Additives for Biobased Products

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QMS Certified to ISO 9001:2008 (With Design) REACH and GHS Compliant

8282 Bavaria Road - Macedonia, Ohio - 44056 March 2015
Additives for Biobased Lubricants

Why Convert from Mineral to Biobased Fluids?
As environmental concerns are growing, vegetable oils are finding their way into total-loss lubricants for military applications and outdoor activities such as forestry, mining, railroads, dredging, fishing and agricultural hydraulic systems. Lubricants based on vegetable oils offer significant environmental benefits as well as providing satisfactory performance in a wide array of applications. Government initiatives and advances in biobased lubricant technology are expanding the market for environmentally friendly products.

Hydraulic equipment can experience a hose rupture or fitting leak, releasing oil into the environment. It has been estimated that a hydraulic system can lose as much as three times its sump volume each year.

Shortcomings of vegetable oils, such as low thermo-oxidative stability and poor cold flow behavior may be improved through the use of additives that enhance oxidative stability, improve low temperature properties (pour points) and confer better wear properties.

FUNCTIONAL PRODUCTS’ additives in this catalog improve the performance of commercially available biobased industrial oils such as hydraulic fluids, biodegradable oils for heavy equipment, biobased drip fluid for agricultural equipment including mineral oil-based lubricants for high-temperature applications.

Converting Machinery to Biobased Lubricants
When switching from a mineral oil-based rock drill, bar and chain, gear oil or hydraulic fluid to a biobased system, certain care should be exercised:

- Warm up the machinery to reduce the viscosity.
- Flush the sump and/or system with vegetable oil, circulate and drain.
- Fill with biobased fluids.
- Note the clarity and color of the oil.
- Inspect the machinery fluids frequently in order to learn how the fluid behaves.

Spent fluids may be recycled with filtration and in some cases may be reinvived with booster additives.

Compatibility
All FUNCTIONAL PRODUCTS’ biobased additives are compatible with vegetable oils. Most additives are also compatible with some synthetic esters. See the Technical Data Sheets for specific information regarding ester compatibility.

Definitions
Biobased — According to the Office of the Federal Environmental Executive, biobased products are commercial or industrial products (other than food or feed) that are composed in whole or in significant part of biological products or renewable domestic agricultural materials (including plant, animal, and marine materials) or forestry materials. In the past, The United States Department of Agriculture (USDA) generally described biobased in reference to products, including lubricants and greases, that were made of at least 51% biological materials.
**Thickeners for Biobased Lubricants**

Triglyceride oils are preferred as base stocks for blending hydraulic gear oils, rock drill oils and lubricants intended for use in environmentally sensitive applications. A drawback is the low viscosity of 40 cSt at 40°C. A thickener may be used to provide higher viscosity, and a tackifier may be used to provide tack to the finished product.

**FUNCTIONAL V-508, 508M and V-515** are thickeners for vegetable or animal-based oils to blend lubricants of ISO 46, ISO 68 or ISO 100 viscosity grades. **FUNCTIONAL V-516** is a thickener for high oleic vegetable oils used to blend lubricants of ISO 46, ISO 68 or ISO 100 viscosity grades. These thickeners are ideal for use with synthetic esters. **FUNCTIONAL V-508** and **V-508M** are best for use with dioctyl adipate, ditridecyl adipate, C<sub>6</sub>, C<sub>7</sub>, C<sub>8</sub> polyl esters, trimethylolpropane tricarprolate and triocyl trimellitate. **FUNCTIONAL V-515** and **V-516** are best with triisodecyl trimellitate and diisodecyl phthalate.

**FUNCTIONAL V-508F** is a thickener for vegetable or animal-based fatty oils, used to blend lubricants of ISO 46 or ISO 68 viscosity grades. **V-508F** has excellent high-temperature properties, is shear stable, and has a PSSI of 28%. With approximately 70% biodegradable content, **V-508F** is biodegradable under all widely used standards.

