ALTERNATIVE SOLUTIONS

Ronald Knecht (the Netherlands) and Jon Brown (USA), Quaker Chemical Corporation, discuss the pros and cons of alternative mineral oil-based hydraulic fluids that reduce the risk of fire hazards in mining operations.

In mining operations, a fire can increase the risk of personal injuries, as well as heighten the likelihood of losses in both capital and production. These losses include not only potential damage to buildings and equipment, but can also encompass interruptions in production that can idle operations for days or even months.

In a mining operation, one major cause of fire can be the ignition of mineral oil hydraulic fluids. In most operations, hydraulic units are used to operate the equipment, and in many cases, a mineral oil-based hydraulic fluid is employed to fuel the hydraulic unit. While mineral oil has the definitive advantage of a good cost-performance ratio, it is a distillate from crude oil and not always the safest choice due to its tendency to catch fire easily. Fortunately, there are alternatives available to manage the risk presented by mineral oil-based hydraulic fluids, and reduce the chance of an ignition, without jeopardising the performance or productivity.

Types of fire-resistant hydraulic fluids

The standard hydraulic fluids used in the mining industry are mineral oil-based. However, an alternative to these fluids are fire-resistant hydraulic fluids, as described in Table 1 using the ISO 6743/4 classification.

For each fluid type, there are both pros and cons. Table 2 shows a comparison of the performance properties of several hydraulic fluid types. The properties shown are

Table 1. Fire-resistant hydraulic fluids using ISO 6743/4 classification			
Water-based fluids		Water-free fluids	
HFA-E	Oil in water emulsions: - Water content >80% - Common use 1 - 5%	HFD-R phosphate ester fluids	Phosphate ester-based. These products are less used because of CMR reputation
HFA-S	Synthetic aqueous solutions: - Water content >90% - Common use 1 - 5%	HFD-U	Based on other compounds, but mainly synthetic, polyol ester and natural esters (renewable resources)
HFC water glycols	Water glycol solutions: - Water content >35%		

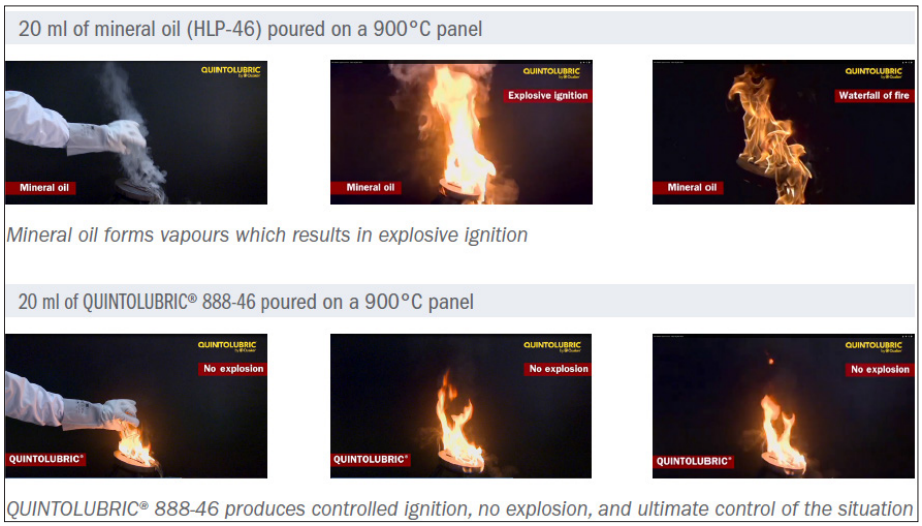

Figure 1. QUINTOLUBRIC 888 is Quaker's best-in-class, ester-based, synthetic, water-free, fire-resistant hydraulic fluid (HFD-U). QUINTOLUBRIC 888 is endorsed by multiple major hydraulic component OEMs worldwide.

considered important by both maintenance managers, as well as purchasers.

Properties of hydraulic fluid types

As shown in Table 2, mineral oil offers good hydraulic fluid performance attributes at a reasonable price. However, because mineral oil is not biodegradable, it is not environmentally friendly. Additionally, mineral oil delivers a higher total cost of operation when the risk of fire and worker safety is factored into the cost of use.

Oil in water emulsions (HFA) is the only true hydraulic fluid that is incapable of catching fire. This product is referred to as '95:5' fluid for the high content of water mixed with low percentage of oil emulsion. HFA fluids have high biodegradability, good cooling properties and are often used in the metal working industry, as well as the hydraulic cylinders found in underground longwall mining operations. Due to the high content of water, issues include formation of bacteria/fungi, as well as lower long-term corrosion protection than a mineral oil product.

Invert emulsions (HFB) are emulsions where water is suspended in the oil. The oil to water ratio is typically 60:40 and is a cost-effective, fire-resistant fluid for certain underground mining applications. The effectiveness of the invert emulsion can decrease over time due to the evaporation of the water from the product. Issues include shorter shelf life as well as inherent instability.

Phosphate ester (HFD-R) fluids, an older fluid technology, are fire-resistant by chemistry. However, they are formulated with materials considered to be carcinogenic, mutagenic and reprotoxic (CMR) chemicals. The combustion fumes they produce are neurotoxic. While these phosphate ester-based products provide good pump lubrication, they can limit the service life of servo valves. HFD-R fluids can be 10 - 15 times more expensive than mineral oil and need to be carefully maintained, as these products can form aggressive acids as they age. Today, they are used mainly in power generation, although they are (at times) found in mining operations as well.

