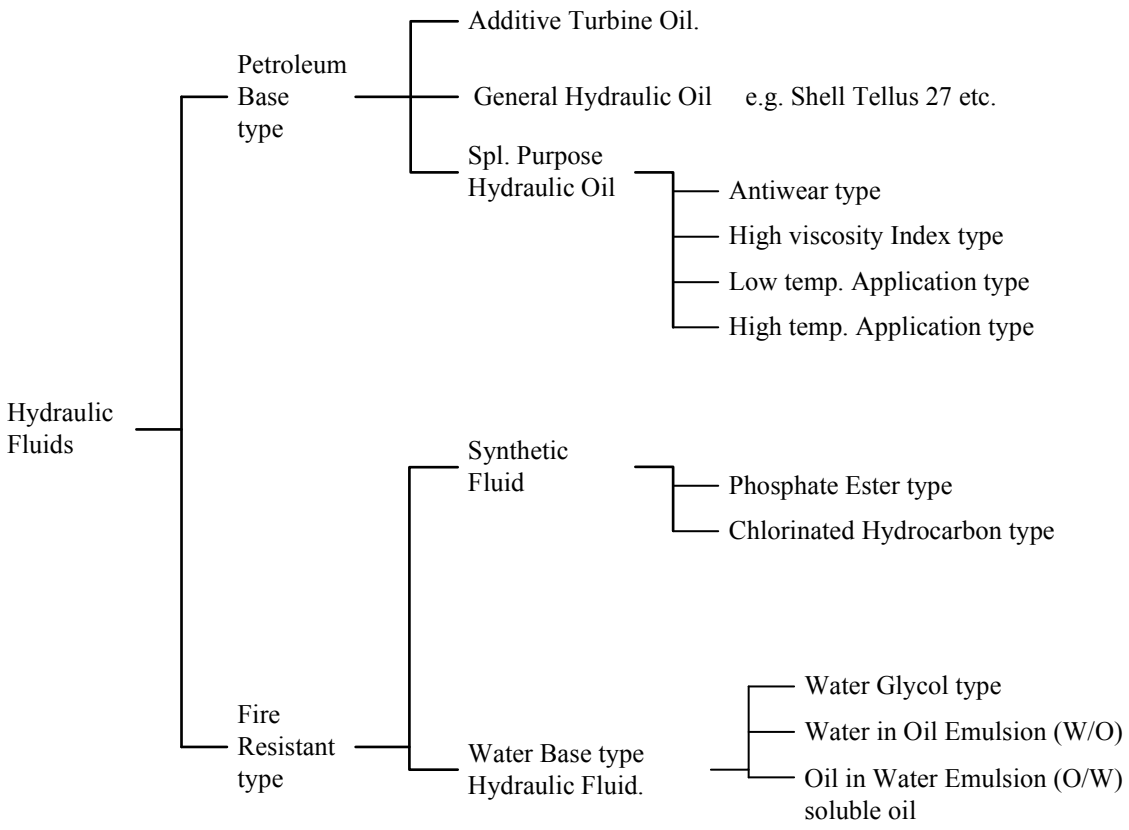
HYDRAULIC FLUIDS

Hydraulic Fluids

Classification and Characteristics :-

Many varieties of oil have been developed for various applications of Hydraulic systems. However, the types given below are widely used in the industry.



