Choosing the Right Hydraulic Fluids

Jayanta Ray explains the importance of selecting the right hydraulic fluid to protect the equipment in challenging conditions.

When it comes to hydraulic fluids, the operating practices of yesterday are long gone. Today the pressure is on hydraulic systems. Hydraulic systems are expected to deliver optimum performance while operating under higher pressures, higher temperatures and tougher operating conditions.

Selection of right hydraulic fluids hence becomes important to protect the equipment in challenging conditions for longer periods through:

- Thermal and oxidation stability
- Excellent wear control
- System efficiency

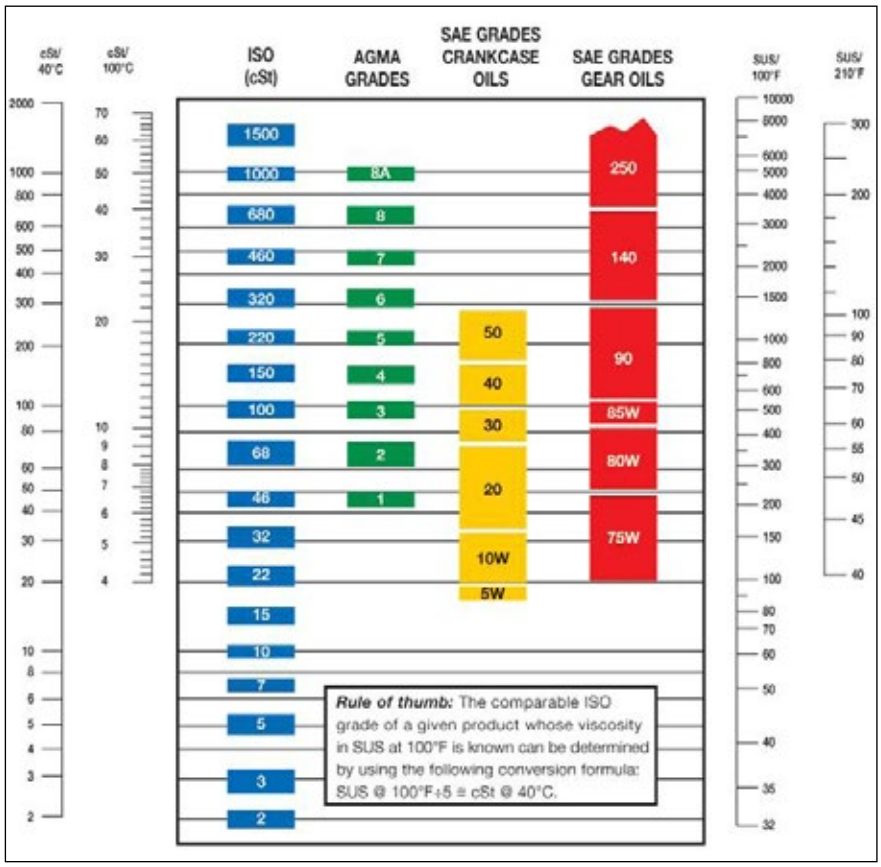
Understanding hydraulic fluid

In order to choose right hydraulic fluid, we need first understand the few important points related to hydraulic fluid. Hydraulic fluid is the medium of power transfer in hydraulic equipment, it is important to know the properties of hydraulic fluids and its influence on system performance. There are different types of fluids based on their availability,

Table 1: ISO viscosity grades based on kinematic viscosity (centistokes/c St) at 40°C

ISO VG	Minimum [cSt]	Maximum[cSt]
2	1.98	2.42
3	2.88	3.52
5	4.14	5.06
7	6.12	7.48
10	9	11
15	13.5	16.5
22	19.8	24.2
32	28.8	35.2
46	41.4	50.6
68	61.2	74.8
100	90	110
150	135	165
220	198	242
320	288	353
460	414	506
680	612	748
1000	900	1100
1500	1350	1650

