PAG Lubricant Selection In Rotary Screw Compressors

Polyalkylene glycol (PAG) base fluids have been used in rotary screw compressor lubricants since 1985. Originally patented in 1981, and adopted as factory fills for new systems, Ingersoll Rand and Sullair have continued to promote the benefits and value of this chemistry over three decades later.

All these years later, the use of PAG is still commonplace thanks to the various benefits their chemistry offers; including:

- The molecular structure of PAG base fluids result in their inability to form insoluble byproducts, meaning they are chemically incapable of creating varnish, sludge or carbon deposits.
- PAGs are incredibly efficient in their cooling abilities with lower operating temperatures in extreme environmental conditions with about 10% higher thermal conductivity than PAO's and excellent heat transfer.
- With higher system pressures, lubricant flash points decrease. The naturally higher flash point of PAGs provide a higher degree of safety and reduced thermal degradation as compared to PAOs, esters and other synthetics.
- With a lubricant carryover rate as low as 2ppm, use of PAGs require less make up fluid than PAO's or other synthetic hydrocarbons. This also leads to less lubricant migrating downstream into the air system.

True PAG Chemistry

The PAG Chemistry used by Original Equipment Manufacturers (OEMs) is a blend of the PAG with a pentaerythritol ester (POE). The benefit of including the POE into the formulation is twofold. POEs provide enhanced seal condition across a wide range of elastomers, helping to prevent swelling and shrinking. PAGs are also known to have poor metal wetting properties, and the inclusion of POE helps to mitigate this characteristic. As a result, POEs enhance the barium corrosion inhibitors performance by allowing it to coat the metal surfaces inside the system.

The breakdown of components (shown to the right) are documented on each OEM's SDS for their respective product. While general concentration ranges vary slightly in efforts to protect the true formula, the component families are the same.

Ingersoll Rand Ultra Coolant

Name	Concentration	% by Weight
Polypropylene Glycol	60-70%	60-70%
Pentaerythritol Ester	25-30%	25-30%
Aromatic Amines	4-6%	4-6%
Additives	<1%	<1%

Sullair Sullube

Name	Concentration	% by Weight
Polypropylene Glycol	65-75%	65-75%
Pentaerythritol Ester	22-27%	22-27%
Alkylated Diphenylamine	4-6%	4-6%
Barium Sulfonate	<0.3%	<0.3%

Aftermarket Variations in Chemistry

Aftermarket variations of PAG lubricants vary greatly, and caution should be taken to ensure the chemical makeup of the lubricant meets both the distributor and end user expectations.

- PAG Blends – PAG blends do contain polyalkylene glycol but the amount used in the formula can vary greatly, from as little as 10% to over 70%. Also, the higher cost of the pentaerythritol ester in the formulation leads many manufacturers to utilize diesters as a substitute.
- PAG Replacements – PAG replacements contain no polyalkylene glycol at all and instead include a diester blended with a synthetic hydrocarbon. The diester allows for adequate compatibility with the true PAGs but have limited miscibility and solubility with these fluids.

The presence of diesters in aftermarket PAG blends and PAG replacements can have adverse consequences to performance when in operation. Diesters degrade in the presence of water (found in compressors in the form of condensate), forming an alcohol and an acid. Analysis of compressor sludge deposits from these types of fluids have shown to include metal salts of these acids which tend to plug separators and oil filters. They may also result in the coating of oil coolers, impacting their efficiency. These alternative formulations also commonly have greater lubricant carryover over 5 ppm, compared to the 2 ppm of True PAGs.

True PAGs are designed to have an operating life of 8,000 hours at 215°F, while aftermarket chemistries (those PAG blends and PAG replacements) are commonly rated by their manufacturers for 8,000 hours of operation at 200°F. This would only allow for approximately 5,000 operating hours at an equivalent 215°F.

Lubricant Comparison

The Sullair Sullube, Ingersoll Rand Ultra Coolant and SA Performance SAP 8000 series are of the same chemical formulation.

Properties	Test Method	Sullair's Sullube	SAP 8000-32	IR's Ultra Coolant	SAP 8000-46
Base Fluid Type	-	PAG/POE	PAG/POE	PAG/POE	PAG/POE
Color	-	Green	Green	Natural	Natural
Initial pH	-	8 – 10	8 – 10	8 – 10	8 – 10
TAN (mgKOH/g)	ASTM D664	<0.25	<0.25	<0.25	<0.25
Density @ 15°C	ASTM D1298	0.989	0.987	0.987	0.990
Viscosity @ 40°C (cst)	ASTM D445	37.2	36.9	46.8	48.1
Viscosity @ 100°C (cst)	ASTM D445	7.05	7.04	8.49	8.73
Viscosity Index	ASTM D2270	153	154	159	161
Flash Point °C (°F)	ASTM D92	253 (486)	257 (495)	271 (520)	270 (519)
Pour Point °C (°F)	ASTM D97	-45 (-49)	-45 (-49)	-55 (-67)	-56 (-68)
Copper Strip Corrosion	ASTM D130	1b	1b	1a	1a
Foam Tendency (Sequence I, II, III)	ASTM D892	0/0, 0/0, 0/0	0/0, 0/0, 0/0	0/0, 0/0, 0/0	0/0, 0/0, 0/0

Conclusion | The SAP 8000 series is the only aftermarket True PAG chemistry available to date. Identical formulation chemistry to Sullair Sullube and Ingersoll Rand Ultra Coolant, the SAP 8000 utilizes the same polyalkylene glycol/pentaerythritol ester base fluid composition paired with a proprietary additive package including barium corrosion inhibitor. Formulated by the same chemist that designed the fluids in use today by Sullair and Ingersoll Rand, the SAP 8000 is an excellent alternative for distributors looking to provide aftermarket fluids to their customers without compromising fluid quality.