Application

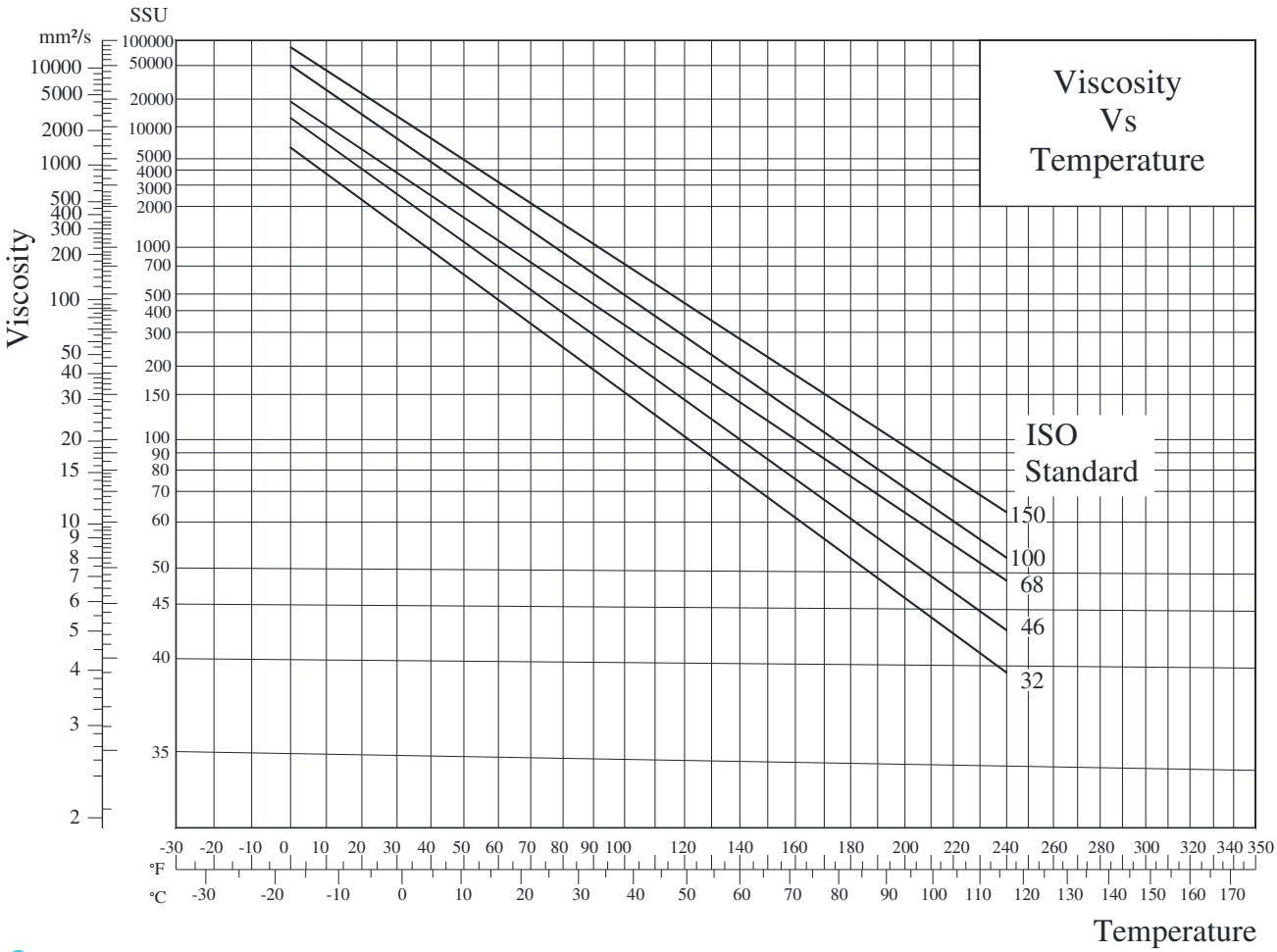
Sl. No.	Classification	Characteristics	Applications
1.	Additive Turbine Oil	Stability at high temp. is good, long life and good performance as compared to ordinary Turbine Oil.	General purpose and/or High temp. applications
2.	General Hydraulic Oil	Economical, stability characteristics, pour Characteristics at low temp. is good.	General purpose and/or moderately low temp. application
3.	Anti-wear type Hydraulic Oil	Wear at high pressure is prevented, stability of characteristics is good.	High pressure and/or High temp. applications.
4.	High Viscosity Index type Hydraulic Oil	Change in viscosity is very small even with change in temp. However, oil life is short.	M/c tools uses due to wide temperature ranges.
5.	Low temp. application Hydraulic Oil	It can be used effectively as low as -30^0C to -40^0C. However, it cannot be used at temp. above 30^0C due to decrease in viscosity.	Specially meant for frozen rooms and/or very low temp. regions.

Sl. No.	Classification	Characteristics	Applications
6.	High temp. application Hydraulic Oil.	It can be used from 80^0C - 100^0C with less deterioration, even for continuous operation. Characteristics are good at above temp. range. Normally, additive Turbine Oil is used for such applications	High temp. application
7.	Synthetic fluids	Lubrication and stability characteristics are good. However, it is costly and affect the sealing material.	High pressure and/or fire resistant applications.
8.	Water-Based type Hydraulic fluids.	Lubrication characteristics are not so good. However, it is economical, as compared to synthetic fluids and does not much affect the sealing materials.	Low pressure and/or Fire resistant applications.

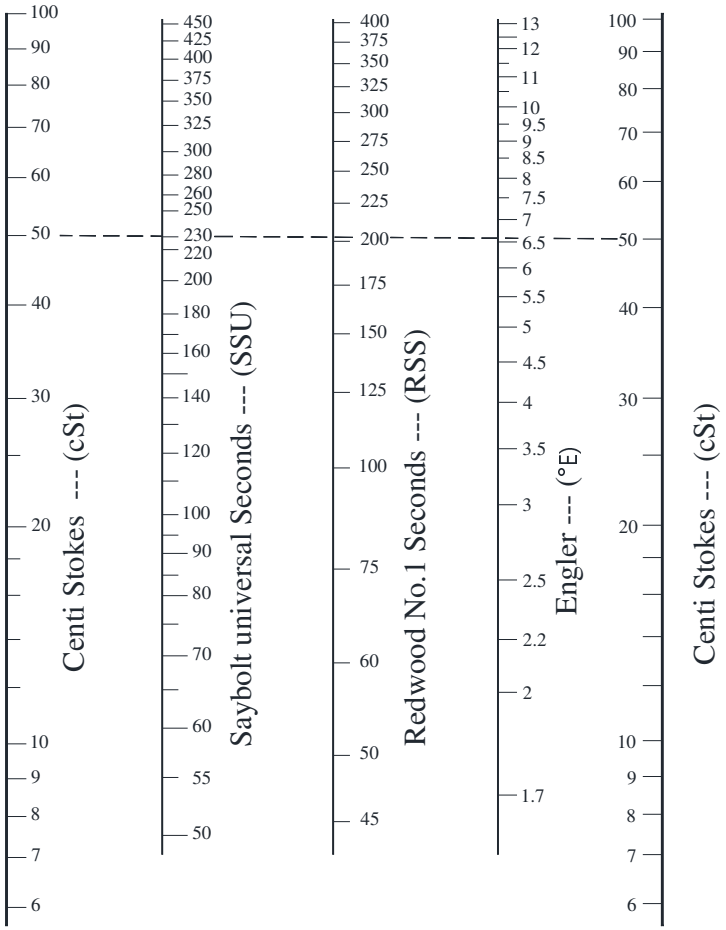
Typical Properties of some Hydraulic Fluids.

