PAGs

Earn a Second Look

By James R. Kovanda

In April, General Electric Power Generation Services issued Revision H of its stringent GEK 32568 specification for gas turbine lubricants. This document enables polyalkylene glycol based turbine fluids that meet the specification to be accepted for use in GE gas turbines, with full coverage under the equipment maker's warranty.

The revision followed more than five years of field testing of these synthetic fluids in large-frame turbines, during which time they showed no varnish issues and no trips attributed to the turbine fluid.

With first three and now 24 power generation turbines in service during this time, American Chemical Technologies was proud to be among those providing regular data and information about PAG turbine oil performance to GE, which is the largest gas turbine producer worldwide.

Although PAGs have been around for several decades, there have been significant improvements in additive technologies over that time, making this OEM approval particularly significant. It recognizes that there are PAG lubricants available now that have been designed to eliminate the issues of the 20-plus-year-old formulations.

Today's advanced PAGs can be either water soluble or oil soluble, and by selecting the right type, the finished lubricant can be tailored to satisfy the end user's exact need, whether it's for fire resistance, hydrolytic stability, long fluid life, environmental acceptability, system cleanliness, sludge and deposit control, or some other performance criteria. The possibilities are far broader than what was seen 25 years ago, making any stereotype or generalization you read today about PAGs as a class likely to be erroneous and outdated.

Unlike petroleum base oil, the PAG molecule is "designed and not refined." This means PAGs can be designed to have a wide range of molecular weights, viscosities and functionalities, by modifying the ratios and addition orders of its base chemicals (ethylene oxide and propylene oxide).

Astute formulators can use PAG chemistries to create high-value, high-performance lubricants — and then what? If they're at all like ACT, they'll find that having the right product doesn't automatically open doors. That takes technical expertise, reliable test data, years of field experience, open-minded end users, and persistent hammering at barriers to overcome entrenched ideas and prejudices.

This article hopes to offer some insights into PAGs' evolution, including the roadblocks and hurdles faced as new formulations were launched.

The '50s: Water Glycols

Polyalkylene glycol based fire-retardant hydraulic fluids got their start in the postwar era, when the military sought a solution to lubricate the catapults on aircraft carriers. Fire-retardant, or "FR", water glycol fluid was formulated in the 1950s and put in service to eliminate the catastrophic fires that had occurred with petroleum-based lubricants with low flash and fire points.

Over the years, hydraulic system design required higher-performing FR fluids that could handle greater operating pressures and temperatures. In the 1970s, polyol esters were introduced as FR fluids capable of satisfying these requirements. They were compatible with the power units, and would outperform the water-based lubricants. The challenge with esters, though, remains their inherent hydrolytic instability, which can cause premature component failure and reduction in fluid service life.

By the early 1990s, industries that required the use of FR fluids in their more sophisticated systems were searching for hydraulic fluids capable of handling extreme operating temperatures and pressures, with the added need for performing favorably with water and condensation in the lubricant. To satisfy this need, ACT formulated and patented a non-aqueous PAG-based fluid and attained Factory Mutual (now FM Global) approval for this high performance FR hydraulic fluid. Initially, these fluids were introduced into steel and aluminum plants that had been using ester-based chemistries. But to allow for any appreciable expansion and growth, OEM approval was necessary.

The '90s: Things Heat Up

Initial inquiries and meetings with one of the world's largest hydraulic system OEMs exposed the fact that information available on early PAG based products

Gas turbines being built for the power industry. (Photo: GE)

depicted the formulations as being very aggressive to anything the fluid came into contact with — seals, paints, sight glasses, etc. To say the least, there was reluctance on this major OEM's part to consider PAGs for use in its hydraulic equipment.

CAT 973 loader handling hot slag. (Photo: Caterpillar)

We continued to canvass the market with this chemistry, trying to identify applications where competing fluids could not provide adequate lubrication and/or fluid service life. One such industry that reared its head was mobile equipment used in the slag industry.

Slag is a byproduct of steel and is used as the aggregate in the production of asphalt. Large bucket-loaders are employed to haul slag out of a steel casting application, and these operate at sustained fluid temperatures of over 180 degrees F. This application is extremely taxing on a hydraulic fluid, and perhaps better cooling systems might help. But because this is a relatively small market, the OEMs that produce loaders for typical outdoor use were unwilling to modify the cooling systems.

The slag industry had experienced 1,000 hours of life on piston pumps using water-based water glycol fluid, but doubled that to 2,000 hours when it converted to polyol esters in the 1980s. At the time, it felt satisfied with that.

In 1992, ACT approached a manager of a large fleet within an integrated steel mill who was still seeking improvement and agreed to give a PAG based FR fluid a trial. The first trial on the identical equipment yielded pump life of over 16,000 hours, and the mill has set a 12,000-hour maintenance interval on its fleet as a result. Twenty years later, this PAG-based chemistry is the staple FR fluid used across the slag industry worldwide in all applications requiring FR fluid. As a result, the fluid is a purchasable option within Caterpillar, John Deere, Kawasaki, Komatsu and Kress, to name a few.

