Universal fluids that function in different types of systems have never really taken off. An analysis of the issues and problems—and a couple of success stories.

By Maurice E. Le Pera and Allen S. Comfort
Vehicle, equipment and machinery systems require a variety of lubricating oils and fluids to operate satisfactorily. The lubricating oils and fluids needed differ widely in their performance because of their intended use and differing system requirements. This is particularly true in automotive applications, including passenger cars, heavy-duty vehicles, agricultural equipment and construction machinery.

The evolving nature of the automotive industry (increasing power density of engines, more computer-assisted functions, etc.), coupled with new and more challenging environmental regulations, has markedly changed the lubrication requirements for engine oils, gear lubricants and other fluids over time. These changes have resulted from the need to accommodate higher engine operating temperatures and combustion pressures, extended drain intervals, improved fuel economy and engine efficiencies, reduced overall emissions and similar changes. In addition, the introduction of new engines, powertrain technologies and hydromechanical systems (for example, the continuously variable transmission) has caused an increase in the number of engine oils, gear lubricants, transmission fluids and other special-purpose fluids and oils within the marketplace.

The increasing number of these automotive products is most visible in the recommendations different manufacturers provide in their individual owners manuals. Troy, Mich.-based, Motor Information Systems, a Hearst company, publishes an annual summary of automotive lubrication requirements called the “Chek-Chart Lubrication Recommendations Guide.” A copy of the 2005 edition revealed the following:

• 22 types of engine oils.
• 10 types of gear lubricants.
• 14 types of automatic transmission fluids.
• 3 types of manual transmission oils.
• 4 types of hydraulic fluids.
• 21 types of power steering fluids.
• 37 types of special lubricant-fluids.

Within the group of special lubricant-fluids was even further specialization, as many products were listed individually.

Given the sheer number of individual products, one can see the potential for misapplications. Expense is also a factor; the higher the infrastructure costs of storing and distributing these products, the lower the opportunity for cost savings through high-volume purchases and the higher the disposal costs. Obviously, if an oil could be formulated to provide multiple functions (i.e., to be a multipurpose or universal oil), the user/consumer would benefit for those reasons given above.

Formulation issues

Formulating a multipurpose or universal oil, however, is not simple. Different performance needs are best handled by different basestocks and additive chemistries, and the performance testing required for each of the products varies accordingly (see Table 1).

For example, engine oils and gear lubricants differ not only in viscosity requirements but also in necessary additives. Gear lubricants for hypoid gear systems need additives to provide extreme pressure performance, whereas these qualities are not needed for engine oils. Likewise, automatic transmission fluids require a different type of friction modification than that needed by gear lubricants and engine oils and have a greater need for seal conditioners and other components to ensure elastomer component dimensions do not change with use. In addition, all these oils differ greatly from metalworking fluids, which may require completely different additive and basestock combinations to control the conditions inherent in metalworking processes (high friction, high temperatures and tool wear).

Table 1 does not show the individual performance tests for each of these products because of the different and diverse procedures used. For example, testing for wear protection is relatively simple for hydraulic fluids because only laboratory methods are used, whereas the testing required for engine oils involves an engine dynamometer. Likewise, gear oils require specialized rig tests for determining wear that are far removed from laboratory procedures. Incor-
porating individual performance requirements (e.g., engine oil, gear lubricant, hydraulic fluid, metalworking fluid) into a multipurpose or universal oil would require not only new types of additives but also probably higher additive treatment levels and possible basestock changes. All of these would have to function synergistically if the intended objective was to be realized. To illustrate this, Table 2 briefly summarizes the typical range of additive levels found in a sampling of different products.

Table 2 shows engine oils representing those products that require higher rates of additive treatment. For example, a typical API CE SAE 15W-40 engine oil is composed of 78% base oil and 22% additives, broken down as 9% viscosity index improver and 13% detergent-inhibitor package. The detergent-inhibitor package, in turn, consists of 62% dispersant, 0.9% corrosion inhibitor, 0.1% demulsifier and 0.1% antifoaming additive.

Given the increased number and types of additives as well as higher treatment levels that would be required in formulating multipurpose or universal oils, there exists the potential that more additives might lead to possible compromises in the oil quality, as well as increasing the potential for adverse or anti-synergistic additive interactions. Engine oil formulators are already having difficulties in trying to maintain the delicate balance between fuel economy, emission requirements, extended drain intervals and engine durability. This balance would be adversely impacted if one were to attempt introducing the types of extreme pressure additives required for gear lubrication.