Property (Typical Values)	Mineral Oil	Water Glycols	Water-in-Oil Emulsions	Chlorinated Aromatics	Phosphate Esters	Phosphate Esters Blends	Silicones (Improved Types)
Specific gravity	0.86 ~ 0.98	1.060	0.916 – 0.94	1.43	1.275	1.15	0.93 – 1.03
Viscosity (General)	Low– V.High	Low-Medium	Low	Low-High	Low-High	Low-High	Low-High
Typical cSt at 38^0C	22 ~ 44	44	66	32	44	55	---
Viscosity index	70-100	150	---	Low (30-10)	Low (40-50)	Low	High
Flash Point ^{0}C (Typical)	221	None	None	216	260	246	100-150
Flammability	High	Non-Flammable	Fire resistant	Fire resistant	Fire resistant	---	Non-flammable
Max. service temp. ^{0}C	107	65	65	150	150	150	615 – 370 Toxicity
Toxicity	None	None	Slight	Slight	Slight	Slight	---
Comparative lubricity (Bearing load tester)	1.0	4.0	2.3 – 3.0	1.2	1.2	1.2	---
Pump Life	Standard	Comparable at low pressure	Reasonable	Comparable	Comparable	Comparable	Fair to comparable
General lubricity	V. good	Fair	Fair	Good	V. good	V. good	Fair to good
Suitability for roller bearing	V. good	Poor	Fair	V. good	V. good	V. good	---
Compatibility with standard seals	Yes	Poor	Yes	Not Compatible	Not Compatible	Not Compatible	Not Compatible
Suitable seals	Synthetic rubber	Synthetic Rubber	Synthetic Rubber	Special rubber, e.g. Butyl & Silicone	Special rubber, e.g. Butyl & Silicone	Special rubber, e.g. Butyl & Silicone	Special rubber, e.g. Viton upto 230^0C
Corrosion & rust prevention	V. good	Fair	Fair to good	Fair to good	Fair to good	Fair to good	Fair
Effect on standard Paints	None	May soften	None	Not Compatible	Not Compatible	Not Compatible	---
Particular Limitation	Flammable	Poor lubricity	Subject to shear Breakdown	High cost, Not com-patible with mineral oil, seals	High cost, Not com-patible with mineral oil, seals	High cost, Not com-patible with mineral oil, seals	Very High Cost, low bulk modulus
Comparative cost	100	40	150 – 200	700	500	600	---
Comparative weight	100	120	110	150	125	130	---

Viscosity Vs Temperature



Conversion of unit of Viscosity



For Viscosity above 100 cSt, the following formula to be used.

SSU x 0.22	=	cSt
RSS x 0.2435	=	cSt
^{0}E x 7.6	=	cSt

Necessary properties of Hydraulic oil

The properties required are basically classified into two. viz., physical properties required for normal operation and chemical properties required for stability during long term operations. Following are the properties generally required.

1. Suitable viscosity and a preferably high viscosity index.
2. Pouring characteristics
3. Lubrication characteristics
4. Chemical stability of additives
5. Resistance to carbonizing due to heating.
6. Oxidation stability
7. Anti-rust and anti-corrosive
8. High shear strength
9. High degree of demulsibility
10. Anti-foam properties and very low compressibility
11. Compatibility with seals

Generally, additive Turbine Oil or general hydraulic oil available in the market are used widely. In case, spindle oil, cutting fluid or kerosene etc., are used, then this has to be taken into account during selection of Hydraulic equipment and circuit design.

Fire Resistant Hydraulic Fluids :-

These Fluids are used for Hydraulic systems which are likely to be used in hazardous areas, where there is a possibility of the fluid catching fire, if it gushes out of pipes or leaks through while in operation. These fluids have sufficient fire resisting properties, but they have many drawbacks as compared to petroleum base fluids. Hence, a lot of points have to be considered for designing these systems, also during operation and maintenance of these systems.
The characteristics of various types of fire resistant fluids are very much different from each other. Hence, these should be understood and taken care of during application.
For fire resistant fluids, the checking aspects during use are much more important than petroleum base oil. Especially for water base fluids, the life of equipment is much dependent on proper checking of the fluids.

