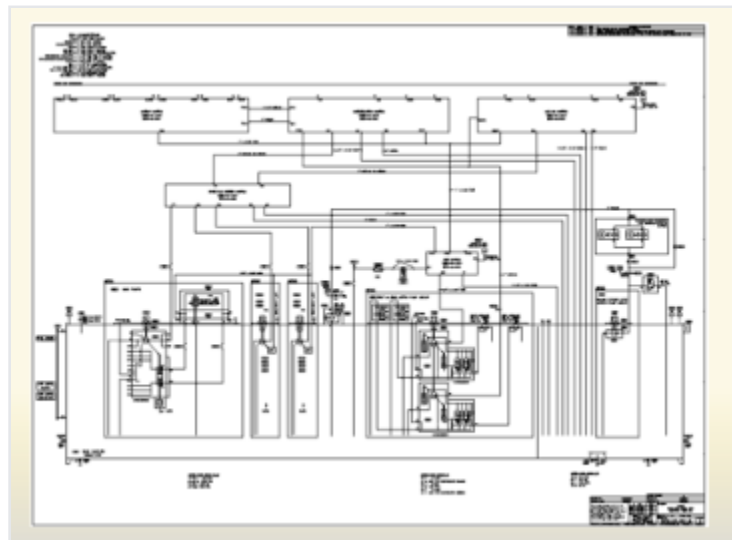
Modern control systems are moving towards connectivity for improvements in productivity, maintainability and flexibility








Documentation



- Important that all documents are up to date, especially the schematics and Bills of Materials.

- They should be available to people internally and easily available if they need to be sent to others for troubleshooting.

Training

A regular training program ensures that associates:

- Understand the schematics
- Understand the component functions and system functions
- Apply knowledge to troubleshoot problems
- Reduce downtime

Previous images and recommendations are selected from presentations by **Jeff Grube** and **Michael Kramer of Bosch Rexroth** about extrusion press hydraulic systems, from the AEC Press Maintenance Workshops, Atlanta, 2015 through 2023.

See also recommendations for Hydraulic System Upgrades by Michael Kramer in Chapter C – Press Modernization.

Hydraulic System Troubleshooting

Adapted from Oilgear Bulletin 910000A with permission.

Trouble Shooting Hints for Hydraulic Systems

PROBLEMS	PROBLEM CAUSE AND CORRECTIVE STEPS
Noisy pump – air leaking into the system	a) Be sure the oil reservoir is filled so that pump intakes are well below the surface with main ram extended.
	b) Check pump packing, pipe, and tubing connections and all other points where air can be drawn into the system. One way to check a suspected leak on the intake side is to pour oil over it, or pack grease around the suspected area. If the pump noise stops, you’ve found your leak.
	c) Keep the hydraulic system as clean as possible. Avoid allowing lint to get into the system. Avoid condensation as it may cause damage to pump parts, bearings, valve spools, valve solenoids, etc. Rusty solenoids do not perform satisfactorily. They should be checked periodically for rust or moisture and cleaned up when required.
Low pressure in system	Relief valve setting too low. Relief valve may have been reset. If setting is too low, fluid may flow from pump through relief valve back to reservoir without going to output device. To check relief valve setting, block discharge line beyond relief valve and check line pressure with gauge.

PROBLEMS	PROBLEM CAUSE AND CORRECTIVE STEPS
Erratic action	Valves, pistons, etc., sticking or binding. First check the suspected part for mechanical deficiencies such as misalignment of shaft, worn bearings, etc., then look for signs of dirt, fluid sludge, varnishes and lacquers caused by fluid deterioration. Look for out-of-range temperatures, air in the fluid, and low reservoir level.
Relief valve stuck open	Look for dirt or sludge in valve. Clean if necessary. Stuck valves may be an indication that the system contains dirty or deteriorated fluid.
Leakage in system	Check the whole system for escaping fluid. Serious leaks in the open area are easy to find; however, leaks often occur in concealed piping. Install a pressure gauge and relief valve in the discharge line near the pump and then progressively block the circuit downstream until the leak is located. A high leakage path through a valve or component generates heat. A hot spot in a circuit often indicates the point of leakage.
Incorrect control valve setting – fluid short-circuited to reservoir	If open center directional control valves are unintentionally set at neutral, fluid will be returned to the reservoir. No pressure will be developed. Also, scored control valve pistons and cylinders can cause this trouble.

	Trouble Shooting Hints for Hydraulic Systems (Continued)	Trouble Shooting Hints for Hydraulic Systems (Continued)
PROBLEMS	PROBLEMS	PROBLEM CAUSE AND CORRECTIVE STEPS
Air bubbles in the intake fluid	Air bubbles in the intake fluid	If fluid level is low, air bubbles will form in the reservoir. Check the fluid level daily.
Cavitation	Cavitation	(Cavitation is the formation of a void in a pump when it does not get enough fluid.) Check for loose suction pipes. Check for a clogged or restricted intake line or plugged reservoir breather. Fluid viscosity may be too high to permit the pump to prime itself. This condition may result from too low ambient temperature or use of wrong viscosity fluid. Recheck fluid recommendations.
Loose or worn pump parts	Loose or worn pump parts	Look for worn gaskets and packing, replace if necessary. Usually there is no way to compensate for wear in a part; it is always better to replace it.
Stuck valves	Stuck valves	Parts may be stuck by metallic chips, bits of lint, carbonized fluid, etc. If so, disassemble and clean thoroughly. Avoid the use of files, emery cloths, steel hammers, etc., on machined surfaces. Products of fluid deterioration such as gums, sludge, etc., may also cause sticking. Use solvent to clean parts and wipe dry before reassembly. If parts are stuck by corrosion or rust, they will probably have to be replaced.
Overheating	Overheating	a) Fluid viscosity too high. Recheck fluid recommendations. Unusual temperature conditions may cause fluid of improper viscosity to thicken.
		b) Cooler plugged.
		c) Relief valve blowing.

	Trouble Shooting Hints for Hydraulic Systems (Continued)	Trouble Shooting Hints for Hydraulic Systems (Continued)
		d) Valve leaking.
		e) Cooling water too warm.
Internal leakage too high	Internal leakage too high	Check for wear and loose packings. Fluid viscosity index may have changed.
Excessive discharge	Excessive discharge	Trouble may be caused by abnormal setting of relief valve. If so, reset. Also, check for sticking relief valve.
Fluid cooler clogged	Fluid cooler clogged	If fluid temperatures run abnormally high, they will go even higher with clogged fluid passages. If you find this condition, flush out the shell side of the cooler and “brush clean” the water tubes. If this does not work, try solvent.
Low fluid	Low fluid	If the fluid supply is low, less fluid will be available to dissipate the heat. This will cause a rise in fluid temperature. Be sure that fluid is up to level. Always fill the tank from clean fluid drums and pump the fluid through the circulating fluid filtration unit.

General Trouble Shooting for Many Types of Pumps

TROUBLE	PROBABLE CAUSE and CHECK	REMEDY
Pump not delivering fluid	a) Suction passage blocked.	Clean.
	b) Suction line loose or disconnected.	Correct.
	c) Fluid viscosity too heavy.	Heat fluid or change to lighter viscosity. See manufacturer’s recommendations.
	d) Suction filter clogged.	Clean and/or replace. Suction filters should have a capacity (gpm) at least twice the pump output. (Oilgear does not recommend use of suction filters for their pumps.)
	e) Pump rotation not correct. (Most pumps are marked to show correct rotation.)	Correct immediately; could cause severe damage.
Pump not developing pressure	a) Relief valve setting not high enough.	Block fluid circuit and reset relief valve using a pressure gauge.
	b) Relief valve stuck open:	
	1. Foreign matter under valve	Disassemble and clean. If valve spool or seat has been damaged, it may require honing or replacement. Reassemble and adjust.

TROUBLE	PROBABLE CAUSE and CHECK	REMEDY
	2. Broken valve spring.	Replace. Be sure to remove all broken particles.
	c) Relief valve venting.	Check all venting relief valves to be sure vent is being blocked. Remove piping at relief valve and insert plug to test relief valve.
	d) Worn pump: test pump according to manufacturer's recommendation.	Replace pump.
	e) Open valve in system.	Locate and repair.
Excessive or high peak pressures	a) Binding relief valve plunger.	Disassemble and clean out dirt and sludge. Check spool for burrs; dress with a stone, lap or replace.
	b) Relief valve spring screwed down solid.	Readjust or replace spring with one of higher "K" value.
	c) Control valve shifting so as to block fluid circuit.	Readjust valve spool shifting rates.

GENERAL TROUBLE SHOOTING FOR MANY TYPES OF PUMPS (CONTINUED)

TROUBLE	PROBABLE CAUSE and CHECK	REMEDY	REMEDY
Pump noise	Air in pump:		
	a) Air bubbles in intake fluid.	Return lines must be well below fluid level and baffled from pump intake.	Return lines must be well below fluid level and baffled from pump intake.
	b) Pump cavitating due to low fluid level.	Fill reservoir to proper level.	Fill reservoir to proper level.
	c) Suction filter clogged or too small.	Clean or replace with larger unit.	Clean or replace with larger unit.
	d) Reservoir breather.	Clean breather, check size and replace if too small.	Clean breather, check size and replace if too small.
	e) Partially clogged intake line.	Clean.	Clean.
	f) Suction pipe loose.	Tighten, replace gasket or "O" ring as required.	Tighten, replace gasket or "O" ring as required.
	g) Leaks in other piping subject to suction.	Tighten, replace gasket or "O" ring as required.	Tighten, replace gasket or "O" ring as required.

TROUBLE	PROBABLE CAUSE and CHECK	REMEDY	REMEDY
	Note: A connection that will not leak fluid under pressure may leak air under suction.	Test by pouring fluid over connection while under suction and note change in pump's noise or flow of fluid into connection.	Test by pouring fluid over connection while under suction and note change in pump's noise or flow of fluid into connection.
Excessive heating	a) Operating above continuous duty rating of pump for extended periods.	DANGEROUS. Alter method of operation. See pump manufacturer's recommendation.	DANGEROUS. Alter method of operation. See pump manufacturer's recommendation.
	b) "Blowing" relief valve.	Alter operations or increase relief valve setting if below pump rating.	Alter operations or increase relief valve setting if below pump rating.
	c) High ambient temperature.	Install or increase heat exchanger capacity.	Install or increase heat exchanger capacity.
	d) Leakage past hydraulic cylinder piston rings.	Replace rings – rehone cylinder if required.	Replace rings – rehone cylinder if required.
	e) Leakage past worn valves.	Replace.	Replace.
	f) Low fluid level in reservoir.	Fill reservoir to proper level.	Fill reservoir to proper level.

Note: The following section on hydraulic system filtration and cavitation is based on a presentation by the late Jack Hayes of Oilgear at the AEC Press Maintenance Seminar, in , , and is used here with permission. Some parts of this paper have been updated according to new standards; refer to Oilgear Bulletin 90007-D.

Proper System Maintenance to Avoid

Contamination and Cavitation

by **Jack Hayes**, Oilgear Company

Contamination

All systems are contaminated. They start out contaminated due to the various manufacturing processes, such as machining, welding, and cutting. They continue to ingest more contaminants during operation, from component wear, reservoir breathers, cylinder rod packings, and new "clean" oil.

The level of contamination increases exponentially if left unchecked, and eventually leads to total components failure. As operator of an extrusion press, you have two choices:

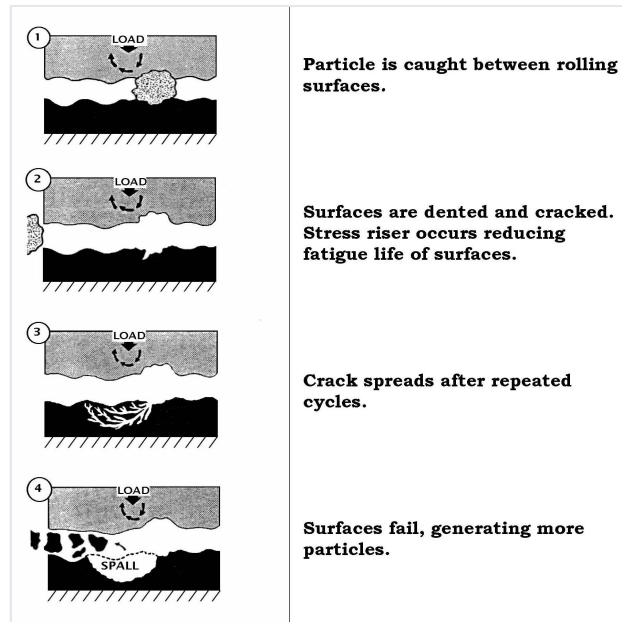


Figure 5-8: Wear Mechanisms of Anti-Friction Bearings

■ **Accept contamination as a way of life. In this case you must accept:**

- unscheduled downtime
- increased repair costs
- greater hydraulic fluid costs
- costs for lost production.

■ **Install a properly designed filtration system, which:**

- addresses wear problems associated with both rolling and sliding surfaces.
- is capable of cleaning a previously contaminated system.
- is sized to handle the ingestion rate of new contaminants.
- is easily maintained.

Five Filtration Myths

There are 5 common myths about hydraulic system filtration, which may cause profound and costly mistakes:

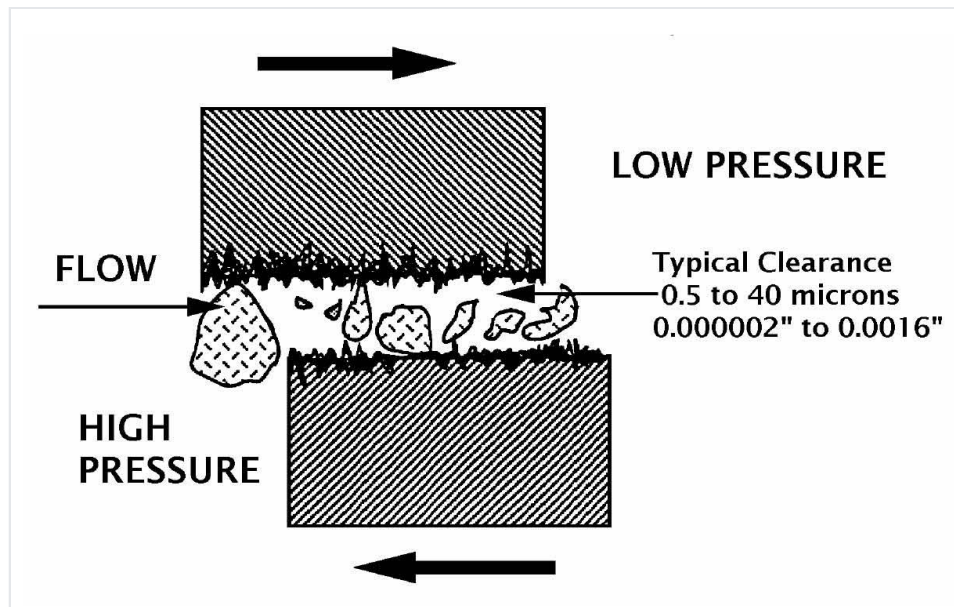


Figure 5-9: Wear Mechanism of a Sliding Surface

Myth #1: Particles less than 10 microns in size are harmless. A good understanding of how wear takes place in a hydraulic component debunks this commonly held belief. Both sliding and rolling surfaces are affected.

Typical clearances between bearing surfaces are subject to load and viscosity of lubricants. This can be as little as 5 micrometers or 0.00002 inches.

Particles that are most damaging are the ones equal to or slightly larger than the clearances.

Because they are continuously being work hardened, many of these particles are extremely hard, usually much harder than the parent surfaces.

They become imbedded in the “soft” surfaces and cut away material from the opposing surface.