### Typical Properties

<table>
<thead>
<tr>
<th></th>
<th>V-508F</th>
<th>V-515</th>
<th>V-516</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compatibility</td>
<td>High-oleic canola oil, esters, dioctyl adipate, trimethylpropane tricarprolate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>0.93</td>
<td>0.93</td>
<td>0.91</td>
</tr>
<tr>
<td>Lbs. per Gallon</td>
<td>7.75</td>
<td>7.75</td>
<td>7.60</td>
</tr>
<tr>
<td>Flash Point</td>
<td>150°C (300°F)</td>
<td>150°C (300°F)</td>
<td>&gt;260°C (500°F)</td>
</tr>
<tr>
<td>Kinematic Viscosity @ 100°C</td>
<td>7000 cSt</td>
<td>8000 cSt</td>
<td>5500 cSt</td>
</tr>
<tr>
<td>Color (ASTM D1500)</td>
<td>Yellow (&lt;4)</td>
<td>Yellow (&lt;4)</td>
<td>Yellow (&lt;2)</td>
</tr>
</tbody>
</table>

### Treatment Levels in High-oleic Canola

<table>
<thead>
<tr>
<th>Typical / High Shear Service</th>
<th>ISO 46</th>
<th>ISO 68</th>
<th>ISO 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>V-508F</td>
<td>2.0%—2.5%</td>
<td>4.5%—5.0%</td>
<td>8.0%—9.0%</td>
</tr>
<tr>
<td>V-508M</td>
<td>3.0%—3.5%</td>
<td>7.0%—7.5%</td>
<td>13%—14%</td>
</tr>
<tr>
<td>V-515</td>
<td>2.0%—2.5%</td>
<td>6.0%—7.0%</td>
<td>15%—16%</td>
</tr>
<tr>
<td>V-516</td>
<td>1.5%—2.0%</td>
<td>5.0%—6.0%</td>
<td>12%—15%</td>
</tr>
</tbody>
</table>

Warming **FUNCTIONAL PRODUCTS’** biobased additives to 65°C (150°F) may facilitate pumping and handling. Extended storage at elevated temperatures is not recommended for any product derived from vegetable oils. Safe handling precautions are the same as those to be used with vegetable oils; see the current Safety Data Sheet for details.
Additives for Biobased Products

Low Temperature Performance of Thickeners for Biobased Lubricants

Pour points were determined for solutions of **FUNCTIONAL V-508F** and **V-515** in high-oleic canola oil (H-OC), dioctyl adipate (DOA) and trimethylpropane trioleate (TMPTO).

<table>
<thead>
<tr>
<th></th>
<th>V-508F</th>
<th>V-515</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H-OC</td>
<td>DOA</td>
</tr>
<tr>
<td>Haze Onset (°C)</td>
<td>-12</td>
<td>-12</td>
</tr>
<tr>
<td>Pour Point (°C)</td>
<td>-15</td>
<td>-9</td>
</tr>
<tr>
<td>Haze Onset (°C)</td>
<td>-22</td>
<td>-12</td>
</tr>
<tr>
<td>Pour Point (°C)</td>
<td>-25</td>
<td>-15</td>
</tr>
</tbody>
</table>

- Solutions in H-OC and DOA were prepared to be ISO 46, while TMPTO solutions were prepared to be ISO 68 (TMPTO is ISO 46 without additives).

**Cold Flow Improvers for Vegetable Oil Based Lubricants**

**FUNCTIONAL PD-551, PD-555C** and **PD-557** modify wax crystal formation in biobased lubricants. Their primary use is to improve the cold flow properties of biobased lubricants at temperatures below the cloud point. These products are effective under both rapid-cooling and extended cold-storage conditions. Cold flow improvers are effective in hydraulic fluids, chain saw oils, pneumatic tool lubricants and other lubricants made from canola oil, sunflower oil or other triglycerides. The low viscosity of **PD-555C** makes it very easy to handle.

**FUNCTIONAL PD-580** meets the EPA Design for the Environment specifications.

### Typical Properties

<table>
<thead>
<tr>
<th></th>
<th>PD-551</th>
<th>PD-555C</th>
<th>PD-580</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Composition</strong></td>
<td>Proprietary Copolymer</td>
<td>Proprietary Copolymer</td>
<td>Proprietary Copolymer</td>
</tr>
<tr>
<td><strong>Diluent</strong></td>
<td>Vegetable Oil</td>
<td>N/A</td>
<td>Vegetable Oil</td>
</tr>
<tr>
<td><strong>Appearance</strong></td>
<td>Light-colored Liquid</td>
<td>Light-colored Liquid</td>
<td>Light-colored Liquid</td>
</tr>
<tr>
<td><strong>Odor</strong></td>
<td>Mild</td>
<td>Mild</td>
<td>Mild</td>
</tr>
<tr>
<td><strong>Specific Gravity</strong></td>
<td>0.93</td>
<td>0.93</td>
<td>0.93</td>
</tr>
<tr>
<td><strong>Lbs. per Gallon</strong></td>
<td>7.75</td>
<td>7.75</td>
<td>7.75</td>
</tr>
<tr>
<td><strong>Flash Point</strong></td>
<td>&gt;160°C (320°F)</td>
<td>&gt;160°C (320°F)</td>
<td>&gt;160°C (320°F)</td>
</tr>
<tr>
<td><strong>Kinematic Viscosity</strong></td>
<td>200 cSt at 100°C</td>
<td>300 cSt at 100°C</td>
<td>300 cSt at 100°C</td>
</tr>
</tbody>
</table>