Phosphate Ester Type:

This fluid demands preventing of leakage in the system because of high fluid and system cost and also preventing mixing of external elements/contaminants. Following are the key points for checking.

a). Leakage from pipe lines
b). Clogged Conditions of Stainer and study of clogged particles.
c). Condition of seals
d). Particles floating on upper level of fluids and particles settled at tank bottom.

Water Glycol type:

Suction resistance and evaporation of water affect the systems. Hence, this should be taken care periodically.

a) The condition of filter to be checked once in a week and in case clogged, particles should be removed.
b) Checking the percentage of water in the fluids as water tends to evaporate during use.
c) Checking the contaminants in the tank, both those floating on top as well as those settled at bottom; especially because this fluids does not have good lubrication characteristics.
d) Performance and condition of pressure control valve
e) Mixing of petroleum base oil to be avoided. This can be detected by checking the presence of bubbles on the fluid upper surface.
f) Fluids temp. should be within the recommended range (Approx. -30^0C to 65^0C max)

W/O type Emulsion:

Suction resistance end separation of water from the fluid are likely to affect the system. Hence, they should be taken care of.

a) The condition of filters to be checked once in a week and in case clogged, then clogged partials should be removed
b) Water separation is checked through the drain cock. In case system has not run for more than 1 week, then before starting the pump, the necessary care should be taken.
c) Check the contaminants in the tank; both those floating on top & the settled at the bottom; especially because this fluids does not have good lubrication characteristics.
d) Fluids temp. should be within the recommended range (Approx. 10^0C to 50^0C)

Control of Contamination

Due caution must be paid for maintaining control over contamination of the operating oil which can otherwise lead to breakdowns shorten the life of the unit. Please maintain the degree of contamination with in NAS Grade 10.
The suction port must be equipped with at least a 100 µm (150 mesh) reservoir type filter and the return line must have a line type filter of under 25 µm.

Limit of Contamination

Type of system applications	Required contamination grades			Filtration Grade B_x ≥75
	Acc. To ISO/DIS 4406	Acc. To NAS 1638	Acc. To TGL 28084/46	
Against ultra fine contamination and clogging of sensitive system. Lab. Aviation and astronautics	13 / 19	3 – 4	≤0.05	3
High performance-servo-systems, high pressure system for long life-endurance. Aviation, tool-machineries, steering (controls system)	15 / 11	4 – 6	≤1.0	6
Proportional valves, industrial-hydraulics with high operating-security, high level mobile hydraulics.	16 / 13	7 – 8	≤2	10
Mobile hydraulics, mechanical engineering, medium pressure systems.	18 / 14	7 – 9	$\leq 1_{3m}$	16
Heavy-industries low-pressure system. Mobile hydraulics, water hydraulics.	19 / 15	9 – 11	$\leq 2_{3m}$	25

Counting Method NAS 1638 Standards (Grain quantity: No. of particles in 100 ml of Oil)

Size (µm)	Class													
	00	0	1	2	3	4	5	6	7	8	9	10	11	12
5 – 15	125	250	500	1,000	2,000	4,000	8,000	16,000	32,000	64,000	128,000	256,000	512,000	1,024,000
15 – 25	22	44	89	178	356	712	1,425	2,850	5,700	11,400	22,800	45,600	91,000	182,400
25 – 50	4	8	16	32	63	126	253	506	1,012	2,025	4,050	8,100	16,200	32,400
50 – 100	1	2	3	6	11	22	45	90	180	360	720	1,440	2,880	5,760
above 100	0	0	1	1	2	4	8	16	32	64	128	256	512	1,024

Weight Method

NAS	Class	100	101	102	103	104	105	106	107	108
	mg/100ml	0.02	0.05	0.10	0.3	0.5	0.7	1.0	2.0	4.0
MIL	Class	A	B	C	D	E	F	G	H	I
	mg/100ml	Less than 1.0	1.0~2.0	2.0~3.0	3.0~4.0	4.0~5.0	5.0~7.0	7.0~10.0	10.0~15.0	15.0~25.0

Limit of Water Content

Applicable conditions	Limits
Fluid becomes milky with water contained	To be replaced immediately
Systems in which operating fluid circulates and returns to reservoir and which are not to be stopped for a long period of time.	1000 ppm
Systems with long piping lines in which operating fluid in circuits does not completely circulate.	500 ppm
Systems to be stopped for a long period of time (safety systems) of systems in which operating fluids in circuits moves little and precision control systems.	300 ppm
Permissible values for non-additive fluids are 1/2 of the above values respectively. 1 ppm = 1/1,000,000 Parts.	