Typical Critical Clearances of Fluid Power Components

Component	Typical Clearance	
	Microns	Inches
Gear Pumps		
Gear to Side Plate	0.5 - 5	0.00002 - 0.0002
Gear Tip to Case	0.5 - 5	0.00002 - 0.0002
Vane Pumps		
Tip of Vane	0.5 - 1.0*	0.00002 - 0.0002

Component	Typical Clearance	Typical Clearance
Sides of Vane	5.0 - 13	0.0002 - 0.0005
Piston Pump		
Piston to Bore	5 - 40	0.0002 - 0.0016
Valve Plate to Cylinder	0.5 - 5	0.00002 - 0.0002
Servo Valve		
Orifice	130 - 450	0.005 - 0.400
Flapper Wall	18 - 63	0.0007 - 0.0025
Spool - Sleeve	1 - 4	0.00004 - 0.00016
Control Valve		
Spool - Body	1 - 23	0.00004 - 0.0009
Poppet	13 - 40	0.0005 - 0.0015

*Estimate for thin lubricant film

Myth #2: The manufacturer's micron rating for a filter is a good indication of filter performance.

Actually, the manufacturer's rating means nothing and can be deceptive. It is not unusual to find a 3 micron filter manufactured by company "A" to be less efficient than a 10 micron filter from company "B".

The only way to compare filters is by Beta ratings.

The filter industry has recognized that the manufacturer's nominal ratings not only fail to indicate the size of dirt that can be removed, but are also invalid for comparison purposes. Therefore, many of these manufacturers developed an ANSI standard (B93.31-1973) for determining how well a filter removes contaminants⁴.

The test involves passing fluid of a known contamination level through an element and measuring the number of contaminants of a given size upstream and downstream. The efficiency of the elements is expressed as the ratio of the number of upstream particles versus downstream particles. This ratio is referred to as the Beta ratio. It can be applied to any size contaminants; typically Beta 3 and Beta 10 referring to 3 micrometers and 10 micrometers respectively.

$x = N_x \text{ upstream} / N_x \text{ downstream}$

Example: $N_x \text{ upstream} = 350$

4. For more information on the rating of filters refer to Oilgear Bulletin 90007-D, page 5-41.

$N_x \text{ downstream} = 10$

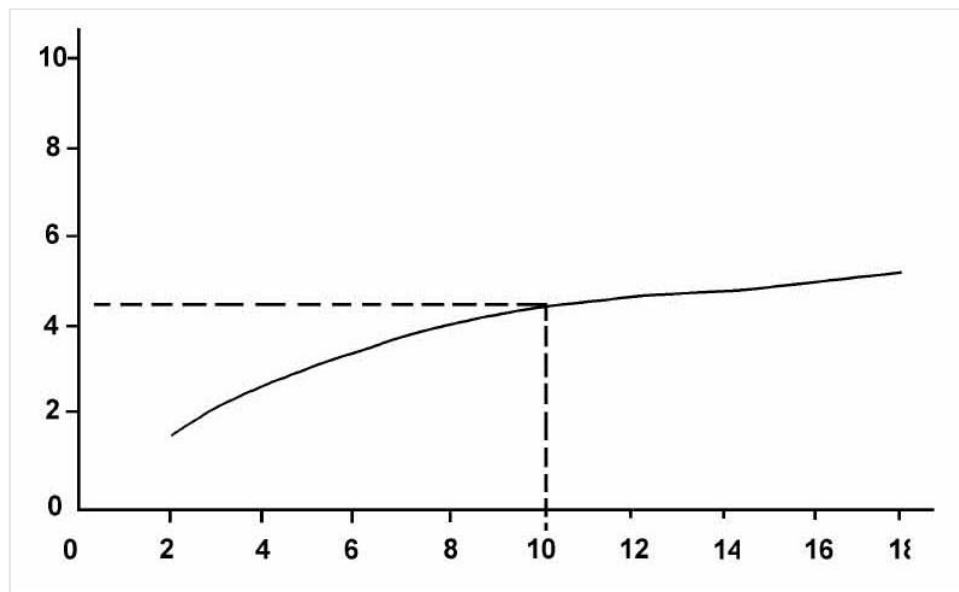
$\text{Beta} = 350 / 10 = 35$

Beta Ratio as related to Efficiency in %

Beta	Efficiency
1.0	0
2.0	50
4.0	75
8.0	87.5
16.0	93.75
32.0	96.87
64.0	98.44
75.0	98.67

$x = 75$ is considered "absolute" by some manufacturers.

All filters, regardless of the manufacturer's rating, will have a Beta rating for a number of different size contaminants. For instance, a nominal 3 micron filter might have a Beta₃ of 4 and a Beta₁₀ of 16. In reality this "3 micron" filter is nothing more than a good 10 micron filter removing approximately 94% of all 10 micron particles.



Dynamic Flow Beta

Finally, it is important to note that the efficiency is adversely affected by pulsating flow. The dynamic flow Beta will typically be lower than for steady flow, i.e., the filter will be less effective if the flow rate is varying.

Myth #3: Clean oil remains relatively clean until a catastrophic failure occurs. From the discussion on wear, it is plain to see that contaminants are continually being generated within an operating system. Further, the rate is exponential since a single contaminant can generate thousands.

Figure 5-11 below illustrates clearly how the rate of contamination is affected by filtration.

A 25 micron "nominal" filter is replaced with a $\beta_3 = 75$. After 20 minutes the particle count of 5 micron particles per milliliter has dropped from 20,000 to approximately 200. During the next 300 hours the particles per ml dropped to less than 25! Then the 3 micron absolute filter is replaced with a 25 micron nominal filter. Within 100 hours the particle count increases back to more than 8000.

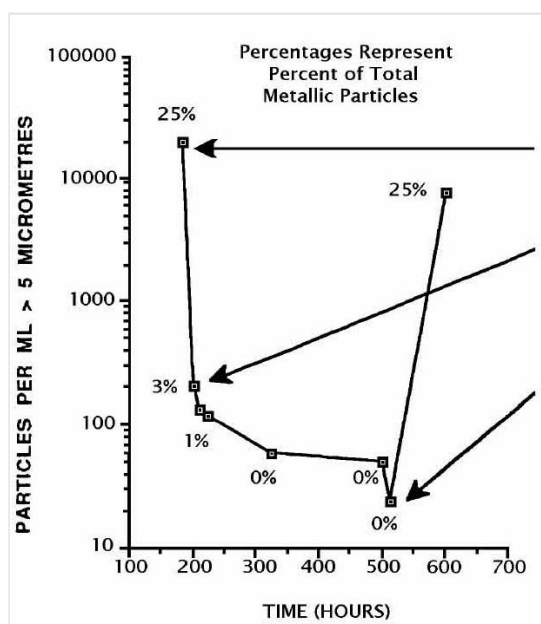


Figure 5-10: Dynamic Flow Beta vs. Steady Flow Beta for Cyclic Flow

In this demonstration a nominal 25 micron filter was replaced with a β_3 (Beta 3) rated filter. As indicated by the graph, the contamination was dramatically reduced over 300 hours. Then to confirm the results, a new 25 micron nominal filter was reinstalled, and the result was a return to the previous contamination level very quickly.

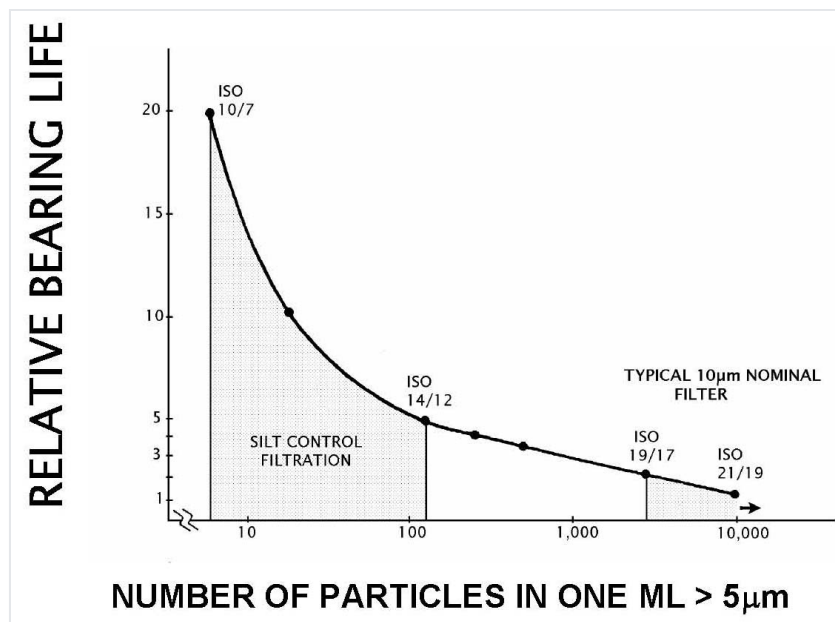
Myth #4: New oil is clean oil. Filtration is always recommended when adding fluid to reservoirs. To demonstrate, forty-three samples representing nine different oil companies and sixteen different supply sources were included in a "New Fluid" survey. The table below shows some typical results. Keep in mind that the upper contamination limit for a useable fluid is approximately 800 particles per milliliter.

New Fluid Average Particle Count per Milliliter

Greater than 10 Micrometers

Sample	Container Size (Gal)	10 M
1	1	265
2	55	20
3	1	193
4	55	4097
5	1	530
6	55	342
7	1	20,839
8	5	22,028
9	5	7,003
10	55	3,269
11	5	76
12	55	63
13	0.25	238
14	1	92
15	5	18
16	1	45
17	55	313
18	1	315
19	5	45
20	2	60
21	55	155

It should also be noted that when adding fluid, the most efficient filters should be used (minimum Beta = 20). Since the fluid only passes through the filter element once when adding fluid, the filter must be capable of removing most contaminants. Otherwise, if the new fluid is extremely contaminated, many particles would be ingested into the system.



Steady Flow Beta

Myth #5: Finer filters must be changed more frequently. Since a coarser filter allows more contaminants to circulate, the rate of contamination is greater. Contaminants create new contaminants so the filter has to trap dirt that otherwise would not have been generated.

Field tests have proven that after a system has reached a high level of cleanliness, the need for element replacement drops dramatically.

Old Filtration Axiom

"It is economically implausible to filter an entire 2000-2500 gallon reservoir using 3 micron absolute filters (Beta₃ = 0.75). The filter elements would need to be constantly replaced, driving up the preventative maintenance costs. Ten micron nominal filtration for the bulk of the oil is more than adequate, followed by 3 micron filters to protect the critical devices, i.e., servo valves."

Figure 5-13: Old filtration arrangement

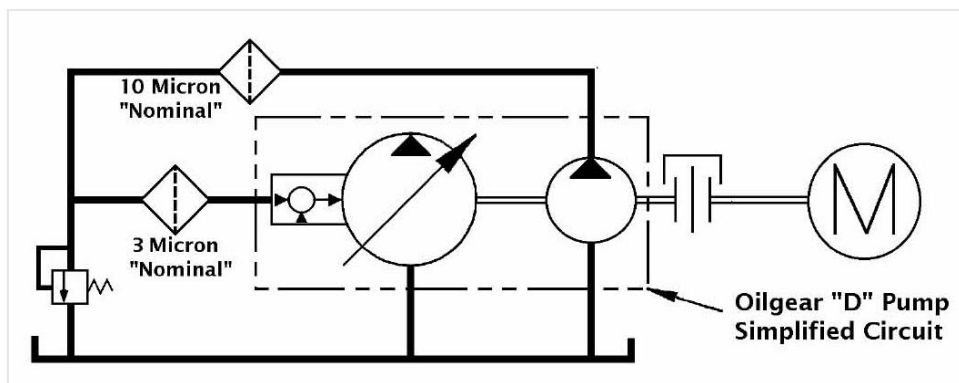


Figure 5-11: Particle Ingestion Rate

With the old circuit arrangement, the finer 3 micron filter would continually fill with contaminants and bypass, while the 10 micron filter would have to be changed less frequently. This is partially the reason for the erroneous impression that finer filters have to be changed more often.

As the press ages, the rate of ingestion increases due to wear and soon the filtration becomes completely inadequate. A catastrophic failure will eventually occur.

New Filtration Axiom

Three micron absolute filters ($\text{Beta}_3 = 75$) should be used to filter the entire system to an extremely clean level. Twenty-five (25) micron "boulder catchers" are placed in front of the critical devices, i.e. servo valves.

Figure 5-14: New filtration arrangement

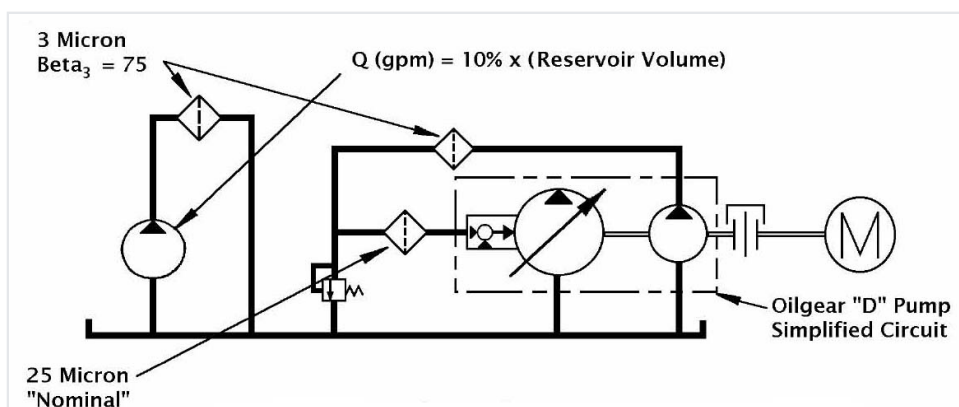


Figure 5-12: Summary of bearing life vs. particle size, experience from studies cited in References – Bearing Life (page 5-19).

With this new filtration arrangement the entire system is maintained at an extremely low level of contamination. Since only a few contaminants are available to generate more, the ingestion of new contaminants is limited to the external environment, i.e., breathers and rod packings. The filter system can easily keep pace with this rate. The elements last longer and replacement costs drop.

The 25 micron "boulder catcher" is only necessary to catch large particles that are either generated by the pilot pump or that manage to avoid the main filters.

Replace the 5 Myths of Yesterday with the 5 Rules of Today:

Rule #1: Oil cannot be too clean.

Rule #2: Use Beta ratios when evaluating filters.

Rule #3: Filtration must be continuous.

Rule #4: Filter oil when adding to or filling a system.

Rule #5: The finer the filter the lower the costs.

Ingredients for Effective Filtration.

Field experiences have proven that the most effective filter systems are recirculating systems -- "kidney loops" -- that run continuously. When sized and maintained properly, this arrangement has been shown to dramatically reduce maintenance costs associated with hydraulic failures.

Three key ingredients for design are:

Efficient filters: 3 = 75

- **Large capacity filters: P for a clean element is less than 25% of the by-pass setting.**
- **High Flow (Q) Rates: Q (gpm) 10% of the Volume of the Reservoir**

Measuring Fluid Cleanliness

The standards and methods for measuring hydraulic fluid cleanliness have changed greatly in recent years. Refer to Oilgear Bulletin 90007-D beginning on page 5-41 for more information.

Cavitation

Many of the pumps that are returned to the factory for repair show signs of cavitation. The evidence ranges from slightly eroded surfaces to deep irregular cavities. If left uncorrected, cavitation can lead to the early destruction of a pump.

Cavitation occurs when either a void or an air bubble in the fluid is suddenly exposed to high pressure. The pressure causes the void or bubble to collapse at extremely high velocities. When the collapsing void or bubble disappears, the high velocity oil literally runs into itself causing spot pressures that can reach 200,000 psi. Sudden pressures of this magnitude cause noise and eat away at the metal surfaces.

