SYNTHETIC LUBRICANTS WHAT ARE THEY

The production of many synthetic lubricants begin with base stocks which are synthesised from high volume hydrocarbon intermediates. For example, polyalphaolefin (PAO) base fluids are synthesised from ethylene. Others synthetics however, start with very basic raw material. For example, silicone based fluids are made from sand (SiO_2), require considerable energy, and there are many steps in their manufacture including handling of very corrosive materials. These variable manufacturing steps account for the broad price range for synthetics and the much higher price for the 'exotics synthetics' such as fluorosilicones. Unlike mineral oil base stocks, which are a complex mixture of naturally-occurring hydrocarbons refined from crude oil, synthetic base stocks are man-made, having controlled molecular structure with predictable properties. As with all present-day fluids lubricants, synthetics are formulated by combining the base stocks with selected additives.

SYNTHETIC LUBRICANTS, PROPERTIES & INDUSTRIAL APPLICATIONS

For the most part, synthetic lubricants are very different, not only from conventional petroleum lubricants, but also from each other. Quite often, the selection of a given synthetic lubricant for a specific application is determined by one or more outstanding properties of that synthetic which are beyond the capability of the conventional petroleum lubricants and/or where the additional cost can be justified.

POLYALPHAOLEFINS

Polyalphaolefin oligomers (PAO), 1 commonly referred to as synthetic hydrocarbons, have many favorable properties which contribute to their rapidly growing use for a variety of industrial applications. They have low pour points, low volatility, good software compatibility, thermal stability, hydrolytic stability, chemical inertness and good natural lubricity.

The high temperature stability in the absence of air has led to the use of PAO as the sealing fluid and lubricant for the mechanical seals of pumps handling polystyrene process liquid at 450°F (232.2°C). A nitrogen inert atmosphere is maintained over the sealing fluid.

A formulated PAO lubricant, because of its hydrolytic stability, has shown extended life in replacing a polyolester high temperature lubricant for the bearings and gears of non-lube rotary positive blowers used as steam booster compressors. Labyrinth seals allowed leakage of live steam into the lubricant resulting in breakdown of the polyolester.

Since PAO have low pour points, they are also used in refrigeration compressors. Applications include ammonia and fluorocarbon compressors.

ORGANIC ESTERS

Organic esters, diesters and polyolesters (POE), are being used for many industrial applications. Most additives are readily soluble in organic esters. This characteristics provides flexibility in formulating lubricants, both 100% organic esters and organic esters combined with other synthetics.

Because of their improved fire-resistant properties and oxidation stability, diester lubricants are used for air compressors applications, particularly reciprocators. 2 Diesters provide a solvency action resisting sludge and varnish formations when used for reciprocating air compressor cylinder lubrication. Reduced lubricant feed rates to the cylinders are also possible, as low as 50% the required mineral oil rates. Cleaner valves and less lubricants reduce the chance of fires and explosions in reciprocating air compressor systems.

As reciprocating air compressor crankcase lubricants, diesters provide cleanliness resulting in better heat transfer and prevention of moving parts sticking. The result can be less power usage.

Polyolesters have excellent high temperature properties, and, in general, have improved properties over the diesters, 3 including long-term hydrolytic stability and software compatibility. Table 1 shows a comparison of properties for diesters and polyolester lubricants commonly used for industrial applications.

Table 1 COMPARATIVE PROPERTIES - DIESTER VS POLYOLESTER

Properties	Diester	Polyolester
Viscosity 210°F (98.9°C), cSt.	9.4	11.3
100°F (37.8°C), cSt.	106.8	76.7
Flash Point (°F/°C),	510/265.6	545/285
Autoignition Temperatures (°F/°C),	770/410	865/462.8
Evaporation, % Loss (22 h at 300°F),	0.9	0.4
Oxidation-Corrosion Stability (42 h at 425°F) 5 liters/h air)		
Acid no. increase (mgKOH/g),	5.64	1.71
Percent Viscosity Increase (100°F),	24.0	13.5
Four-ball Wear Test (1 h, 600 rpm, 129°F, 40 kg Load)		
Wear Scar (mm),	0.64	0.37

ORGANIC ESTERS, cont.