- System and Paper element micron ratings

Applicable System	Paper element ratings
General hydraulic systems	30µm
Servo-valves or systems using filters under 10µm	5 µm
Systems controlling micro-flow rate with solenoid valves or flow control valves and systems using components with sliding parts of less than 15µm diametrical clearance.	10 µm
Test stands of hydraulic components and systems	10 µm

Hydraulic Oil for YUKEN Elements

Recommended Fluid Viscosity and Temperature

Use under conditions where the viscosity and temperature of the hydraulic fluid remain in the ranges as indicated in the following table.

Sl. No.	Name	Viscosity Range cSt	Temperature Range ^{0}C
1.	Piton Pumps	20 ~ 400	0 ~ + 60
2.	Vane Pumps [Low Start - up at 600r/min.]	20 ~ 400 100 (max.)	0 ~ +70
3.	Gear Pumps	10~100	0 ~ + 60
4.	Pressure Controls	15 ~ 400	-15 ~ + 70
5.	Flow Control Valves Flow Control and Check Valves Feed Flow Control	20 ~ 200	-15 ~ + 70
	Throttle and Check Valves Deceleration Valves Deceleration and Check Valves	15 ~ 400	-15 ~ + 70
6.	Directional Controls	15 ~ 400	-15 ~ + 70
7.	Mobile Control Valves		-20 ~ + 80
8.	Modular Valves	15 ~ 400	-15 ~ + 70
9.	**Electro Proportional Valves** Pilot Relief Valves Relief Valves Relieving and Reducing Valves Flow Control Valves Flow Control and Check Valves Relief and Flow Control Valves Directional and Flow Control Valves Direct Operated Directional and Flow Control Valves	15 ~ 400 20 ~ 200	-15 ~ + 70
10.	Actuators	10 ~ 400	0 ~ + 60

Brands

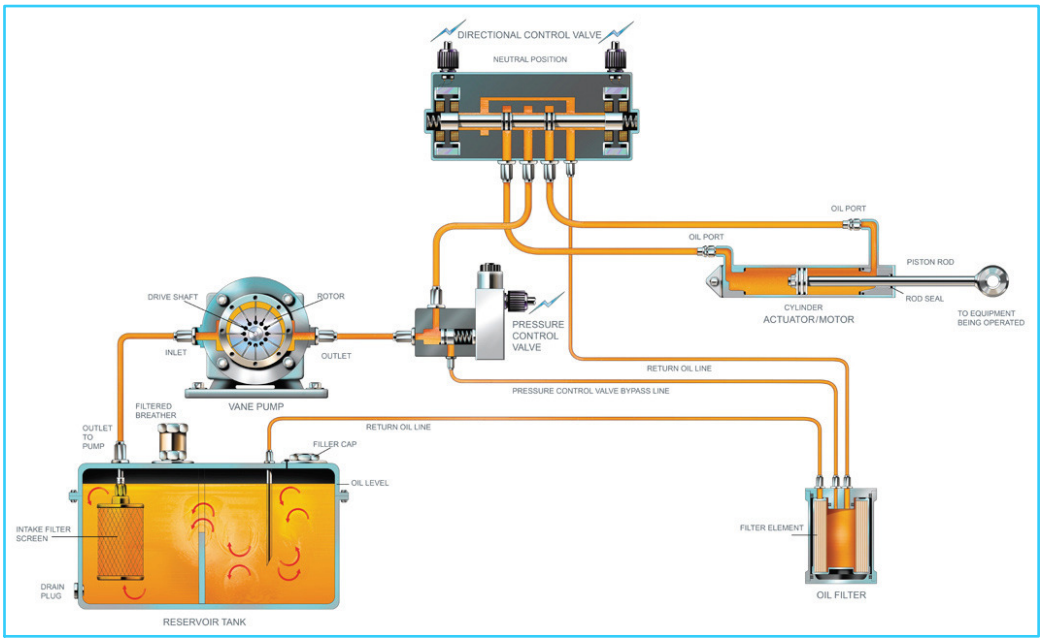
The table below gives the equivalent brand names for various Grades of petroleum based hydraulic oil generally used.

		Name of Manufacturer					International Equivalent	
Grade of Oil	ISO Standard	IOC	BPC	HPC	Chemoleums	Gulf Oil	Mobil	Shell
		Anti Wear type						
3	VG 32	Servo System - 32	Hydrol 32	Enklo 32	Erato – AW– 32	Harmony AW32	DTE 24	Tellus 32
4	VG 46	Servo System - 46	Hydrol 46	Enklo 46	Erato – AW– 46	Harmony AW46	DTE 25	Tellus 46
5	VG 68	Servo System - 68	Hydrol 68	Enklo 68	Erato – AW– 68	Harmony AW68	DTE 26	Tellus 68
		Improved Antiware type additive added						
3	VG 32	Servo System HLP - 32	Hydrol HLP - 32	Enklo HLP - 32	Erato – HD– 32	Harmony AW32	---	---
4	VG 46	Servo System HLP - 46	Hydrol HLP - 46	Enklo HLP - 46	Erato – HD – 46	Harmony AW46	---	---
5	VG 68	Servo System HLP - 68	Hydrol HLP - 68	Enklo HLP - 68	Erato – HD – 68	Harmony AW68	---	---

Hydraulic System Care & Maintenance

Background

Hydraulic machines power the moving parts of many kinds industrial machines by applying the force of a fluid under pressure. Some systems are very small, simple and straight-forward to very large, high pressure systems with a complex array of servo valves and pumps. No matter the size or complexity, proper maintenance of both the system and the hydraulic oil is crucial in maximizing uptime and reducing repair costs.