The solution is to eliminate voids and air bubbles in the oil. Voids occur when high vacuum is present in the suction line. This vacuum causes the entrained air (air that is normally in solution at atmospheric pressure) to come out of solution thus creating a void. Avoid restrictions in the suction lines including strainers, elbows, and pipe reductions.

If the cause was air, the bubble will “diesel” causing oxidation and nitration. This burned fluid will cause the components to become coated with a varnish like material resulting in sticking valves, etc.

Air bubbles can be eliminated by:

- Repairing loose suction pipes.
- Ensuring that all return lines terminate below oil level.
- For presses using two-way pump circuits:
 - repair all leaks in high pressure piping.
 - maintain packings and rod seals on the side cylinders.
- Maintain oil level in reservoir.
- Install protective plates over the tank prefill connections.
- Maintain oil temperatures above 120oF.

Besides contamination, cavitation is the most frequently occurring condition leading to catastrophic destruction of pumping equipment. Furthermore, this cavitation is almost always attributable to air ingestion, especially in older systems. The importance of the elimination of air cannot be overemphasized.

References:

"Filter Recommendations for Oilgear Equipment," Bulletin 90007-D, The Oilgear Company, Reissued: June 1991.

The Pall Hydraulic Filter Guide," Bulletin PIHC-1E, Pall Corporation, August 1985.

"The Pall Lubrication Filter Guide," Bulletin PIHC-IE, Pall Industrial Hydraulics Corporation, March 1983.

"Achieving and Assessing Hydraulic System Fluid Cleanliness," David Carson, Marketing Manager, Pall Industrial Hydraulics Corporation, May 1985.

"Filtration Products From Schroeder" 4th Edition, Schroeder Brothers Corporation, L1896C, February 1990.

References – Bearing Life:

- Lowenthal, S.E., Moyer, D.W., Needelman, W., "Effects of Ultraclean and Centrifugal Filtration on Rolling Element Bearing Life," Transactions of ASLE, Journal of Lubrication Technology, Vol. 35, 1981.
- Macpherson, P.B., Bhachu, R., Sayles, R., "The Influence of Filtration on Rolling Element Bearing Life," presented at Mechanical Failures Prevention Group meeting, Bethesda MD, April 1981.

- Dalal, H., Senholzi, P., "Characteristics of Wear Particles Generated During Failure Progression of Rolling Bearings," Trans. ASLE, Vol. 30 (#), p. 233, 1976.
- Fluid Contamination Classifications, NAS 1638.

by **Jack Hayes**

Oilgear Company

Farrel

Extrusion Press

Operation and Maintenance Training Course

The following information is taken from a Farrel training course manual, circa 1968. The training course was offered to new owners of Farrel extrusion presses. This information is both interesting and useful, for users of older as well as modern presses.

Hydraulic Maintenance page 5-21

Troubleshooting Hydraulic Problems page 5-25

Glossary of Hydraulic Terms page 5-29

HYDRAULIC MAINTENANCE

A. Hydraulic Oil

Foreign matter such as dust, water, lint, and other components can seriously impair the action of a hydraulic system.

Precautions to be Taken When Handling Oil:

- Store oil drums so that no water or dirt collects on the drum.
- Before opening the drum, wipe off any loose dirt so that it will not enter the drum or the hydraulic system when filling or adding oil.
- Before adding oil to the hydraulic system, clean off the filling plug with clean, lint-free rags.
- If all the oil from the drum is not used, reseal the drum and mark it "Clean Unused Oil".
- Replace the filling plug on the hydraulic reservoir immediately after filling.

Lack of oil may produce irregular operation of the system. Maintain the proper oil level in the hydraulic reservoir. If the pump intake becomes partially uncovered, air will be drawn into the system. To check the oil level, place the press ram in the full return position. Do not overfill the tank. If too much oil is added, it will leak out the breather or filler opening.

Use a first quality hydraulic oil of the correct viscosity as recommended by the press manufacturer. The hydraulic oil must do two things: it must transmit power efficiently, and it must lubricate adequately.

Have the oil checked every 6 months for contamination. With the press in operation, drain about a quart of oil into a clean container and send the sample to a chemical laboratory or your oil supplier to be analyzed.

Pull magnets once a week. Any accumulation of metal indicates trouble. Locate the source of the metal before running (for example, pumps or side cylinders). Some metal fuzz will usually be present.

No hard and fast rules can be laid down for making oil changes because of the great variety of service conditions. If oil filtration is good, and other factors favorable, the oil may be kept for several years.

Many plants have portable oil filters that are temporarily hooked up to each press. The length of time the portable filter is operated on each press is dependent on filtering capacity and the capacity of the oil in the tank.

Be sure the system is clean each time you change oil. Remove as much old oil as possible; bleed the old oil out of the lowest point in the system. Try to drain the oil when it is warm. Finally, remove any sludge, dirt or contaminants from the tank by cleaning with clean, lint free rags.

If your press has integral oil filters, check them periodically. If your oil filter has a pressure gauge, change the filter element when the indicator reaches the change mark. Replace the element if it shows signs of foreign material on the surface. When the element is replaced, drain and clean the filter body.

Repair oil leaks as soon as possible. Oil costs money, so why let it leak out on the floor? Oil leaks can also be a safety hazard, if anyone should slip on it. The most likely spots for oil leakage are at pipe joints, tube joints, hose connections, and shaft seals on hydraulic pumps and motors. Tightening every nut in sight may not be the way to stop leakage. Look for worn gaskets and packing. Replace if necessary.

B. Hydraulic Pumps

Oilgear Pumps: When receiving new or rebuilt Oilgear pumps, check the following:

1. IMPORTANT: Drain port #1 must be open to discharge above the oil level. (No tube or pipe is required.)
2. When pump is shipped without tubes in place, remove all pipe tap protectors (not pipe plugs) from the bottom case.
3. Port numbers are stamped on the bottom case. Install pipe as recommended in Oilgear Bulletin. Make sure pipes are tightened properly with correct thread engagement to assure no air will enter the circuit.

Cold Starting Oilgear Pumps

Equipment can occasionally be started at temperatures below the low temperature limit shown in the table providing:

1. The temperature is not more than 25o F below the low limit.
2. The temperature is at least 5o F above the pour point of the oil.
3. The operator can be relied on to start the unit in accordance with the following cold starting procedure:

Drive the input shaft of the unit for about 5 seconds and let it rest for 20 seconds. Repeat about 10 times. Then drive the input shaft about 20 seconds and let it rest 20 seconds. Repeat about 5 times. Let the pump run until the oil temperature reaches 80oF, before starting the auxiliary pump. Run the unit continuously and operate the press at light loads to warm up the oil in the entire system.

Oil operating temperatures should be maintained at 120oF. Maintaining and not exceeding an operating temperature of 120oF will extend the life of the oil.

Other Hydraulic Pumps

Procedure for starting new and repaired Vane Pumps:

Do not start a cold pump with hot oil, also, do not start a hot pump with cold oil. In both cases the pump could seize. Hydraulic pumps are manufactured with very close tolerances and rapid temperature variations can cause them to seize. Always start a new or rebuilt vane pump under pressure on the first run so that back pressure is present to assure adequate internal lubrication. The pump should be started by jogging the drive motor. This allows the pump to develop its prime while speed is being built up. Allow the pump to run for a half hour, checking constantly to see that it does not heat up. Once the vane pump is broken in, it may be started under no-load conditions.

When installing new pumps and motors check the direction of rotation before running. Check the alignment of the coupling between the pump and the motor. Make sure the pump is protected by a relief valve on the pressure side. The relief valve should never be set over the maximum pressure rating of the pump.

C. Hydraulic Piping, Tubing and Flexible Hose

The three primary considerations in the selection of lines and fittings which will best serve the circuit conditions are: material, inside diameter, and wall thickness.

Pipe and Tubing Classifications:

Piping and pipe fittings are classified according to wall thickness and nominal size. Wall thicknesses are: standard, extra heavy, and double-extra heavy. Recently a trend has developed toward the use of schedule numbers, instead of wall thickness to classify pipes and pipe fittings.

Tubing differs from pipe in its size classification. Tubing is designated by its actual outside diameter and wall thickness.

When you purchase tubing, specify SAE, 1010 dead soft, cold drawn, seamless steel hydraulic tubing (or equivalent). Always use tubing with wall thickness recommended by the press manufacturer or within the limitation set forth by the tubing supplier.

When you purchase piping, specify, ASTM A106-55T, grade B, cold drawn, soft annealed seamless and pickled clean hydraulic pipe. Always use piping with a wall thickness recommended by the press manufacturer or within the limitation set forth by the piping supplier.

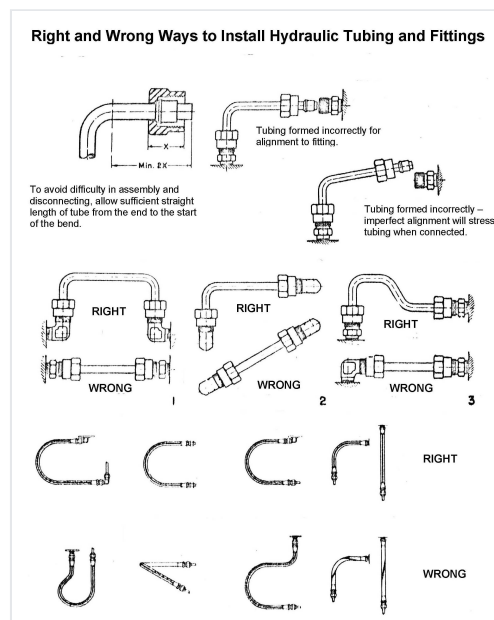
IMPORTANT: support tubing and pipe wherever necessary to prevent vibration. Pipe and tube failures are generally caused by shock and vibration. The constant vibration fatigues the pipe or tube, causing it to fail.

Before installing piping or tubing, make sure it has been thoroughly cleaned of saw and file chips, scale or other foreign matter which will cause damage to the equipment.

Pipe and pipe fittings on hydraulic machinery are usually of the threaded type. When cutting threads, the use of dull pipe cutting dies should be avoided, since their tendency is to drag rather than cut metal; torn or poor threads often result in a leaky connection.

When applying thread sealant, such as teflon tape, start two threads up to prevent the sealant from entering the system. This does not hold true for Loctite hydraulic type sealant. Loctite is compatible with hydraulic oil.

Figure 5-15: Right and wrong ways to install hydraulic tubing and fittings



Lines should normally be kept as short and free of excessive bends as possible. However, tubing generally should not be assembled in a straight line, because a bend tends to eliminate strain by absorbing vibration and will compensate for thermal expansion and contraction. Bends are preferred to elbows or sharp turns, because bends cause less power loss. An ideal bend radius is 3 times the pipe or tube inside diameter.

When using flexible hoses, follow the supplier's recommendation on working pressures, bending radii and method of installation. Do not twist or place the hose in axial torsion. Bend in one place only. A good working rule is that the bend radius should be 9 or more times the OD (outside diameter). Provide sufficient slack to compensate for changes in length under working conditions. Avoid flexing or straining. Avoid sharp and excessive bends. Avoid rubbing against the press components; the abrasive action will wear through the hose wall, and it may eventually burst.

D. Relief Valves

A relief valve is sometimes prevented from operating properly by dirt or foreign matter beneath the pressure control cone and its seat. This results in a fluctuating pressure or a complete drop in pressure. Usually relief valve troubles can be remedied by loosening the jam nut and backing off the adjusting screw. This relieves the pressure control spring and often will allow the circulating oil to clean away the dirt. If this fails, disassemble and clean the valve. Check the orifice hole in the valve piston, check piston springs, make certain the piston moves freely in the body and has no tendency to stick. Inspect the pressure control cone and seat. Inspect the valve piston and seat.

Relief valves can be controlled remotely by tubing a remote control valve to the vent port on the main relief valve. If you are unable to control the pressure with the remote control valve, disconnect the tubing at the vent connection and install a pipe plug. If you are able to control the pressure with the plug in the main relief valve, the problem is in the remote control valve.

Valves

Pipe line shock is not usually caused by valves shifting at peak pressure. When any shock or vibration is noted, the press should be immediately checked to determine the cause. It will generally be found that adjustment of the chokes on the valve will rectify this condition.

Some of the things that cause trouble on 4-way valves are:

- mechanical linkage sticking
- solenoids malfunctioning
- binding spools due to insufficient clearance between spool and valve body
- scored spools
- oil impurities coating the spool
- unbalanced condition caused by excessive spool and body wear

- improper installation
- broken springs
- lack of pilot pressure.

When a solenoid operated valve is energized, a binding spool will prevent the solenoid from being drawn in against its stop. When the plunger does not seat properly the solenoid will hum or buzz. Also, failure of the plunger to rest against its stop will cause a high current in the solenoid coil, which in turn results in overheating of the solenoid coil. If the binding spool is not corrected, the overheating of the solenoid coil continues and will eventually cause the coil to burn out.

Hydraulic Cylinders

Because of their simple construction, little can go wrong other than worn packing, misalignment, and loose joints.

External Leakage: If leakage is discovered around the end caps, tighten the cap. If this fails to stop the leak, replace the gasket. If the unit leaks around the piston rod, tighten or replace the packing as necessary. Do not tighten the packing gland too tight as this might cause excessive wear, chatter, and friction load.

Internal leakage: Leakage can take place around the piston, resulting in lost efficiency or sluggish movement. This may be due to either worn piston packing, worn piston rings, or scored cylinder walls. The latter is usually caused by abrasive material in the oil.

Misalignment: Piston rods must be in line at all times. Any undue strain because of misalignment will result in excessive wear of the piston or piston rod packing.

Lubrication: Lack of ram lubrication often causes packing to seize, resulting in erratic ram movement.

Burrs: Rams are made of hard and soft ground shafting and can easily be marred by striking with metallic objects. Since burrs will quickly damage packing, they should be removed immediately.

TROUBLE-SHOOTING HYDRAULIC PROBLEMS

In a well-designed, closed hydraulic circuit such as you now have on your Farrel-Watson-Stillman press, hydraulic trouble is minimized if the correct set-up and start-up procedures are followed and periodic maintenance checks are made. These maintenance checks have been listed in the preceding sections of this manual. However, by training the operating and maintenance personnel to IMMEDIATELY REPORT any of the following deviations from normal and BY IMMEDIATELY TAKING REMEDIAL ACTION, most major breakdowns can be eliminated.

Trouble Signs:

- A. Noise in the system
- B. Over-heating oil
- C. Loss of speed
- D. Loss of pressure
- E. Oil leakage

A. Noise in the System

Noise in a hydraulic system can normally be noticed immediately. The noises your operating personnel should watch for and report are as follows:

1. Noisy pumps
2. Pipe line shock and/or vibration
3. Valve slam
4. Ram chatter

The above noises can occur separately or in unison. When they occur separately, it is relatively easy to segregate the offending unit and determine the action necessary to remove the cause. When two or more occur at the same time, the offending unit is harder to trace.

1. Noisy Pumps. A noisy pump is usually the result of one of the following:

- a. Cavitation (lack of sufficient suction volume)
- b. Aerated Oil (suction of air)
- c. Mechanical failure (bearings, bushings, pistons, etc.)