Although polyolester lubricants are about twice the cost of a diester, the overall costs are less with polyolester due to reduced lube usage and less maintenance and clean-up costs.

Polyolester are preferred for air compressor cylinder lubrication if the discharge air temperature are 300°F or above and if a decision is made to minimize lubricant usage through microlubrication. 4

For rotary screw compressors operating above normal 180°F operating temperatures, polyolester are a better choice than the polyalphaolefins, particularly where there is continuous operation under heavy loads. At 220 to 230°F operating temperatures, polyolester have an approximate 5,000-hour life as compared to 2,500 hours for polyalphaolefin. 5 Polyolester lubricants are suitable for rotary screw air compressor applications involving oil well drilling, mining, multi-stage compressors and compressors in hot ambient temperatures locations. Other polyolester industrial applications include: (a) chain lubricant for 400°F air ovens. Claims of a 15% saving in energy through conversion from mineral oil to a polyolester lubricant, (b) lubricant for porous metal bushings in furnace blower fans, and (C) gear and bearing lubricant for 350°F positive rotary air blowers.

POLYPHENYL ETHERS

Polyphenyl ethers 6 have radiation resistance to 1010 ergs/gram °C, thermal stability up to 850°F, and oxidative stability as high as 600-700°F with proper inhibitors. Polyphenyl ethers have very low vapor pressures reaching vacuums in the 10-10 torr range making them ideal for high vacuum uses. They do, however, have a relatively high pour point (40°F) and they are expensive ($1,700-$2,000 + per gallon range.) These factors limit their use to specialized vacuum, high temperature, and radiation resistant fluids and lubricants applications.

SILICATE ESTERS

Silicate esters 1 have good low temperatures properties. They do, however, have very poor hydrolytic stability, and will break down to form gels just in contact with moisture in the air. This characteristic limits their use to closed systems. For example, silicate esters are used for low temperature refrigeration compressor lubrication.

PHOSPHATE ESTERS

Phosphate esters 7 are being used as fluids and lubricants primarily because of their good fire-resistant properties (autoignition temperatures over 1,000°F (537.5°C). Even when ignition, the phosphate esters will continue to burn only if the severe conditions required for ignition are maintained. Used includes fire-resistant lubricants for heavy duty industrial gas turbines and auxiliary equipment and hydraulic fluids in steel mills, foundries, and other plants where the fluid could leak onto hot surfaces. Phosphate esters have a high bulk modulus giving extremely fast response in electro-hydraulic servo systems. These systems are commonly used where precise control is required, such as turbine speed control.

Phosphate esters have been used as air compressor lubricants primarily because of their high autoignition. Explosions have been reported, however, caused by excessive amounts of lubricant in the compressed air systems. Also, moist hot air can gradually cause phosphate esters to break down. The degradation products (strong acids) attack paints and rubber seals, gaskets and diaphragms.. Because this is particularly troublesome if the air is used for instrumentation, phosphate esters are being replaced by other synthetics for air compressor lubrication. Also, phosphate esters are considered undesirable contaminants in waterways.

POLYALKYLENE GLYCOLS

The non-sludge forming characteristic of polyalkylene glycols 8 has led to their use for high temperature applications. For example, polyglycols can be mixed with graphite for lubrication of 2,000°F (1,093°C) refractory kiln bearings. The polyglycol products of degradation flash off or burn clean leaving the solid lubricant without any tar deposits.

Water soluble polyglycols are used as water based fire-resistant hydraulic fluids. One novel application for water soluble polyglycol lubricants is the valve actuators of large gas transmission lines located outdoors in subzero climates. In the past, with conventional lubricants, moisture would condense and freeze up the actuators in the wintertime. With the polyglycol lubricants, the moisture dissolves in the polyglycol and the resulting solution has a subzero pour point, eliminating the freezing problem.

The use of polyglycol lubricants for hydrocarbon gas compressor applications is expanding rapidly, particularly for oil flooded rotary screw compressors. polypropylene glycol is performing extremely well in propane refrigeration compressors. This lubricant reduces hydrocarbon solubility and good viscosity/temperature characteristics with a viscosity index over 200.