Hydraulic Fluid Care

Hydraulic fluids are the life blood of the hydraulic system. The hydraulic fluid transmits pressure and energy, seals close-clearance parts against leakage, minimizes wear and friction, removes heat, flushes away dirt and wear particles, and protects surfaces against rusting. Conventional petroleum (mineral) oils are normally used in hydraulic systems, but fire-resistant, synthetic, and biodegradable fluids are used in other situations.

There are four key objectives that are essential in gaining optimum service life of hydraulic fluids:
Control the Temperature — Heat develops in the fluid as it is forced through the pumps, motor tubing, and relief valves. In conventional systems, excessive temperatures will oxidize the oil and can lead to varnish and sludge deposits in the system. Conversely, running the temperature too low will allow condensation in the reservoir and increase the likelihood of pump cavitation.
Typical industrial hydraulic system temperatures often range between 43°C to 65°C. Selection of the proper grade of hydraulic oil is critical to ensure cold start, high temperature protection and to obtain the optimum system efficiency. Keep systems which operate on a water based fluid below 60°C to prevent the water from evaporating. The deposits caused by oil degradation can plug valves and suction screens and cause high-tolerance servo valves to seize and/or operate sluggishly. To allow heat to radiate from the system, keep the outside of the reservoir clean and the surrounding area clear of obstructions.
Make sure the oil cooler is functioning properly and keep air-cooled radiators free of dirt. Normal temperature drop for most oil coolers is 12°C to 15°C. Reservoirs should be filled to the proper level to allow enough fluid residence time for the heat to dissipate and to shed water and dirt. In modern equipment using servo valves, oil degradation can be even more damaging. High pressure (up to 280 Kgf/cm^2), high temperatures, and small reservoirs stress the fluid. With minimal residence time and high pressures, entrained air bubbles can cause extreme localized heating of the hydraulic fluid. This results in nitrogen fixation that, when combined with oil oxidation, can form deposits which will plug oil filters and cause servo valves to stick.

Keep Systems Clean — Even new systems may be contaminated and should be cleaned before use. Prevent contaminants such as dirt, water, cutting fluids, and metal particles from entering the system around the reservoir cover, openings for suction and drain lines, through breather fill openings, past piston rod packing, and through leaks in pump suction lines.

Keep the Fluid Clean — Keeping hydraulic fluids clean begins with good storage and handling practices. To prevent contamination before use, store new fluid in a protected area and dispense it in clean, dedicated containers. Clean the fill cap before removing it to add hydraulic fluid. On critical NC systems, use quick disconnect hoses and filter all oil added to the reservoir through a 5 micron filter.
Full-flow filters designed into the system keep the fluid clean while in service. These filters are often forgotten and go into bypass mode, thus allowing dirty oil to circulate. Inspect fluid filters frequently and change or clean them before they go into bypass mode. Portable filters will supplement permanently installed filters and should be constantly rotated from system to system **regardless if you think the system requires filtering or not.**
Systems should be filtered long enough to pass the total volume of oil through the filter at least 10 times.
Portable filters should be used when transferring new oil from drums or storage tank to a system-especially for NC machines.
Keep an Oil Analysis Program — Generally system hydraulic oil should be drained annually. However, with an effective oil analysis program, you can safely increase that interval while at the same time provide yourself with an "early warning" of possible mechanical problems. At minimum, check your critical and large volume hydraulic systems at least annually by oil analysis. Semi-annual or even quarterly sampling intervals may be required for extremely critical machines.

