Offroad Hydraulic Fluids: Beyond Biodegradability

With Europe and the United States leading the way, the globe is moving toward lubricant solutions that are environmentally friendly.

By Kathryn Carnes
oad equipment is often massive, frequently and apt to be found in some of the most operationally sensitive places on the planet.

The development of biodegradable lubricants and similar machinery fluids targeted for applications in environmentally sensitive offroad service environments in synthetic and vegetable oil has aided in this growth, as has a push from regulatory agencies. Initiatives such as the 2002 Farm Bill associated U.S. Department of Agriculture (USDA) draft guidelines that exactly what products would be for use by federal agencies and contractors are the latest in a long line by western governments to help the effects of activities on offroad areas.

A list of fluids that has been the focus of attention in offroad equipment lubricants. According to Miller et. al., experts estimate that 70% to 80% of fluids leave systems through leaks, breakage and fitting failure. All lubricants, including hydraulic based on mineral oil, notes Hildob Krop, senior researcher and consultant within the Chemical Risks Unit of the IVAM, a research organization and consultancy on sustainability affiliated with the University of Amsterdam. "Many fractions of mineral oil have both low aerobic and low anaerobic biodegradability and are well known for their adverse staining effects on organisms. Owing to these (and other) physical, chemical and (eco) toxicological properties and the high volumes lost into environmental compartments (like water), mineral oil makes up an important chemical pollutant."

Thus, the call for "biodegradable" or "environmentally friendly" alternatives is increasing (a discussion of the imprecision of those terms is presented in the sidebar "What's in a Name," page 36). Predictably, these are the fluids most likely to be lost to the environment, either by design (e.g., chainsaw oils, which are total-loss lubricants) or because accidents and leaks are common (e.g., hydraulic fluids).

Already, the highest volume of environ-
mentally friendly lubricants (EFLs) is in hydraulic fluids, according to Miller et al., the best commercial estimates put that number at about 75%. This is particularly true in Europe, where strict national standards have led to relatively wide adoption of environmentally friendly hydraulic fluids; one recent report in TLT stated that as much as 25% of the hydraulic fluids sold in Sweden were EFLs, the vast majority of them based on synthetic esters. However, even in Europe, Krop notes, the use of EFLs is the exception rather than the rule. A European Union (EU) innovation project on Lubrication in Inland and Coastal Water Activities (LLINCWAt), conducted from 1999 to 2003 under the auspices of the IVAM, dramatically pointed out the prevalence of non-eco-friendly fluids in use. This EU project stimulated the awareness on the existence of biolubricants, testing and demonstration of the performance of these products in applications on and around inland and coastal waters and has made it indisputably clear that biolubricants are already available in Europe for the majority of applications and that they have at least comparable—and sometimes even better—technical performance than conventional lubricants,” Krop says. The largest drawback is their purchase price, which is higher than that of conventional, mineral oil-based lubricant.” A recent review of trends in mobile equipment concluded that the demand for environmentally friendly hydraulic fluids will increase. The effects of expected growth in demand for EFLs are already being felt. Earlier this year, Cargill Industrial Oils & Lubricants doubled the capacity of its Chicago manufacturing plant, where the company’s Agri-Pure base oils are made. Elsewhere, R&D programs are hard at work on the problem of finding new vegetable and vegetable-derived base stocks.

For example, Caterpillar Inc., the North American heavy-duty OEM, has teamed up with the Agricultural Research Services’ National Center for Agricultural Utilization Research in the development and testing of more than 50 new fluids derived from vegetable oils—including the familiar soybeans, canola, corn and sunflower, along with more exotic types, such as lesquerella and meadowfoam—as replacements for current less-biodegradable fluids in industrial applications.

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Biodegradable vs. Environmentally Friendly

It seems inevitable that in discussing lubricant products for use in environmentally sensitive service, at least two issues will generate debate (or at the very least confusion).

The first of these concerns the concept of biodegradability itself. A conservative count yields about a dozen tests of biodegradability worldwide, with no one set of test criteria or conditions serving as a universal standard. A recent report* delineated some of the variances among test methods and measurements that contribute to this confusion.

In the context of emerging European and U.S. standards, another, more complex issue is arising; the distinction between environmental friendliness and biodegradability. Even more than biodegradable, the label “environmentally friendly” may be open to interpretation.

