Cost and Performance Advantages of Multigrade Hydraulic Fluids

D.G. Placek and C.W. Hyndman
RohMax USA

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Abstract

A long-term study was conducted in Canadian forestry equipment to compare the performance of monograde (seasonal) and multigrade (year-round) hydraulic fluids. This environment and application offer a challenging mixture of ambient and operating temperatures where proper viscosity is critical for minimizing downtime and maximizing profitability. Most fleet operators accommodate the extreme temperature conditions by using seasonal monograde fluids.

Fifteeen different test units were outfitted with temperature recording equipment. These units were selected to include a variety of hydraulic system designs from a number of equipment manufacturers. The data gathered indicates that the hydraulic oil is running much hotter than anticipated in most of the forestry equipment monitored. This problem is difficult to resolve, as many systems do not offer adequate cooling capacity. Selecting an oil with the right viscosity is important in order to minimize heat generation due to internal pump leakage.

A test matrix was developed to closely monitor the performance of several road graders and tree de-limbers during winter and summer service. The study documents oil temperatures and pressures, leakage rates, and maintenance considerations that are encountered in the field. Commercially available hydraulic fluids were chosen for evaluation. Multigrade oils offer the user a much wider temperature operating window (TOW), which is often required in outdoor operations or in hard working systems where the fluid absorbs and holds heat. Multigrade fluids tend to be slightly higher in cost per gallon, but were found to offer significant savings when maintenance and disposal costs are considered. Cost savings ranged from 20% to 55% per unit depending on leakage rates.

The significant cost and performance benefits documented in this study are applicable to any hydraulic system that experiences seasonal temperature variations. The use of a high quality shear stable multigrade hydraulic fluid can reduce downtime and maintenance costs, while delivering consistent system response.Though multi-graded lubricants are widely used in North American and European countries, single-graded lubricants are still predominantly used in Asian market. This tendency is probably due to the misunderstandings that multi-graded lubricants are only beneficial under cold climate and are expensive.

Keywords: Hydraulic, Multigrade, Field, Forestry, Temperature.

Biodata

DOUG PLACEK is a global product manager for RohMax USA based in Horsham, Pennsylvania, USA. He is responsible for the RohMax line of viscosity index improver additives designed for use in hydraulic fluid applications. Doug holds a B.S. in Chemical Engineering from Drexel University and a M.S. in Organization and Management from LaSalle University. Doug is a member of STLE, SAE, ASTM and CDMA, and has authored a variety of patents and publications in the areas of synthetic lubricants and additive technology.

CHARLES HYNDMAN is a research group leader for RohMax USA based in Horsham, Pennsylvania, USA. He is responsible for product development and technical service support for RohMax hydraulic fluid additives. Bud holds a B.S. in Chemistry from Temple University. Bud is a member of ASTM Committee D-2 on Petroleum Products and Lubricants, SAE, STLE, and various automotive groups of the Coordinating Research Council.

Introduction

Selecting a hydraulic fluid with an optimum balance of cost and performance can be a difficult challenge. Criteria such as fluid price per gallon, OEM performance guidelines, temperature and pressure expectations, as well as other unique system requirements must be considered. Once a fluid is placed in service, it should exhibit long life and minimize maintenance costs. How can the right product be found?

A good starting point is proper fluid viscosity selection, which is a critical factor in hydraulic system performance. The right fluid must transmit power and lubricate moving parts over the entire operating temperature range. This requires the fluid to be thin enough to flow at cold start-up temperatures, and thick enough to create a protective lubricating film in the pump at peak operating temperatures. OEM's have designed their equipment to operate with fluids having specific viscosity profiles. A system operating with fluid that is too thick or too thin will experience sluggish response or failure.

A long-term study was conducted in cooperation with the Forest Engineering Research Institute of Canada (FERIC) in year-round operations in Kapuskasing Ontario. Additional details can be found in FERIC technical note TN-251 (1). Interviews with area contractors indicated that there was no problem in selecting a fluid to meet OEM guidelines, but it was unclear if these fluids were truly optimum considering local operating conditions and maintenance practices. This environment and application offer a challenging mixture of ambient and operating temperatures where proper viscosity is critical for minimizing downtime and maximizing profitability.

1. Field Test Design

1.1 Equipment

A variety of equipment from a number of major suppliers was monitored, including the following:

4 Harvesters
2 Forwarders
2 Delimbers
2 Cleaning Machines
2 Graders
3 Feller-Bunchers

1.2 Hydraulic Fluids

Contractors were surveyed to identify the major types of hydraulic oil that were available and widely used. Three commercially available hydraulic fluids from major North American suppliers were selected for detailed evaluation. These fluids can be described as:

TABLE 1 - TEST OILS

Type	ISO Grade	Viscosity @ 40°C	Temperature @ 5000 cSt	Temperature @ 10 cSt
Monograde "seasonal" Winter Grade	ISO VG 22	22 cSt	-37°C	67°C
Monograde "seasonal" Summer Grade	ISO VG 100	100 cSt	-8°C	104°C
Multigrade "year-round" L22-34 (220)*	ISO VG 46	46 cSt	-33°C	106°C

*according to ASTM D 6080

The temperature operating window for any hydraulic system can determined by examining pump requirements. This information can be obtained by contacting the OEM, or, a summary of many pump fluid specifications can be found in a recent technical paper by Herzog et.al. (2). Typical specifications for hydraulic fluids used in Canadian forestry equipment require that the oil never get thicker than 5000 cSt, or thinner than 10 cSt.