Table 2: Conversion chart from ISO VG to AGMA and SAE grades



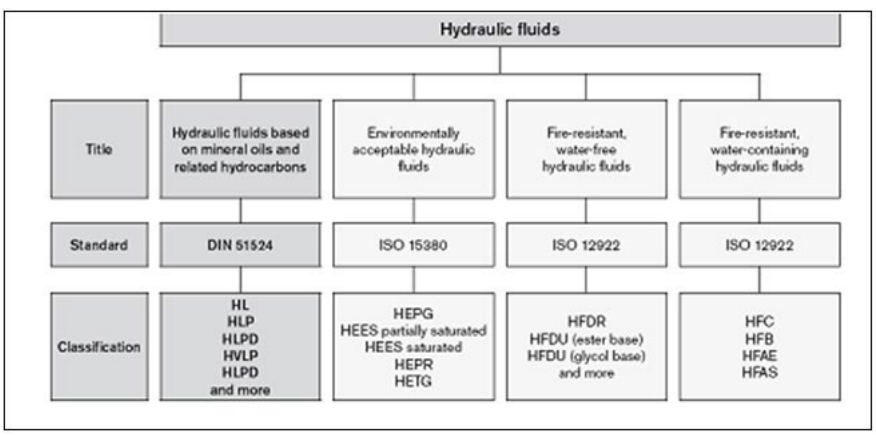
working purpose etc. So it is imminent that selection of fluid depends on the working conditions of the hydraulic equipment. In order to select a fluid one has to be clear about the operating conditions of hydraulic equipment and this can be achieved by testing the equipment with different fluids and select the fluid that gives the best performance. But it may be difficult for end user to do follow such process in field and hence most user follow Industry Standards and OEM Guidelines for such selection.

The fluids are generally classified on the basis of their viscosity, which makes a chart which is useful for the industries to select the fluid for the particular function. The classifications ranges from a simple ISO to the recent classification ASTM D 6080-97 (classifying based on viscosity).

Classification of hydraulic fluids based on ISO viscosity grade

Most of the fluids used are classified with ISO standards. The ISO standard fluids are mainly classified based on the kinematic viscosity at 40°C. The fluid is mainly taken at 40°C which is taken as a reference temperature between the maximum operating and the ambient temperatures. The ISO classification is done on 18 main fluids based on their viscosity grade. *Table 1* shows the viscosity range of a fluid on its ISO VG. *Table 2* shows conversion factors from ISO VG Grades to AGMA and SAE Grades.

Table 3: Types of hydraulic fluid



Types of hydraulic fluids

According to ISO, there are three different types of fluids according to their source of availability and purpose of use.

Hydraulic oil classification descriptions:

- HH Non-inhibited refined mineral oils
- HL Refined mineral oils with anti-oxidation and anti-rust properties
- HM HL with improved anti-wear properties
- HR HL oils with VI improvers
- HG HM oils with anti-stick slip properties
- HS Synthetic fluids with no specific fire resistant properties
- HF Symbol for fire-resistant fluids, with additional letters according to type
- HFAE Oil in water emulsions or aqueous solutions containing maximum 20 per cent mass of combustible materials
- HFAS Solutions of chemicals in water containing minimum 80 per cent mass water
- HFB Water in oil emulsions containing maximum 25 per cent mass of combustible materials
- HFC Aqueous solutions with viscosity-increasing additives and minimum 35 per cent mass water
- HFD Fire-resistant non-aqueous fluids which are further divided with additional letters according to type
- HFDR HFD based on phosphoric acid ester
- HFDS HFD based on halogen-containing compounds
- HFDT Mixtures of HFDR and HFDS
- HFDU Fire-resistant fluids of other compositions.

The above classifications of HF-type fluids describes only the fluid category

without taking into consideration any characteristics except fire resistance.

Selection of right hydraulic fluid

It is not easy to choose a right hydraulic fluid, hence it is desirable to follow few standard steps as below:

- Determine the type of equipment in use e.g mobile application or industrial application.
- Severity of the duty cycle, e.g operating pressure, speed etc in pumps or valves.
- Temperature stability of the equipment during operating condition.

Types of equipment/application

Industrial hydraulic systems: Viscosity and anti-wear levels are key in industrial use: These equipment are operating under normal indoor conditions and generally use a conventional antiwear-type hydraulic fluid with appropriate viscosity. Choosing the right viscosity fluid is important because it ensures the system's best overall performance and that the components are protected. The antiwear agents contained in the oil protect the hydraulic pump components from premature wear.

Mobile hydraulic equipment: Multi-grade fluids are more effective in mobile applications: Mobile equipment (off-highway and construction equipment) are subject to high pressures, severe duty cycles, and wide temperature extremes during all year round in areas with seasonal climates. Their fluid needs to work well at low temperatures for winter time start up, while maintaining enough viscosity at high temperatures to protect during severe service or hot weather.