Table 1. Comparison of Different Oils and Fluids

<table>
<thead>
<tr>
<th>Application</th>
<th>SAE Grade</th>
<th>Detergent-Inhibitor Package Additive Treat Rate</th>
<th>Viscosity Modifier Treat Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger car engine oil</td>
<td>Single Grade Multigrade</td>
<td>6-14</td>
<td>--</td>
</tr>
<tr>
<td>Heavy-duty diesel engine oil</td>
<td>Single Grade Multigrade</td>
<td>12-19</td>
<td>6-12</td>
</tr>
<tr>
<td>Automotive transmission fluid</td>
<td>Single Grade Multigrade</td>
<td>6-12</td>
<td>3-14</td>
</tr>
<tr>
<td>Automotive gear and transmission oil</td>
<td>Single Grade Multigrade</td>
<td>5-12</td>
<td>25-35</td>
</tr>
<tr>
<td>Tractor hydraulic fluid</td>
<td>Single Grade Multigrade</td>
<td>6-9</td>
<td>4-8</td>
</tr>
<tr>
<td>Industrial hydraulic fluid</td>
<td>Single Grade Multigrade</td>
<td>0.5-1.5</td>
<td>2-12</td>
</tr>
<tr>
<td>Grease</td>
<td>--</td>
<td>2-6</td>
<td>Contains a thickener</td>
</tr>
</tbody>
</table>

The individual data shown represent typical values for each of the product types listed. Although additional characteristics exist for these products (e.g., sulfated ash content, foaming, rust protection, galvanic corrosion, and individual function values such as antiwear or oxidation protection), they are not included here.

Table 2. Typical Lubricant/Fluid Compositions

<table>
<thead>
<tr>
<th>Service Classifications</th>
<th>Engine Oil</th>
<th>Gear Oil</th>
<th>Automatic Transmission Fluid</th>
<th>Hydraulic Fluid</th>
<th>Universal Tractor Transmission Oil</th>
<th>Machine Tool Sideways Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILSAC GF-4</td>
<td>API GL-5</td>
<td>MERCON &amp; Dexron III</td>
<td>ISO 22</td>
<td>API SF/CE &amp; GL-4</td>
<td>Cincinnati Machine P-53</td>
<td></td>
</tr>
<tr>
<td>Properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Viscosity @ 40°C</td>
<td>60.0 cSt</td>
<td>141.8 cSt</td>
<td>35.4 cSt</td>
<td>20.9 cSt</td>
<td>112.5 cSt</td>
<td>--</td>
</tr>
<tr>
<td>Viscosity Index</td>
<td>136</td>
<td>139</td>
<td>99</td>
<td>34</td>
<td>95</td>
<td>--</td>
</tr>
<tr>
<td>Pour Point, °C</td>
<td>-36</td>
<td>-48</td>
<td>-27</td>
<td>-27</td>
<td>-12</td>
<td>--</td>
</tr>
<tr>
<td>Flash Point, °C</td>
<td>255</td>
<td>190</td>
<td>237</td>
<td>232</td>
<td>246</td>
<td>--</td>
</tr>
<tr>
<td>API Gravity</td>
<td>28.75</td>
<td>28.03</td>
<td>30.96</td>
<td>32.65</td>
<td>30.10</td>
<td>--</td>
</tr>
<tr>
<td>Total Base Number</td>
<td>7.8</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>12.8</td>
<td>--</td>
</tr>
</tbody>
</table>

Some fuel-efficient engine oils reportedly lose their ability to reduce friction due to additive interactions and depletion resulting from antioxidant reactions. As mentioned above, any changes in additives or basestocks can create a domino effect in altering the desired performance quality. The
Formulating a multipurpose or universal oil, however, is not simple. Different performance needs are best handled by different basestocks and additive chemistries.

Concerns regarding performance tradeoffs take on greater importance in formulating multipurpose or universal oils as the addition of those additives not typically used in one product application could result in some loss in performance (e.g., increased deposits or changes in frictional characteristics). As an extreme example, consider what would happen if sulfurized or chlorinated compounds typically used for metalworking fluids were introduced into an engine oil. This question of performance tradeoffs would lead to increased development costs as even subtle changes in a given formulation typically necessitate retesting. For engine oils, this involves the time-consuming and expensive engine dynamometer testing.