To reduce the pour point of canola or other low-saturate triglyceride oils to below -23°C (-10°F), a treatment of 0.3% to 0.5% is usually sufficient. To reduce the pour point to below -29°C (-20°F), a treatment of 0.5% to 1.0% is usually sufficient. For stability in extended storage at -23°C (-10°F), a treatment level of 1.0-2.5% is usually necessary. Since the responsiveness of triglyceride to wax-crystal modifiers is extremely variable and may be dependent on the cooling history, the user should determine the appropriate treatment level.
Tackifiers for Biobased Lubricants and Esters

Biobased tackifiers are additives that confer tack or stringiness to lubricants made from vegetable or animal based fatty oils. They are principally used to provide adherence in chain oils, saw guide oils, down hole drilling oils, open gear oils or oils used to lubricate in baking or food processing facilities. They may also be used to inhibit stray mists or to provide drip resistance in other products. They may also be used to provide thickening and tack in oils that contain high levels of fatty additives, such as cutting oils.

**FUNCTIONAL V-584** has been approved by the NSF as an additive for lubricants with incidental food contact (#120913, category HX-1, HX-2). It is principally used to provide adherence in chain oils in environmentally sensitive or food-processing locations. It will also inhibit stray mists and provide drip resistance. For tackifying vegetable oil based single use lubricants, **FUNCTIONAL V-584** may be used at lower treatment level.

**FUNCTIONAL V-592** is recommended for use with synthetic esters and blown or polymerized vegetable oils that can be difficult to additize. A unique blend of synergistic polymers, **V-592** imparts tackiness and adhesion to synthetic esters.

### Typical Properties

<table>
<thead>
<tr>
<th></th>
<th>V-515</th>
<th>V-584</th>
<th>V-592</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Composition</strong></td>
<td>Polymer</td>
<td>Polymer</td>
<td>Polymer</td>
</tr>
<tr>
<td><strong>Compatibility</strong></td>
<td>Vegetable Oil</td>
<td>Vegetable Oil</td>
<td>Vegetable Oil, Blown Vegetable Oil, Synthetic Esters</td>
</tr>
<tr>
<td><strong>Lbs per Gallon</strong></td>
<td>7.75</td>
<td>7.75</td>
<td>7.95</td>
</tr>
<tr>
<td><strong>Flash Point</strong></td>
<td>150°C (300°F)</td>
<td>150°C (300°F)</td>
<td>150°C (300°F)</td>
</tr>
<tr>
<td><strong>Kinematic Viscosity</strong></td>
<td>8000 cSt at 100°C</td>
<td>2500 cSt at 40°C</td>
<td>900 cSt at 100°C</td>
</tr>
<tr>
<td><strong>Thickening Efficiency (10% in Canola Oil)</strong></td>
<td>75 cSt at 40°C</td>
<td>60 cSt at 40°C</td>
<td>70 cSt at 40°C</td>
</tr>
<tr>
<td><strong>Color (ASTM D1500)</strong></td>
<td>Yellow-orange (&lt;4)</td>
<td>Hazy Yellow-orange (&lt;3)</td>
<td>Light Yellow (&lt;1)</td>
</tr>
</tbody>
</table>

A treatment level as low as 1% will provide tackiness in a vegetable oil. The typical treatment level for a chain lube is 3-7%; about 5% will bring a vegetable oil to ISO 46 and 10% to ISO 68. Due to its high viscosity index, a fatty-oil derived ISO 46 product may actually have a higher viscosity at 100°C than many ISO 100 mineral based products. The slight residual haze in these higher viscosity blends does not affect performance. A treatment level of between 0.2% and 1.0% of **FUNCTIONAL PD-551** or **PD-555C** can inhibit the freezing of the base oil, extending the usable temperature range of the lubricant. Minimization of hydrocarbon aerosol escape from mist lubricated and pneumatic equipment requires about 1%. Since there are no standardized test methods for tackiness or stray-mist inhibition, the appropriate treatment level is best determined by the user.

While warming **FUNCTIONAL V-515** to about 65°C (150°F) or **FUNCTIONAL V-584** to about 50°C (120°F) may facilitate pumping and handling, extended storage of these or any other vegetable oil derived products at elevated temperatures is not recommended. For best tackiness retention, do not warm above about 65°C (150°F).

