Next-Generation Ester Grease Survives Higher Temps

By Brian Holley

Automotive design engineers who need a grease for operating environments that reach 175°C are often forced to specify a perfluoropolyether (PFPE), one of the most expensive synthetic lubricants. Now, a new "high-temperature ester" can offer a cost and performance alternative.

Synthetic esters, which are chemically similar to polyalphaolefins, are lubricious oils with low volatility. Due to their affinity for metal, especially steel, iron, and copper, esters provide excellent wear protection. They are ideal for loaded bearings, powdered-metal bearings, potentiometers, and cut-metal and powdered-metal gearing, if proper seals are used. They also offer minimal viscosity change with temperature, a quality of a good wide-temperature lubricant.

Complex polyol ester base oils are known for their high-temperature stability and low evaporation loss, especially in thin film. Their useful temperature range is –54°C to 150°C. When mixed with a gellant and fortified with special additives to reduce noise and wear, they are popular greases for both electrical contacts, bearings, and gears. However, increasingly hotter operating environments in the automotive world, coupled with the industry's grueling, 3X life-cycle testing, often demands a little more high-temperature "chutzpah" than traditional esters can offer.

Certainly, PFPEs excel in high-temperature environments. In fact, no other synthetic grease survives higher temperatures better. But PFPEs can be overkill. Truly high-performance lubricants, PFPEs are thermooxidatively stable; compatible with most any plastic, elastomer, and metal; non-flammable; non-toxic; unaffected by harsh chemicals and fluids; and suitable for continuous temperatures of 250°C or higher. The engineer's dilemma is: If I only need 175°C, why do I have to buy all that?

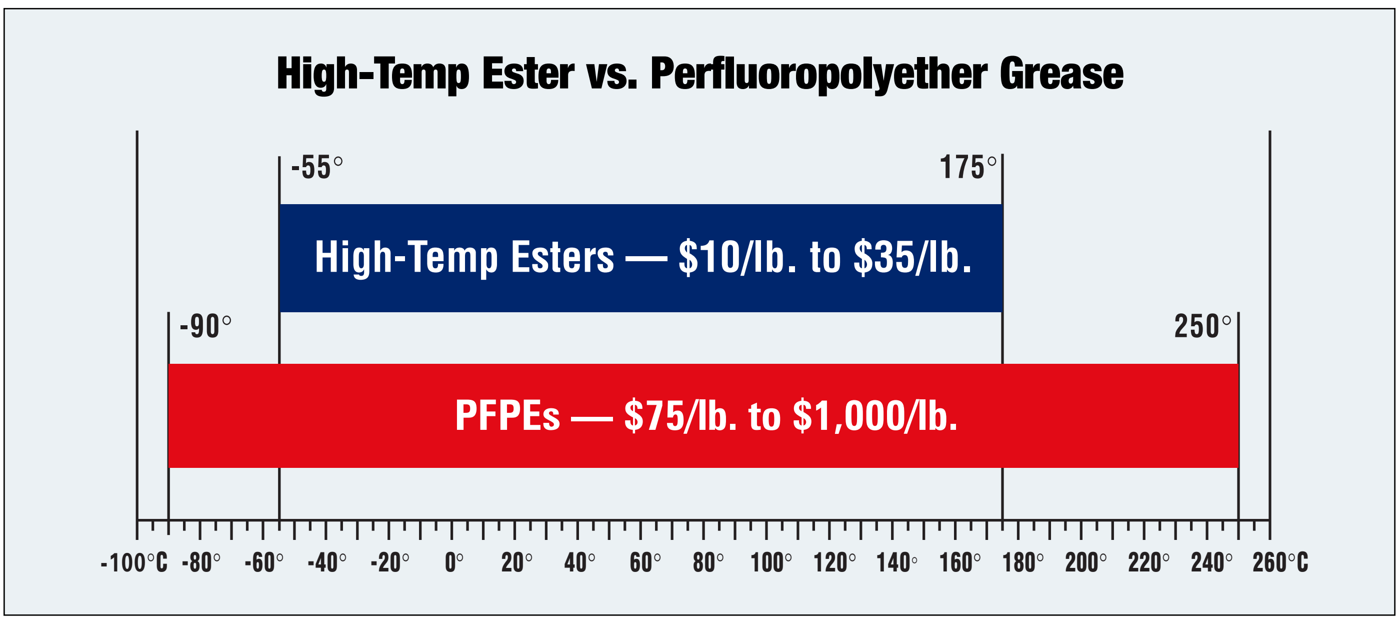

Figure 1: Cost /Temperature Comparison
New high-temperature esters survive temperatures up to and exceeding 175°C, about 25 degrees higher than traditional esters, making them rivals to expensive PFPEs for some applications.