The ideal hydraulic fluid for mobile applications is one that flows like a lighter oil at low temperatures but protects like a heavier oil at high temperatures: a multigrade hydraulic oil. This is similar to using SAE 5W-30 or 10W-30 multi grade engine oil in our cars, which can be used year-round without problems.

Why use multi-grade hydraulic fluids in mobile equipment: Benefits of using a good-quality, high Viscosity Index (VI) multi-grade hydraulic fluid:

- It maintains a more consistent viscosity as temperature changes, so the system continues to perform properly.
- Better flow ability at low temperatures for severe cold-weather condition. Fewer problems with cavitation, sluggishness, shudder or drift is experienced by the equipment.
- Able to maintain viscosity at high temperatures to protect system components and maintain overall efficiency.
- Improves energy efficiency and reduces fuel consumption as it can provide greater mechanical and volumetric effectiveness.
- Can be used year-round and over wide temperature ranges.

Table 4: Typical operating temperatures & pressures in hydraulic systems

Pump Type	Temp °C/°F max.	Pressure bar/psi	Viscosity ISO VG
Gear	70/158	34.5/500	32-68
	60/140	34.5/500	15-32
Vane	70/158	34.5/500	15-22
	70/158	69/1,000	22-46
	60/140	69/1,000	15-32
	40/104	69/1,000	10-15
Piston	70/158	34.5/500	15-22
	70/158	172.5/2,500	22-46
	60/140	172.5/2,500	32-46
	40/104	172.5/2,500	15-22
	70/158	293/4,250	46-68
	60/140	293/4,250	22-46
	40/104	293/4,250	15-22

Severity of the duty cycle

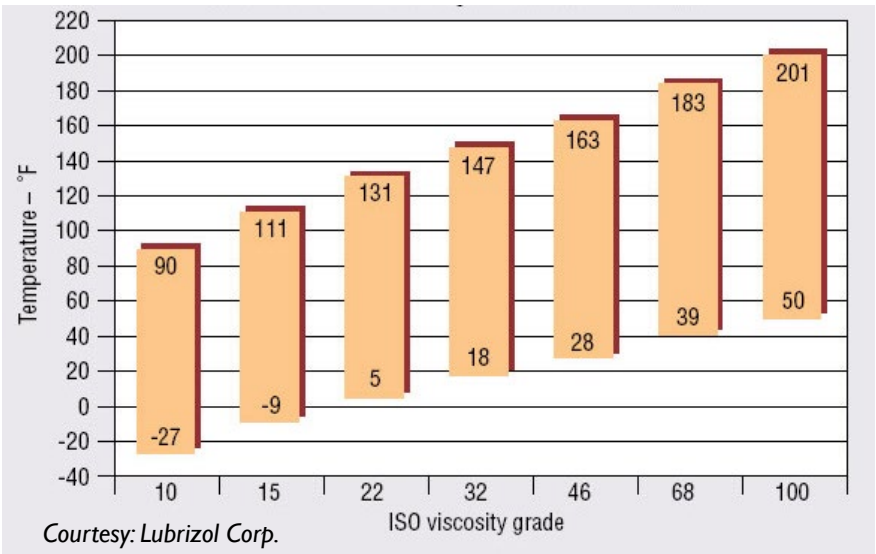
Duty cycle is the proportion of time during which a component, device, or system is operated. The duty cycle can be expressed as a ratio or as a percentage. When specifying components for a hydraulic power unit, the prime mover is sized based on torque, speed, and power requirements of the hydraulic pump. When it comes to hydraulic systems, care taken during the specification process can pay dividends in terms of maintenance and component longevity. That's because when hydraulic system components are properly specified, the system operates at a higher level of efficiency, generates less damaging heat, and lasts longer. Key parameters while discussing Hydraulic Fluid are its flow requirements, operating pressure (psi) and length of duty cycle.

Factors on which severity of operation depends are:

Hydraulic pump: The hydraulic pump produces the flow to perform the work. The rate of flow determines the speed at which the equipment will operate. Therefore, it is important to follow the equipment manufacturer's recommendation. An undersized pump may do the work, but slowly. An oversized pump may cause equipment to operate too fast, creating a potentially dangerous situation of heat, oil degradation etc.

