Additives for Biobased Products

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QMS Certified to ISO 9001:2015 (With Design) REACH and GHS Compliant
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.

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.

Functionality

Spent fluids may be recycled with filtration and in some cases may be revived 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, V-515 and V-521 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, C6, C7, C8 polyol esters, trimethylolpropane tricaprylate and trioctyl 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.

FUNCTIONAL V-521 is a shear stable (30% PSSI) thickener for vegetable or animal-based oils. FUNCTIONAL V-521 does not have as large an impact on low temperature performance of the thickened oils as other thickeners.

FUNCTIONAL V-508, V-508F and V-508M are LuSC listed for EU Ecolabel formulations and suitable for use in Vessel General Permit (VGP) applications.

### Typical Properties

<table>
<thead>
<tr>
<th></th>
<th>V-505</th>
<th>V-508F</th>
<th>V-515</th>
<th>V-516</th>
<th>V-521</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compatibility</td>
<td>High-oleic canola oil, esters, dioctyl adipate, trimethylpropane trioleate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>0.93</td>
<td>0.93</td>
<td>0.93</td>
<td>0.91</td>
<td>0.93</td>
</tr>
<tr>
<td>Lbs. per Gallon</td>
<td>7.75</td>
<td>7.75</td>
<td>7.75</td>
<td>7.60</td>
<td>7.75</td>
</tr>
<tr>
<td>Flash Point</td>
<td>150°C(300°F)</td>
<td>150°C(300°F)</td>
<td>150°C(300°F)</td>
<td>&gt;260°C(500°F)</td>
<td>150°C(300°F)</td>
</tr>
<tr>
<td>Shear Stability, PSSI (ASTM 6278)</td>
<td>15%</td>
<td>29%</td>
<td>51%</td>
<td>51%</td>
<td>30%</td>
</tr>
<tr>
<td>Kinematic Viscosity @100°C</td>
<td>8000 cSt</td>
<td>7000 cSt</td>
<td>8000 cSt</td>
<td>5500 cSt</td>
<td>5000 cSt</td>
</tr>
<tr>
<td>Color (ASTM D1500)</td>
<td>Yellow (&lt;4)</td>
<td>Yellow (&lt;4)</td>
<td>Yellow (&lt;4)</td>
<td>Yellow (&lt;2)</td>
<td>Yellow (&lt;2)</td>
</tr>
</tbody>
</table>

### Typical Properties

<table>
<thead>
<tr>
<th>ISO 46</th>
<th>ISO 68</th>
<th>ISO 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>V-505</td>
<td>1.0% – 3.0%</td>
<td>5.5% – 7.5%</td>
</tr>
<tr>
<td>V-508F</td>
<td>2.0% – 2.5%</td>
<td>4.5% – 5.0%</td>
</tr>
<tr>
<td>V-508M</td>
<td>3.0% – 3.5%</td>
<td>7.0% – 7.5%</td>
</tr>
<tr>
<td>V-515</td>
<td>2.0% – 2.5%</td>
<td>6.0% – 7.0%</td>
</tr>
<tr>
<td>V-516</td>
<td>1.5% – 2.0%</td>
<td>5.0% – 6.0%</td>
</tr>
<tr>
<td>V-521</td>
<td>3.0% – 4.0%</td>
<td>8.5% – 9.5%</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.
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).

### Low Temperature Performance of Thickeners for Biobased Lubricants

<table>
<thead>
<tr>
<th>V-508F</th>
<th>V-515</th>
<th>V-521</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-OC</td>
<td>DOA</td>
<td>TMPTO</td>
</tr>
<tr>
<td><strong>Performance without PD-555C</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haze Onset (ºC)</td>
<td>-12</td>
<td>-12</td>
</tr>
<tr>
<td>Pour Point (ºC)</td>
<td>-15</td>
<td>-9</td>
</tr>
<tr>
<td><strong>Performance with PD-555C</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Haze Onset (ºC)</td>
<td>-22</td>
<td>-12</td>
</tr>
<tr>
<td>Pour Point (ºC)</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-585** 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-585** meets EPA Safer Choice and CleanGredients criteria.

<table>
<thead>
<tr>
<th>Typical Properties</th>
<th>PD-551</th>
<th>PD-555C</th>
<th>PD-585</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diluent</td>
<td>Vegetable Oil</td>
<td>N/A</td>
<td>Vegetable Oil</td>
</tr>
<tr>
<td>Appearance</td>
<td>Light-colored Liquid</td>
<td>Light-colored Liquid</td>
<td>Light-colored Liquid</td>
</tr>
<tr>
<td>Odor</td>
<td>Mild</td>
<td>Mild</td>
<td>Mild</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>0.93</td>
<td>0.93</td>
<td>0.93</td>
</tr>
<tr>
<td>Lbs. per Gallon</td>
<td>7.75</td>
<td>7.75</td>
<td>7.75</td>
</tr>
<tr>
<td>Flash Point</td>
<td>&gt;160ºC (320ºF)</td>
<td>&gt;160ºC (320ºF)</td>
<td>&gt;150ºC (300ºF)</td>
</tr>
<tr>
<td>Kinematic Viscosity</td>
<td>200 cSt at 100ºC</td>
<td>300 cSt at 100ºC</td>
<td>1500 cSt at 100ºC</td>
</tr>
</tbody>
</table>

To reduce the pour point of canola or other low-saturate triglyceride oils to below -23ºC (-10ºF), a treatment of 0.3% to 0.5% is usually sufficient. To reduce the pour point to below -29ºC (-20ºF), a treatment of 0.5% to 1.0% is usually sufficient. For stability in extended storage at -23ºC (-10ºF), 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) and is LuSC listed for EU Ecolabel formulations and suitable for use in Vessel General Permit (VGP) applications. 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. In order to add tack to vegetable oil based single use lubricants, FUNCTIONAL V-584 may be used at a 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, FUNCTIONAL V-592 imparts tachiness and adhesion to synthetic esters.