Hydraulic System Care

Hydraulic system maintenance is just as important, and directly related to, hydraulic oil maintenance. All the filtering and analysis done on a hydraulic oil would be meaningless and futile if the system itself is in a shambles.
A 10 Point Check — A lubrication technician or operator responsible for hydraulic system maintenance should, at minimum, perform the following 10 point checklist as part of a routine weekly "quick scan" of a hydraulic system:
1. Check fluid levels. Add oil (if needed) via portable filtration (if available). DO NOT MIX OILS! Use the same oil brand and viscosity grade that is being used in the system.
2. Inspect breather caps, breather filters and fill screens -DO NOT punch holes in screens in order to expedite adding oil.
3. Check filter indicators and/or pressure differential gauges.
4. Visually inspect all system hoses, pipes, pipe connections for leaks and frays. Hydraulic fluid leakage is a common problem for industrial systems. Excessive leakage is environmental and safety hazard, increases waste streams and oil consumption and if ignored, can reduce the system capacity enough to overheat the system.
5. Check system temperature via built-in thermometers or hand-held infrared detectors. Normal temperature range for most systems is 43°C to 60°C. If temperatures are high, check cooler operation and relief valve settings.
6. Visually inspect inside of the reservoir for signs of aeration (via the fill hole using a flashlight). Aeration is a condition in which discrete bubbles of air are carried along in the stream of oil as it enters the pump. Visual signs of aeration in the reservoir are generally foaming and/or little whirlpools taking small gulps of air into the suction strainer. Causes of aeration include: low fluid levels, air leaks in the suction line; low fluid temperature; fluid is too viscous to release air or maintain suction at the pump, or faulty shaft seals. When air leaks are suspected on the suction line, smothering these points with oil will usually pinpoint the leaks by creating a marked change in pump noise. A pump ingesting air sounds as if it were gargling marbles.
7. Listen to the pump for the signs of cavitation. Cavitation is slightly more complicated than aeration, but bares some similarities. Cavitation occurs when air is released from the hydraulic oil during momentary depressurization at the pump suction and then imploded onto metal surfaces upon discharge. These implosions are extremely destructive to pump surfaces. A cavitating pump will emit a high-pitched whine or scream. Causes of cavitation are the same as those of aeration with the exception of suction side air leaks. How do you discern aeration from cavitation? One way is to install a vacuum gage on the suction side and make sure the pressure is equal too or greater than that prescribed by the pump manufacturer. Foaming in the reservoir is usually the telltale sign of aeration.
8. Inspect a small sample of fluid for color, signs of contamination and odor. Keep in mind that visual inspection is limited in that it will only detect signs of excess contamination.
9. Scan electrically controlled servo valves with an infrared thermometer. High valve and solenoid temperatures (over 65°C) usually indicate the valve is sticking.
10. Scan the electric drive motor for housing hot spots and rotor bearing temperatures using an infrared thermometer.

Fluid Change-Out Recommendations

These are the proper steps to follow when changing the hydraulic fluid in a system.

1. **Drain the system while the fluid is hot to keep contaminants in suspension.
2. Empty fluid from cylinders, accumulators and lines that might not drain properly.
3. Mop, siphon, or pump out oil left in the reservoir.
4. Wipe reservoir clean with lint free rags and remove rust and free paint.
5. Replace or clean filter elements, strainers and clean filter housings.
6. Refill the system with new fluid making sure to vent high points.
7. Restart and check system for proper operation.

**For systems that exhibit high deposit, sludge and/or varnish formation: a petroleum based cleaner (such as Mobil System Cleaner) may be required. Follow manufacturers recommendations.

Safety Precautions

Hydraulic systems operate under very high pressures. Shut the system down and relieve system pressure before opening any part of the system that is under pressure. Do not allow spray from any high pressure leak to contact any part of the body, as serious injection injuries may result. Pumps, valves and motor may become hot; be cautious of incidental contact between bare skin and hot surfaces. Keep hands and clothing away from moving parts of the system.

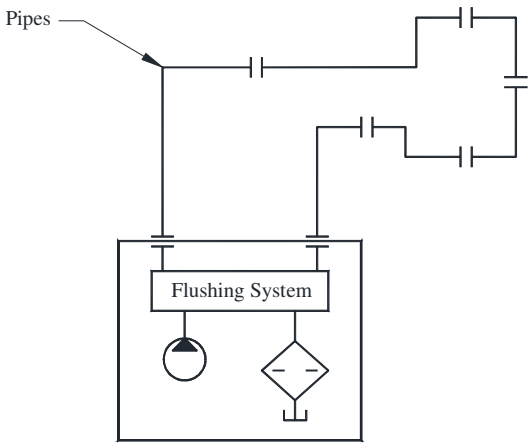
Flushing of Hydraulic System

When the customer requires flushing procedure, the following information should be collected.
1. Application & outline of the hydraulic system. (E.g. Pumping Unit, No. Of Valve stands and Accumulator stands)
2. Type of pipes & fittings used. (E.g. Crimping type, Weldon type, Flanges)
3. Material size & length of the pipe used to connect from pumping unit to Accumulator, Valve Stand and Cylinders.

Purpose

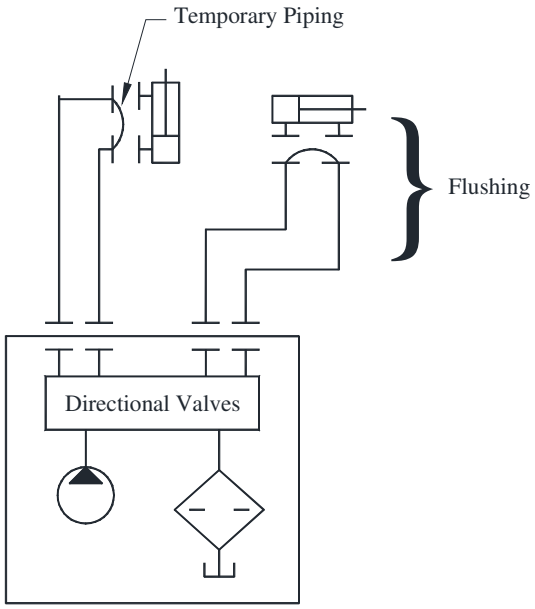
1) The main purpose of the flushing is to eliminate sludge, varnish, debris and contaminated or degraded fluid from pipes and other internal surfaces and system dead spots. This contamination may arise at the time of welding at stock or due to corrosion. This prevents failure of components and system.
2) Before assembling at the main system, initially all the pipes should be clean. If it is not clean, remove pipes from main system and apply for acid treatment and off line flushing. It prevents main system from large amount of contamination.

