Make the Choice — Fire-Resisting Hydraulic Oils

Hazards are ever-present in the steel plant environment, and a heightened awareness and emphasis on safety is a necessary priority for our industry. This monthly column, coordinated by members of the AIST Safety & Health Technology Committee, focuses on procedures and practices to promote a safe working environment for everyone.

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Comments are welcome. If you have questions about this topic or other safety issues, please contact safetyfirst@aist.org. Please include your full name, company name, mailing address and email in all correspondence.

The steel industry and the insurance market have shared interests when it comes to loss prevention. The potential cost of interruption to production and damage to people, property and reputation from an incident, be it a fire, molten metal breakout or data breach, can devastate businesses and far outweigh the cost for implementing mitigating loss prevention measures. The difficulty often comes with the commitment to invest in the increased costs of including many loss prevention measures in day-to-day operations, especially when the loss probability may be considered low.

Wouldn't it be great, in the case of fire risk, to have a product that is inherently safer and available at a similar or even the same initial and operational cost?

Risk Hierarchy

For the insurance industry, risk elimination is the always the first goal. However, when considering the complex risks associated with steel production, the total elimination of risk is seldom. The need for powerful hydraulic systems such as for rolling mills, blast furnace casthouse equipment, continuous casting and the like is inherent to steel production. Risk transfer and control is imperative to keep the fire risk associated with hydraulic systems as low as possible.

Within the steel industry and many others like it, the risk of a pressurized hydraulic oil leak from mineral oil–based systems — which may or may not form an atomized mist — is a constant challenge and has resulted in many significant losses. Powerful fires can be ignited from the oil mist or leak from hot surfaces, nearby electrical equipment and so on. Hydraulic oil fires can travel several meters, presenting a significant containment challenge for automatic fixed fire protection. Potential for continued oil discharge until the hydraulic system is isolated ultimately raises the risk of putting firefighting personnel in a difficult and potentially life-threatening situation. Oil cellars are often located in the depths of a basement, making access harder.

Mineral hydraulic oils are petroleum based and whilst not technically flammable (flash point greater than 60°C (131°F), they are combustible. Typically they have a flash point between 150–250°C (302–482°F) and an auto ignition temperature of 300–350°C (572–662°F). Very-high-pressure and large-volume mineral oil hydraulic systems, especially in hot areas, pose a significant fire risk.

To reduce the risk of ignition, fire-resisting hydraulic oils were developed. There is a wide array of products now on the market that can be separated into three main categories:

- High-water-content fluids: These fluids use water as the primary medium. Water content is typically 90% or even greater. The remaining content is typically additives that provide lubrication and corrosion-resisting properties.
- Water glycol fluids: The water content is less in these fluids, typically between 30% and 60%. Glycol is added as an antifreeze agent as are thickeners to increase viscosity and additives for lubrication and corrosion-resisting properties.
- Synthetic water-free fluids.

Water-Based Hydraulic Fluids

It's easy find many fire-resisting hydraulic oils that are now used within the steel industry. Almost all are introduced upon equipment inception or replacement, as they were designed and specified to use the fire-resisting fluid at that stage when capital expenditure is available. Commonly, due to superior fire-resisting qualities, high-water-content and water glycol fluids are used.

It is critical that water-based fluids are monitored and maintained correctly for the performance of the hydraulic system to be reliable; otherwise a machinery breakdown could be the result. Issues with evaporation when used in hot process areas can be a problem that could lead to pressure loss and reliability problems. Incorrect water concentration can affect fluid viscosity, potentially causing more leaks in the system and accelerate the corrosion of seals, actuators and other equipment within the system. It is imperative that routine monitoring of water-based fluids is undertaken, including quality measures such as viscosity and water hardness.