The difference in the noise between a mechanical failure and cavitation or air entrainment is very pronounced, therefore easily distinguishable.

a. Cavitation is caused by a reduction of the volume of oil being drawn into the pump to a volume less than the output of the pump. This creates a vacuum condition in the pump and without sufficient oil to keep all the piston chambers filled, a hammering effect on the pistons is created. This condition is usually caused by closure of the suction line by foreign material or, in the case of an Oilgear "D" style pump, by malfunction of the suction valve.

b. Aerated Oil is usually due to leakage on the suction side of the pump, permitting air to enter the oil lines, or by low oil volume in the tank, allowing the oil to vortex around the suction line, which in turn allows air to be drawn into the pump. The third cause of aerated oil is due to a discharge line discharging above the oil surface or air leakage through packing into main cylinder and then through the prefill valve into the tank.

c. Mechanical Noise can usually be attributed to one of the following causes:

- Natural failure of a mechanical part. This seldom happens as all the units are designed, machined and assembled under very rigid procedures as to material, workmanship and cleanliness.
- Contaminated oil. This is usually the result of poor housekeeping and a poorly organized preventive maintenance system.
- The other causes of this type of failure are usually traceable to failure of the personnel to report changes from the normal before they become major and cause pump failure. Some of these changes are as follows:
 - Overheating of the oil which can directly affect bearing wear and life.
 - Loose tie down bolts on the pump or motor allowing the coupling to misalign.
 - Excessive shock due to pressure peaking and too-rapid decompression.

When any of the above or similar conditions are noticed, the press should be checked out immediately to remove the cause by adjustment, cleaning or replacing of the part found to be the primary cause.

Troubleshooting Tips - Noisy Pumps

Cause: Air leaking into the system.

What to do: Be sure oil reservoir is filled to normal level and that oil intake is below surface of oil. Check pump intake side by pouring oil or applying grease over the connections. If the pump noise stops, you have found the leak.

Cause: Cavitation (the formation of a vacuum in a pump when it does not get enough oil.)

What to do: Check for clogged or restricted intake line. Oil viscosity may be too high. The intake line may be too long.

Cause: Stuck pump vanes, valves, pistons, etc.

What to do: Parts may be stuck by metallic chips, bits of lint, etc. If so, disassemble and clean thoroughly. Avoid the use of files, emery cloth, steel hammers, etc on press surfaces. Products of oil deterioration such as gum, sludge, varnish, and lacquer may be the cause of sticking. Use solvent to clean parts and dry them

thoroughly before re-assembling. If parts are stuck by corrosion or rust, they will have to be replaced. Be sure the oil you are using has sufficient resistance to deterioration and provides adequate protection against rusting and corrosion.

2. Pipe Line Shock and/or Vibration. Pipe line shock and vibration are usually caused by pressure peaking, decompression, and air in the system. When any shock or vibration is noted, the press should immediately be checked to determine the cause. It will usually be found that cleaning and adjusting the cushions on the directional valves, cleaning and adjusting of relief valves and inspection for and correction of any leaks allowing air to enter the system will eliminate this condition.

This pipe line shock and/or vibration quite often accompanies a noisy pump, especially if the pump noise is due to cavitation or aerated oil. By correcting the condition found in the pump, the shock and vibration will be eliminated.

3. Valve Slam. This condition is more difficult to notice as it is often necessary to be close to the valve to hear it. When it is discovered, adjustment of the valve chokes can usually clear up this condition.

4. Ram Chatter. Ram chatter is invariably accompanied by a noisy pump and line vibration. However, due to the noise level, in some plants, ram chatter may be the first symptom to show. When any of the cylinders move with a chatter either in advance or return, an immediate close check should be made to determine the cause. Usually the cause will be found to be one of the causes outlined above for noisy pump and line shock or vibration.

B. Overheating Oil

Overheating of the oil in a hydraulic press can severely shorten the life of all component parts and be a constant source of malfunction and maintenance downtime. The major causes of overheated oil are often the direct fault of the operating personnel. They are:

- lack of water flow through the cooler
- improper operation of the press
- just plain over working of the press.

Any time an extrusion operation demands peak pressure from the pumps over a major portion of the billet length, steps should be taken to change the procedure as to billet heat, billet length or diameter, or number of die apertures. A common fault of many operators is to leave the control handle on either high or full volume during the pressure peaking. This causes a high percentage of the oil to be discharged over the relief valve and thereby causes high heating of the oil. Judicious operation of the press will substantially reduce the heating of the oil -- reduce the volume of the oil to a point corresponding to the flow of metal through the die during. As the pressure drops, the operator can increase the pump volume until the extrusion speed meets the required velocity.

Good operation of a press, with long life and low maintenance, can be obtained if the operating personnel will program all extrusions as to billet heat and billet length. This will allow all breakthroughs to be made at not more than 2900 psi oil pressure and insure against overheating of the oil. Under no circumstances should a press be held at peak pressure with relief valves blowing for more than thirty seconds at the most. It is much better to kill the cycle, reject the billet and start over than to overheat the pump and oil, thereby shortening the expected life of the pumps and valves. If the billet starts to flow during the thirty second period, the volume of oil should be reduced to a point just sufficient to maintain billet flow. Then as the pressure needed for extrusion decreases, the volume can be increased to a point giving normal extrusion speed specified for the section being extruded.

Other causes of overheating of the oil are internal pump leakage, internal cylinder leakage and valve malfunction causing orificing of the valve. Periodic checks of the pump and cylinder leakage should be made. Normally 10 to 12% slippage is acceptable in the overall system. However, if there is 10 to 12% slippage at any one point, it should be rectified. The "D" pump slippage can be checked by blocking the ports, reducing the pressure setting on the relief valves and proceeding as follows:

With the pressure port blocked and the relief valves set at a minimum, start the motor. On the "D" style pumps the pressure valve should now be screwed in with the pump in neutral.

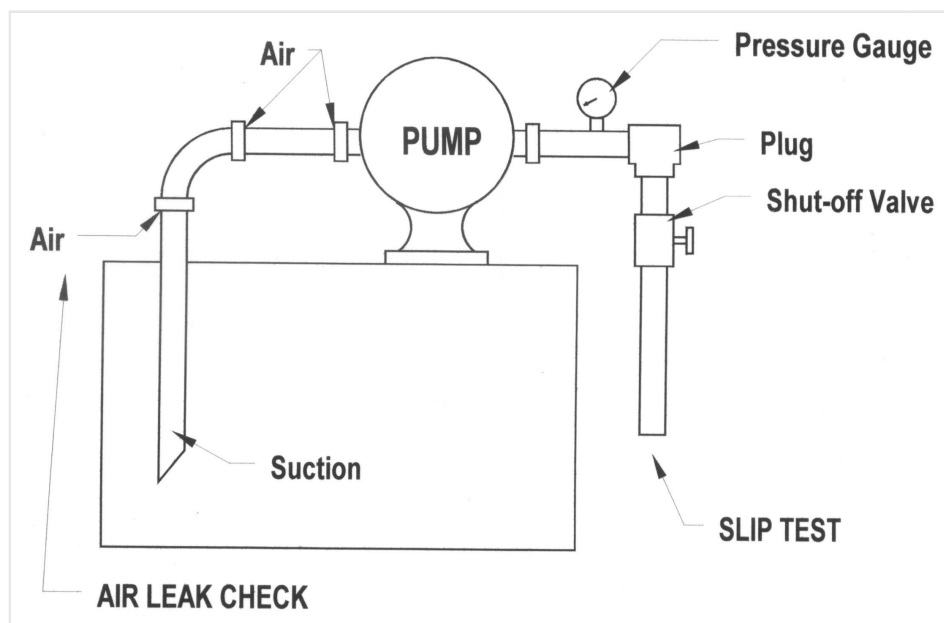


Figure 5-16: Checking Oilgear "D" pumps for slippage.

Then the pump should be stroked slowly off center to determine the amount of stroke needed to give 3000 psi against the blocked port. The percentage of stroke needed to give 3000 PSI will show the percentage of slippage in the pump. On the stroke "tell-tale" or indicator which is built into each pump, there are three lines. The farthest out is marked F, the center is marked 0 and the farthest in is marked F. Between the F and 0 marks the distance is .530". A permissible distance of approximately .050" is normal for 3000 PSI. This

corresponds to 10% slippage. It is suggested that when this distance becomes greater than .050" to .100", steps be taken to replace or recondition the pump. Loss of efficiency of the pump, plus the speeding up of the deterioration of the pump from this point on, can seriously effect the production from the press.

The other pumps on your press do not have a built-in indicator. The best means of checking these pumps is by segregating them from the system and by means of a valve in the line down stream from the relief valve directly measuring the oil flow at 3000 PSI.

To check leakage past piston rings on the cylinders, the press should be put into manual, and the cylinders to be checked stroked fully to the return or in position. By manually holding pressure against the cylinders while opening the air bleed or choke on the end heads of the cylinder, the leakage of oil past the piston rings can be checked. This check is made by catching the oil from the air vent of cushion in a measuring pail and timing the interval for one gallon of flow at 3000 PSI. A leakage of two to three gallons per minute is acceptable; up to five gallons per minute is permissible.

Internal valve leakage is harder to determine. The quickest way to check for this is to check comparative temperatures of the pressure and return line in the case of directional valves and of the pressure and dump line in the case of relief valves. If the return or dump line shows an increase of temperature over the pressure line, you can assume that the valve is leaking. The only time this check will not be accurate is when the press has been operating at peak pressure and the relief valves have been blowing. In this case higher heat in the dump line would be a normal reaction. Of course, this would never be the case if the press is being operated correctly as to pressure and volume as outlined in the section devoted to overheating of the oil.

Troubleshooting Tips - Overheating Pumps

Cause: Oil viscosity too low or too high.

What to do: Check oil recommendations. If you are not sure of the viscosity of oil in the system, it may be worth your while to drain the system and install oil of the proper viscosity.

Cause: Internal leakage too high.

What to do: Check for wear and loose packing. Oil viscosity may be too low.

Cause: Excessive discharge pressure.

What to do: If oil viscosity is found to be okay, trouble may be caused by a relief valve set too high or sticking closed.

Cause: Poorly fitted pump parts.

What to do: Poorly fitted parts may cause undue friction. Look for signs of excessive wear, be sure all parts are in alignment.

Cause: Oil cooler clogged.

What to do: Disassemble oil cooler, remove foreign material around cooler coil bundle.

C. Loss of Speed

Normally one of the foregoing causes of noise and/or overheating will be noticed before any reduction in speed becomes apparent.

Other than the above, the main causes of speed loss are usually attributable to malfunction or non-function of a valve either dumping a pump back to tank or restricting oil flow so that the volume is reduced below that required for the specified speed. This usually is a failure of an electrical component, either a solenoid coil or one of the electrical units commanding the solenoid, such as a relay, limit switch, or timer.

D. Loss of Pressure

Loss of pressure can and usually does follow as a result of any of the foregoing causes of noisy pump, oil overheating, or loss of speed.

Loss of pressure can also be caused by pump slippage, check valves not seating, relief valves venting to tank, or malfunction of a control or directional valve.

Troubleshooting Tips - Pump not Pumping

Cause: Pump shaft turning in wrong direction.

What to do: Run pump in direction as indicated by arrow on housing.

Cause: Pump shaft not turning.

What to do: Check coupling engagement. Check for broken shaft.

Cause: Intake clogged.

What to do: Check intake line from reservoir to pump. Be sure filters and strainers are not clogged.

E. Oil Leakage

All oil leakage except those covered previously will be visible upon inspection of the press during maintenance checks. The caution here is to make sure that leaks are fixed immediately upon discovery and not allowed to increase and become major maintenance problems.

GLOSSARY OF HYDRAULICS TERMS

ACCUMULATOR - a chamber in which a liquid can be stored under pressure and from which it can be withdrawn upon demand.

ACTUATOR – a device for converting hydraulic energy into mechanical energy; typically a motor or cylinder.

AERATION - air in the hydraulic fluid. Excessive aeration causes the fluid to appear milky and components to operate erratically because of the compressibility of the air trapped in the fluid.

AMPLIFIER - a device for amplifying the error signal sufficiently to cause actuation of the stroke control. Several types of servo amplifiers are used at the present time: electronic (DC, AC, phase sensitive, and magnetic) and mechanical.

ANNULAR AREA - a ring shaped area - often refers to the net effective area of the rod side of a cylinder piston, i.e., the piston area minus the cross-sectional area of the rod.

BACK CONNECTED - a condition where pipe connections are on normally unexposed surfaces of hydraulic equipment. (Gasket mounted units are back connected.)

BACK PRESSURE - usually refers to pressure existing on the discharge side of a load. It adds to the pressure required to move the load.

BLEED-OFF - to divert a specific controllable portion of pump delivery directly to reservoir.

BY-PASS - a secondary passage for fluid flow.

CAVITATION - a condition where liquid does not entirely fill the existing space. (Usually associated with pump inlet).

CHAMBER - a compartment within a hydraulic unit. May contain elements to aid in operation or control of a unit. Examples: Spring chamber, drain chamber, etc.

CHANNEL - a fluid passage, the length of which is large with respect to its cross-sectional dimension.

CHARGE (supercharge) –

- To replenish a hydraulic system above atmospheric pressure.
- To fill an accumulator with fluid under pressure (see precharge pressure.)

CHARGE PRESSURE - the pressure at which replenishing fluid is forced into the hydraulic system (above atmospheric pressure).

CHECK VALVE - a valve which permits flow of fluid in one direction only.

CHOKE - a restriction, the length of which is large with respect to its cross-sectional dimension.

CLARIFIER (from JIC Hydraulic Standards) - a device for removing harmful materials which affect the properties of a fluid. A clarifier is usually an auxiliary unit.

CLOSED CIRCUIT - a piping arrangement in which pump delivery, after passing through other hydraulic components, by-passes the reservoir and returns directly to pump Inlet.

CLOSED - a system in which the output or one or more elements is compared to some other signal to provide an actuating signal to control the output of the loop.

COMMAND SIGNAL (or input signal) - an external signal to which the servo must respond.

COMPENSATOR CONTROL - a displacement control for variable pumps and motors which alters displacement in response to pressure changes in the system as related to its adjusted pressure setting.

CONTROL - a device used to regulate the function of a unit (see Hydraulic Control, Manual Control, Mechanical Control, and Compensator Control).

CONTROL PANEL - (See Panel).

COUNTERBALANCE VALVE - a valve which maintains resistance to flow in one direction but permits free flow in the other. Usually connected to the outlet of a vertical double-acting cylinder to support weight or prevent uncontrolled falling or dropping.

CRACKING PRESSURE - the pressure at which a pressure activated valve begins to pass fluid.

CUSHION - a device sometimes built into the ends of a hydraulic cylinder which restricts the flow of fluid to the outlet port, thereby decelerating the motion of the piston.

CYLINDER - a linear motion device in which the thrust or force is proportional to effective cross-sectional area, and the hydraulic pressure acting on it. See: Single Acting Cylinder, Double Acting Cylinder.

DEADBAND - the region or band of no response where an error signal will not cause a corresponding actuation of the controlled variable.

DECOMPRESSION - the slow release of confined fluid to gradually reduce pressure on the fluid.

DELIVERY - the volume of fluid discharged by a pump in a given time, usually expressed in gallons per minute (gpm).

DE-VENT - to close the vent connection of a pressure control valve permitting the valve to function at its adjusted pressure setting.

DIFFERENTIAL CURRENT - the algebraic summation of the current in the torque motor. It is a function of the value of error signal and is measured in MA.

DIFFERENTIAL CYLINDER - any cylinder in which the two opposed piston areas are not equal.

DIRECTIONAL VALVE - a valve which selectively directs or prevents fluid flow to desired channels.

DISPLACEMENT - the quantity of fluid which can pass through a pump, motor, or cylinder in a single revolution or stroke.

DITHER - an alternating signal imposed upon the stroke control in order to reduce the effects of some small non-linearities.

DOUBLE ACTING CYLINDER - a cylinder in which fluid force can be applied in either direction.

DRAIN - a passage in, or a line from, a hydraulic component which returns leakage fluid independently to reservoir or to a vented manifold.