Water glycols (HFC) are used in mining operations as storage fluids, as well as extensively in other industries, representing approximately 50% of the total fire-resistant hydraulic fluids market. Because of their high water content, HFC fluids provide very good fire resistance. In price, it is comparable to mineral oil and less expensive that water-free hydraulic fluids. However, HFCs do not measure up in performance attributes. Component service life generally is shorter, more fluid management is needed, and energy consumption is 10 - 20% higher compared to mineral oil or polyol ester-based fire-resistant hydraulic fluids. All issues drive up the total cost of operations (TCO).

Polyol ester-based fluids (HFD-U) are the best alternative to mineral oil. While they are more expensive, they deliver a lower total cost when you consider the reduction in fire risk and improvement in worker safety. Also, with polyol ester-based fluids, manufacturers do not sacrifice the fluid's performance, and they are environmentally friendly.

Understanding the term 'fire-resistant'

'Fire-resistant' is often misunderstood to be the same as 'fire-retardant' – or the ability to suppress a flame. The only hydraulic fluids that can truly be considered fire-retardant are the high water content (HFA) fluids. Almost all

Table 2. Hydraulic fluid comparison when used in a fire hazardous situation				
Property	Mineral oil	Phosphate ester (HFDR)	Water glycol (HFC)	Synthetic polyol ester (HFD-U)
Fire resistance	- -	++	+++	+
Environmental performance	-	+ and -	+ and -	++
Thermal stability	++	++	-	+
Fluid maintenance	+	- -	- -	+
Component life/system reliability	+	+ and -	- -	+
Price	++	- -	++	+ -
Total cost of operation	-	-	- -	+

fire-resistant hydraulic fluids will burn under certain conditions. HFC fluids will ignite if a certain amount of water evaporates. And while most HFD-U fluids will burn, they will not cause the ignition – unlike the explosion that the mineral oil will, which leads to an uncontrollable situation.

Fluids can be tested to determine their fire resistance. The most common and generally accepted tests are those used by Factory Mutual (FM Global), the testing and the approval arm of a major industrial insurance underwriter. By using an FM Global-approved hydraulic fluid, operators can often reduce their insurance premium. Many other organisations and companies have also developed fire resistance tests, usually to simulate a certain type of real world accident.

Figure 1 shows the comparison between ignition of mineral oils and HFD-U fluids.

Choose change over experience

Polyol ester technology has been in use for about half a century and in may fire-hazardous applications in opencast and underground mining – from belt transfer points to large earth moving equipment. If a manufacturer makes the decision to change to a polyol ester – such as Quaker Chemical Corporation's QUINTOLUBRIC® 888 series – in their hydraulic system, the conversion process is not complicated. Typically, no changes need to be made to the hydraulic unit when converting from a mineral oil or water glycol hydraulic fluid to a polyol ester fluid. That said, the conversion must be done with care as there are several grades and qualities of polyol ester (HFD-U) fluids available on the market.

The important check that must be performed are not only compatibility evaluations with the existing mineral oil, but also the paint inside the tank, seals, hoses, valves and pump. In the end, tests will show that the type of paint is critical (single component paints can be incompatible), as well as pump approvals. It is also important to remember that several different suppliers exist for polyol ester fluids, but most pump builders only approve some suppliers without any restriction on rpm and maximum pressure. Experience teaches that when paint compatibility is good, no changes or restrictions are needed for the hydraulic system. To guarantee the fire resistance of the new fluid, less than 5% residual mineral oil should remain.

Case Studies

Underground roof bolter

A customer was using a mineral oil-based hydraulic fluid in a diesel-powered underground roof bolter. The company had an incident where a worn fluid hose burst and sprayed hydraulic oil over a hot manifold. The product began to smoulder but fortunately the operator was able to find and use a fire extinguisher before the accident turned into a disaster. As a result, the customer switched to Quaker's fire-resistant QUINTOLUBRIC 888-68 and no more incidents have occurred.

Tunnel boring machine

A tunnelling company in Australia had always used mineral oil-based hydraulic fluid to operate their tunnel boring machine (TBM) until they won the bid for a project in an environmentally sensitive area. Once the company learned of the reduced environmental impact of Quaker's QUINTOLUBRIC HFD-U hydraulic fluid and made the change, they were able to operate their TBM's without fear of environmental issues.

Earthmoving equipment

In an opencast mining operation in South America, a customer had multiple near-misses when an older piece of earthmoving equipment leaked mineral oil-based hydraulic fluids near hot components. After assessing the risk, the operation chose to add a fire-suppressant system, and also change to a fire-resistant hydraulic fluid. The earthmoving equipment is now able to operate with a lower risk of fire and the opencast mining operation was, therefore, able to lower insurance premiums associated with the machine.

Phosphate esters

An underground coal mine had traditionally used phosphate esters (HFD-R) in their fluid couplings at the longwall headgate. At elevated temperatures, the plugs would burst and release a toxic smoke that was the result of the phosphate esters heating up. Due to the operating temperature and technical properties necessary, the mine chose to switch to QUINTOLUBRIC 888-68 polyol ester-based fluid (HFD-U), which not only eliminated the creation of toxic fumes, but also was a more cost-effective alternative to the phosphate ester-based fluid.WC