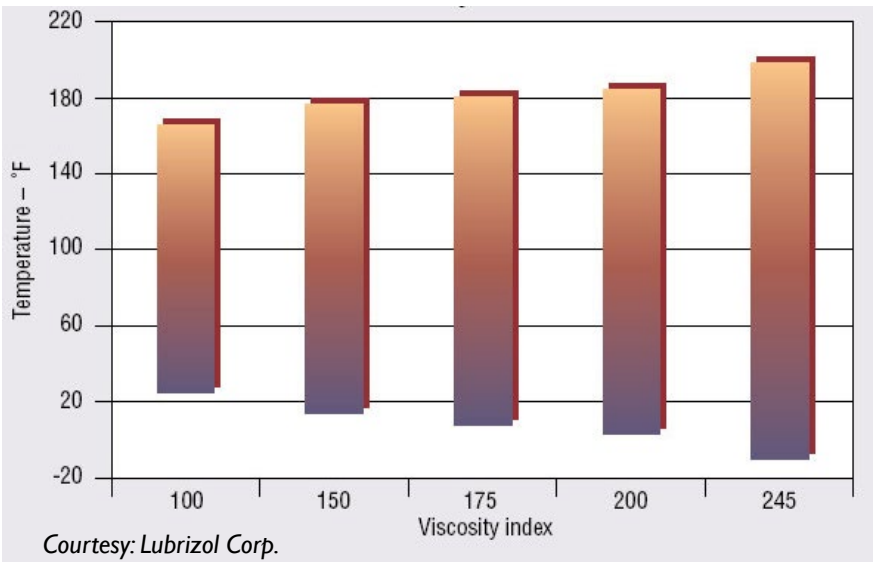
Operating pressure: Operating pressure determines the force generated within the hydraulic system. This is another area where the equipment manufacturer's specifications must be adhered to. The pump selected must be able to tolerate the operating pressure up to the relief valve setting.

Duty cycle: The duty cycle of the equipment must be considered when specifying sump size and type, and when determining whether or not a heat



Courtesy: Lubrizol Corp.

Figure A: Operating temperature ranges for conventional hydraulic fluid.



Courtesy: Lubrizol Corp.

Figure B: Operating temperature ranges for ISO VG hydraulic fluid.

exchanger may be required. Longer duty cycles result in higher temperatures. In order to dissipate heat, sump capacity may need to be increased. Some applications with short or intermittent duty cycles will require only enough sump capacity to extend the hydraulic cylinder. Applications with longer duty cycles require larger sumps or heat exchangers. The determining factor is oil temperature. As long as the operating temperature stays below 60°C the sump size is adequate. Aluminium tanks are more effective at dissipating heat than steel or polyethylene. Polyethylene tanks are lightweight and are a good choice for a dump trailer but should not be used in long duty cycle applications.

Hoses: Hoses must be adequately sized. Hose diameters should be based on system flow and not port size. Undersized pressure hoses create restriction and increase neutral system pressure which increases system heat. Undersized return hoses can create restriction and damage the directional valve. Such hoses can also cause pump cavitation. All of these situations will increase maintenance costs by shortening component life.

Oil condition: The life of every hydraulic component is directly affected by the choice and condition of the oil.

Two major causes of hydraulic pump failure, contamination and heat, are preventable if the oil is properly maintained. Regularly keeping oil clean by correct sampling methods and establishing a schedule for filter replacement is necessary. Also, oil temperature should be cooled by maintaining the proper level and keeping the sump clean which in turn will substantially increase the life of the oil and every other component.

Operating temperature range and temperature stability

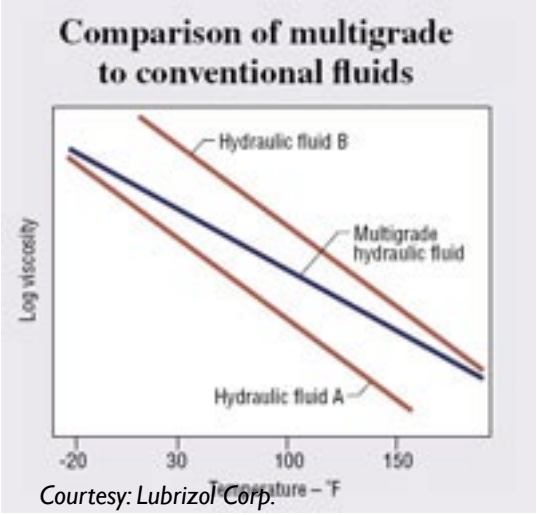
Operating temperature range of hydraulic fluids: *Figure A* shows ISO 32, 46, and 68, the most commonly used viscosity grades because they have the appropriate viscosity at the temperatures usually seen in industrial hydraulic systems. *Figure B* provides more detail on ISO VG 46 fluids.

