Lubricants and Fuel Additives

Dow's Synthetic Gas Turbine Fluid – The First PAG to meet GEK 32568 (h)

Polyalkylene Glycol™
Synthetic Turbine Fluid Technology

An introduction to product, chemistry and performance

Avoid Costly Shutdowns and Maintenance with PAG-based Synthetic Turbine Fluid from Dow

Varnish build-up in heavy-duty gas turbines is a leading cause of costly unplanned shutdowns and resulting lost power generation capacity. The culprit is conventional petroleum-based turbine oil, which breaks down to form varnish and sludge that cause servo valves to stick.

Use of filtration to remove solid degradation byproducts addresses a symptom but not the root cause of varnish formation: the petroleum-based turbine oils themselves. For the best protection against varnish-related shutdowns, switch from petroleum-based turbine oil to non-varnishing PAG-based Synthetic Turbine Fluid.

PAG-based Synthetic Turbine Fluid from Dow helps prevent shutdowns and the high cost of lost electrical power generation capacity. It also cuts the expense of varnish prevention maintenance measures.

Proven in more than ten years of turbo compressor service, PAG-based Synthetic Turbine Fluid – a combination of polyalkylene glycol (PAG) base fluid with a proprietary additive package – improves the all around performance of your

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lubrication system, increases turbine reliability and operational efficiency, and provides year-round protection against seasonal changes.

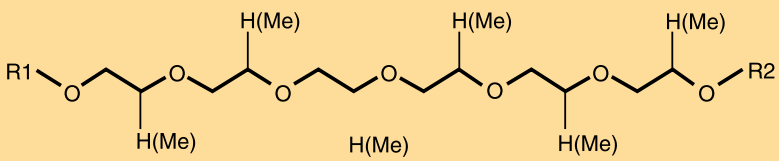
After five years of continuous service on the original fluid charge, installations in gas turbines show more than 75 percent remaining useful life with no deposit formation and without the need for additional filtration. PAG-based Synthetic Turbine Fluid has enabled over 48,000 "varnish free"* operating hours" – further demonstrating that PAG-based Synthetic Turbine Fluid can be expected to last significantly longer than petroleum-based turbine oils.

In the following pages, we'll demonstrate why PAG-based Synthetic Turbine Fluid offers better tribological characteristics and performance than petroleum-based turbine oil.

*Data collected over the course of 5.5 years since November 2007.

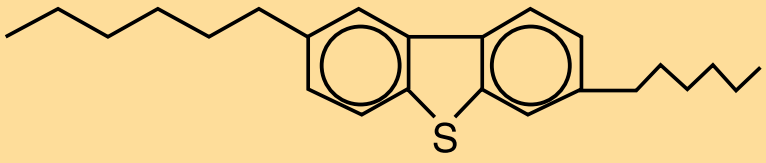
Chemical Composition (PAG-based Synthetic Turbine Fluid vs. Petroleum-based Turbine Oil)

PAG-based Synthetic Turbine Oil



The copolymers of EO & PO provide a unique structure to PAG that only produces low molecular weight by-products of oxidation

Petroleum-based Turbine Oil



Petroleum-based Turbine Oils have aromatic, paraffinic, naphthenic and sulfur/nitrogen heterocylic structures which easily oxidize to form high molecular weight by-products

(Source: A.J. Caines and R.F. Haycock, Automotive Lubricants Reference Book. 1996)

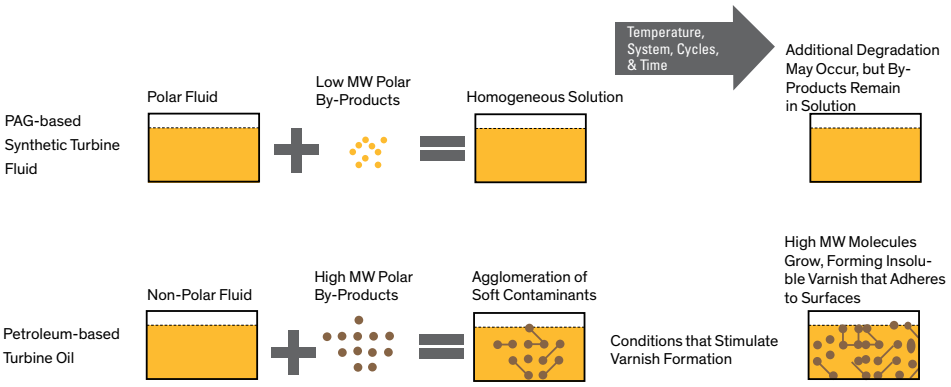
Performance Advantages of PAG-based Synthetic Turbine Fluid

- **Non-Sludge or Varnish Forming –** varnish build-up in gas turbines can cause servo valves to stick and turbine units to shut down, resulting in unplanned maintenance costs.
- **Less Potential for Microdieseling –** PAG-based Synthetic Turbine Fluid reduces the potential for entrained air bubbles that can cause problems with microdieseling.
- **Reduced Static Discharge –** PAG-based Synthetic Turbine Fluid provides better electrical conductivity than petroleum-based turbine oil, reducing the potential for static discharge.
- **Hydrolytic Stability –** PAG-based Synthetic Turbine Fluid will not break down and react with water, minimizing fluid degradation and acid formation that can damage equipment.
- **High Temperature Stability –** The fully saturated PAG molecule is very stable at high temperatures and resistant to thermal degradation at temperatures up to 120°C (250°F), resulting in longer oil life and increased reliability.
- **Reduced Friction –** The inherent lower coefficient of friction and higher viscosity index of PAG-based Synthetic Turbine Fluid allows the use of a lower viscosity grade, reducing friction, increasing overall system efficiency and reducing thermal demand on bearings.
- **All-Weather Service –** With a higher viscosity index than petroleum-based turbine oils, PAG-based Synthetic Turbine Fluid retains excellent viscosity characteristics over a wider temperature range than petroleum-based oils.
- **Material/Gas Seal Compatibility –** PAG-based Synthetic Turbine Fluid is compatible with commonly used seals, hoses and metals.
- **Detergency –** PAG-based Synthetic Turbine Fluid is a natural detergent, so systems remain clean, and free of staining or sticky residue.
- **Biodegradable/Low Toxicity –** PAG-based Synthetic Turbine Fluid is classified as "inherently biodegradable" and environmental impact is low if the product is spilled. PAG-based Synthetic Turbine Fluid also satisfies stringent criteria for toxicity.

