Improving Equipment Productivity and Fuel Economy with the Dynavis® Additive System for Hydraulic Fluids

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Operators of mobile hydraulic equipment are driven by very practical yet challenging motivation to do more work, in less time and at the lowest total cost without compromise on safety. Concerns over air pollution and CO₂ emissions are also driving hydraulic equipment builders to develop new innovations and improvements in efficiency and fuel economy in off-road equipment. Every supplier to this market, including lubricant manufacturers, must find ways to offer improved efficiency and lowest total cost for these demanding customers.

There is now technology available to improve the efficiency and fuel economy of hydraulic equipment through the proper formulation and selection of hydraulic fluids. This concept of Maximum Efficiency Hydraulic Fluid (MEHF) has been developed by RohMax Oil Additives over the last several years. Starting from mathematical models of hydraulic circuit thermodynamics, RohMax progressed through lab-scale pump tests in gear, vane and piston pumps, and finally demonstrated the benefits in full scale, off-road equipment tests. This innovation was recently recognized by ICIS through their 2007 Innovation Awards, “Innovation with the Greatest Beneficial Environmental Impact.” Now RohMax is offering Dynavis®, a complete additive solution for hydraulic fluid formulators who want to deliver the MEHF performance level to their customers.

This article briefly describes the technology behind MEHF and Dynavis. It then reports on the results of a field test of a Dynavis fluid in a hydraulic excavator. This field test demonstrated up to a 26% improvement in fuel economy in the excavator, as well as a 6% improvement in productivity.

MEHF Explained

The overall efficiency of a hydraulic pump or motor is a combination of two factors, mechanical efficiency and volumetric efficiency. Both of these factors are a function of hydraulic fluid viscosity but they react in opposite ways. As described in Figure 1, higher viscosity (that is, higher resistance to flow) causes a decrease in efficiency as the pump has to do more work just to move the fluid through the system. On the other hand, volumetric efficiency increases with higher viscosity because thicker oil suffers less wasteful leakage through the internal recycle pathways that are designed into pumps and motors. These recycle pathways (sometimes called internal leakage) allow the fluid to lubricate the sliding surfaces of the pumps. As the flow through these pathways increases, the output of the pump decreases and therefore so does the volumetric efficiency. An optimized hydraulic fluid offers a balance, where a fluid is thin enough to flow effi-

![Figure 1. Effects of Viscosity on Overall Pump Efficiency](image-url)
ciently but thick enough to pump efficiently. Because viscosity is a function of temperature, an efficient hydraulic fluid has to maintain this balance over a wide range of operating temperatures. Equipment may need to start when it is very cold, and still operate when the fluid is very hot by the end of the day. This wide temperature operating range is the reason that multi-grade hydraulic fluids are often used in mobile hydraulic equipment. The benefits of multi-grade hydraulic fluids at colder temperatures (lower startup temperatures, elimination of heaters, smoother cold temperature operation) are well understood in the industry. But the lower viscosity at cold temperatures is accompanied by a higher viscosity at high temperatures, where the volumetric efficiency plays an increasing role in overall system efficiency. Hence the need for high viscosity index MEHF fluids which display a significantly reduced viscosity loss at elevated temperature compared to lower VI conventional fluid offerings. Thus well designed multi-grade hydraulic fluids can increase the efficiency across the entire temperature operating range.

The Dynavis Additive System
Hydraulic fluid formulators have at their disposal a wide range of additive technologies to enhance fluid life (drain interval), corrosion resistance, wear protection, viscosity (low temperature and multi-grade performance) and many other properties. Dynavis is an additive system specifically designed to formulate Maximum Efficiency Hydraulic Fluids (MEHF). It consists of antiwear/antioxidant/corrosion inhibition (AW/AO/CI) packages and shear stable Viscosity Index Improvers (VII) that are optimized to work together and consistently deliver improved fuel efficiency and productivity in hydraulic equipment.

Field Trial Performance
A Dynavis hydraulic fluid was tested in a Caterpillar® excavator in order to measure its performance relative to the OEM-recommended fluid. The test consisted of a repeated work cycle where fuel consumption and work completed were measured over time. The test showed that fuel consumption per work cycle decreased 18% or 26% depending on the throttle setting of the excavator. In addition, the productivity (work cycles per hour) increased 6% to 24%.

