Polyalkylene Glycol

Synthetic Turbine Fluid Technology

An introduction to product, chemistry and performance

Technical information for turbine fluids marketed by The Dow Chemical Company and American Chemical Technologies, Inc.

Polyalkylene Glycol-based
Synthetic Turbine Fluid Technology

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

After ten years of service, original installations show more than 50 percent remaining useful life with no deposit formation and without the need for additional filtration. In more than 20 months of service in gas turbines, PAG-based Synthetic Turbine Fluid has performed very well – 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.

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 heat transfer and lower coefficient of friction 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.

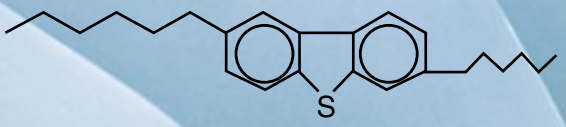
Fluid Chemistry	Fluid Polarity	By-Product Polarity	Molecular Weight Range	Explanation of Oxidation	Composition
PAG-based Synthetic Turbine Fluid	**Polar**	**Polar (i.e. Organic Acids)**	**Low**	Low molecular weight by-products are soluble in the PAG base fluid. This is due to the polar nature of both, as like dissolves in like. Since these are low molecular weight and soluble there is no agglomeration during hot and cold cycles. Therefore, PAG-based Synthetic Turbine Fluid is non-varnish forming.	Polyalkylene Glycols (PAGs) are homopolymers of ethylene oxide or propylene oxide, or co-polymers of ethylene oxide or propylene oxide. Because of this unique structure, PAG-based Synthetic Turbine Fluid provides a non-varnish forming characteristic.
Petroleum-based Turbine Oil	**Non-Polar**	**Polar**	**High (i.e. Peroxides and Carbonyl species)**	High molecular weight by-products of oxidation are attracted to each other. These agglomerate to produce larger molecules as they undergo hot and cold cycles. As these high molecular weight molecules increase in size, they separate and form insoluble varnish. Molecular chains attach to one another as oxidation continues to take place, therefore varnish creation persists.	Petroleum-based turbine oils contain sulfur and aromatics which are oxidized to produce polar products, which polymerize, increase viscosity, and create varnish.

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)	2.017	2.064
Thermal Conductivity @ 40°C (104°F), watts / m°K (PLTL-73)	0.145	0.1

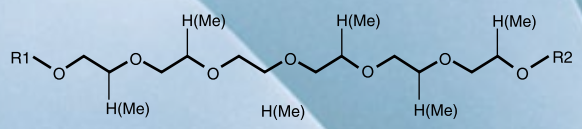
*Typical properties, not to be construed as specifications.

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

Petroleum-based Turbine Oil



PAG-based Synthetic Turbine Fluid

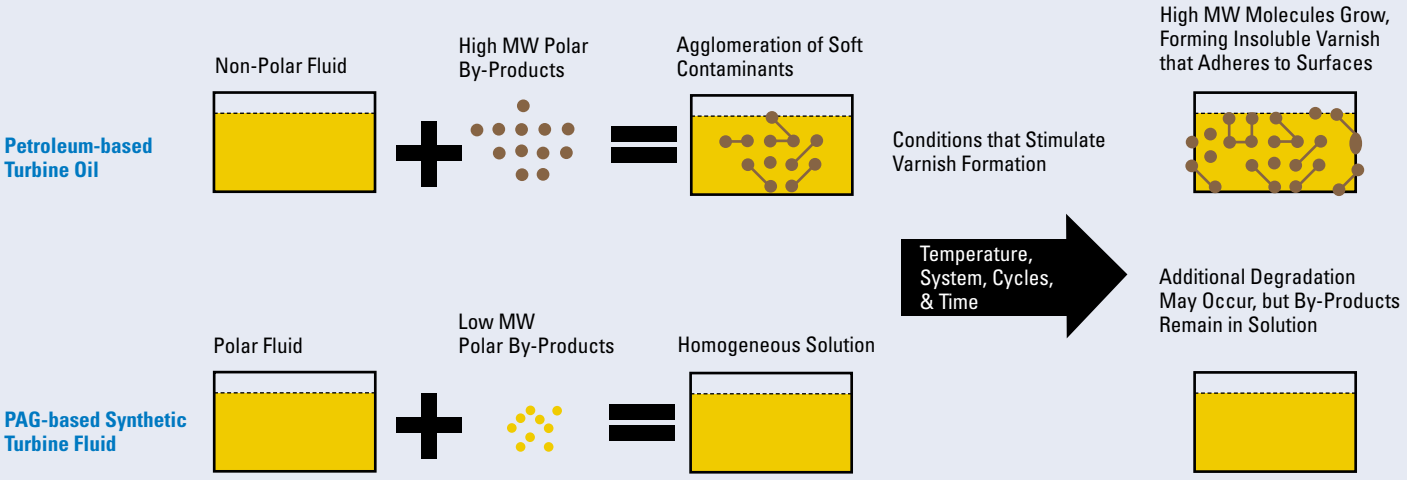


(Source: A.J. Caines and R.F. Haycock, Automotive Lubricants Reference Book. 1996)

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

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

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



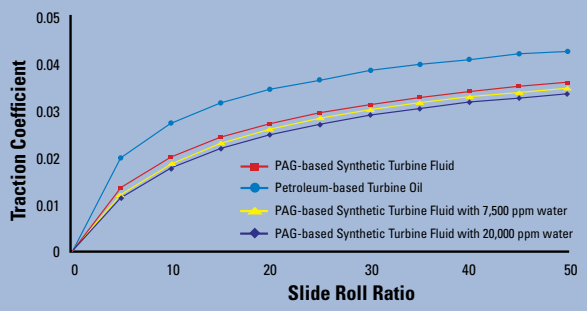
Tribological Characteristics of PAG-based Turbine Fluid

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.

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



Mini-Traction Machine Steel Ball on Steel Disk

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).

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

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.

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 + 4000 ppm water	50	1.0

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

To Learn More…

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Published August, 2009

Printed in U.S.A.

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Form No. 119-02253-0809 AMS