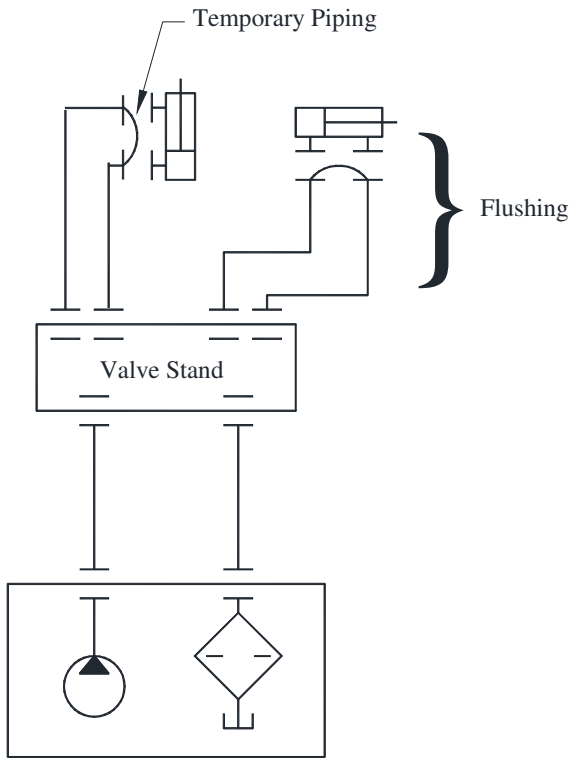
Fig. shows outline of offline flushing for pipes using offline flushing unit.



Preparation Before Flushing

1) Use VG32 oil as flushing medium for best result. If VG32 is not available use system oil.
2) Filter element should be 10µm or 25µm also advisable but it may take long time for complete flushing.
3) Use 3nos. filters for each unit.
4) Use kerosene as cleaning medium.
5) Use tray for collecting oil to clean small components.
6) Use sponge rubber to absorb the oil from surfaces, do not use ordinary cloths.





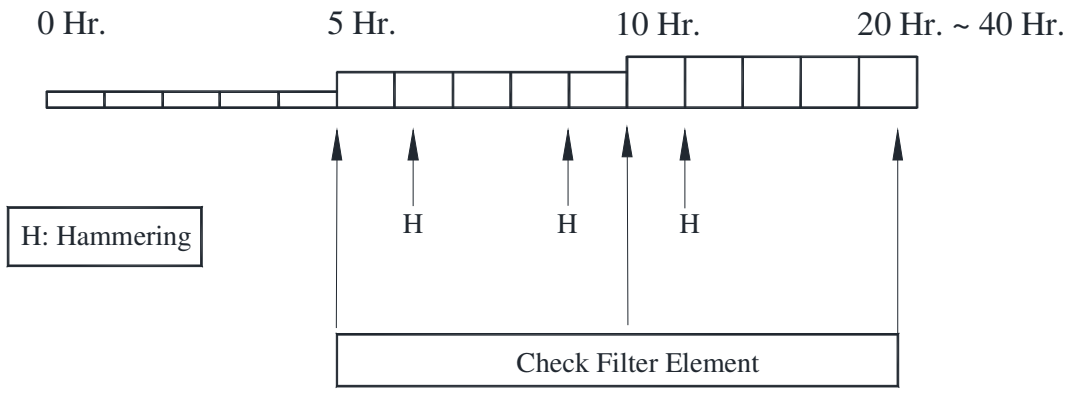
Flushing Method

1) Flushing has to be done for each cylinder pipe one by one.
2) Flushing Hour: 10hr ~ 40hr.
3) Hammering has to do on the pipes while flushing each pipe.
4) Check the oil status.
5) Final check and finishing.

Flushing Process

1) Fill the Recommended oil to tank and the volume of the oil should be equal to 1/3rd of tank volume, total pipe volume and cylinder volume.
   Total oil required = (Tank volume x 1/3) + (Pipe Volume) + (Cylinder volume)
2) Confirm the status of all Return line filters i e. clogging indicator, micron ratings etc.
3) Keep main relief valve at full opening.
4) Run the Pump.
5) Set the Pressure at 20 Kgf/cm^2 at main relief valve.
6) Change the directions of flow by operating directional valve by mechanically or Electrically.
7) Check oil leakages at all connecting Points.
8) Once again check oil level in the tank.

Time Chart For Flushing



As time chart shows keep on hammering and check filter element at indicated points.
If any contamination is not found in filter element stop the flushing process and finish.
If it is found, continue the flushing process.