The Army’s experience

In the past, industry has made few major efforts toward developing and marketing multipurpose or universal oils capable of performing multiple functions. This hesitancy more than likely is the result of the high developmental costs mentioned above. Additionally, customer acceptance of such a product would require a considerable degree of marketing. Nevertheless, there are two areas where multipurpose oils have been successful—equipment used by the U.S. Army and agricultural equipment.

For years, the Army has been a major supporter of multipurpose or universal engine and powertrain oils. The driving forces behind this effort have been to minimize both the logistics and supply requirements for its ground fleet of vehicles and equipment and to lessen the chances of maintenance mistakes that might occur due to misapplication. Coupled with this is the need for flexibility in logistics and supply systems because of the nature of military operations (i.e., the necessity to provide for many different types of vehicles and engines operating in widely differing environmental conditions and operating modes).

The Army’s “bread and butter” engine oil, described in Performance Specification MIL-PRF-2104H (Lubricating Oil, Internal Combustion Engine, Combat/Tactical Service), has served this role well over many years. Oils meeting this specification are not just intended for internal combustion engines but also are used in powershift transmissions, hydraulic systems and non-hypoid gear systems for engineering/construction equipment, material-handling equipment and all types of combat/tactical ground equipment.

Wherever possible, automotive specification products are used in as many applications as possible, accepting some performance tradeoffs in favor of reduced logistics. Military Handbook MIL-HDBK-838 (Lubrication of Military Equipment) recommends that equipment manufacturers use military standardized lubricants. Nonstandard lubricants can be approved only when the contractor indicates that a particular vehicle or piece of equipment will not perform satisfactorily otherwise. Unfortunately, this has been relatively difficult to enforce as contractors typically cite safety or warranty concerns if they cannot specify a particular—usually brand-name proprietary—product. In citing these concerns, rarely have contractors provided any testing documentation to support them.

One such example of a warranty concern occurred in the mid-1970s during procurement of the John Deere 410 Loader Backhoe as part of the Army’s Commercial Construction Equipment (CCE) program. Under this program, the Army adopted a policy of procuring “off-the-shelf” commercial CCE.

Recognizing that many of these items had supplier-imposed lubrication requirements, the Army approached ASTM’s Committee D2 on Petroleum Products and Lubricants in 1974 to see whether a multipurpose hydraulic fluid specification could
be developed, given the existing numbers of proprietary fluids. No agreement was reached as each equipment manufacturer preferred its individual proprietary fluid and maintained that the military’s primary engine oil would create problems if used as a hydraulic and transmission fluid.

The contract award to John Deere and Co. in 1975 for the 410 Loader Backhoe introduced the first wet-brake-equipped commercial vehicle into the Army’s inventory. It was accompanied by the requirement to use John Deere’s IDM-J20A Transmission and Hydraulic Fluid as a field lubricant. Recognizing the potential for application of the military’s engine oil by maintenance crews, the Army proceeded to determine whether the military-spec engine oil could provide equivalent performance to the IDM-J20A factory-fill fluid.

The results of these laboratory bench tests, wet-brake tests, full-scale wear tests and field evaluations subsequently revealed the military engine oils to not only be equivalent to the JDM-J20A fluid but, in many instances, superior. Table 3 highlights some of the more critical test results where superior performance of the military oils was fully demonstrated when compared to the John Deere reference oil.

Concern about using engine oils for wet-brake applications recently surfaced again with procurement of the Deployable Universal Combat Earthmover (DEUCE). The manufacturer maintained that although these systems could tolerate the Army’s engine oil, continual use of this oil could decrease their life because of the oil’s lower coefficient of friction. However, the manufacturer has not provided any data to support its claims.

Apart from the questioned use of engine oils for wet-brake clutch applications, wherever possible the Army continues to use engine oils in more than one application. Engine oils are used in manual clash-type transmissions, transfer cases, power steering pumps, hydraulic systems and automatic and powershift transmissions. Reviewing any lubrication

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**Multipurpose quest stymied by diverse industrial needs**

By Kathryn Carnes
Features Editor

As in automotive applications—in fact, to an even greater degree—few lubricants for industrial equipment can be classified as “multipurpose,” despite the fact that end-users continue to express interest in such fluids and lube manufacturers continue to try making them, says Frans Van Antwerpen, project manager at New Jersey-based consultancy Kline and Co. Such fluids potentially could save users money by reducing storage needs, eliminating tramp oil concerns and allowing for single-source purchasing. However, several factors conspire against development of these fluids, says Van Antwerpen.