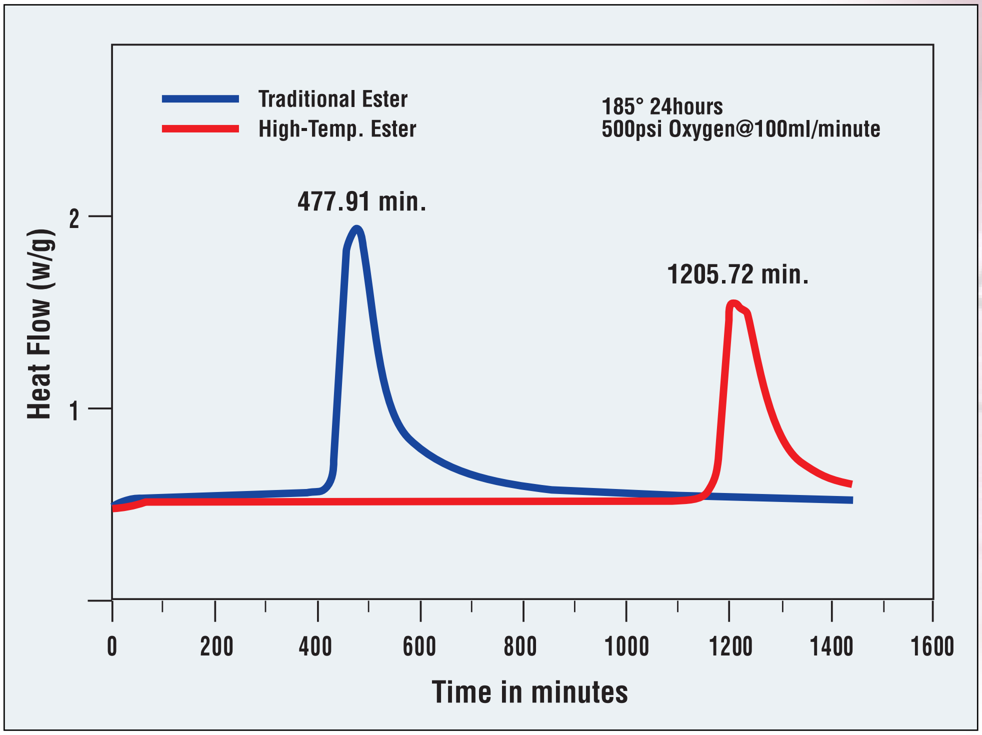

Figure 2: The Temperature Advantage
When tested in a Differential Scanning Calorimeter, an ester grease fortified with a new antioxidant survived higher temperatures longer than a comparable ester grease without the antioxidant. At 185°C under 500 psi of pure oxygen, the new high-temp ester survived for 20 hours, compared to about 8 hours for the traditional grease.

In search of an alternative for an automotive switch manufacturer, Nye Lubricants, Inc. experimented with a new antioxidant that successfully boosted the high-temperature capabilities of traditional esters from 150°C to 175°C — precisely the margin the switch manufacturer wanted. Using a Differential Scanning Calorimeter to compare two ester greases, identical in formulation except that one contained the new antioxidant, showed that the grease with the antioxidant lasted more than twice as long as the traditional ester. Specifically, when placed in a test chamber at 185°C for 24 hours under 500psi of pure oxygen, continually replenished at 100 ml/minute, the "high-temperature ester" took 1205.72 minutes or just over 20 hours to burn, compared to the traditional ester that reached exotherm after 477.91 minutes or just under 8 hours (*See Figure 1*).