In *Figure C*, note that the multi grade fluid has the low-temperature fluidity of the lighter Fluid A, while maintaining the high temperature viscosity of the heavier Fluid B. What differentiates multigrade hydraulic fluids from conventional fluids is that they contain polymer additives, called viscosity modifiers (VM) — also known as viscosity index improvers — in addition to the hydraulic performance package. These VMs keep the fluid viscosity more consistent over the temperature range encountered during use.

Multi-grade fluids are also known as high viscosity index (VI) fluids. VI is a measure of how much a fluid's viscosity changes with temperature. A higher VI number means the viscosity changes less as the fluid temperature increases and decreases, which is desirable. Conventional fluids typically have VI around 100. By comparison, a multigrade fluid should have VI of at least 140 or more.

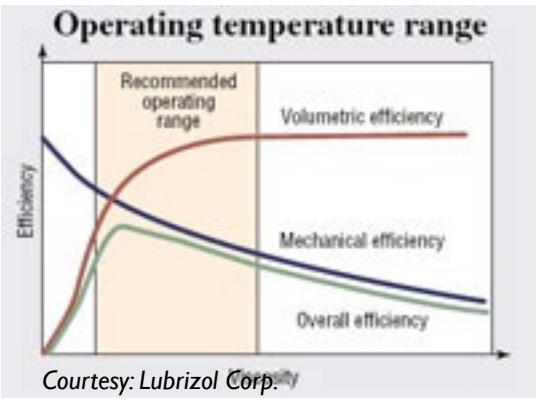
Operating within the recommended viscosity range helps ensure that equipment is protected and that it operates most efficiently, as shown in the graph in *Figure D*.

Temperature stability of hydraulic fluids: Fluid temperature stability is essential to for any machines. All hydraulic fluids have practical limits on the desirable operating temperature range - both high and low. The machine loses stability and are subject to conditional failure whenever



Courtesy: Lubrizol Corp.

Figure C: Viscosity index for multigrade fluids shows how they offer both low-temperature fluidity and high-temperature viscosity.



Courtesy: Lubrizol Corp.

Figure D: Operating within the recommended viscosity range helps ensure that equipment is protected and that it operates most efficiently.

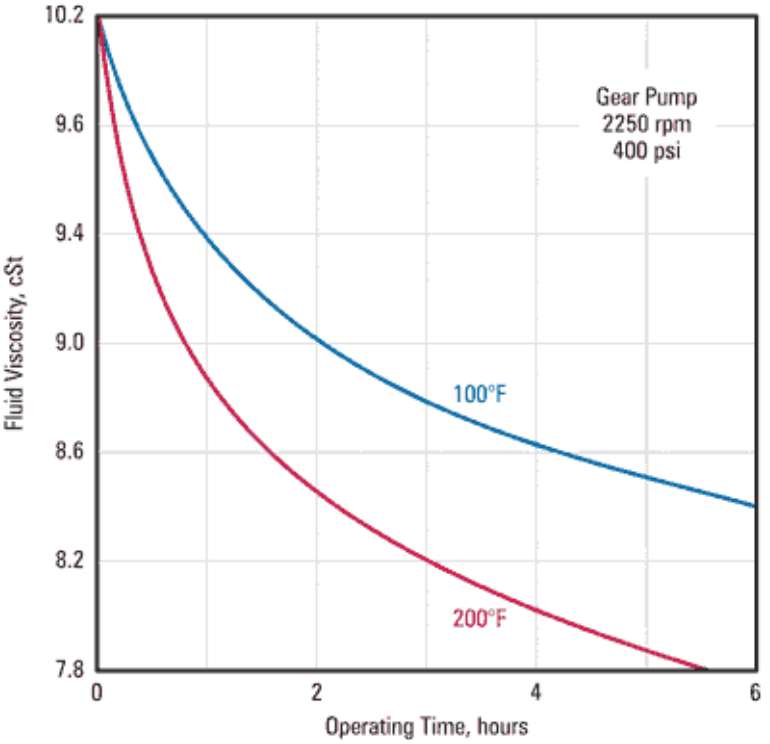


Figure E: Effect of temperature and operating time on shear stability of fluid.

the system's fluid temperature violates these limits. If not attended, the conditional failure ultimately results in both material and performance degradation of machine components.

