HYDRAULIC FLUIDS FOR MINING EQUIPMENTS

Augusto Fernandes
Product Application Specialist
Hydraulic System Designs

- Power Output
- System Pressure
- Operating Temperature
- Energy Efficiency
- Hydrostatic Drives
- Low Speed High Torque Motors
- Reduced Environmental Impact

- Oil Service Life Expectation
- Emissions Controls

INCREASED STRESS ON HYDRAULIC FLUID

- Reservoir Size
- Downtime & Idle at Start-up
- Finer Filtration

DEMAND FOR NEWER FLUIDS

Trends
Hydraulic Fluid Selection

- Multiple options for selection of hydraulic fluids.

- Selection of hydraulic fluid often a commodity driven purchase decision.
  - Consider life-cycle maintenance costs.

- Key need to consider application challenges and demands on lubricant prior to selection and rationalization on site.
Hydraulic Pump Testing Trends

**STRESS ON OIL**

0-250 bar (vane) + 280 bar (piston) /110°C

Denison HF-0 (T6H20C Hybrid Vane/Piston); Komatsu Hitachi 35+35 Pump test

207 bar/95°C; 250 bar/0-230 bar/95°C

Denison HF-2 (T6C vane Pump; Water); Bosch Rexroth A2F

Vickers 35VQ25 (Vane Pump); Vickers PVH 57 (Piston Pump)

345 bar/75°C-100°C

Denison HF-0 (T5C Vane Pump; P46 Piston Pump)

140 bar/80°C

General anti-wear – Vickers V104C (Vane Pump)

TBA

Bosch Rexroth piston pump (TBD)
Implications for Hydraulic Fluids

- As equipment designs and environmental legislations change, specifications for hydraulic fluids are becoming more demanding.

- Recognition of the need for more differentiated performance specifications driving more differentiated products in all areas.

- Hydraulic fluids design is constantly evolving.

- Shift in experience of work force.
Different OEMs Recommend Different Oils

- Major manufacturers are split between use of engine oil type fluids and hydraulic type fluids.
- Both fluid types can work very well in mobile equipment depending on design and application.
- As always, the starting point for fluid selection is the manufacturers recommendation.

<table>
<thead>
<tr>
<th>OEM</th>
<th>Primary Recommendation</th>
<th>Secondary Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Komatsu</td>
<td>Engine Oil</td>
<td>Hydraulic Oil</td>
</tr>
<tr>
<td>Caterpillar</td>
<td>Engine Oil</td>
<td>Hydraulic Oil</td>
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<tr>
<td>Hitachi</td>
<td>Hydraulic Oil</td>
<td>-</td>
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<tr>
<td>JCB</td>
<td>Hydraulic Oil</td>
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<tr>
<td>Liebherr</td>
<td>Engine Oil/ATF</td>
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<tr>
<td>Terex</td>
<td>Engine Oil</td>
<td>Hydraulic Oil</td>
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<tr>
<td>Manitou</td>
<td>Hydraulic Oil</td>
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<tr>
<td>Volvo CED</td>
<td>Hydraulic Oil</td>
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</tbody>
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### Mobile And Static Systems Impact Operational Severity

<table>
<thead>
<tr>
<th>Mobile Hydraulic Systems</th>
<th>Industrial (Static) Hydraulic Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pump Capacity/Small Reservoir</td>
<td>Large Oil Reservoir</td>
</tr>
<tr>
<td>No time for air/water separation</td>
<td>Time for air/water separation</td>
</tr>
<tr>
<td>High operating pressures</td>
<td>Mostly lower operating pressures</td>
</tr>
<tr>
<td>Variable operating temperatures</td>
<td>Mostly operating under constant temperatures</td>
</tr>
<tr>
<td>Harsh environment</td>
<td>Relatively clean environments</td>
</tr>
<tr>
<td>Usually pressurised reservoir</td>
<td>Reservoir more or less open to air</td>
</tr>
<tr>
<td>Hydrostatic drives often present</td>
<td>Less likely to have hydrostatic drives</td>
</tr>
</tbody>
</table>
Shell Solutions to These Challenges... Energy Efficiency

- Improving the energy efficiency of hydraulic systems is a major focus for many OEM’s and operators as a way to help reduce operating costs.