<table>
<thead>
<tr>
<th>Typical Properties</th>
<th>V-515</th>
<th>V-584</th>
<th>V-592</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compatibility</td>
<td>Vegetable Oil</td>
<td>Vegetable Oil</td>
<td>Vegetable Oil, Blown Vegetable Oil, Synthetic Esters</td>
</tr>
<tr>
<td>Lbs per Gallon</td>
<td>7.75</td>
<td>7.75</td>
<td>7.95</td>
</tr>
<tr>
<td>Flash Point</td>
<td>150°C (300°F)</td>
<td>150°C (300°F)</td>
<td>150°C (300°F)</td>
</tr>
<tr>
<td>Kinematic Viscosity</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>Thickening Efficiency (10% in Canola Oil)</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>Color (ASTM D1500)</td>
<td>Yellow-orange (&lt;4)</td>
<td>Yellow-orange (&lt;3)</td>
<td>Light Yellow (&lt;1)</td>
</tr>
</tbody>
</table>

A treatment level as low as 1% will provide tachiness 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 and HF-580 are compatible with TMP trioleate diluents for increased thermal and oxidative stability.

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
Additives for Biobased Products

**Saw Guide Oil Additive Package**

**FUNCTIONAL SGP-567** is designed for formulating saw guide oils in either biobased or conventional base stock formulations. **FUNCTIONAL SGP-567** is a robust, non-hazardous, multifunctional additive that provides antiwear, mild EP, rust protection and enhanced lubricity. **FUNCTIONAL SGP-567** is recommended for multi-blade, gang saws and trimmers commonly used in lumber production.

**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.

**Multifunctional Rock Drill Package**

**FUNCTIONAL SGP-567** should be used at 1.5% by weight in vegetable oil. The addition of a thickener, **FUNCTIONAL V-515**, will increase the viscosity to the higher ISO grades required for this application. **FUNCTIONAL V-584** may also be added to increase adherence of the oil to the saw guides and blades. For continuous saw operation in climates below -20°C, a pour point depressant such as **FUNCTIONAL PD-555C** is recommended for biobased formulations.

**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

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**Typical Properties**

<table>
<thead>
<tr>
<th></th>
<th>HF-546</th>
<th>HF-580</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appearance</strong></td>
<td>Hazy Light Green Liquid</td>
<td>Clear Amber Liquid</td>
</tr>
<tr>
<td><strong>Odor</strong></td>
<td>Mild</td>
<td>Mild</td>
</tr>
<tr>
<td><strong>Specific Gravity</strong></td>
<td>0.92</td>
<td>0.98</td>
</tr>
<tr>
<td><strong>Lbs. per Gallon</strong></td>
<td>7.7</td>
<td>8.2</td>
</tr>
<tr>
<td><strong>Flash Point</strong></td>
<td>&gt;150°C (300°F)</td>
<td>&gt;230°C (450°F)</td>
</tr>
<tr>
<td><strong>Kinematic Viscosity</strong></td>
<td>80.0 cSt at 100°C, 684 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>2.5%</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Finished ISO 220 Rock Drill Oil Performance</th>
<th>Typical Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formula (by weight in high oleic canola oil)</td>
<td></td>
</tr>
<tr>
<td>Functional RD-535 5%</td>
<td>Flash Point (COC)  &gt;150°C</td>
</tr>
<tr>
<td>Functional V-508F</td>
<td>Kinematic Viscosity at 100°C (ASTM D445) 36 cSt</td>
</tr>
<tr>
<td>For ISO 220 15%</td>
<td>Kinematic Viscosity at 40°C (ASTM D445) 225 cSt</td>
</tr>
<tr>
<td>For ISO 320 18%</td>
<td>Viscosity Index 211</td>
</tr>
<tr>
<td>For ISO 460 20%</td>
<td></td>
</tr>
<tr>
<td>Performance</td>
<td>4-Ball EP Test (ASTM D1783), weld load 250 kg</td>
</tr>
<tr>
<td></td>
<td>Timken Load Test (ASTM D1782), failure point &gt;70 lbs. (31 kg)</td>
</tr>
<tr>
<td></td>
<td>Emulsion Stability (ASTM D1401) 1/6/73 (30 min)</td>
</tr>
</tbody>
</table>

**Biodegradable Two-Cycle Engine Oil**

**FUNCTIONAL TWO-CYCLE ENGINE OIL** is inherently biodegradable and compatible with gasolines containing 10wt% ethanol. This product meets JASO-FD specifications. **FUNCTIONAL TWO-CYCLE ENGINE OIL** outperformed synthetic oil in testing. 50:1 dilution is recommended.

### Functional Two-Cycle Engine Oil

<table>
<thead>
<tr>
<th>Typical Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flash Point</td>
</tr>
<tr>
<td>Kinematic Viscosity</td>
</tr>
<tr>
<td>Biodegradable</td>
</tr>
</tbody>
</table>

### Performance

| Functional Two-Cycle Engine Oil | 4.80 |
| Synthetically Reference Oil    | 4.45 |

**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>Untreated Canola Oil</th>
<th>With 1% AO-550</th>
</tr>
</thead>
<tbody>
<tr>
<td>RVPOT</td>
<td>36 minutes</td>
</tr>
<tr>
<td>AOCs Cs 12b</td>
<td>4 hours</td>
</tr>
</tbody>
</table>
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