The field test was run in a Caterpillar® 318CL tracked excavator. The unit is powered by a 125HP diesel engine driving two hydraulic piston pumps and three hydraulic piston motors for moving and turning the vehicle (see photo in Figure 2). In order to measure a repeatable work cycle, a pile of loose dirt was placed at one end of a 100-foot long course. The work cycle consisted of taking a scoop of dirt as large as possible from the pile, rotating the cab 180˚, traveling forward full speed for 100 feet, dropping the dirt, rotating again 180˚ and returning full speed 100 feet to the start. This cycle was repeated for 6 hours under each test condition including two engine throttle settings, 90% and 100%.

Two fluids were evaluated in the field test. The first was the OEM-branded and recommended 10W (L46-46) hydraulic oil. Fresh oil was purchased and used in the test. The second oil was a Dynavis Maximum Efficiency Hydraulic Fluid (L32-100). After running the test with the reference oil for one day at each throttle setting, the oil was completely changed to the Dynavis MEHF test fluid and run again for full days at each throttle setting. The oil was then changed back to the reference oil and run again, confirming the original baseline measurements.

The results of the test are summarized in Figure 3. At both throttle settings tested, the Dynavis hydraulic fluid allowed the excavator...
tor to complete more work cycles in a given period of time. This is because the increased in-service viscosity of the MEHF fluid increased the actual flow rate out of the pumps and through the motors increasing the volumetric efficiency of the system. Furthermore, even at the same throttle setting the diesel engine consumed less fuel when running the Dynavis fluid because the more efficient hydraulic system required less power to accomplish the same amount of work. By combining the fuel consumption and productivity gains into a measure of fuel consumed per work cycle, the final results of 18 – 26% improvement can be calculated.

This field test was run under mild ambient and operating conditions. Outdoor temperatures ranged between 45-65°F (7-18°C) for both fluids. Average temperatures in the hydraulic fluid reservoir ranged between 90-142°F (32-61°C) with peak temperatures of 100-153°F (38-67°C). Because the efficiency advantages of MEHF fluids increase with higher operating temperatures, this field test is a good indicator of significant potential improvement in equipment efficiency under harsher conditions as well.

Financial and Environmental Benefits
The fuel saving benefits of Dynavis are easy to see in the test described above. But when these benefits are extended over the typical life of a hydraulic fluid, the results are even more impressive. The recommended drain interval for equipment used in this field test is 4,000 operating hours. If the test were extended over this complete lifetime, the excavator would burn 3,300 fewer gallons (13,000 liters) of fuel. At typical prices in the United States where this test was conducted, this results in a savings of at least $8,000 (more in most other countries). In addition to these savings in fuel costs, the increased productivity offered by the Dynavis fluid could be worth significantly more.

Finally in just one hydraulic excavator, 3,300 fewer gallons of diesel fuel burned could result in a decrease in emissions and a reduction in CO2 production of ~33.3 metric tons (U.S. EPA standard CO2 production of 10.08kg/gallon diesel). 

Conclusions
RohMax Oil Additives is pleased to offer the Dynavis additive system to lubricant manufacturers who are looking for ways to increase their customers’ productivity and reduce their total cost of operation. Furthermore it is honored to offer the industry a cost-saving solution that also has recognized environmental advantages. More information on Dynavis including calculators to estimate the benefits of MEHF for an entire fleet of equipment can be found at www.dynavis.net, or by contacting RohMax Oil Additives at www.rohmax.com.

<table>
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<tr>
<th>Test Conditions</th>
<th>Fuel Consumed per work cycle, kg/cycle</th>
<th>Fuel Consumption Improvement, Percent</th>
<th>Fuel Consumed per Hour, kg/hour</th>
<th>Fuel Consumption Improvement, Percent</th>
<th>Work Cycles per Hour, Cycles/hour</th>
<th>Percent Improvement</th>
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<tr>
<td>Cat HYDO 10W (L46-46) Full Throttle</td>
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<td>53.5</td>
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<td>+ 13.8%</td>
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<tr>
<td>DYNAVIS MEHF (L32-100) 90% Throttle</td>
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<td>+ 8.6%</td>
<td>49.7</td>
<td>+ 24.3</td>
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References
5. For more information on the “L-grade” nomenclature for hydraulic fluids see the National Fluid Power Association Recommended Practice for Viscosity Selection T2.13.13.

Figure 3. Field Test Results

http://www.epa.gov/otaq/climate/420f05001.htm#calculating.