Typical Physical Properties*	PAG-based Synthetic Turbine Fluid	Typical ISO 32 Petroleum-based Turbine Oil
Viscosity Grade	25	32
Kinematic Viscosity @ 40°C cSt (104°F cP) (ASTM D445)	26.23 (25.84)	32.44 (27.90)
Kinematic Viscosity @ 100°C cSt (212°F cP) (ASTM D445)	5.19 (5.11)	5.56 (4.78)
Viscosity Index (ASTM D2270)	132	109
Specific Gravity (relative density) (ASTM D941)	0.985	.86
Pour Point, °C (°F) (ASTM D97)	-48 (-55)	-30 (-22)
Flash Point, °C (°F), Closed Cup (ASTM D92)	242 (468)	215 (420)
Specific Heat @ 40°C (104°F), joules / g°K (ASTM E1269)	2.103	2.058
Thermal Conductivity @ 40°C (104°F), watts / m°K (PLTL-73)	0.145	0.1

*Typical properties, not to be construed as specifications.

Comparison of Oxidation Processes (PAG-based Synthetic Turbine Fluid vs. Petroleum-based Turbine Oil)



Tribological Characteristics of PAG-based Turbine Fluid

Laboratory evaluations of PAG-based Synthetic Turbine Fluid provide further indications of its excellent lubricating qualities.

Friction

Traction performance testing on a PCS Instruments Mini Traction Machine showed that PAG-based Synthetic Turbine Fluid demonstrates lower traction coefficients than a petroleum-based turbine oil under specified test conditions (as shown in the figure to the right). This low coefficient of friction can allow operating energy savings, and has been confirmed by a decrease in temperature measurements of operating turbine bearings.

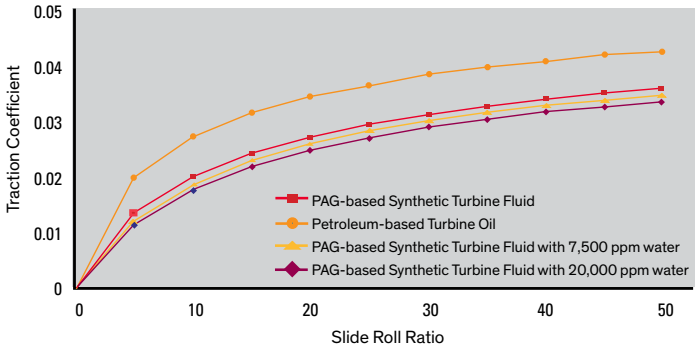
Excellent Wear Performance

The wear preventative properties of PAG-based Synthetic Turbine Fluid in sliding contact were determined on neat and water-containing fluid per the ASTM D4172 standard test. PAG-based Synthetic Turbine Fluid shows excellent anti-wear performance, even with as much as 2% water in the fluid, as well as after over 1,411 hours of operation in a turbine. Note that PAG-based Synthetic Turbine Fluid passes the ASTM D665 rust prevention test, which is run with 10% water (100,000 ppm water). This is compared to petroleum-based oils, which are only tolerant up to 50-100 ppm.

Air Release

Using the ASTM D3427 standard test, PAG-based Synthetic Turbine Fluid shows excellent air release for both neat fluid and fluid contaminated with water. These air release times are lower than those typical of petroleum- and hydrocarbon-based turbine fluids. Prolonged air release times can lead to pump cavitation, microdieseling, premature oxidation and component wear.

Traction Curve of Turbine Fluids Conditions: 70°C, 0.8 GPa Load at 1000 mm/sec



Mini-Traction Machine Steel Ball on Steel Disk

Four-Ball Wear Testing on PAG-based Synthetic Turbine Fluid, ASTM D 4172 Test Condition: 40 Kg, 1200 rpm, 1 hour, 75°C

Fluid	Scar Diameter, mm
PAG-based Fluid neat	0.65
PAG-based Fluid + 7500 ppm water	0.67
PAG-based Fluid + 20,000 ppm water	0.66
PAG-based Fluid + 2900 ppm water after 1411 operating hours in GE 7FA Turbine	0.66

Air Release Characteristics of PAG-based Synthetic Turbine Fluid, ASTM D3427 Test Method

Fluid	Temperature, °C	Minutes to 0.2% Entrained Air Volume
PAG-based Fluid neat	50	0.4
PAG-based Fluid + 2000 ppm water	50	0.7
PAG-based Fluid + 4,000 ppm water	50	1.0

For additional information:
In the United States and Canada,
this PAG-based Turbine Fluid is available from:
American Chemical Technologies, Inc.
1-800-938-0101 • www.americanchemtech.com

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	+32-3-450-2240	
Pacific	+800-7776-7776	
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Latin America (Brazil)	+55 11-5188-9222	

*Toll free service not available in all countries

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