“Even the industry does not agree on a meaning,” A.D. Beitelman writes.1 “It is generally assumed that EFLs (environmentally friendly lubricants) must not be toxic and must biodegrade in a relatively short time, but no consensus has been reached on testing methods,” including such fundamental tests as which organisms should be used in toxicity tests, what the duration of testing should be, and what level of biodegradation is sufficient for the term “biodegradable” to be meaningfully applied, he states.

“Environmentally friendly” suggests negative adverse environmental effects,” says Hildo Krop, senior researcher and consultant within the Chemical Risks Unit of the IVAM, a research organization and consultancy on sustainability affiliated with the University of Amsterdam. “It is important to realize that whenever a negative environmental effect is found, a relation is looked for of its cause. This is done by searching and analyzing the chemical substance(s) causing this effect and then reducing their concentrations or deleting them from the formulation. (For more information, Krop suggests the articles listed to the left.)

Nigel Battersby, a project leader for industrial lubricants at Shell Global Solutions, prefers the term “environmentally acceptable” and adds that criticisms like those in the Beitelman article are outdated.

“In Europe, at least, there is a consensus on which test methods and organisms to use and the duration of the tests,” Battersby notes, pointing to the OECD (Organization for Economic Co-operation and Development) tests, which represent consensus from the member countries (the United States and Japan, as well as many in Europe).

“Where there is still some variation is in what constitutes an acceptable test result for an ‘environmentally acceptable lubricant.’

“It is important to know not only the manufacturer’s definition of environmental safety or biodegradability but also the performance limitations of the product,” wrote Miller et. al. in 2002.2 “The product must be considered in a total life cycle assessment ‘from cradle to grave,’ which includes the performance chemistry, base fluids, manufacturing conditions, ability to be recycled, disposal and packaging,” they say.

This broader consideration of the environmental effects of a lubricant may mean more testing and certainly will require a more intimate knowledge of how lubricant components perform, functionally and ecologically, at all stages of their lifetime. <<

EUROPE CONSIDERS ‘ECO-LABELING’

The EU Eco-Labeling Board is a regulatory body that promulgates criteria for a wide range of consumer and industrial products, which can then be marketed as environmentally friendly. In February 2004, alongside discussions of criteria for eco-labeling of refrigerators, dish soaps and mattress textiles, the board began to consider criteria for the eco-labeling of lubricants. This effort is mainly driven by the wish of industry and users to harmonize the many existing national eco-labels, Krop says, and is relying heavily on the expertise of the IVAM and the results of the LLINICWA to help develop the criteria for lubricants.

To this point, the classes of lubricants have been proposed for inclusion in the EU’s eco-labeling system: hydraulic fluids, chainsaw oils, gear oils, greases and concrete release agents. At the time of this writing, criteria for hydraulic fluids and greases have been fleshed out most explicitly. The initial proposed criteria (and the scientific evidence supporting them) were presented to the EU Eco-Labeling Board in a Concept Background Document late last year. In the main, these criteria are “modeled after the criteria in the Blue Angel [German standards], the Nordic Swan [Nordic countries’ standards] and the Swedish Standard,” the background document states. Since that initial presentation, the criteria have been updated (see Table 1).
Apart from the provisions outlined in Table 1, the Concept Background Document discussed the potential importance of life-cycle assessments (LCAs) in evaluating fluids. "The European Eco-label is meant to be Europe's premier award for products that are genuinely better choice for the environment," the background document notes. "In evaluating the comparative improvements, considerations have to be made regarding each life stage of the product. In the case of lubricants...the aspect of biodegradability is not necessarily the main criterion. All cradle-to-grave processes should be taken into account, even the pre-production stage of the life cycle, including extraction and processing of raw materials."

A typical LCA design for lubricants based on vegetable oil (in part) and mineral oil is shown in Figure 1. A full discussion of the steps in these schemes and typical findings and limitations of past LCAs are presented in Theodori et. al. The authors note that, because of different analysis designs, assumptions and criteria, wide variation exists among LCA findings.

"A clear comparison between lubricants (partly) based on vegetable oils and conventional mineral oil-based lubricants is not easy since no LCA was conducted where all the life cycle stages were integrated," they wrote. "Especially the lack of data on the effects and fate of ingredients in the lubricants when they are emitted into the environment (during use) hampers the full analysis of all life cycle stages."

