Technical Topic

Fire Resistant Fluids

In Power Generation

The importance of fluid selection and maintenance is never more apparent than on the Electro Hydraulic Controls (EHC) that are responsible for governing steam supply to turbine generators. High pressures and temperatures dictate the use of fire resistant fluids to mitigate the potential for dangerous and expensive fires. Phosphate esters are the most common fluid used in EHC systems in power turbine control systems. Phosphate esters used in EHC systems require special care and maintenance compared to mineral oils.

What is a Fire Resistant Fluid?

Fire resistant hydraulic fluids are specially formulated lubricants that are more difficult to ignite and do not propagate a flame from an ignition source. Fire resistant should not be confused with fire proof, as fire resistant fluids will still ignite and burn given specific conditions.

There are several types of fire resistant fluids and they are generally classified as follows:

- Oil and water emulsions
- Water glycols
- Anhydrous synthetics

More specifically, the International Standards Organization (ISO) further classifies these fluids as follows:

- **HFAE** – oil in water emulsions having no more than 20 percent emulsifying oil
- **HFAS** – synthetic aqueous fluids
- **HFB** – water in oil emulsions typically containing 60 percent oil
- **HFC** – aqueous solutions of glycol and polyalkylene glycol thickener in water
- **HFDR** – anhydrous fluids composed of phosphate esters
- **HFDU** – synthetic anhydrous fluids other than phosphate esters. Examples include polyol esters and polyalkalene glycols.

Evaluation of Flammability

The fire resistance of a fluid is generally measured in one of three ways:

- Ignition of a pressurized fluid spray (spray flammability test)
- Ignition of a fluid when sprayed on a hot surface (hot surface ignition test)
- Ignition of a fluid that has impregnated porous or wick type materials (fluid evaporation test)

Gas turbines, designed to supply power during periods of peak demand, require fast start up without problems

In addition to these tests, Factory Mutual has developed the Spray Flammability Parameter and European Economic Community through the 7th Luxembourg Report developed the "stabilized flame heat release" otherwise known as the "Buxton Test". Both of these standards use spray ignition tests and calculations for heat rate. Detailed descriptions of these tests go beyond the scope of this article.

Care of EHC Fluids

The most commonly used fluids for EHC systems are HFDR (phosphate ester type). Triaryl phosphates are most commonly used in EHC systems.

HFDR fluids require special care and maintenance in service, especially in EHC systems. Water content, resistivity, acid content, chlorine content, mineral oil content, metals and cleanliness all need to be monitored and maintained for optimum performance in the system.

Phosphate esters are hygroscopic (have a natural affinity to absorb water) but also have poor hydrolytic stability (i.e. the fluid can degrade in the presence of water). In the presence of water, phosphate esters undergo hydrolysis reactions, which can lead to increasing acidity, system corrosion and/or erosion of sensitive components. As such, water content and Total Acid Number (TAN) should be closely monitored on a regular basis.

Where servo valves are used, a high fluid resistivity (or low conductivity) is necessary to avoid electromechanical erosion of the valve spool. Low resistivity is usually found when the fluid has become acidic through hydrolysis, or is contaminated with chlorine compounds or other particulates.

Very small amounts of chlorine (particularly in the form of chloride ions) can cause servo valve erosion problems. Chlorine contamination can result from the use of chlorinated solvents, from cooling system leaks and chlorides absorbed from the air when the system is near the sea.

Mineral oil content must also be controlled. Excess mineral oil contamination (> 0.5 percent) can adversely affect foaming and air release properties. Higher quantities (> 4 percent) will reduce the fire resistance and oxidation stability.

Minimizing particulate contamination is important at all times when fine tolerance servo valves are used. Servo valves are particularly sensitive to abrasive wear and erosion from particulates; leading to loss of system sensitivity and control. Particulate contamination may also impact the resistivity of the fluid causing further erosion of the valve components.

Phosphate Ester Fluid Conditioning

In order to maintain suitable fluid condition, special conditioning methods are used. With phosphate esters this is normally achieved with an adsorbent solid filter such as Fuller's earth or activated alumina in combination with vacuum dehydrators and standard particulate filters.

The Fuller's earth or activated alumina is used to strip acids and chlorides from the fluid to maintain a low fluid acid number level. Typically, the acid number should be maintained below 0.2 mgKOH/g and chlorine content should be maintained below 100 ppm. Also, calcium, magnesium and sodium levels should be monitored. Excess amounts of these materials may be an indication that the adsorbent filters need to be replaced. More recently, Ion Charge Bonding (ICB) filters are being used that avoid metal leaching from adsorbent filters.

Vacuum dehydrators can be used to maintain a low water content as well as assist in the removal of entrained air in the fluid. Water content should generally be held below 0.15 percent or 1,500 ppm.

Particulate filters can be used to reduce and maintain the particulate level in an oil. The cleanliness is reported according to the ISO cleanliness classification (ISO 4406) of the fluid. Typically, 2 micron, beta > 75 filters are required to prevent particulates from damaging or blocking servo valve components. An ISO Cleanliness code of 18/16/13 or lower should be targeted.

Fluid Condition Monitoring

A rigorous fluid condition monitoring program is essential to maintain long trouble-free operation. A suggested schedule of fluid analysis tests follows:

- Viscosity at 40°C – ASTM D445
- Water Content – ASTM D6304
- Mineral Oil Content – (Chromatography or IR Spectroscopy)
- Flash Point – ASTM D92
- Auto-ignition temperature – ASTM D2155
- TAN – ASTM D664
- Volume Resistivity – ASTM D1169
- Cleanliness (ISO Particle Count 4406)
- Foaming Tendency – ASTM D892
- Air Release Properties – ASTM D3427
- Metals – ASTM D5185

TAN, water content, particulate contamination (particle count) and volume resistivity are recommended to be monitored on a monthly basis. Other properties are typically monitored on a quarterly or semi-annual basis.

Material Compatibility

Special considerations must be taken with phosphate esters regarding material compatibilities. Phosphate esters will soften some paints requiring the use of selected epoxy based paints or leaving the reservoir unpainted. Phosphate esters are not compatible with the standard nitrile rubber seals typically used in mineral oil systems and require the use of specialized seal materials. Additionally, care should be taken when mixing phosphate esters from different suppliers. In general, phosphate esters are compatible with other phosphate esters, however the equipment manufacturer and/or fluid supplier should be contacted about specific compatibility issues.

Reference:

- "Current Standards for Certification of Fire Resistant Hydraulic Fluids Used in General Industrial Applications", Fluid Power Journal Jan/Feb 2006 pp. 30-36.
- "Managing the Health of Fire Resistant Steam Turbine Electro hydraulic (EHC) EHC Control Oils", Machinery Lubrication 2006
- Reolube Turbofluids Guide to their maintenance and use, Great Lakes Chemical Corporation Publication

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