For example, suppose you were trying to design a single fluid to function as a way oil, hydraulic fluid and metalworking fluid. While all three functions might require high-temperature capability, other desired properties are mutually exclusive, Van Antwerpen points out.

“In the case of a metalworking fluid, one of the things you really need is for it to be cleaned off of the workpiece easily. But you want a way oil to stay put where it is applied. These two needs are contradictory, and it would be very hard to design a fluid that can do both,” he says. Similarly, the viscosity needs of these three functions would not be compatible, nor would some of the additive chemistries that traditionally are used in formulation.

Another problem, Van Antwerpen says, lies in the relative cost of the various fluids (due to volumes, component requirements and similar factors). “Hydraulic fluids are cheap, especially compared to metalworking fluids, which are much more expensive,” he says. “Even if you succeeded in making a fluid that functioned in both applications, what you would wind up with is a very expensive hydraulic fluid, because the costs would be dictated by the more expensive formulation. That would not be acceptable, so the fluid would not really be marketable as a multifunctional fluid.”

Even within the class of metalworking fluids, different needs dominate within different major categories of products: metal-removal fluids (for cutting, boring, grinding) tend to be focused on cooling the tool and workpiece, while metal-forming fluids (for stamping and drawing) more often need to provide lubrication and extreme-pressure protection.

As a practical matter, Van Antwerpen adds, even different manufacturers of similar types of equipment (motors or compressors, for instance) tend to each specify a particular proprietary oil of some sort, citing warranty concerns.

“Once the warranty period is over,” Van Antwerpen notes, “a single gear oil or compressor oil would be used in all of those types of equipment, no matter what lube the manufacturer had specified. In that sense, lube consolidation occurs. But using a gear oil as a hydraulic fluid? End users are interested and manufacturers are trying—so far, unsuccessfully.”

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Order (LO) document will reveal numerous locations other than the engine's crankcase where engine oil is specified. LOs accompany each individual vehicle or equipment and provide the necessary instructions as to types and quantities of lubricants, lubrication points, lubrication intervals and similar usage guidance.

For example, the LO for the M911 Heavy Equipment Transporter (LO9-2320-270-12) specifies engine oil to be used not only in the engine but also the auxiliary transmission, transfer case, automatic transmission, hydraulic reservoir and steering system. On the other hand, the LO for the commercially procured (i.e., off-the-shelf) M1008 Tactical Cargo Truck 1-1/4 ton (LO9-2320-289-12), commonly called the Commercial Utility Cargo Vehicle, specifies Dexron II automatic transmission fluid for the transmission, transfer case and power steering pump and reservoir. These cases illustrate the difference between military-designed vehicles vs. those procured commercially, in the latter case the contractor generally has the final say on what lubricating oils and fluids will be used.

**Agricultural experience**

Within the agricultural industry as early as 1980, a paper reported on the development of a multi-use engine oil for farm tractors that satisfied requirements for the engine, transmission, gear system and hydraulics. This development represented a start toward multipurpose or universal oils that has persisted in these applications; however, the momentum has not carried over to other vehicular or machinery applications.

Marketing multipurpose oils for agricultural equipment demonstrates the range of products available. One manufacturer advertises a “Universal Oil” designed to be used in a variety of heavy-duty diesel and gasoline engines, powershift transmissions and general hydraulic applications. Another manufacturer recommends a premium, multifunctional tractor oil for farm machinery that naturally lubricates aspirated or turbocharged diesel engines, transmissions and hydraulic and immersed wet-brake systems. Most tractors now use a common reservoir for fluids serving transmissions, final drives, wet brakes and clutches and hydraulic systems.

To satisfy this market, some lubricant formulators have developed a specific class of oils called universal tractor transmission oils (UTTOs) that are commonly used in North America. In Europe and some other areas of the world, farmers have accepted the concept of super tractor oil universal oils (STOUs). The key difference between the STOUs and the UTTOs is that an STOU can also be used in the engine as well as the transmission, final drive, wet brakes and clutch and hydraulic system. There are no industrywide standards for either UTTOs or STOUs, as shown in Tables 4 and 5; instead, OEMs set their own standards. For more information about UTTO and STOU requirements, respectively, visit [http://www.lubrizol.com/ReadyReference/DrivelineLubricants/10-tractor/default.asp](http://www.lubrizol.com/ReadyReference/DrivelineLubricants/10-tractor/default.asp).