- Need to develop robust and statistically relevant procedures to evaluate efficiency benefits through use of hydraulic fluids and control variables.
  - Formation of CCEFP multidisciplinary committee.

- Shell has developed computer based modeling techniques and controlled field based tests to compare the energy efficiency and fuel economy benefits of different hydraulic fluids.
Improving the energy efficiency of hydraulic systems is a major focus for many OEM’s and operators as a way to help reduce operating costs.

Over a ‘working day’* Tellus S4 ME 46 gave fuel savings of 1.5% - 1.9% when compared to a typical antiwear hydraulic fluid (ISO type HM).

*working day result significant at 99% confidence level.
Barrick Gold, a large mining company in Western Australia, have been conducting a trial of Tellus S4 ME 68 (formerly Tellus EE) in a conveyor system powered by Hagglunds hydraulic motors.

Careful measurement of energy consumption before and after converting to Tellus S4 ME 68 has demonstrated an energy saving of 5.3% relative to Tellus S2 M 68.
Compliance with emission regulations on off-highway vehicles requires additional treatment devices – space becomes a factor – reduce hydraulic reservoir sizing to fit space remaining.

Reservoir size decreasing from a 4:1 or 3:1 ratio of sump size to flow rate to now less than 1:1 – very low oil residence time in tank.

Lubricants with improved air release performance allow for improved system design and minimizes effective compressibility.

* Compared to requirements included in DIN 51 525 HLP specification.
Shell Solutions to These Challenges... Temperature Operating Window

- High equipment availability, including reduced time for start-up is a major driver for mobile equipment operators.
- Equipment operated and exposed to wide temperature swings during winter or overnight can be exposed to major stresses upon start-up.
- Pump cavitation as a result of very high fluid viscosity at start-up can significantly reduce pump life.
- Hydraulic fluids possessing excellent low temperature fluidity, a high viscosity index and being shear stable help in protecting pumps at low start-up temperatures.
**Pump Efficiency**

- Shell Tellus S4 ME displays excellent shear stability and resistance to thinning in service.
  - high viscosity index without the use of Viscosity Index Improver Additives

- Thinner fluid at high temperatures causes:
  - High wear rates of pump parts
  - High leakage
  - System failure
  - Loss of Reliability
  - Loss of Productivity
  - Increased Costs
Hydraulic Fluid Consumption

- Blown hydraulic hoses and leaking seals on hydraulic cylinders are major contributors to high hydraulic oil consumption on mobile equipment:
  - Increases oil consumption.
  - can reduce pump/system efficiency.
  - Non-availability of equipment and unplanned downtime.
  - safety hazard.
  - environmental hazard.

- “Smart hoses” like Eaton Life Sense hydraulic hose condition monitoring system:
  - A hose-condition sensor continuously monitors hose conditions via electrical measurement technology-sends alert to user.
Minimizing Environmental Impact

- Specifications and Ecolabeling.
- Utilization of renewable raw materials.
- Significant fines from EPA for discharges to the environment.
- Positive steps for license to operate for companies.
- Consideration for ore handling – ship loaders and unloaders.
Shell Solutions to These Challenges... Biodegradable Lubricants

- Synthetic ester based biodegradable hydraulic fluid designed with a measured bio-based content of over 80% m/m (ASTM D 6866) exceeding USA Federal Procurement requirement for bio-based hydraulic fluids (USDA Bio-preferred program limit of 44%)

- Low ecotoxicity towards marine and plant life

- Performance
  - low temperature fluidity for low temperature start-up – wider “temperature operating window”
  - Anti-wear characteristics exceeding mineral oil limits imposed by OEM’s
  - Compatibility with yellow metals, seals, hoses
  - Resistance to deposit formation with long fluid life

Shell Naturelle Hydraulic Fluid HF-E 32
Cam ring at the end of the test – the original machining marks are still clearly visible