Safe handling precautions are the same as those to be taken with vegetable oils; see the current Safety Data Sheet. **FUNCTIONAL V-584** and **V-515** have a shelf life of 6 months. Avoid mechanical shearing during handling and blending to minimize possible loss of tackiness.
**Additives for Biobased Hydraulic Fluids**

**FUNCTIONAL HF-546** is an additive package for producing ISO 46 hydraulic fluids. It is formulated to provide excellent antiwear and corrosion resistance, oxidative stability, foam resistance, cold flow properties and resistance to water. **HF-546**, **HF-560** and **HF-580** are compatible with TMP trioleate diluents for increased thermal and oxidative stability.

**FUNCTIONAL HF-560** is an additive package for producing Military Specification MIL-PRF-32073 type hydraulic fluids based on biodegradable esters or vegetable oils. **FUNCTIONAL HF-560** provides oxidation and corrosion protection, extreme-pressure/antiwear activity, and resistance to water and foaming. Refined vegetable oils are recommended to pass the military oxidation requirement. To improve the oxidative stability of the vegetable oil, **FUNCTIONAL AO-550** may be used at 2.2% treat.

**FUNCTIONAL HF-560** is an additive package for producing Military Specification MIL-PRF-32073 type hydraulic fluids based on biodegradable esters or vegetable oils. **FUNCTIONAL HF-560** provides oxidation and corrosion protection, extreme-pressure/antiwear activity, and resistance to water and foaming. Refined vegetable oils are recommended to pass the military oxidation requirement. To improve the oxidative stability of the vegetable oil, **FUNCTIONAL AO-550** may be used at 2.2% treat.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Specifications of Finished Hydraulic Fluid to Meet MIL-PRF-32073</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-oleic Canola Oil 95.65%</td>
<td><img src="https://example.com/additive.png" alt="Additive Formulation" /></td>
</tr>
<tr>
<td><strong>FUNCTIONAL HF-560</strong> 1.85%</td>
<td><img src="https://example.com/test-results.png" alt="Test Results" /></td>
</tr>
<tr>
<td><strong>FUNCTIONAL V-516</strong> 1.5%</td>
<td><img src="https://example.com/test-results.png" alt="Test Results" /></td>
</tr>
<tr>
<td><strong>FUNCTIONAL PD-551</strong> 1.0%</td>
<td><img src="https://example.com/test-results.png" alt="Test Results" /></td>
</tr>
</tbody>
</table>

**FUNCTIONAL HF-580** is a non-hazardous light color, low odor additive package which is compatible in a wide variety of base oils including vegetable oils, high oleic algal oils, modified castor oils and synthetic esters including TMP and pentaerythritol esters. It also has outstanding solubility in Groups III and IV oils (PAOs) as well as OSP fluids. **HF-580** can be formulated in high oleic canola oil to ISO 46 grade using approximately 2.5% **FUNCTIONAL PD-551** as a highly shear stable thickener. The ISO 46 grade passes the V104C Vane Pump Test (ASTM D7043) and exhibits excellent demulsibility, rust and copper inhibition, 4-ball wear performance and hydrolytic and thermal stability. **FUNCTIONAL HF-580** shows exceptional RPVOT oxidative stability, especially when used in base fluids with high oleic, high saturate and low polyunsaturate content such as very high oleic algal oils, modified castor oils and OSPs.

**Open Gear Oil Additive Package**

**FUNCTIONAL GA-502** is an EP additive designed for use in biobased open gear lubricants. **FUNCTIONAL GA-502** contains antiwear additives, demulsifiers, a pour point depressant and a tackifier. Fluids containing **FUNCTIONAL GA-502** are suitable for use in environmentally sensitive areas. The typical treat level is 2–3% in a suitable base stock.