Inspection and maintenance routines of the seals, for example, are established using original equipment manufacturer (OEM) guidelines, making them the standard for that equipment. This is great for new plants or significant upgrade projects, but what about an existing plant that is 20–30 years old, which is entirely normal for the steel industry? There may have been some maintenance horror stories of poorly managed retrofits to replace mineral oil–based hydraulic oils with fire-resisting alternatives. Seal compatibility issues or corrosion from water-based fluids are known. Such events over time have often, not always, prompted a cultural dislike for even contemplating retrofitting fire-resisting hydraulic oils into critical existing hydraulic systems.

Compromise Solution

Synthetic water-free hydraulic oils are developed using a combination of synthetic esters. They possess superior flash point and auto ignition temperatures compared to mineral oil–based hydraulic systems, which they are designed to replace.

When the systems are located in cut-off rooms with good fire-stopping and maintenance arrangements, the chances of a leak igniting is reduced, as is the explosive ignition potential generated from mineral oils. It is the explosive-type properties upon ignition of mineral-based hydraulic oils that provides the intense initial flash fire that is so powerful.

There have been scenarios where, due to the pressure, a pinhole leak has traveled from equipment, is ignited by hot surfaces and the resulting fire spreads to the building roof several meters above. The fire has then spread across the roof, causing localized structural collapse onto other equipment, which could have been avoided. Whilst synthetic water-free, fire-resisting fluids may still burn, the intense ignition and powerful inception of fire is significantly reduced, meaning the risk of fire spread is far less probable and more easily controlled.

They are also very compatible, as they do not include corrosive media such as water. Common seal types such as nitrite butadiene rubber (NBR), fluorocarbon rubber (FPM), polytetrafluoroethylene (PTFE) and the like used in mineral oil systems are compatible; they are biodegradable too.

In one case, a system drain and rudimentary clean-out of the main storage tank of the mineral oil–based fluid, which was refilled and re-commissioned with synthetic water-free hydraulic fluid, was all it took to successfully complete the retrofit. This retrofit took place earlier this decade on critical blast furnace equipment that was 30 years old. This particular retrofit was completed during a blast furnace reline in a 100-day shutdown; however, consideration could be given to do the retrofit during shorter planned outages.

The reliability of the system has been the same since the retrofit and, as a result, equipment on the other blast furnaces on the same site are planned to be retrofitted.

The ongoing maintenance cost of using synthetic water-free, fire-resisting fluid is very comparable to mineral oil–based hydraulic fluids as well. Fluid life and lubrications levels are similar — if not better — than mineral-based oils.

So the perfect time to introduce fire-resisting hydraulic fluids is on new equipment. To improve loss prevention and simultaneously limit investment, the retrofit of mineral oils using synthetic water-free fluids on existing plants should not be ruled out. It's true that water-based hydraulic fluids possess superior qualities in terms of fire safety and should be the place to start; however, the seal compatibility or equipment replacement costs may make them out of reach for companies that cannot afford to invest so heavily.

Prepare for Change

A formal technical management of change (MOC) process is the key to ensuring any retrofit is successful. The process for assessing the retrofit may include trialing the fire-resisting fluid on similarly aged hydraulic equipment that is not process critical. A good MOC process should include a series of gates or approvals to ensure the correct stakeholders are involved to commit to the change. Engagement with oil and process equipment OEMs is imperative, as are the experience and willingness of the plant operator to make the change.

Like with many changes, they are often done in a reactive way, so those who have had the unfortunate experience of dealing with the immediate issues and the aftermath of a hydraulic fire are more likely to want a solution that is inherently safer to provide certainty in the future. Not all but many who have not had that direct experience may be less willing to make the change. The culture change will only come through constant challenging, correcting, planning, doing, checking and acting.

Conclusion

For the steel and insurance industries, well-maintained hydraulic systems may sit there quite happily for the entire design life and not produce a problem, but before there is a leak it may be an opportune time to ask, "Can we replace the existing mineral oil with something more fire-safe?" Assess the retrofit correctly and it may just work.

It's not the perfect solution, as it does not entirely eliminate the risk, but it goes a long way toward achieving it. ✦