ELECTRO-HYDRAULIC SERVO VALVE - a directional type valve which receives a variable or controlled electrical signal and which controls or meters hydraulic flow.

ERROR (or error signal) - the signal which is the algebraic summation of an input signal and a feedback signal.

FEEDBACK (or feedback signal) - the output signal from a feedback element.

FEEDBACK LOOP - any closed circuit consisting of one or more forward elements and one or more feedback elements.

FEEDBACK TRANSDUCER - an element which measures the results at the load and sends a signal back to the amplifier.

FILTER - a device for the removal of solids from a fluid wherein the resistance to motion of such solids is in a tortuous path.

FLOW CONTROL VALVE - a valve which controls the rate of oil flow.

FLOW RATE - the number of units of volume of a fluid passing by any given point in one unit of time, e.g., gallons per minute (gpm).

FOLLOW VALVE - a control valve which ports oil to an actuator so the resulting output motion is proportional to the input motion to the valve.

FORCE - any cause which tends to produce or modify motion. In hydraulics, total force is expressed by the product P (force per unit area) and the area of the surface on which the pressure acts, $F = P \times A$.

FOUR-WAY VALVE - a directional valve having four flow paths.

FRONT CONNECTED - a condition wherein piping connections are on normally exposed surfaces of hydraulic components.

HEAD - the force exerted by a column or body of fluid due to its height and weight.

HEAT EXCHANGER - a device in which heat is added to or removed from hydraulic fluid.

HYDRAULIC BALANCE - a condition of equal opposed hydraulic forces acting on a part in a hydraulic component.

HYDRAULIC CONTROL - a control which is actuated by hydraulically induced forces.

INTENSIFIER - a device which increases the working pressure over that delivered by a primary source.

LINE - a tube, pipe, or hose which acts as a conductor of hydraulic fluid.

LINEAR ACTUATOR - a device for converting hydraulic energy into linear motion, for example a cylinder or ram.

MANUAL CONTROL - a control actuated by the operator, regardless of the means of actuation. Example: lever or foot pedal control for directional valves.

MAXIMUM PRESSURE VALVE - see relief valve.

MECHANICAL CONTROL - any control actuated by linkages, gears, screws, cams or other mechanical elements.

METER - to regulate the amount or rate of fluid flow.

METER-IN - to regulate the amount of fluid flow into an actuator or system.

METER-OUT - to regulate the flow of the discharge fluid from an actuator or system.

MOTOR - a rotary motion device which changes hydraulic energy into mechanical energy; a rotary actuator.

ORIFICE - a restriction, the length of which is small in respect to its cross-sectional dimensions.

PANEL –

- A group of fluid control units mounted to form one assembly on a plate or in a casting, and having a single mounting surface.
- A plate on which a number of fluid components can be mounted.

PASSAGE - a machined or cored connection which lies within or passes through a hydraulic component and acts as a conductor of fluid.

PILOT PRESSURE - auxiliary pressure used to actuate or control hydraulic components.

PISTON - a cylindrically shaped part which fits within a cylinder and transmits or receives motion by means of a connecting rod.

PLUNGER - a cylindrically shaped part which has only one diameter and is used to transmit thrust.

POPPET - that part of certain valves which prevents flow when it closes against a seat.

PORT - the open end of a passage. May be within or at the surface of a component housing or body.

POTENTIOMETER - a control element in the servo system which measures and controls electrical potential.

POWER PACK - an integral power supply unit usually containing a pump, reservoir, relief valve and directional control.

PRECHARGE PRESSURE - the pressure of compressed gas in an accumulator prior to the admission of liquid.

PRESSURE - the action of a force against a restriction or obstruction. Fluid pressure is a force in the nature of a thrust distributed over an area or force per unit area ($P = F/A$) expressed usually in pounds per square inch (psi).

PRESSURE DROP - the reduction in pressure between two points in a line or passage due to the energy required to maintain flow: may be deliberate.

PRESSURE OVERRIDE - the difference between the cracking pressure of a valve and the pressure reached when the valve is passing full flow.

PRESSURE REDUCING VALVE - a valve which limits the maximum pressure at its outlet regardless of the inlet pressure.

PRESSURE SWITCH - a switch operated by a rise or drop in fluid pressure.

PUMP - a device (or converting mechanical energy into fluid transmission of that energy.

REGENERATIVE CIRCUIT - a piping arrangement for a differential type cylinder in which discharge fluid from the rod end combines with pump delivery to be directed into the head end.

RELIEF VALVE - a pressure operated valve which by-passes pump delivery to the reservoir, limiting system pressure to a predetermined maximum value.

REPLENISH - to add fluid to maintain a full hydraulic system.

RESTRICTION - a reduced cross-sectional area in a line or passage which produces a pressure drop.

ROTARY ACTUATOR - a device for converting hydraulic energy into rotary motion; a hydraulic motor.

SEQUENCE -

- The order of a series of operations or movements
- To divert flow to accomplish a subsequent operation or movement.

SEQUENCE VALVE – a pressure operated valve which diverts flow to a secondary actuator while holding pressure on the primary actuator at a predetermined minimum value after the primary actuator completes its travel.

SERVO MECHANISM (servo) - a mechanism subjected to the action of a controlling device which will operate as if it were directly actuated by the controlling device, but capable of supplying power output many times that of the controlling device, this power being derived from an external and independent source.

SERVO VALVE -

- A valve which controls the direction and quantity of fluid flow in proportion to an input signal.
- A follow valve.

SIGNAL - a command or indication of a desired position or velocity.

SINGLE ACTING CYLINDER - a cylinder in which hydraulic energy can produce thrust or motion in only one direction. (Can be spring or gravity returned.)

SPOOL - a term loosely applied to almost any moving cylindrically shaped part of a hydraulic component which moves to direct flow through the component.

STRAINER - a device for the removal of solids from a fluid wherein the resistance to motion of such solids is in a straight line.

STROKE -

- The length of travel of a piston or plunger.
- Sometimes used to denote the changing of the displacement of a variable delivery pump.

SUB-PLATE - an auxiliary mounting for a hydraulic component providing a means or connecting piping to the component.

SUPERCHARGE - (see charge)

SURGE - a transient rise in hydraulic pressure in a circuit.

SYNCHRO - a rotary electromagnetic device generally used as an AC feedback signal generator which indicates position. It can also be used as a reference signal generator.

TACHOMETER - (AC/DC) - a device which generates an AC or DC signal proportional to the speed at which it is rotated and the polarity of which is dependent on the direction of rotation of the rotor.

THROTTLE - to permit passing of a restricted flow. May control flow rate or create a deliberate pressure drop.

TORQUE - turning effort of a fluid motor usually expressed in inch pounds.

TORQUEMOTOR - an electromagnetic device consisting of coils and the proper magnetic circuit to provide actuation of a spring restrained armature, either rotary or translatable.

TWO-WAY VALVE - directional control valve with two flow paths.

UNLOAD - to release flow, (usually directly to the reservoir), to prevent pressure being imposed on the system or portion of the system.

UNLOADING VALVE - a valve which by-passes flow to tank when a set pressure is maintained on its pilot port.

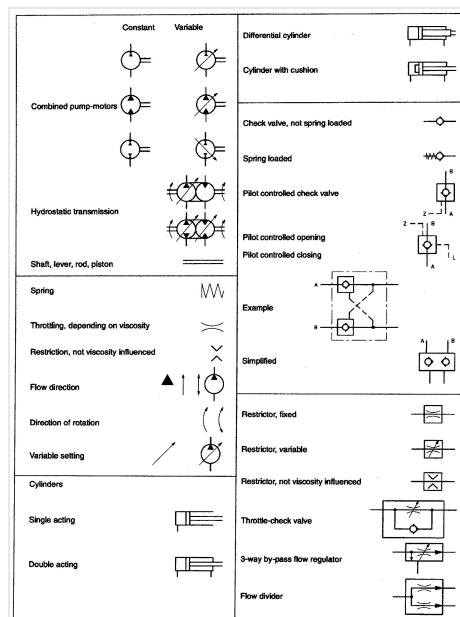
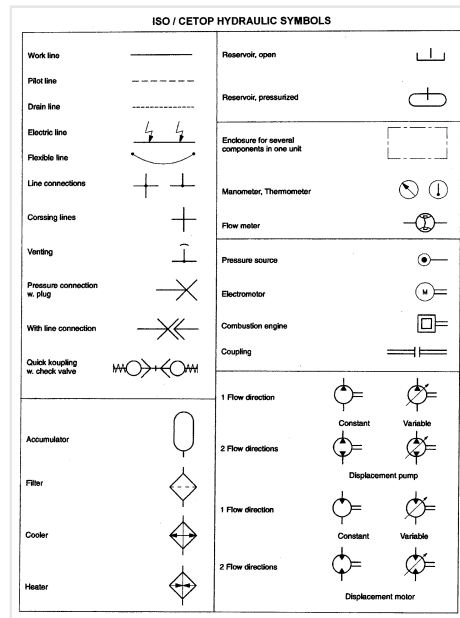
VALVE a device for controlling flow rate, flow direction or pressure of a fluid.

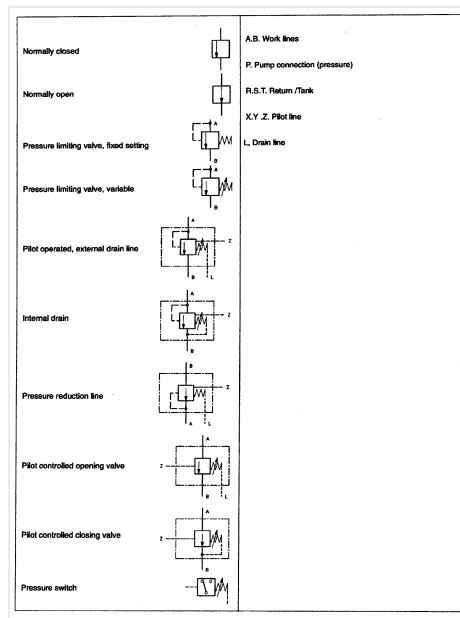
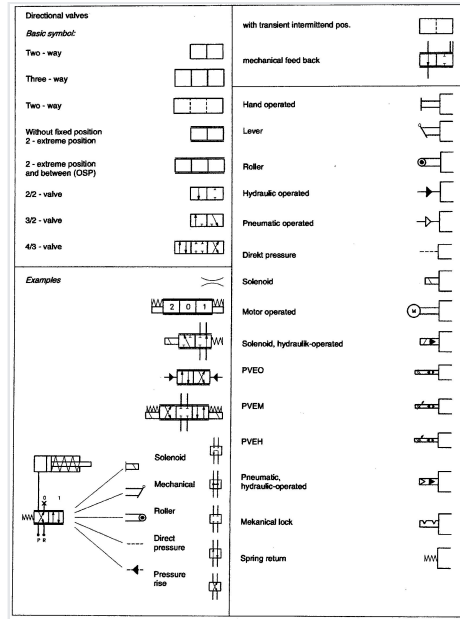
VENT –

- To permit opening of a pressure control valve by opening its pilot port (vent connection) to atmospheric pressure.
- An air breathing device or a fluid reservoir.

VISCOSITY - the measure of resistance of a fluid to flow.

VISCOSITY INDEX - a measure of the rate at which temperature changes cause a change in viscosity.





HYDRAULIC SYSTEM SURVIVAL TECHNIQUES

FOR OILGEAR EQUIPMENT⁵

You may have a new system or one that has been running for years. In either case, there are some parameters in which to stay in order for your Hydraulic System to run long and within specifications. We feel that if your maintenance department understands the requirements our equipment can be installed and will run properly.

This bulletin will describe these Survival Techniques.

A. FLUID

By running a pump with the correct viscosity fluid, the bearings, pistons, and other parts are protected. Viscosity is affected by the viscosity grade and inlet temperature. These requirements are shown in the Fluid Recommendation Bulletin 90000 and Fluid Suppliers Bulletin 90008. Keep in mind that oil tends to retain air when run below 120o F so this is a good operational temperature.

B. CONTAMINATION

It is obvious that if the heavily loaded fluid separating high speed parts contains excessive contaminants, rapid wear will occur. The maximum contamination level defined by the ISO code is shown in the Fluid Recommendation Bulletin 90000 and is explained and correlated to the Oilgear grade in the Filtration Bulletin 90007-D (page 5-41).

It is recommended that the contamination level be determined every 3 months so that you can detect a rise in the level. This might indicate a pending component failure, filters that are not being maintained, or inadequate filtration. If assistance is required, call your Oilgear sales representative. For other periodic checks and tests, refer to Service Suggestions Bulletin 910000.

C. STORAGE

If you have a pump in storage, you want it to perform well whenever it's installed. If the unit is stored for many years and it is not protected, damage can occur. As the pump changes temperature, air is exchanged and moisture can be left inside. After about a year, the rust inhibitor in our test oil may be depleted and rusting can occur. A rusty piston can stick in the cylinder bore causing the destruction of the pump.

We recommend plugging the open holes and filling the pump with fluid as described in Storage Recommendation Bulletin 90006 (page 5-54). Kits can be supplied to prepare your stock unit for long term storage, or a repair or exchange unit can be supplied, prepared, and filled. The pump should then survive an almost indefinite storage period.

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D. SERVICE

While your equipment is running, a routine check of critical parameters will maximize your up-time and minimize operational problems. Our suggestion for items to check on a daily basis and items to check less frequently are shown in Service Suggestions Bulletin 910000. Keep in mind, Oilgear can provide field servicemen who can run the more difficult periodic checks such as system and pump efficiency tests or a periodic tune-up of a more complicated system.

For information on keeping the pumping pistons in contact with the thrust rings in our C and D type pump, refer to Bulletin 90021.

E. REPAIRED OR REPLACEMENT UNITS

If you have had a pump failure, the system is often saturated with debris and a pile of debris can be on the floor of the reservoir just below the pump suction pipe. A repaired pump with tight fits may not be able to tolerate this high level of contamination. Therefore, the system should be cleaned. See Bulletin 90022.

F. EDUCATION

One of your best Preventative Maintenance efforts is in a well trained maintenance staff. By their knowing about the operation and required maintenance of our equipment, you will be assured of proper running and minimum downtime. Call the Oilgear Service Department for information on the Fluid Power or schedule. For an in-plant school, call your local district office or the Milwaukee Service Manager.

G. CAVITATION

Many of the pumps that are returned to the factory for repair show signs of cavitation. The evidence ranges from slightly eroded surfaces to deep irregular cavities. If left uncorrected, it can lead to the early destruction of a pump.

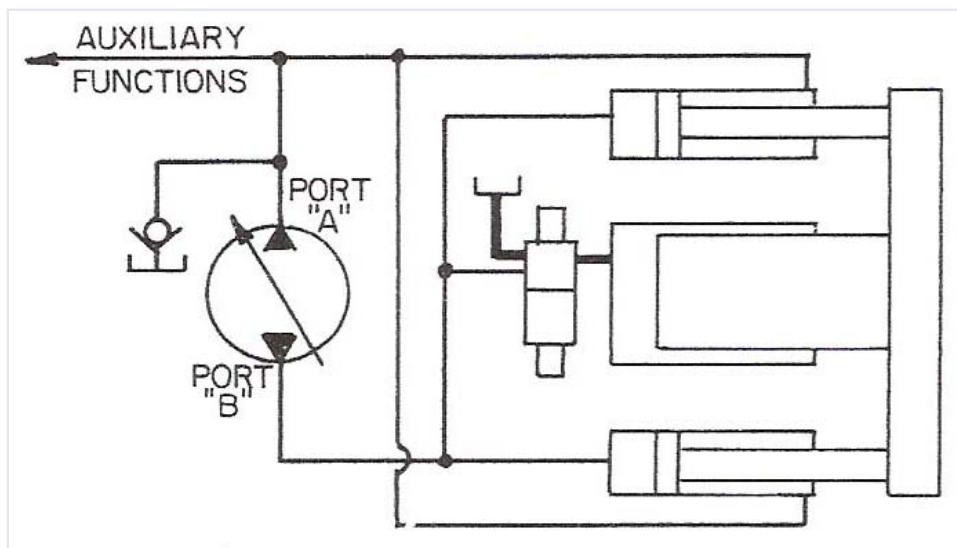
Cavitation occurs when either a void or an air bubble in the fluid is suddenly exposed to high pressure. The pressure causes the void/bubble to collapse at extremely high velocities. When the collapsing void/bubble disappears, the high velocity oil literally runs into itself causing spot pressures that can reach 200,000 psi. Sudden pressures of this magnitude cause noise and eat away at the metal surfaces.

