Hydraulic Fluids

Modern hydraulic applications demand compact machines designed with tighter tolerances and that run at faster cycle times. They are designed to work with small amounts of fluids. They operate at higher pressures, temperatures, and speeds. Under these circumstances, fluids are subjected to severe stresses.

Hydraulic fluids must be carefully maintained throughout their service life. Three important points concerned with the proper maintenance of fluids are (1) Knowing the type of contaminants, (2) means for controlling contamination, (3) assessing the health of the fluids. Analysis of fluid can help detect an emerging problem in the system.

Functions of Hydraulic Fluids

- Transmit power
- Provide lubrication to moving parts
- Provide sealing between clearances
- Assist in the removal of contaminants and heat

Preparation of Hydraulic Fluids

Hydraulic fluids are prepared from base stocks and additives. The base stock possesses all the essential characteristics to perform well in a particular class of hydraulic systems. Some examples of the base stock are petroleum oils, high-water-based fluids, synthetic fluids, and vegetable oils.

Many types of fluids can be formulated by adding the base stock with varieties of additives, to meet the exacting requirements of complex systems. Blending the base fluid with suitable additives can improve fluid's physical and chemical properties, and make the properties more stable even in the presence of heat, oxygen, and water.

Fluid Characteristics

Viscosity

If the fluid is exposed to cold temp, then its viscosity tends to be high and more energy is required to pump the fluid. A thick fluid produces higher pressure drop and generates excessive heat.

If the fluid is exposed to hot temp, then its viscosity tends to be low. A fluid that is too thin tends to rupture the fluid film between sliding surfaces and produces leakages.

The fluid must be thin enough to make it flow smoothly but thick enough to maintain sufficient lubricating film between sliding surfaces and to provide a proper sealing.

Viscosity Index
Certain hydraulic systems are subjected to wide variations in temperatures. A high-pressure, high-precision hydraulic system is sensitive to changes in the viscosity of its fluid medium at low temperatures. Mobile hydraulic systems are exposed to the outside environment. Such systems require high viscosity index (VI) fluid to maintain its viscosity at a constant value irrespective of variations in the temperature.

Fluid Compressibility
A good fluid should have very low compressibility (high bulk modulus) so that it remains 'stiff', and that helps to get a fast response from the system. However, the compressibility of the hydraulic fluid increases with an increase in the temperature and the pressure to which it is subjected.

Lubricity
A fluid provides a load-carrying film in the clearance between two moving surfaces. The film prevents metal-to-metal contact and thus minimizes friction. Under modest load conditions, petroleum fluids satisfy the lubrication requirements of systems. With high loads, it is hard to maintain a sufficiently thick fluid film. Fluids for such application should be formulated with EP additive to improve its load-carrying properties.

Wear Resistance
A fluid intended to be used under normal operating conditions should be formulated with anti-wear additives to improve its wear resistance. An anti-wear additive is the stabilized zinc dithiophosphate (ZDP). The ZDP under highly stressed condition may produce undesirable ash. Fluid manufacturers look for environmentally-safe ashless additive alternatives to zinc-based additives.

Oxidation Resistance
Over a period, fluid passes through various components and naturally oxidizes and forms reaction products, such as acids, sludge, gum, and varnish. The exposure of the fluid to heat, metal catalysts, air, and water accelerates the natural process of oxidation. The signs of the oxidation process appear as changes in its colour, odour, and acidity level. A superior hydraulic fluid should resist any reaction with oxygen. Better oxidation resistance can be achieved by selecting a base fluid having good chemical stability. Antioxidants can be used for the excellent oxidation resistance and the effective neutralization of acids.

Corrosion Resistance
Corrosion occurs due to the reaction of moisture and oxygen in the fluid with metal surfaces. It leads to abrasive wear of the parts and increases the leakage by opening up tolerances of close-fitting parts. System rusting occurs when oxygen and moisture attack ferrous parts. Chemical corrosion occurs when acids tend to attack copper and brass parts. A suitable rust inhibitor added to the fluid protects the fluid against system rusting and chemical corrosion.

Stability
It refers to the fluid's ability to resist its degradation in the presence of extreme temperatures or increased chemical activities or water. That is: The fluid should have excellent thermal, chemical, and hydrolytic stabilities. Thermal Stability refers to the ability to resist degradation when subjected to high temperatures and extreme shear. Chemical Stability refers to the ability to resist degradation when subjected to increased chemical activities. Hydrolytic stability refers to the ability to resist chemical decomposition in the presence of water.

The categories of Hydraulic Fluids
As modern hydraulic systems require high-performance hydraulic fluids to meet the stringent requirements of the systems, manufacturers prepare varieties of hydraulic fluids.

Petroleum-based Fluids

They have good lubricating and corrosion-inhibiting properties. They are low-cost fluids. They are available in a broad range of viscosities. But, they are flammable. They are also toxic and not very much bio-degradable. They must be compatible with the materials of construction (seals).

Fire-resistant Fluids

They are needed for high-temperature or hazardous hydraulic applications. Two basic types of fire-resistant fluids are (1) High-water-based-fluids (HWBF) and (2) Synthetic fluids. HWBFs are very much fire-resistant due to their high water content. Synthetic fluids have an exceptional fire-resistant property but are costly. ISO 6743-4 divides fire-resistant fluids into HFA, HFB, HFC, and HFD.

Synthetic Fluids (HFD type)

Synthetic fluids are prepared from alkaline compounds blended with additives. Synthetic fire-resistant fluids are (1) Phosphate esters, (2) Polyol esters, (3) Halogenated hydrocarbons. They have good fire resistance and excellent lubrication characteristics. But, they are expensive and often not compatible with many seal materials. They may also give off toxic vapours, and require special disposal plan.

Biodegradable Fluids

For ecologically-sensitive applications, where fluid leakage could have an adverse impact on the environment, there is a demand for ecologically safe 'green' fluids. The best choice of fluids for such applications is the biodegradable fluid. On the occurrence of spillage, a readily biodegradable fluid breaks 60% of the fluid into harmless products, a result of the reaction with naturally occurring bacteria, when exposed to the atmosphere for twenty-eight days in a standard test. The most important base fluids of biodegradable hydraulic fluids can be (1) Synthetic esters and (2) Vegetable oils.

Reference: JOJI PARAMBATH, Industrial Hydraulic Systems – Theory and Practice, Universal Publishers, Boca Raton, USA, 2016. Please visit: http://www.universal-publishers.com/book.php?method=ISBN&book=1627340580

Note: A comprehensive account of the topic is given in the textbook on 'Industrial Hydraulic Systems-Theory and Practice' by Joji Parambath.