**Trends**

Although at least some within the user community would welcome multipurpose or universal oils, there seems to be no concerted effort within the industry to promote a single oil providing multiple functions. Part of this reluctance probably is a result of how the industry operates. Marketing a greater number of individual products is likely to generate greater profit margins. Unfortunately for the consumer, this practice increases the overall operating
costs for vehicles, equipment, and machinery systems.

Another possible factor is the tendency of some OEMs to promote their own proprietary products. This tendency was evidenced in a recent article that discussed trends in automotive gear lubricants. These trends were (1) the move toward special OEM-approved extended-drain lubricants and (2) the control of lubricant sales by the OEMs themselves.

Within the current timeframe and looking toward the next several years, it appears there will be no major changes in vehicle, equipment and machinery systems using lubricating oils and other fluid products. Vehicle and equipment systems still will use the internal combustion engine as their primary power source. Likewise, expect mechanical processes that factory machinery systems utilize to undergo minimal changes, except for increased automation.

In addition, because of recent problems with some equipment manufacturers who mandated using proprietary transmission oils in place of military lubricating oils, the Army may step away from its longtime association with multipurpose engine oils altogether and embrace a different approach. This proposed change was strongly supported by both OEMs and lubricant manufacturers in an Army survey conducted in August 2002 to gauge the suppliers’ opinions on current and future trends affecting military ground equipment. The overwhelming reasons given for the separation of the engine and transmission requirements included the ability to optimize component durability and performance, formulate for longer drain intervals and reduce formulation costs.

Arguing for multipurpose oils, however, is the concept of lubrication consolidation, which has surfaced as a means of reducing maintenance costs, extending equipment life and simplifying the purchasing process. Although lube consolidation has been primarily directed toward factory machinery, for which sig-

Table 3. Friction and Wear Testing Comparing John Deere’s JDM-J20A Reference Oil with Military Specification Engine Oils

<table>
<thead>
<tr>
<th>Tests</th>
<th>John Deere Limit</th>
<th>John Deere Reference Oil</th>
<th>Arctic Engine Oil (OEA)</th>
<th>Engine Oil (OE/HDO-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caterpillar TO-2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slip Time, % increase</td>
<td>15 max</td>
<td>25 [Fail]</td>
<td>7.1</td>
<td>13.2</td>
</tr>
<tr>
<td>Bronze wear, mm</td>
<td>0.25 max</td>
<td>0.14</td>
<td>0.07</td>
<td>0.16</td>
</tr>
<tr>
<td>Steel wear, mm</td>
<td>0.10 max</td>
<td>0.09</td>
<td>0.06</td>
<td>0.09</td>
</tr>
<tr>
<td>Allison C-3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slip Time, @ 5500 Cycles</td>
<td>0.85 max</td>
<td>0.99 [Fail]</td>
<td>0.72</td>
<td>0.79</td>
</tr>
<tr>
<td>Torque (at 0.2-s Slip Time)</td>
<td>75 min</td>
<td>55 [Fail]</td>
<td>105</td>
<td>90</td>
</tr>
<tr>
<td>Torque Differential @ 0.2-s Slip Time</td>
<td>50 max</td>
<td>49 [Fail]</td>
<td>9</td>
<td>24</td>
</tr>
<tr>
<td>Transmission Final Drive Wear</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Hand, mm</td>
<td>Report</td>
<td>0.09</td>
<td>0.02</td>
<td>0.06</td>
</tr>
<tr>
<td>Right Hand, mm</td>
<td>Report</td>
<td>0.07</td>
<td>0.03</td>
<td>0.07</td>
</tr>
</tbody>
</table>

CONTINUED ON PAGE 28
significant numbers and types of lubricating oils and fluids exist, some of the methodology would certainly be applicable to the automotive industry. Very possibly, this need for reduced costs and improved quality control may become a motivator for promoting multipurpose or universal oils. Should cost or some other driver create a groundswell for development of multipurpose or universal oils, new additive chemistries would more than likely be necessary to insure satisfactory performance of these multifunctional products.

Conclusions
The option of multipurpose or universal oils certainly has considerable merit from the standpoint of the end-user, be it a truck driver, farm vehicle operator or factory metalworker. All would benefit from some increased level of consolidation of lubricant and fluid products. Whether any substantial industrywide effort ever surfaces to create such oils, however, really rests with the end-user, who will ultimately decide how many products will be accepted. <<

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References