The Solution is to eliminate voids and air bubbles in the oil. Voids occur when high vacuum is present in the suction line. This vacuum causes the entrained air (air that is normally in solution at atmospheric pressure) to come out of solution thus creating a void. Avoid restrictions in the suction lines including strainers, elbows, and pipe reductions.

If the cause was air, the bubble will “diesel” causing oxidation and nitration. This burned fluid will cause the components to become coated with a varnish like material resulting in sticking valves, etc.

Air bubbles can be eliminated by:

- Repairing loose suction pipes.
- Ensuring that all return lines terminate below oil level.
- For presses using two-way pump circuits:
 - repair all leaks in high pressure piping.
 - maintain packing and rod seals on the side cylinders.
- Maintain oil level in reservoir at maximum safe level. Install baffle plates over the tank pre-fill connections. Maintain oil temperatures at or above 120o F.



Besides contamination, cavitation is the most frequently occurring condition leading to catastrophic destruction of pumping equipment. Furthermore, this cavitation is almost always attributable to air ingestion, especially in older systems. The importance of the elimination of air cannot be overemphasized.

Two- Way Pump Circuit Example

During extrusion on "B" port, air can be ingested through:

1. Leaking connections anywhere on "A" port side.
2. Worn rod packing on side cylinders.
3. Low reservoir level.

When delivering at "A" port, air can be ingested through:

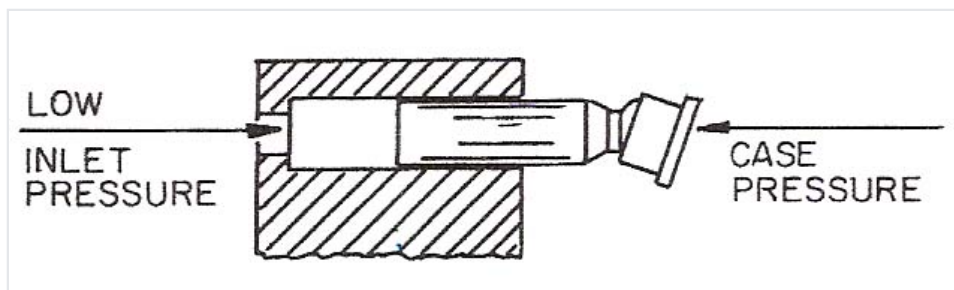
1. Leaking connections anywhere on "B" port side.

2. Worn main ram packing.

H. CASE PRESSURE

Many of our pumps have a drain line that runs from the case back to the reservoir. It is generally important that this line does not combine with other lines, filters, or coolers before it enters the reservoir because excessive case pressure may be created.

In many pumps, if the case pressure is higher than the inlet pressure there can be a net force on the piston that pushes it into the cylinder on the suction side which then slams back on the shoe running surface when it sees high pressure. After doing this for a while, catastrophic damage can occur.



Besides restricted drain lines, high case pressure can be caused by controls that shift suddenly and discharge into the case, directional valves shifting suddenly sending a pulse into the drain line, relief valves that suddenly blow into the drain line, etc. Often, a high speed recorder is required to detect this spike in case pressure because pressure gages are too sluggish.

Large diameter, short drain lines that run directly to the reservoir are the best solution to this problem.

I. PARTIALLY FILLED CASE

Many of our units are designed to run with the case full of oil. If they run partially full, the fluid tends to centrifuge to the outside leaving foam toward the center. The limited lubrication causes parts to overheat and bum up. The impact of moving parts on the foam causes cavitation. The end result can be a pump failure.

Often, about one gpm of oil from an external source into the case is required to keep it full and to flush out the foam. Refer to the pump specifications on your unit or contact your Oilgear salesman for a specific recommendation.

Our C, D, and some A pumps run case empty. They are designed to properly lubricate themselves as the drain leakage falls out of a drain hole in the bottom of the pump. No external lubrication is necessary. An unvented case drain filter is not recommended since it causes the pump to run with the case full.

J. RESERVOIR TEMPERATURE

Fluid Recommendation Bulletin 90000 gives the operational temperature for a variety of fluid viscosities. By keeping the fluid at a fairly steady, reasonable temperature, the system operation should remain uniform.

If an oil-to-water heat exchanger is used and the only control on water flow is a shut-off valve, the oil is often too cold. This oil then tends to retain air causing pump cavitation and spongy operation. For good air release, the oil should be kept at 120o F.

Control is reasonable for a while if an inexpensive, small automatic water regulator is used where a bulb senses oil temperature which works through a capillary to regulate a water valve. These valves lend to stick and then are removed and a shut-off valve is the controller. The larger assemblies, which are very reliable, are resisted because of their cost.

A good solution is to use a thermostat set at 120o F in the reservoir that turns on a solenoid operated shut-off valve in the water line. This reliable assembly will turn on and off through the day, keeping your temperature at a uniform level and allowing your system to run smoothly.

K. EQUIPMENT INSTALLATION

1. New Equipment

Filling - Particular care must be taken when filling the main reservoir. Fluid should be pumped using a portable filter unit having an element with a Beta 10 ratio of at least 15 and a good by-pass indicator. The system should then be flushed with a temporary pump and system filter elements checked and cleaned/replaced as necessary.

Samples - Fluid samples should be taken at various intervals during this flushing procedure to ensure that contamination is being removed and to indicate when the fluid is at its acceptable level. See Bulletin 90000. An ISO contamination level of 18/15 or an Oilgear level of 2 would be a typical maximum.

- After the full flushing run and all piping has been reconnected, the system should be run unloaded for a while to expel any air that has been trapped and the reservoir level rechecked. This will probably involve stroking the cylinders, and in some cases they will also need to be bled. Be aware of any "high" points in the system where air may be trapped.

2. Replacement Equipment

To properly install and start-up replacement equipment so it can run as well as and have the life potential of new equipment, see Bulletin 90022.

3. Piping

For information on piping, refer to Bulletin 90011. The fluid velocity in lines should be slow enough so it doesn't generate excessive heat, line loss, water hammer, or turbulence in a reservoir. A reasonable velocity in pressure lines is 20 feet per second and in suction lines or lines returning to the reservoir is 5 feet per second. The return line can be enlarged near the reservoir to reduce the velocity. To calculate line velocity in feet/second:

$$V = 0.408 \times G / ID^2$$

Where: G = Gallons per minute of pump and ID = pipe or tube inside diameter in inches

4. Unusual Fluids

If your equipment is running near hot parts or equipment, a fire resistant fluid should be considered by you and your insurance company. Our equipment generally has viton seals and the paint is an epoxy; both stand up to a variety of fluids. When you determine the fluid type, contact your Oilgear salesman for a confirmation of the compatibility.

- Phosphate Ester - see Bulletin 90000 Fluid Recommendations for proper viscosity.
- Water Based - see Bulletin 90009, High Water Content Fluid, for our Laboratories Report.
- There are other types of fluids that are less fire resistant, however, that have fewer compatibility problems than a water base or Phosphate Ester fluid. See your fluid supplier and insurance company for a recommendation.

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FILTRATION RECOMMENDATIONS

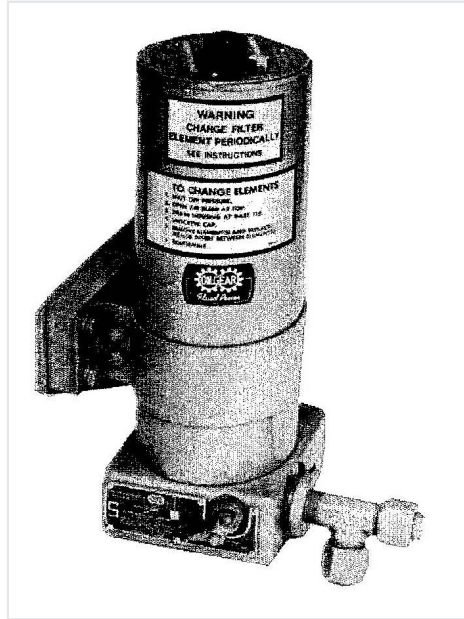
For Oilgear Equipment⁶

PURPOSE

Contaminated hydraulic fluid is the designated culprit more than half of the time when the premature break down of a system component occurs. As a result, customers, distributors, and often we ourselves are skeptical when dirt is blamed for hydraulic equipment failures. Hydraulic systems are constantly ingesting

6. Reference Material Description Bulletin OILGEAR Fluid Recommendations 90000 OILGEAR Piping Information 90011 This Bulletin 90007-D supplied by and used with the permission of: **The Oilgear Company** 2300 So. Reissued: February, 2002

contaminants from the atmosphere, through cylinder rod seals, component wear, piping, and other sources. The object of having a filter in a hydraulic system is to remove dirt at a faster rate than the ingestion rate in order to keep contamination in the fluid at an acceptable level.



Typical fluid filter with by-pass indicator

This publication provides important information concerning filter element ratings, flow requirements, correct placement in a hydraulic circuit, and maintenance.

This document is intended to be a guide; it is current as of the publication date and is subject to change without notice.

DIRT REMOVAL RATING

A number of years ago the filter industry recognized that nominal or absolute micron filter ratings fail to indicate the size of dirt particles that would be removed and that they were also invalid in comparing the capability of elements made by various manufacturers. A standard was written to establish an accurate way of determining how efficiently a filter would remove contaminants from a hydraulic system.

The international standard for rating the efficiency of a hydraulic or lubrication filter was known as the Multi-pass Filter Performance Beta Test. The Beta ratio or rating is determined under laboratory conditions, and the results of the test are reported as a ratio; the number of particles greater than a designated size upstream of the test filter, compared with the number of the same size particles downstream of the filter.

Ref.: ISO 16889

Number of upstream particles > X (c)

Beta-X (c) = -----

Number of downstream particles > X (c)

Where X (c) = particle size

A Beta ratio of 1.0 means that no particles are stopped by the filter. A Beta ratio of 100 (meaning a ratio of 100 to 1) means that for every 100 particles upstream, 99 particles are trapped for every one that gets through, for an efficiency of 99%. (Refer to Table "A")

Table A – Beta Ratio vs. Efficiency

Beta Ratio	Efficiency
1	0
2	50%
5	80%
10	90%
20	95%
75	98.70%
100	99.00%
200	99.50%
1000	99.90%
5000	99.98%

Filter elements are usually specified by nominal or absolute filtration level in $\mu\text{m(c)}$.

Example: B10(c) nominal = 10 μm nominal

B5(c) absolute = 5 μm absolute

The absolute element rating indicates the smallest particle size the media in an element is capable of removing. The nominal rating indicates the average particle size the media in an element will remove.

Note: The filter element Beta rating defines the filter media efficiency only. It does NOT indicate how clean the fluid is. This requires a fluid sample analysis by Automatic Particle Count (APC) or a manual microscopic count.

III. CONTAMINATION STANDARD CHANGES

For several decades, AC Fine Dust (ACFD) has been utilized for primary calibration of liquid particle counters, for filter testing, and for component contamination sensitivity testing. The AC Spark Plug Division of General Motors Corporation originally sold ACFTD, but it is no longer being produced. The obsolescence of ACFTD has led to the adoption of a new test dust and four new ISO fluid power standards that affect filter performance testing, particle counting, and data reporting.

ISO and SAE developed dust to replace ACFTD. This has resulted in a new standard: ISO 12103-1, which defines four different grades of dust. ISO Medium Test Dust (ISO MID), having a particle size distribution close to ACFTD, has been selected as the replacement dust for calibration and testing purposes. However, although similar to ACFTD, ISO MTD dust produces test results that are somewhat different from ACFTD. Therefore, results of both the laboratories' filter performance test (including filter efficiency and dirt holding capacity) and automatic particle counting can be significantly affected. This is only an artifact of the testing; filter performance and actual contamination levels in the field will remain the same as before.

IV. NIST CERTIFICATION OF ISO MTD

The US National Institute of Standards and Technology (NIST) undertook a project to certify the particle size distribution of ISO MTD. The certification of ISO MTD resulted in the establishment of a traceable Standard Reference Material (SRM) as a suspension of known dust in a test fluid. SRM 2806 is the NIST reference number assigned to the test fluid. This standard reference test fluid consists of 2.8 mg/l of ISO MTD suspended in MIL-H-56Q6 fluid. NIST determined that for particle sizes below 10 μ m, the actual particle size is greater than previously measured by APC calibrated with ACFTD. Particle sizes and Beta ratios reported based on NIST determination are represented as X μ m (c), with (c) referring to "certified" calibration and sizes traceable to NIST. Therefore, the new definition of particle size will have an effect on filter performance data and fluid cleanliness measurements. (Refer to Table "B" – Comparison of ACFTD vs. NIST)

V. Filter Media

Media (also referred to as mat) is a term used to describe any material used to filter particles out of a fluid flow stream. The job of the media is to capture particles and allow fluid to flow through. For fluid to flow through, the media must have holes or channels to direct the fluid flow and allow it to pass. As the fluid flows through the media, it changes direction continuously as it works its way through the maze of media fibers. As it works its way through the depths of the layers of fibers, the fluid becomes cleaner and cleaner. Generally, the thicker the media, the greater its dirt holding capacity.

VI. How Filter Media collects particles

There are four basic ways media capture particles. The first, called **inertia**, works on large, heavy particles suspended in the flow stream. These particles are heavier than the fluid surrounding them. As the fluid changes direction to enter the fiber space, the particle continues in a straight line and collides with the media fibers where it is trapped and held.

The second way media capture particles is by **diffusion**. Diffusion works on the smallest particles. Small particles are not held in place by the viscous fluid and diffuse within the flow stream. As the particles traverse the flow stream, they collide with the fiber and are collected.

The third method of dirt particle entrapment is called **interception**. Direct interception works on particles in the mid-range size that are not quite large enough to have inertia and not small enough to diffuse within the flow stream. These mid size particles follow the flow stream as it bends through the fiber spaces. Particles are intercepted or captured when they touch a fiber.

The fourth method of capture is called **sieving** and is the most common mechanism in hydraulic filtration. Sieving takes place when the particle is too large to fit between the fiber spaces.

VII. Typical Factors in Component Life

1. 70% from surface degradation

Mechanical wear from:

- Abrasion
- Fatigue
- Adhesion

2. Obsolescence

3. Accidents

VIII. Sources of Contamination

1. Built in from Components. These are caused during the manufacture, assembly and testing of hydraulic components. Metal filings, small burrs, sand and other contaminants are routinely found in initial clean up filtration of newly manufactured systems.

- Cylinders
- Fluid. Fluid in shipping containers is usually contaminated to a level above what is acceptable for most hydraulic systems. Adding new fluid can be a source of contamination, even though it is fresh from the drum; new hydraulic fluid isn't necessarily clean. Note: Fluid may look clean but it may not be. Remember, the human eye can only see particles about 40 μm in size. We are concerned with particles 5 to 25 μm .