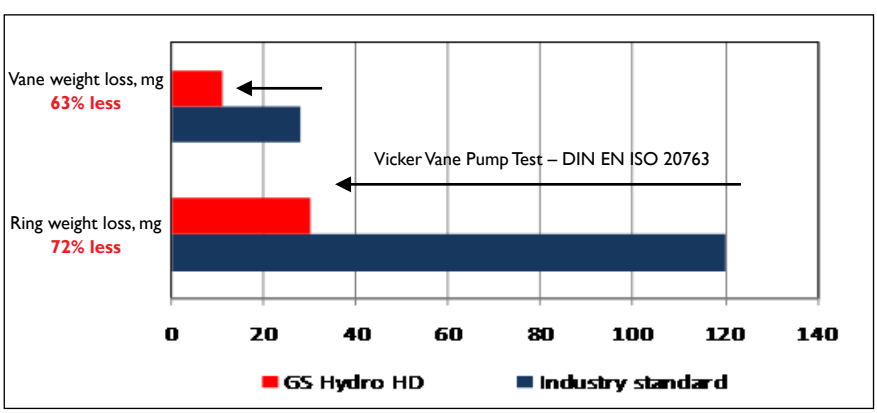
Temperature extremes have an unwanted effect on component materials as well as machine performance. When temperature is too low, fluid viscosity is high.

At low temperatures, the fluid often reaches the point where it actually becomes semi solid and will no longer flow (pour point). For hydraulic circulating systems, high oil viscosity causes a drastic drop in the oil's static pressure as suction draws the oil into the pump's inlet. This pressure reduction results in the creation of vaporous bubbles and causes air normally dissolved in the oil. When the pump compresses this fluids with air entrapped, the bubbles violently implode on the high-pressure side, creating loud noises, strong vibrations and wear of internal pump parts. Under these high-viscosity conditions, other system problems arise, such as filters enter bypass, and even collapse.

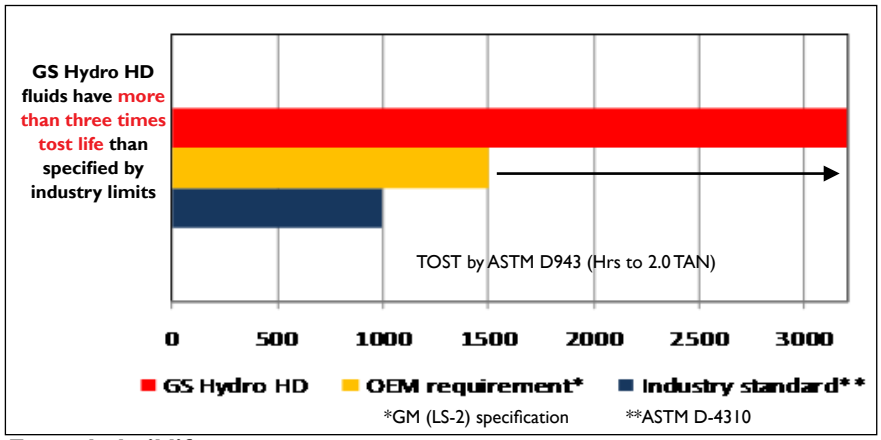
High temperature also accelerates wear, destroys hydrodynamic lubrication regimes, increases the oxidation rate, encourage additive depletion and affects other critical aspects of the machine.

Hydraulic fluids exposed to prolonged high temperature can experience permanent deterioration. In addition, irreversible viscosity change can also occur when a fluid having poor shear stability encounters high temperature.

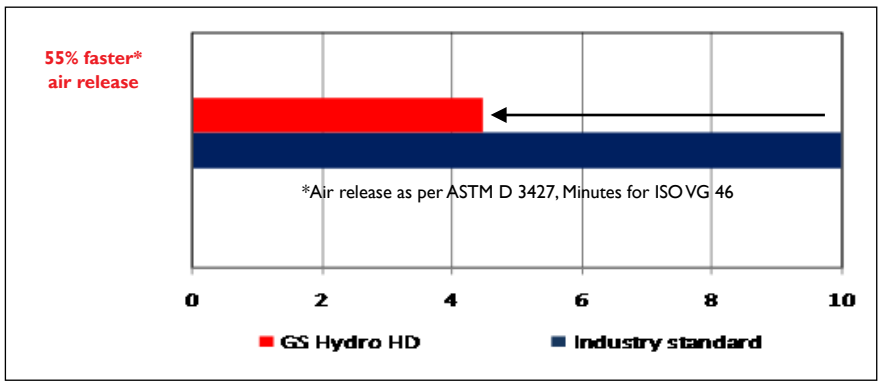
Some fluids are very viscosity-sensitive with respect to temperature where commonly add polymers called Viscosity Index (VI) improvers are added to improve the situation .These improvers consist of long molecular chains which increase the VI of the blended oil. The high shear rates and turbulent flow conditions normally existing in fluid systems can cause a continual but often tolerable reduction in fluid viscosity. The shear stability of an oil is the property which reflects the susceptibility