Thus, despite all the attention in the background document, no LCA is proposed to be required for the EU Eco-label. David Sharp, European product regulatory affairs manager for additives maker, Lubrizol Corp., suggests that the EU approach is appropriate, citing both the limitations of LCAs to date and the small, individually market-driven demand for eco-labeled products. "The demand for [eco-labeled] products will probably grow in the future as environmental concerns increase, but the overriding driver in the near term is still expected to be performance-related demands," Sharp says. "However, introduction of legislative eco-labeling requirements would likely lead to increased demands for environmentally acceptable formulations."

U.S. ALSO PROMOTES LCAs

In the United States, LCAs are also beginning to garner attention. The USDA has tapped into this growing interest and is boosting the use of LCAs within the context of the draft guidelines for biobased products that would be preferred for purchase by federal agencies under the 2002 Farm Bill. The USDA has worked with the National Institute of Standards and Technology (NIST) in an expansion of NIST's BEES (Building for Environmental and Economic Sustainability) software to include performance data for eight major inputs to biobased products, including soybeans, corn and canola.

The BEES is an LCA tool originally developed for the construction industry; it measures products' environmental performance from raw material acquisition through waste management using the approach specified in ISO 14000 standards. "Due to its comprehensive, multidimensional scope, BEES can account for shifts of environmental and economic burdens from one life-cycle stage to another or one environmental medium (land, air, or water) to another," the BEES for USDA website states, thus highlighting tradeoffs among these factors. For more
Some commercial providers have also developed LCA-like tools. Two such programs are described in the sidebar "Providing Comparative Analyses for Environmental Performance," page 40.

FORMULATION CONCERNS
Lubrizol’s Sharp notes that additive makers are particularly likely to be affected as offroad lubricant criteria become more stringent. Restrictions on metals and R-phrase chemicals would mean rethinking some additives, continuing a trend already in place. For instance, one of the most effective and frequently found additives in heavy-duty hydraulic fluids, the antitrust/ extreme pressure agent zinc dithiodiphosphate, is already a target. Lubrizol’s 7600 series of additives and packages (including Lubrizol 7653, an ashless antitrust concentrate for hydraulic fluids) has been specifically developed for use in zinc-free, biodegradable lubricants. There has also been a shift toward use of advanced vegetable base oils (for instance, high-oleic stocks) and esters to help compensate for the exclusion of certain additives, which may well affect additive makers’ product (and bottom) lines.

Such is the nature of the industry’s evolution, says Allan Barber, Lubrizol’s European technology manager for hydraulics and industrial gear oils.

"In the early ’90s there were predictions that there would be a rapid increase in

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demand for biodegradable fluids," Barber says. "Now, 10 years later, these technologies have their place in the market, and there will continue to be an increase, but they won't replace all standard fluids because of the economics involved... What we've been seeing and what we think we'll continue to see is an evolutionary development of better fluids, both in terms of performance and effects on health and the environment, rather than a revolutionary change in technological advances."

As the notion of eco-friendliness moves beyond biodegradability, lubricant marketers may well be asked to demonstrate an understanding of lifecycle issues heretofore left unquestioned. When and whether LCA will be demanded by regulations or legislation is uncertain, but ongoing efforts in Europe and the United States demonstrate that trends in that direction are gaining ground. <<

Kat Carnes was formerly editor in chief of Lubricants World magazine. She is now a freelance scientific writer. You can reach her at k.carnes@sbcglobal.net.

References

Providing Comparative Analyses for Environmental Performance

As the world moves toward development of consistent and comprehensive lifecycle analysis (LCA) methodologies and tools, commercial marketers are beginning to develop their own products aimed at optimizing environmental and economic performance.

BASF Corp., for example, is promoting its labeling program for "eco-efficient products." This label may be assigned to "any product that performs better than alternative products in BASF's eco-efficiency analysis," the company said in an announcement to the media in February. The program includes an LCA and an independent expert corroborating the test results, the company says. Issued labels will be linked to a website (www.oeea.de), where the results of the analyses will be published, and the designation applies for a three-year period.

Shell Global Solutions has developed a similar tool, a "sustainability matrix," which the company says is quicker and more cost-effective than a conventional LCA. Designed for internal decision making at Shell Global Solutions, this matrix includes environmental, social and economic indicators and allows for side-by-side comparisons of different products. For more information, see the article by Cunningham et al.* The article reports on a comparison between a mineral oil-based and an "environmentally acceptable" hydraulic fluid using the sustainability matrix tool.

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