This high-temperature ester formulation can result in significant cost savings for component manufacturers who are using PFPEs simply to get an incremental 25°C over traditional esters (*See Figure 2*). PFPE greases, which are the only other alternative for environments higher than 150°C range, from $75/lb. to $1,000/lb., depending on which type of PFPE base oil is used. This new breed of high-temp ester greases ranges from only $10/lb. to $35/lb., with the most commonly used formulations falling between $10/lb. and $20/lb.

Importantly, esters offer more than a cost advantage over PFPEs. PFPEs survive well in high temperatures because they have long-chain, slippery molecules. However these "slippery" molecules collapse more quickly than esters under heavier loads, which diminishes a PFPE's ability to prevent wear. At temperature extremes, however, tribological compromises have to be made. Esters, which are more like synthetic hydrocarbons, have a stronger molecular backbone that enables them to carry much heavier loads than PFPEs. Further, antiwear additives, which don't mix well with PFPE oils, combine quite well with esters. Antiwear additives and boundary lubricants are often critical for bearings and gears that start and stop frequently because the elastohydrodynamic (EHD) oil film collapses when motion stops, which allows surfaces to contact. Additives are necessary to reduce wear during these start-stop intervals.

POTENTIAL APPLICATIONS

Nye's first high-temp ester grease, Rheolube 716HT, was designed specifically for high-current/high-temperature switches. Its 175°C upper temperature limit provides the margin automotive headlamp and multifunction switches need to survive life-cycle testing. The average temperature inside these switches is most often well below 175°C, but most OEMs set high-temperature specifications at 175°C because resistive heat can produce temperatures approaching 175°C and because high-current arcing switches and contacts can get quite hot after a number of arcing cycles.

Initial lab studies indicate that this same antioxidant can boost the high-temperature limit of any ester grease, which opens the opportunity to introduce a robust lubricant in applications where only PFPEs have gone before. Start with bearings used in many underhood applications, where ambient temperatures can range from 150°C to 200°C. Idler bearings, alternator bearings, condenser bearings, cooling fan bearings, throttle plate bearings, ABS motor bearings, water pumps, turbochargers, and superchargers — all can benefit from an economically priced grease with good high-temperature capabilities.

Though esters sometimes cause compatibility problems with plastics and elastomers, a high-temperature ester grease would even make a good plastic gear box lubricant. Esters are not recommended for use with polycarbonates, ABS resins, polyphenylene oxides, and polysulfones, for example, but these materials, because of poor tensile strength and poor high-temperature capability, would not likely be used in gearing. High-strength plastics, typically found in gearboxes in underhood applications, are usually chemically stable and could well benefit from a modified ester grease.

Because of their excellent film strength, esters have long been considered good greases for preventing wear on potentiometer tracks. Notably, they work well in thin film which helps prevent contact hydroplaning and resulting intermittancies. While arcing is not usually a problem with potentiometers, high heat generated by resistance may make a high-temperature ester a suitable grease. For example, temperatures can soar in automotive dimmer switches. The high ambient temperature underhood, where more and more potentiometers and other sliding position sensors send signals to other devices or back to the driver, are applications where a high-temperature ester may also prove helpful.

Many motor manufacturers are using powdered-metal bearings as an economical way to support and lubricate rotating motor shafts. Esters are often used in these porous bearings because of their excellent lubricating ability and high-temperature stability. However, if the impregnated oil starts to oxidize, the resulting varnish can clog the pores of the bearing and prevent oil from reaching the shaft. Lubricant starvation and bearing failure would result. Ester oils with this new antioxidant may be a solution.

A major supplier of radiator cooling fan motors is now testing a synthetic oil with this new antioxidant. The oil is also fortified with copper-corrosion and rust inhibitors so that it can be used with sintered iron or sintered bronze bearings. Traditional sintered metal bearing oils could not survive the 1,000-hour, high-temperature life test requirement. While tests are not yet complete at this writing, the new oil has surpassed the 500-hour mark, which far outpaces any other oils the customer has tested.

Whenever an ester doesn't quite have the legs it needs to pass life-cycle tests, studies are showing that a promising, low-cost antioxidant may well provide a very cost-effective '25 degrees' that extends the life and performance of traditional ester lubricants. ■

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