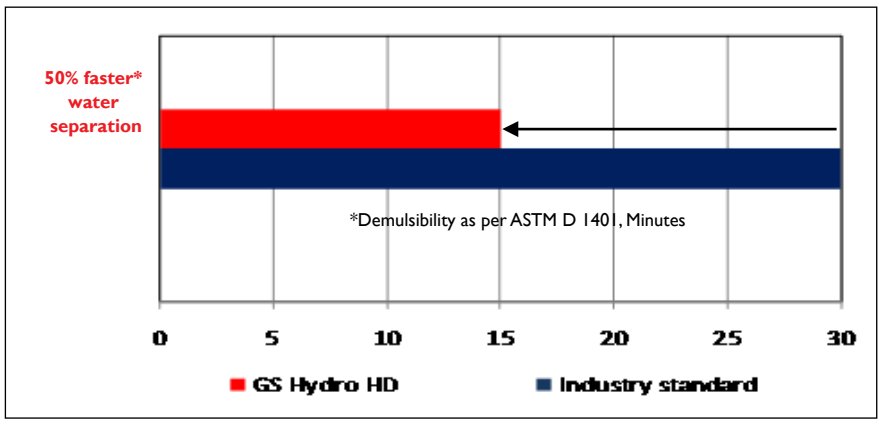
Protection of hydraulic system.



Extended oil life.



Air release.



Water separation.

of a given blend to viscosity degradation. *(Refer to Figure E)*

Finally, the temperature of the sump fluid is not a true representation of the actual oil temperature. In reality, the fluid temperature on the discharge side of the pump is a much better proposition.

Recommendations

You can observe from above article that how important it is to choose a right hydraulic oil.

GS Caltex hydraulic fluids are formulated using Group II+ base oils having exceptional oxidation and thermal stability and advance anti-wear additives. They resist oxidation and sludge built up under heavy and hot operating conditions there by protecting hydraulic components. GS Caltex Hydro HD range of hydraulic oils are suitable for most of the industrial and mobile applications discussed above.

The key performance benefits of GS Hydro HD Series hydraulic fluids are:

Performance standards for GS Hydro HD Oils

- Denison Hydraulics HF-0 (ISO 32, 46, 68)
- Vickers M-2952-S, I-286-S [industrial applications]
- M-2950-S [mobile applications] (ISO 32, 46, 68)
- Cincinnati Milacron P-68 (ISO 32), P-69 (ISO 68), P-70 (ISO 46)
- Mannesmann Rexroth requirements (RE 07 075)
- ISO Standard 6743 Part 4, Type HM
- DIN 51524 Part 2, HLP (ISO 32, 46, 68, 100)
- AAMA Standard 524 Part 2 (ISO 32, 46, 68, 100)
- US Steel 126 and 127
- David Brown Industrial Gears 0A, 1A, 2A, 3A, 4A, 5A

Protection of hydraulic system – better anti-wear properties protect and increase service life of pumps. This minimises maintenance cost

Extended oil life – Exceptional thermal and oxidative stability with lowest level of impurities in the oil help extending the fluid life. This ensures trouble-free operations for longer periods.

System efficiency – The primary function of a hydraulic fluid is to convey power. In use, there are other important functions of hydraulic fluid such as protection of the hydraulic machine components.

GS Hydro HD hydraulic fluids have excellent physical characteristics as below:

Air release – Faster air release ensures precision control and smoother power transfer

Water separation – Faster water separation prevents emulsification of oil. This prevents fluid degradation affecting the operation of valves and pumps, increase wear and corrosion.

The author is General Manager – Industrial and OEM for GS Caltex India Pvt Ltd. He has 22 years of corporate industry experience, of which 19 years in lubricants industry.