- Hoses
- Pumps
- Hydraulic Motors
- Valves
- Piping
- Reservoir
- Other sources

2. Generated

- System Assembly
- System Break-in
- System Operation
- Breakdown of elastomers. This may be from seals, hoses, accumulator bladders, or other elastomeric products.
- Fluid Breakdown. Water Base fluids tend to support biological growth and generate organic contamination and microbes. This requires special consideration.
- Catastrophic component failure

3. External Ingestion

- Reservoir Breathers
- Cylinder Rod Seals / Packings
- Other Components

Ingested or external contamination comes from the environment surrounding the system, the plant atmosphere. Dirt or moisture can enter the hydraulic fluid supply through reservoir breathers, leaking seals, and cylinder rod seals. Special precautions may be required in particularly dirty environments such as foundries. Use special precautions such as pressurized reservoirs, cylinder rod boots (plain or pressurized), and rod flushing.

4. Introduced during Maintenance

- Disassembly / assembly
- Fluid fill or make-up **Caution: See VIII – item 1 above**
- Replacement of failed components. Failure to protect fluid conductor lines during component repair or replacement and cleaning them before re-assembly will often cause premature catastrophic failure.

IX. Cleanliness Classification Standards

1. ISO 4406:1999. Hydraulic Fluid Power-Fluids-Method for coding the level of contamination by solid particles.

2. Scope. This international Standard specifies the code to be used in defining the quantity of solid particles in the fluid in a given hydraulic fluid power system.

3. Normative references. Normative documents which are referenced in the standard, and which contain provisions of this standard.

a. ISO 4407: 1991. Hydraulic fluid power - Fluid contamination - Determination of particulate contamination by the counting method, using a microscope.

b. ISO 11171:1999. Hydraulic fluid power - Calibration of automatic particle counters for liquids.

c. ISO 11500:1997. Hydraulic fluid power - Determination of particulate contamination by automatic counting using the light extraction principle. This principle is based upon the fact that particles absorb or scatter light in proportion to their size. This changes the amount of light received by the APC photo-detector.

4. Basis of Code

a. APC (ISO 4406:1999). The code for contamination levels is comprised of three scale numbers (Example: 21/18/15) which permit differentiation of the dimension and the distribution of the particles as follows:

- The first scale number represents particles equal to or larger than 4 $\mu\text{m(c)}$ per milliliter of fluid.
- The second scale number represents particles equal to or larger than 6 $\mu\text{m(c)}$ per milliliter of fluid.
- The third scale number represents particles equal to or larger than 14 $\mu\text{m(c)}$ per milliliter of fluid.
- Manual microscopic counting (ISO 4407:1991).
- The code for microscopic counting comprises two scales using 5 μm and 15 μm .
- When applicable, a "*" (too numerous to count) or a "-" (no requirement to count) notation can be included when reporting scale numbers.

Example 1: */18/15 means a sample had too many particles equal to or larger than 4 $\mu\text{m(c)}$ to count.

Example 2: -/18/15 means that there is no requirement to count particles equal to or larger than 4 $\mu\text{m(c)}$.

5. Test value relationships to scale numbers - Refer to Table C

If the scale number value is "greater" by:

1 = 2x the amount of dirt

2 = 4x the amount of dirt

3 = 8x the amount of dirt

4 = 16x the amount of dirt

Etc.

If the scale number value is "less than" by:

1 = 1/2 the amount of dirt

2 = 1/4 the amount of dirt

3 = 1/8 the amount of dirt

Etc.

Refer to Table D for graphical representation of the code numbers

X. System Filtration considerations

It is always better to over-design than under-design a filtration system. The advantages include longer component life and longer intervals between element changes. The initial hydraulic system cost is a one-time expense, while maintenance expenses exist for the life of the equipment.

In general, for most hydraulic systems, preventing contamination from entering the system is much more cost effective than removing it.

The contamination level of a hydraulic system should be checked every three months. More frequent checks may be necessary with synthetic or water base fluids and depending on the plant atmosphere.

There are three important factors that must be considered in a filter circuit:

1. Flow rate

The dirt particle removal rate of a filtration system is a function of the efficiency of the element and the amount of flow passing through it. The contamination ingestion rate determines the flow rate (amount of flow) required. As a general guide:

- a. Non-differential Hydrostatic drives: 30% of high pressure pump capacity
- b. Normal industrial differential system: 30 to 100% of high-pressure pump flow volume capacity.
- c. High differential system operating in a dirty (contaminated) atmosphere: 100 % of high pressure pump capacity used to supercharge the high-pressure pump.
- d. The need for return line filtration

2. Effectiveness in a circuit

A filter in an oil fluid system is more effective with warm fluid, which will have a lower viscosity than cold fluid. Filters equipped with a safety by-pass dirt indicator will often by-pass cold fluid. Therefore, for best results, filters should be placed ahead of coolers in a filtration circuit. OILGEAR recommends that reservoirs be heated to room temperature (65 – 70o F.) to facilitate filtration and pump suction at start-up.

3. Location I placement

It is desirable to locate fillers in the circuit so that the warmer fluid is filtered and the flow is steady state. Independent circulation filtering systems offer several advantages:

- a. The system can run continuously, even while the main pumping system is shut down.
- b. A separate filtering system can be shut down for maintenance without affecting production.
- c. A separate filtering system is available for heating and/or cooling, not only for production, but during idle times as well.

Additional filters are recommended in control circuits to protect a sensitive component.

Filters or strainers in a pump suction line are not recommended. If the inlet pressure drop is excessive, the high-pressure pump can cavitate and cause its destruction.

Filters in the main pump delivery are sometimes necessary. They are expensive because they are large (because they must pass the entire pump flow), they must have a high-pressure rating, and in a two-way circuit there must be additional piping around the filter to prevent back flushing.

In some applications, return line filtration must be incorporated. This flow is difficult to filter because it is "pulsing" flow and is often greater than the main pump flow. Therefore, return line filters must be conservatively sized larger, taking the high "pulsing" flow into account.

XI. System Cleanliness Level Guideline for OILGEAR Systems and Components

- Filter elements with B10(c) = 98.7% Efficiency or better
- Fluid bulk (reservoir) cleanliness target of ISO(c)19/16/13 or better for optimum component life
- ISO(c) 21/18/15 maximum

XII. Water Based and Synthetic Fluids

Water based fluids and some synthetic fluids require special precautions due to their specific properties which include low viscosity and operating temperature limitations (Temperature range is generally 32o F to 120o F).

Reservoir breathers, fluid filters, and their elements must be specifically compatible with water. Fiberglass is often chosen for the filter media itself. The filter element and the housing can be made of steel if HWCF's are used or stainless steel. Base mounted filters can be steel or stainless steel, but regardless, the cap must be stainless steel or electro-less nickel-plated to prevent corrosion due to air trapped in the cover area.

Caution: Water based fluids and some synthetic fluids contain additives, which may filter out if the level of filtration is too fine.

Example: The minimum absolute filtration level for a particular 95/5 HWCF is 8 $\mu\text{m(c)}$. Anti-foaming additives will filter out if 7 $\mu\text{m(c)}$ or finer filtration is used.

Consult the fluid supplier for specific guidance regarding minimum filtration levels for synthetic and water base fluids.

Caution: Fluid conversion from oil to water base fluid: It is best to follow the fluid manufacturer's recommendations.

The conversion procedure usually consists of draining , cleaning, and flushing the system before the new fluid is added. Note: if any residual oil is left in the system it may block the filter element to water base fluid flow. As a result the filter may by-pass and no filtration will take place. Therefore, as a precaution, we recommend that filter elements be monitored and changed frequently for the first 6 months after a conversion from oil to a water based fluid.

XIII. Filter Installations

Many things must be considered to properly install filtration in a hydraulic system. The filter must have a pressure rating that will meet the demands of the circuit. In selecting the filter, peak pressure variations should be determined and a filter with a fatigue rating in excess of this pressure should be selected. The filter must be physically located to minimize external abuse and be physically strong enough to survive normal abuse. The filter must have a dirt indicator and alarm to signal when the element is being by-passed. Since the pressure drop across an element is proportional to the velocity of the fluid, one must consider whether this is an acceptable condition during cold start-up. If cold start-up is accepted, and automatic alarms are used, they should be by-passed with temperature sensitive cut-off during cold starting.

All filters must be physically positioned so they are accessible and can be properly maintained. Hydraulic circuits should be arranged so it is convenient to change the element when the dirt alarm indicates the element is full of dirt and a change is required.

CAUTION! Great care must be taken when replacing dirty filter elements to prevent the entry of contaminants into the filler outlet port, which is locted inside of the housing.

If a filter is "base" mounted, drain the housing first, BEFORE removing the dirty element. This is usually accomplished by opening an air inlet bleed in the top cap and the drain plug at the bottom. Note: This drain port should be located, or piped to relocate it, so the dirty fluid can be drained into a bucket and not onto the reservoir or the factory floor. After the housing is drained of the dirty fluid, wipe the inside clean and replace the dirty element with a clean one and re-install the cap.

When the filter is "top" mounted, remove the filter housing and dispose of its dirty fluid and element. It is important to thoroughly wipe out or flush the housing before re-installation of the clean filter element and housing.

Table B:

Comparison of APC measured particle sizes

(ACFTD calibrated vs. NIST calibration)

Ref: ISO 4406: 1999 (E)

Table C: Allocation of Scale Numbers

Ref.: ISO 4406: 1999 (E)

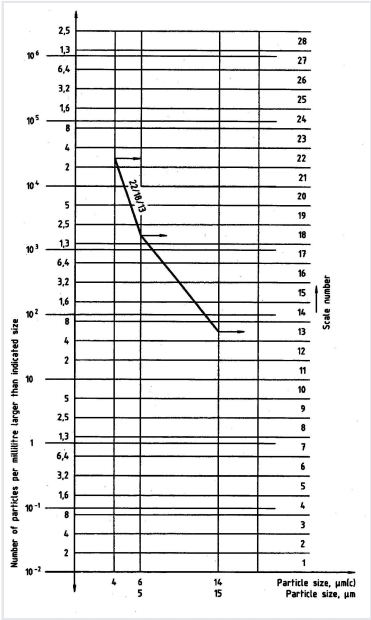
2

Table D – Graphical presentation of the code numberRef.: ISO: 4406: 1999 (E)NOTE Quote scale number at 4 µm (c), 6 µm (c), and 14 µm (c) levels for automatic particle counters, and at 5 µm and 15 µm for microscope counting
--



ACFTD (μm)NIST [μm

(c)]0.84.01.04.22.04.62.75.03.05.14.36.05.06.47.07.710.09.812.011.315.013.615.514.020.017.525.021.230.024.940.031.750.038.2



Number of particles per milliliter:Scale numberMore thanUp to and

including2,500,000>281,300,0002,500,00028640,0001,300,00027320,000640,00026160,000320,0002580,000160,0002440,00080,0002320,00040,0002210

The Oilgear Company

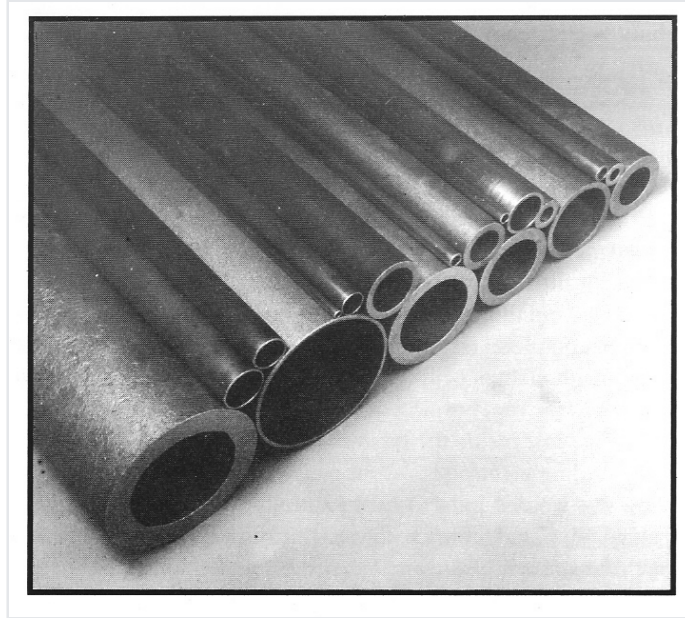
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PIPING INFORMATION

FOR OILGEAR FLUID POWER SYSTEMS⁷

PURPOSE OF INFORMATION:



The primary requirements for piping a fluid power system consist of conductors with the strength to SAFELY handle peak pressures, tubing and fittings in sizes adequate to transmit maximum volumes at reasonable velocities and conductors which are CLEAN and will remain free of contaminants. The designer of piping systems should be aware of the merits and limitations of various conductors and connectors. A study of suppliers' literature will facilitate proper selection and installation. The following printed information is intended only as a guide, is current as of the date of bulletin publication and is subject to change without notice.

I. HYDRAULIC FLUID LINE TUBING

FLARELESS, FLARED AND SELF-FLARING CONNECTIONS: Use the outside diameter size seamless steel tubing (refer to Table "A") with forged steel flareless locking shoulder or self-flaring fittings. Order seamless steel hydraulic fluid line tubing to JIC specifications from supplier warehouse or The Oilgear Company. This tubing is dead soft, cold drawn, clean, oiled and sealed on the ends. Soft, low carbon, steel tubing should be painted or protected against rusting after installation.

7. Reference Material Description Bulletin Fluid Recommendations 90000 Filtration Recommendations 90007 Fluid Supplier Recommendations 90008 This Bulletin 90011-F supplied by and used with the permission of: **The Oilgear Company** 2300 So. Reissued March 1994

II. PIPE OR PRESSURE TUBING

WELDED CONNECTIONS: Where size, pressure, service or mechanical considerations demand, use seamless steel pipe or mechanical tubing (refer to Table "B"). Use butt welded type steel flanges and forged steel fittings. Specific codes may dictate other pipe or tubing materials.

Seamless steel pipe, usually with ASTM specifications A-106, grade B, is available from some supplier warehouse stocks. Cold drawn finish is acceptable, or, if only hot rolled is available, it should be pickled to remove scale. All piping **MUST** be clean and free of scale or corrosion when installed. **AVOID BENDS HAVING A RADIUS SMALLER THAN 12 PIPE DIAMETERS WITH THESE MATERIALS.**

Oilgear uses and stocks cold drawn, annealed, maximum Brinell 135, seamless low carbon steel mechanical tubing (refer to Table "B"). This tubing conforms to ASTM specifications A-519 or to comparable specifications established by Oilgear and suppliers. Use only tubing that is suitable for bending, scale free inside and out, protected with slushing oil against corrosion and has sealed ends.

III. CLEANLINESS

It is desirable to obtain an adequate cleanliness level that will assure uninterrupted operation, eliminate malfunction, accelerated wear or component failures. The required cleanliness level may vary from system to system depending on the contamination sensitivity of the system components, see Fluid Recommendations Bulletin 90000.

SYSTEMS WITH REASONABLY SHORT PIPE LINES: The inside of the pipe or tubing should be bright, clean, free of grease, drawing compounds, oxide scale, carbon deposits and all contamination. Alkaline or petroleum solvents and wire brushing methods should be used to clean the pipe and the ends should be sealed for handling and storage.

Clean each individual piece **BEFORE** assembling into sections. **DO NOT** use rags, waste or other similar substances. Vibrate or tap each individual piece along its entire length to free foreign matter. Dissolve the protective coating on the inside of the pipe with solvent. Once coating is dissolved, drain and blow out with filtered DRY air to thoroughly dry the inside of the pipe.

WARNING!

Always wear safety goggles when using solvents or compressed air. Failure to wear safety goggles could result in serious personal injury.