<table>
<thead>
<tr>
<th>Typical Properties</th>
<th>HF-546</th>
<th>HF-560</th>
<th>HF-580</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appearance</strong></td>
<td>Hazy Light Green Liquid</td>
<td>Hazy Amber Liquid</td>
<td>Clear Amber Liquid</td>
</tr>
<tr>
<td><strong>Odor</strong></td>
<td>Mild</td>
<td>Mild</td>
<td>Mild</td>
</tr>
<tr>
<td><strong>Specific Gravity</strong></td>
<td>0.92</td>
<td>0.96</td>
<td>0.98</td>
</tr>
<tr>
<td><strong>Lbs per Gallon</strong></td>
<td>7.7</td>
<td>8.0</td>
<td>8.2</td>
</tr>
<tr>
<td><strong>Flash Point</strong></td>
<td>&gt;150°C (300°F)</td>
<td>112°C (234°F)</td>
<td>&gt; 230°C (450°F)</td>
</tr>
<tr>
<td><strong>Kinematic Viscosity</strong></td>
<td>80.0 cSt at 100°C</td>
<td>7.0 cSt at 100°C</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>684 cSt at 40°C</td>
<td>131 cSt at 40°C</td>
<td>50 cSt at 40°C</td>
</tr>
<tr>
<td><strong>Treatment Level (by weight)</strong></td>
<td>4.4%</td>
<td>1.85%</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

The service life of the hydraulic fluid is limited by the stability of the vegetable oil; a maximum temperature of 70°C (160°F) is recommended. Heating before blending is not required.
Multifunctional Rock Drill Package

**FUNCTIONAL RD-535** is a high performance oil additive package having EP/antiwear, corrosion inhibition and tackiness properties especially suited for rock drilling applications. **FUNCTIONAL RD-535** is readily biodegradable when formulated with vegetable base stocks and is designed to meet the requirements of pneumatic tools, down-hole and surface drilling equipment. It is formulated with a tackifier to allow the lubricant to adhere to tooling surfaces, further reducing corrosion and wear in the presence of compressed air. It is designed to emulsify water in wet conditions. The wear reduction performance greatly reduces the incidence of premature bit shanking and reduces operating costs.

**FUNCTIONAL RD-535** is a proprietary formulation recommended for vegetable oil base stocks. **FUNCTIONAL RD-535** is soluble in oil, insoluble in water, and contains 20% sulfur and 0.9% phosphorous by weight. See the Technical Data Sheet for additional information. The recommended initial treat level is 5% **FUNCTIONAL RD-535** by weight. The optimum level is dependent on the severity of the application. At 5% by weight in canola oil, the viscosity is 8.6 cSt at 100°C, 33.8 cSt at 40°C and the VI is 249. **FUNCTIONAL RD-535CP** is a similar product that demulsifies water.

**FUNCTIONAL RD-535** may be a skin and eye irritant, and should be handled with suitable personal protection. The maximum heating temperature is 140°F. At higher temperatures, **FUNCTIONAL RD-535** may be a respiratory irritant.

### Finished ISO 220 Rock Drill Oil Performance

<table>
<thead>
<tr>
<th>Formula</th>
<th>Typical Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FUNCTIONAL RD-535</strong>  5%</td>
<td>Flash Point (COC) &gt;150°C</td>
</tr>
<tr>
<td><strong>FUNCTIONAL V-508F</strong> For ISO 220  15%</td>
<td>Kinematic Viscosity at 100°C (ASTM D445) 36 cSt</td>
</tr>
<tr>
<td>For ISO 320  18%</td>
<td>Kinematic Viscosity at 40°C (ASTM D445) 224 cSt</td>
</tr>
<tr>
<td>For ISO 460  20%</td>
<td>Viscosity Index 211</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Performance</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4-Ball EP Test (ASTM D1783), weld load</td>
<td>250 kg</td>
</tr>
<tr>
<td>Timken Load Test (ASTM D1782), failure point</td>
<td>&gt;70 lbs. (31 kg)</td>
</tr>
<tr>
<td>Emulsion Stability (ASTM D1401)</td>
<td>1/6/73 (30 min)</td>
</tr>
</tbody>
</table>

### Anti-oxidant for Biobased Lubricants

Vegetable oils generally have poor oxidative stability that may contribute to oil failure due to the rapid increase in viscosity, and sludge and deposit contamination. BHT or TBHQ may be used as an economic anti-oxidant for vegetable oils at treat rates as low as 0.15% by weight.

For premium performance, **FUNCTIONAL AO-550** is recommended. **AO-550** is a proprietary mixture of oxidation inhibitors, anti-wear agents and rust inhibitors designed to give optimum performance in ashless bar and chain oils, hydraulic fluids, industrial gear oils or whenever enhanced oxidative stability is required of a vegetable or mineral oil.

### AO-550 Performance in Canola Oil

<table>
<thead>
<tr>
<th></th>
<th>Untreated Canola Oil</th>
<th>With 1% AO-550</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPVOT</td>
<td>36 minutes</td>
<td>195 minutes</td>
</tr>
<tr>
<td>AOCS Cd 12b</td>
<td>4 hours</td>
<td>590 hours</td>
</tr>
</tbody>
</table>
Purchasing Information

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