1.3 Temperature Conditions

Ambient temperatures in Kapuskasing Ontario occasionally reached -40°C (-40°F) on winter nights, and peaked at +35°C (95°F) on summer afternoons. In general, oil operating temperatures typically ran 40-60°C above ambient temperatures, but it was not uncommon for the oil to peak at 100-115°C above ambient temperatures in both winter and summer operations. Oil temperatures were measured in the range of -29°C to +135°C over the course of the year. These oil temperature extremes dictate that several monograde hydraulic fluids need to be rotated in service, or a single multigrade be used year-round.

2. Field Test Observations

2.1 Fluid Temperature

Winter monograde fluids offer quick start-up and excellent response at low temperatures, unfortunately, they cannot provide adequate lubrication protection if oil temperatures rise above 65°C. The data gathered indicates that most of the hydraulic systems studied had an average winter operating temperatures around 50-60°C, with extended daily periods of higher temperatures where the oil was too thin. Hydraulic pumps need oil with a minimum level of viscosity, or there is significant internal leakage (backflow) which results in slow oil transmission to the hydraulic cylinders. Slow oil flow means sluggish response and a decrease in equipment productivity. When the flow rate slows down, the operator will typically push the pump to work harder, which creates more heat, and the oil becomes even thinner. This cycle can lead to high wear and decreased pump life.

The use of summer grade hydraulic fluid can be a problem in fall and spring, as evening temperatures occasionally drop below freezing. At this temperature, the summer grade oil thickens above 5000 cSt and morning start-ups can be a problem. Hydraulic pumps require sufficient oil flow to maintain 70-80 kPa suction pressure. When the oil is too thick, there is cavitation at the inlet port which results in high pump wear and sluggish system response. Operators reported that it was common to experience slow start-ups on cold mornings that required 15-30 minutes of slow speed control valve shifting to warm the oil and maintain suction pressures above the minimum limit.

2.2 Fluid Stability

All of the fluids evaluated in this study exhibited good shear stability and constant viscosity characteristics over the one year test period.

2.3 Oil Changes

One of the challenges in using the lower cost monograde oil is scheduling the oil changes. It is often undesirable to take equipment out of service due to seasonal weather patterns, it is far more desirable to conduct maintenance when it fits the work schedule or other planned maintenance events.

When oil changes are performed, it is extremely difficult to drain all of the fluid from the system. This study revealed that only 45-55% of the fluid was drained when changing monograde fluids, which means that the fluid in the system becomes an unknown mixture with unknown operating limits. It is certainly possible to drain the remaining fluid out by manipulating the cylinders and lines, and by flushing the systems several times with new fluid. This practice as it is extremely time consuming and can double or triple the volume of fluid required for an oil change. The cost of such a practice is prohibitive. In addition, when multiple fluids are in use, there is an increased risk of cross contamination during weekly top-off additions.

2.4 Economics

At the conclusion of the test, it was possible to calculate the cost of using each type of fluid. Six units (3 tree delimbers, 3 graders) were selected for detailed evaluation. Each unit saw use of all 3 types of hydraulic oil, and the leakage/make-up rate for each unit was documented. Table 2 shows the total cost of hydraulic fluid, maintenance, and disposal for each unit.

Table 2 - Cost for Oil Maintenance*

	Delimber 1	Delimber 2	Delimber 3	Grader 1	Grader 2	Grader 3
Monograde Oil Change	$1590	$1590	$1590	$953	$953	$747
Monograde Top-off	$1689	$960	$1320	$204	$204	$180
Total Cost	**$3270**	**$2550**	**$2910**	**$1157**	**$1157**	**$927**
Multigrade Oil Change	$374	$374	$374	$231	$231	$141
Multigrade Top-off	$2380	$1360	$1870	$289	$289	$255
Total Cost	**$2754**	**$1734**	**$2244**	**$520**	**$520**	**$396**
Multigrade Savings/Year	$516	$816	$666	$637	$637	$531
% Cost Reduction	***16%***	***32%***	***23%***	***55%***	***55%***	***57%***

*Values reported are Canadian Dollars

Monograde economics assume 2 oil changes per year (summer and winter grades), oil purchased at $1.20/liter, double labor charges ($35/hour), and double fluid disposal charges ($0.0873/liter). Additional costs due lost production time and increased equipment wear are significant, but not accounted for in this analysis. Multigrade economics assume one oil change per year, with oil purchased at $1.70/liter.

Conclusions

1. The data collected in the Canadian field study concludes that the use of multigrade hydraulic fluid assisted in keeping forestry equipment operating in an optimum viscosity range, and offered consistent response and lubrication protection. The use of a single fluid guarantees predictable viscosity temperature performance, as oil mixtures are avoided.

2. Monograde oils are an acceptable low cost option if the hardware can provide excellent oil cooling and constant temperature control. Monograde oils may also be temporarily utilized if there is a high leakage rate and a low cost oil is required prior to service.

3. Multigrade hydraulic fluids are the preferred low cost/high performance option when wide operating range temperatures are encountered. Maintenance, disposal, and downtime costs can be significantly reduced by eliminating semi-annual oil changes in favor of a yearly (or longer) oil change schedule.

References

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