An ISO 150 viscosity grade polyethylene glycol lubricant gives maximum resistance to hydrocarbon thinning can be used for rotary screw compressors handling high concentrations of condensable hydrocarbons (C4+). For well gas and other rotary screw compressors applications involving both condensable hydrocarbons and water vapor, a polyethylene/polypropylene glycol co-polymer lubricant should be used. This lubricant withstands hydrocarbon dilution and, at lubrication operating temperature above 160°F, it withstands water dilutions.

High discharge pressures in rotary screw compressors handling hydrocarbons gases can be a problem. Even though a polyglycol lubricant can be formulated to resist dilution, at high operating pressures the hydrocarbons will continue to continue to condense with the build up of a separate hydrocarbon-rich liquid phase in the lubricant separator tank. This hydrocarbon phase has a very low viscosity and poor lubricity. If this hydrocarbon liquid is carried into the compressor, a bearing failure can occur. The two liquid phases (lubricant and hydrocarbon condensables) do not readily separate by gravity so it is necessary to evaporate or flash off the hydrocarbon phase.

FLUORINATED LUBRICANTS

There are three classed of fluorinated synthetic lubricants currently in use for industrial applications, plus, Fluorinated lubricants are very expensive, these products are listed in Table 2 with approx. costs.

Table 2 FLUORINATED PRODUCTS - AND APPROX. COSTS.

Products	Approx. Costs
Chlorofluorocarbons 9	\$700 - \$1,200 per gallon
Perfluoroalkylpolyethers 10	\$2,500 - \$9,000 per gallon
Fluorosilicones 11,12	\$1,000 - \$1,200 per gallon

High cost limits the use of these lubricants but even so, industrial applications are expanding primarily because of their excellent chemical inertness and solvent resistance.

The chlorofluorocarbons and perfluoroalkylpolyethers are the most inert, even to liquid oxygen and chlorine. Applications include liquid oxygen pumps; compressors and vacuum pumps handling oxygen, fluorine and other extremely active chemicals vapors; and equipment handling solids products with strong oxidizing characteristics. Chlorofluorocarbons have temperatures limitations with rapid evaporation at 300°F and above. Also, they have poor viscosity-temperature characteristics and relatively high pour points compared with perfluoroalkylpolyethers and fluorosilicones.

Fluorosilicone lubricants have good chemical inertness to a wide variety of harsh corrosive chemicals. One of the early applications for fluorosilicones fluids was microlubrication of the cylinders of methyl chloride and hydrochloric acid compressors. 13 Although fluorosilicones are not recommended for liquid chlorine service, laboratory tests demonstrated their inertness to gaseous chlorine under pressure to 90 psia (260.6 kPa) and temperatures to 392°F.

Fluorosilicone greases made with polytetrafluoroethylene thickener have been tested and demonstrated to have improved chemical inertness as compared to conventional hydrocarbon greases. These greases are very expensive.

SILICONES

In addition to fluorosilicones, other types of silicones are also being used for industrial applications. 14 Dimethylsilicones have excellent viscosity-temperature characteristics and are hydrolytically stable but have questionable metal-to-metal lubricating properties. Additives are available, however, to improve their lubricity. 15

Alkylmethylsilicones have excellent lubricating properties due to the formation of thick rigid films in operations. 16 These lubricants are being formulated with highly refined, saturated base fluids and polyalphaolefins for use in a wide variety of reciprocating compressor, oil-flooded rotary screw compressor and vacuum pumps applications. They provide a lasting protective film and, because of their chemical inertness, protect the metal parts against corrosion. Applications include ammonia refrigeration compressors; methyl chloride, hydrochloric acid and sulphur dioxide compressors; and vacuum pumps handling a wide variety of chemical vapors.

CONCLUSIONS

The number of synthetic lubricants and industrial applications are growing rapidly and will continue to grow during the next decade, at this accelerated rate as 'value engineering' is used to identify applications, select the proper synthetic lubricants, and determine overall cost savings.

In applications involving 'once through' lubrication such as cylinder lubrication of reciprocating air compressors, it is very important to minimize the lubricant feed rates. The result is reduced contamination and pollution; reduced maintenance and downtime; reduced fire hazards; and, in some cases, reduced lubricant requirements. To accurately monitor and control these very small synthetic lubricant feeds, conversion of the existing lubricators to microlubrication is required. Proven, commercially available conversion systems are available. In many cases, payback on this hardware is less than a year.

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