After fabricating the pipe into sections, each section should be cleaned with wire brushes or equivalent. Be sure each section is absolutely free of saw and file chips, dirt, abrasive, scale, slag, burrs, welding beads, cleaning fluids or other contaminants. Oil the inside of each pipe section and seal the ends. If the pipe section is to be immediately assembled, add filtered fluid and seal the system. Pressure test the system to

locate and eliminate all leaks. Finally, circulate the system fluid through a full flow return line filter until all micronic foreign matter is removed. Install clean filter elements prior to machine or system start-up. To assure long service life, the system must be kept clean.

WARNING!

NEVER attempt to remove or install any hydraulic component while the system is running! Always stop the pump, shut power off and release pressure from the system before servicing or testing. Severe personal injury or death could result if system pressure is not released before servicing or testing.

SYSTEMS WITH LONG PIPE LINES: Special consideration should be given to the design, installation and preparation for service of systems involving long pipe runs, large heavy pipe sections and other unusual conditions. Start with clean tubing that is pickled, oiled and sealed. Keep all foreign matter out including solvents and moist air. Maintain the oil coating inside the tubing until the system is filled with fluid. Pressure test the system to locate and eliminate all leaks. Circulate the system fluid through a full flow return line filter until all micronic foreign matter is removed. Install clean filter elements prior to machine or system start-up.

NOTE:

When large systems are involved, we suggest contacting The Oilgear Company for information and/or assistance in system start-up.

IV. INSTALLATION

Select the shortest path for tubing consistent with flexibility to resist vibrations and relative movement under load strain. Long lines require larger diameter pipe to reduce head loss and shock resulting from sudden velocity changes. Avoid unnecessary "arches" in the tubing. Install air drain cocks or plugs at high points to facilitate system bleeding. Include tees or small auxiliary pipe taps for installation of test gages. All tubing should fit into position without straining. Tubing may be heated to a low temperature over a large area to remove strain. However, tubing must be re-cleaned to remove scale after any heating. Install suitable braces and supports to reduce tubing vibration or strain. DO NOT weld tubing to its support. Protect all tubing from mechanical loads or abuses. When fittings with copper gaskets are removed, anneal gasket to a dark cherry red before reassembly. Elastomeric seals must be removed before any welding is done.

FLARELESS, LOCKING SHOULDER OR SELF-FLARING JOINTS: Follow the manufacturer's instructions. Be sure the tubing is clean and free of burrs or corrosion.

STRAIGHT THREAD JOINTS: The Oilgear Company can furnish flanges suitable for "SAE J514a" straight thread hydraulic tube fittings with o-ring seals when specified by the customer.

ELECTRIC ARC WELDED TUBE JOINTS: Any joint to be welded must be absolutely clean and dry. DO NOT complete the weld with fittings on the unit. If butt welded fittings are used, only tack weld tubes to fittings, then remove the lines from the unit for complete welding. Always support the tubing and fittings with clamps or fixtures. AVOID concentrating heat at any spot to prevent burning the tubing. Over heating can cause excessive scale inside the tubing. Use AWS E71T-1 wire or E 7018 welding electrodes. Root penetration must be complete. Allow the welded joint to cool naturally, DO NOT CHILL. Welded joints and tubing with wall thickness of 3/4 inch or more should be stress relieved and cleaned. If socket welding is used, observe similar precautions. Be sure the weld fills the socket and forms a smooth fillet to eliminate stress concentration. DO NOT weld steel tubing to brass or iron fittings. Remove all scale and slag on or in the tubes and joints prior to assembling.

FLARED JOINTS: If flared connections are required, use only steel fittings with steel tubing and follow the supplier's recommendations. Carefully remove burrs and clean out any saw or file chips or any other foreign matter. Slide the nut on the tubing. The flare should be made with a tool approved by the fitting manufacturer. Make flare the correct length to provide a good seal between the fitting and the nut. AVOID over working the flare end as it tends to harden the metal and subject it to cracking. To avoid distortion of the fitting wall, insert the tubing nut before tightening the fitting in place.

FLEXIBLE HOSE: When there is motion or excessive vibration between two end connections, The Oilgear Company suggests using a hydraulic flexible hose. Follow the supplier's recommendations on size, type, length, minimum bending radii and the method of installation. Bend the hose in one place only. DO NOT twist or place the hose under axial tension. Use tube fittings and adapter unions to relieve excessive strains. Provide sufficient slack to compensate for length changes under working conditions and to avoid flexing or straining. AVOID sharp or excessive bends. Vertical connections prove the most practical.

WATER HEAT EXCHANGER PIPING: Water lines to and from heat exchanger or coolers will sweat easily. If made with steel tubing, they will rust or corrode. Use galvanized pipe or copper tubing to bring cool water to the exchanger and to carry hot water to drain.

Table "A"

SEAMLESS STEEL TUBING

For Flared, Flareless Locking Shoulder, or Self-Flaring Fittings

		Control Pressure To 500 PSI (34.5 Bar)	Control Pressure To 500 PSI (34.5 Bar)	Low Pressure To 1500 PSI (103.4 Bar)	Low Pressure To 1500 PSI (103.4 Bar)	High Pressure To 3500 PSI (241.4 Bar)	High Pressure To 3500 PSI (241.4 Bar)	Ultra High Pressure To 5000 PSI (344.8 Bar)	Ultra High Pressure To 5000 PSI (344.8 Bar)
SAE	NPT	O.D.	Wall	O.D.	Wall	O.D.	Wall	O.D.	Wall

		Control Pressure To 500 PSI (34.5 Bar)	Control Pressure To 500 PSI (34.5 Bar)	Low Pressure To 1500 PSI (103.4 Bar)	Low Pressure To 1500 PSI (103.4 Bar)	High Pressure To 3500 PSI (241.4 Bar)	High Pressure To 3500 PSI (241.4 Bar)	Ultra High Pressure To 5000 PSI (344.8 Bar)	Ultra High Pressure To 5000 PSI (344.8 Bar)
4	1/8"	1/4"	0.035"	1/4"	0.035"				
5	1/8"	5/16"	0.035"†	5/16"	0.035"				
6	1/4"	3/8"	0.035"†	3/8"	0.049"	3/8"	0.060"	3/8"	0.083"Δ
8	3/8"	1/2"	0.035"†	1/2"	0.049"	1/2"	0.083"	1/2"	0.095"Δ
10	1/2"	5/8"	0.035"†	5/8"	0.049"	5/8"	0.095"	5/8"	0.120"Δ
12	3/4"	3/4"	0.035"†	3/4"	0.065"	3/4"	0.109"	3/4"	0.120"Δ*
16	1"	1"	0.065"	1"	0.109"	1"	0.120"		
20	1-1/4"	1-1/4"	0.065"	1-1/4"	0.120"	1-1/4"	0.156"†Δ		
24	1-1/2"	1-1/2"	0.065"†	1-1/2"	0.120"	1-1/2"	0.188"† Δ		

† Not used by The Oilgear Company

Δ Not flareable per SAE J533

* 4500 PSI (310 Bar) Maximum

NOTE: Some of the above items are not stocked by The Oilgear Company

Table "B"

SEAMLESS STEEL PIPE

For Welded Connections

Normal Pipe	To 700 PSI (48.3 Bar)	To 700 PSI (48.3 Bar)	To 2000 PSI (137.9 Bar)	To 2000 PSI (137.9 Bar)	To 3500 PSI (241.4 Bar)	To 3500 PSI (241.4 Bar)	To 5000 PSI (344.8 Bar)	To 5000 PSI (344.8 Bar)
Size	O.D.	Wall	O.D.	Wall	O.D.	Wall	O.D.	Wall
1/8"	---	---	---	---	0.405"	0.068" (1)	0.405"	0.095" (2)
1/4"	---	---	---	---	0.540"	0.088" (1)	0.540"	0.119" (2)
3/8"	---	---	---	---	0.675"	0.091" (1)	0.675"	0.126" (2)
1/2"	---	---	0.840"	0.109" (1)	0.840"	0.147" (2)	0.840"	0.187" (3)

Normal Pipe	To 700 PSI (48.3 Bar)	To 700 PSI (48.3 Bar)	To 2000 PSI (137.9 Bar)	To 2000 PSI (137.9 Bar)	To 3500 PSI (241.4 Bar)	To 3500 PSI (241.4 Bar)	To 5000 PSI (344.8 Bar)	To 5000 PSI (344.8 Bar)
3/4"	---	---	1.050"	0.113" (1)	1.050"	0.154" (2)	1.050"	0.218" (3)
1"	---	---	1.315"	0.133" (1)	1.315"	0.179" (2)	1.315"	0.250" (3)
1-1/4"	---	---	1.660"	0.140" (1)	1.660"	0.191" (2)	1.660"	0.250" (3)
1-1/2"	1.900"	0.145" (1)	1.900"	0.200" (2)	1.900"	0.281" (3)	1.900"	0.400" (4)
2"	2.375"	0.154" (1)	2.375"	0.218" (2)	2.375"	0.343" (3)	2.375"	0.436" (4)
2-1/2"	2.875"	0.203" (1)	2.875"	0.276" (2)	2.875"	0.375" (3)	2.875"	0.553" (4)
3"	3.500"	0.216" (1)	3.500"	0.300" (2)	3.500"	0.438" (3)	3.500"	0.600" (4)
4"	4.500"	0.237" (1)	4.500"	0.337" (2)	4.500"	0.531" (3)	4.500"	0.674" (4)
5"	5.563"	0.258" (1)	5.563"	0.625" (3)	5.563"	0.750" (4)	---	---
6"	6.625"	0.280" (1)	6.625"	0.718" (3)	6.625"	0.864" (4)	---	---
8"	8.625"	0.322" (1)	8.625"	0.906" (3)	---	---	---	---

- Schedule 40
- Schedule 80
- Schedule 160
- XXH

NOTE: The Oilgear Company does not stock all sizes of large heavy wall pipe.

IMPORTANT

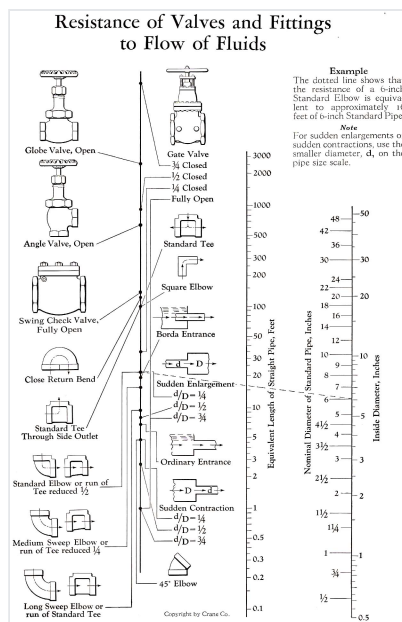
Piping and fittings properly selected and installed can give long and satisfactory service. Defective or contaminated tubing and fittings, improper installation, vibration, repeated severe shocks or mechanical damage may result in serious leakage, breaks, damage or malfunction of hydraulic system components. All these can cost you money in downtime, maintenance and repair costs.

The Oilgear Company

2300 So.

Bulletin 90011 F

Reissued March 1994



INSTRUCTIONS

STORAGE RECOMMENDATIONS FOR OIL GEAR UNITS⁸

PURPOSE OF INSTRUCTIONS

Proper preparation for storage of your OILGEAR pump motor is as important as proper maintenance during usage. The following guideline has been prepared to assist you in correct long term storage procedures for units currently in service which will be put into storage, those already in storage, or those which are shipped by OILGEAR specifically for long term storage. Your acquaintance with these instructions will help you attain satisfactory performance when you unit is placed into service.

PREPARATION - NEW OR RECONDITIONED UNITS:

Units shipped from our factory for long term storage will be fitted with yellow pipe plugs and flanges to seal the units. If the unit is shipped without controls, etc., then covers for control bores, etc., will also be supplied. The unit is then filled with a clean rust inhibitor fluid and shipped to the user. Instructions are provided which show all the plugs and flanges that must be removed before putting the unit into service.

PREPARATION - EXISTING UNITS:

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When removing a unit from service, it should be drained and fitted with pipe plugs and flanges as required to seal it from moisture and contamination. It is suggested that you color code plugs and flanges being installed for easy identification when the unit is returned to service. Any item (plugs, flanges, etc.) installed at the time of storage should also be recorded on an installation drawing or bulletin covering the unit.

FLUID AND FILLING - ALL UNITS:

The customer is responsible for filling the existing unit with appropriate, CLEAN, hydraulic fluid which contains a rust inhibiting additive. By filling the unit with CLEAN hydraulic fluid so it is CASE FULL, you are preventing moisture and contamination from entering the unit during the storage period. Refer to table for correct fill location for your specific unit.

WARNING!

NOT ALL TYPES OF FLUID ARE COMPATIBLE. Special precautions must be taken to assure an existing unit is stored containing the same type of fluid as it is accustomed to using when it is in service. New or reconditioned units should be stored containing a fluid with which it is expected to be used when placed into service. If anything other than a standard petroleum base fluid will be used in service, inform The Oilgear Company so the proper storage fluid can be used.

NOTE!

If the unit will be stored for a period of no more than one year and will be in an environment which is warm, dry and free of atmospheric contamination, it is not necessary to fill the unit with fluid during the storage period.

EXTERNAL PROTECTION - ALL UNITS:

Be sure all chains, bearings, shafts, unpainted surfaces and couplings are well lubricated or covered with a protective grease. Remove breathers if any are installed and replace with appropriate pipe plugs. Breathers may be located on top(s) of unit(s) or reservoir(s). Make certain the unit is well protected from ice, rain or snow.

RESUMING OPERATION - ALL UNITS:

To place a new or reconditioned unit into service, drain storage fluid from the unit and REMOVE ALL YELLOW COLOR CODED PLUGS, FLANGES, ETC., which were factory installed. On an existing unit that was stored, drain storage fluid from the unit and REMOVE ANY PLUGS, FLANGES, ETC., which may have been installed and noted at the time of storage.

Inspect a sample of the drained fluid for rust. If any evidence of rust is found, it is advisable to have the unit disassembled and cleaned before placing it into service. If there is no evidence of rust or water being present, the unit is ready to be placed into service.

IMPORTANT!

Before operating the unit, be sure all pipes, etc., are installed in the proper ports as indicated in the instruction bulletin and/or installation drawing for your particular unit. It is helpful to compare ports (plugged, open or piped) of the unit being replaced with the spare being placed in service. The unit **MUST BE JOG STARTED** prior to release of the unit to production.

ADDITIONAL INFORMATION:

The OILGEAR "Fluid Recommendations" plate attached to the unit specifies the viscosity of fluid and preferred operating temperatures. If no plate is visible, the correct fluid can be determined if the type designation and size of the unit are known. Type designations are stamped on the nameplate attached to each unit. Viscosities for average conditions are listed in Bulletin 90000. Consult your fluid supplier for special precautions to be taken when changing from oil to phosphate ester fluid or phosphate ester to oil. For information on equipment compatibility, operation under unusual conditions or operation with fluids not referred to in the above bulletin consult The Oilgear Company.

TABLE

FLUID FILL LOCATION

PUMPS	LOCATION
"D"	Eyebolt hole in top of pump
"Cft	Eyebolt hole in top of pump.
"DN"	Eyebolt hole in to of pump
"PVL"	Case drain "Port I" in top of unit
"PFL"	Case drain "Port I" in top of unit
"PVS"	Case drain "Port I" in top of unit
"PFS"	Case drain "Port I" in top of unit
"PVV, PVK, PFK	Case drain "Port I" in top of unit
PVWH, PVW, pya, PVZ"	Case drain "Port I" in top of unit
MOTORS	LOCATION
ALL	Case drain hole in top of motor
PREFILL UNITS	LOCATION
ALL	Port 5

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