Late '90s: More Openings

In 1998, the same German OEM that had resisted testing and approving PAG chemistry for its hydraulic power units was now prepared to take a closer look. This OEM was seeing premature pump and servo valve failures in a U.S. steel mill which had a state-of-the-art Automatic Gauge Control mill operating at 5,000 psi and at a sustained temperature of 150 degrees F. This AGC mill had started up in 1991 on polyol ester fluids, but from 1991 to 1998 had averaged only around 3,000 hours of pump life on axial piston pumps rated for 20,000 hours on petroleum oil.

Over that eight-year period, the OEM was forced to replace under warranty all or portions of 37 pumps, at $12,000 per pump. In addition, the mill typically lost one servo valve a week due to varnish/sludge formation, and besides having to change these pumps and valves routinely, the fluid usage averaged 5,000 gallons of make-up approximately every seven weeks.

The OEM gave PAG-based FR fluid an opportunity to prove its mettle. The fluid was put in service in April 1998. Since that time, the AGC system has achieved over 85,000 hours of life on the identical axial pumps, and has not lost one servo valve due to varnish/valve sticking. Mill management claims to be saving an average of $25,000 per month in maintenance costs with the PAG chemistry, and the fluid now lubricates four other AGCs, with similar results.

Next Stop: Aluminum

Based on the success lubricating the very difficult AGC systems, lubricant engineers in other industries who were facing similar issues in demanding applications started to take notice.

The aluminum industry embraced fire retardant PAG chemistry, and it is in use in many of the major plants nationwide. One U.S. mill producing sheet for the canning and beverage industry utilizes PAG based hydraulic fluid from one end of the plant to the other. In 1998, the FR fluid replaced water glycol fluid in the melt and cast department's equipment and took the place of polyol esters in the rolling mill.

While there were no component issues per se in the rolling mill, water ingress into the polyol ester forced the plant to dump and refill its sizable fluid systems three times over a four-year period. Since converting to PAG fluid, which is inert to water, there have been no such expenditures.

On to Power Gen

The power generation industry had a different need. This industry was searching for a more worker-friendly FR fluid, and one that was more forgiving in the event of water ingress, for use in critical

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Electro-Hydraulic Control systems. EHC systems were predominantly using phosphate ester fluids, and were experiencing acidity that drove down resistivity, and the formation of gels that are decomposition products of these chemistries.

In the early 2000s, power generators began converting their sophisticated control systems over to stable PAG chemistry, which now lubricates over 125 of these units within power plants nationwide.

Concurrently, a serious problem with varnish began to surface with many mineral oil based turbine oils as well, causing major pain to gas turbine owner/operators. This phenomenon may be due to changes in base oils, as more API Group II and III base stocks are used, or it could arise from another cause. In any case, operators began seeing tenacious polar decomposition products form in the fluid which are not soluble in non-polar petroleum base stocks; these tend to drop out as varnish-like deposits, plugging tight-tolerance servo valves and causing the turbine to trip (shut down).

Varnish put gas turbine decision-makers in a precarious situation, requiring extensive and elaborate testing to be conducted in outside labs, and forcing the power gen industry to consider the purchase and maintenance of varnish removal filtration skids.

The headaches led turbine engineers and plant operators to seek an alternative: PAG based synthetic turbine fluid. In contrast to petroleum, PAGs are polar in nature (every third atom being oxygen) and produce low molecular weight polar byproducts that will always remain soluble in the fluid. Another plus with PAG synthetic turbine fluid is that equipment efficiency also increases, with users claiming approximately 5 degrees F lower bearing operating temperature.

ACT just turned over five years of successful performance in its first three large-frame gas turbines. There have been no varnish issues, or trips in these units attributed to the turbine fluid. To date, ACT has converted a total of 24 large-frame turbines to PAG synthetic turbine fluid, with another eight scheduled to be converted through fall 2013.

Answering Users

After the above successes — plus others in the hydroelectric and marine industries, where water-soluble non-sheening PAGs have earned the U.S. EPA's highest classification for Environmentally Acceptable Lubricants — the question that ACT still hears most from end users is, "Can we afford to use these synthetics?" Petroleum-based lubricants have provided users reliability at comparatively low cost. The question that a prospective user of a PAG fluid needs to ask is, "Does there exist sufficient experience and data to prove that this fluid will provide value by extending drain intervals, and increase performance in addition to the environmental benefit?" The case studies above show there is.

PAGs are the most forgiving fluids due to their unique and inherent hydrolytic, oxidative and non-varnishing characteristics. This has been proven in many of the most demanding applications across many industries served. PAGs solve the issues that exist with other lubricant chemistries because they are fundamentally different from API Group I to Group IV petroleum hydrocarbons.

Realizing the benefits of using PAGs requires a change in perspective. It is not a one-size-fits-all solution. After the initial up-front investment, PAGs have driven value and savings to each end user. ▮

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