BREOX RFL-X RANGE FOR HFC REFRIGERATION

Introduction

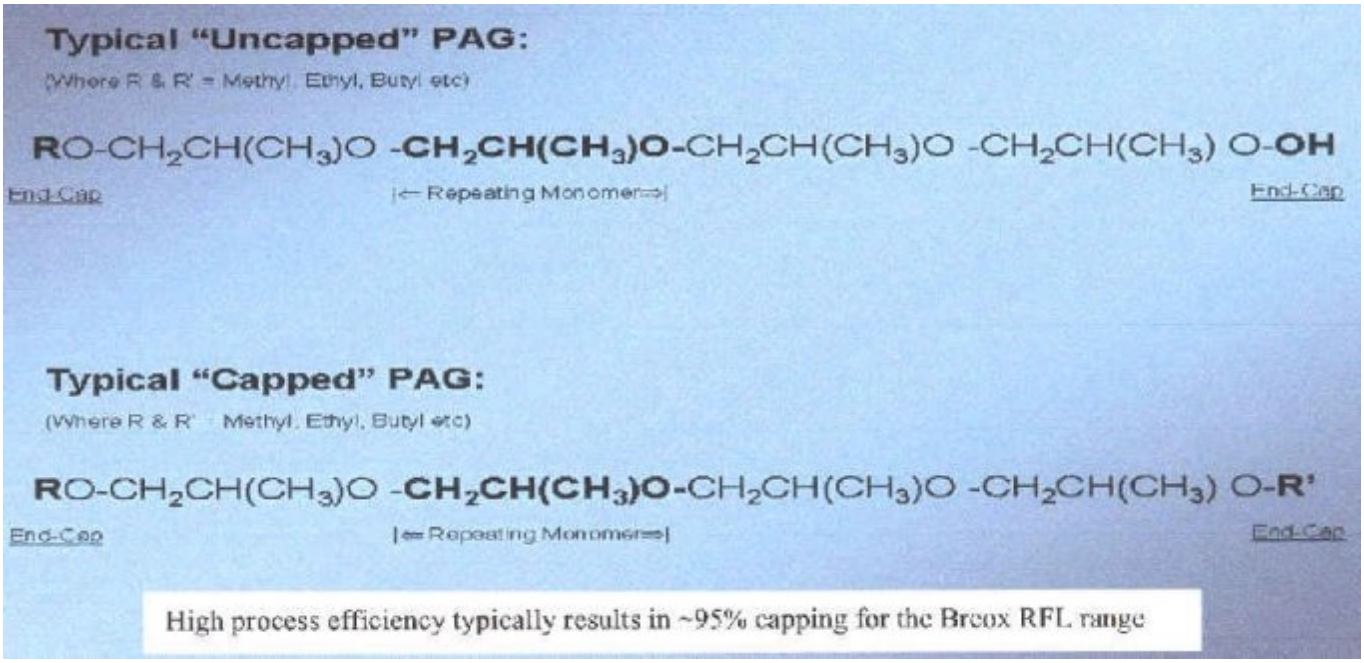
Hydrofluorocarbons (HFCs) are chlorine-free gases, now replacing chlorofluorocarbon (CFC) gases worldwide as more environmentally acceptable refrigerants. HFC R-134a, a hydrofluorocarbon which has no ozone depletion potential, is the principle refrigerant in use. Poor compatibility of HFCs with mineral oil based lubricant systems has led to the introduction of synthetic lubricants for refrigerant applications. Synthetic polyalkylene glycol (PAG) lubricants are well established in the automotive industry as a synthetic fluid suitable for use in air conditioning systems, with the novel structural difference of ***Breox*** RFL polyalkylene glycols also ensuring the lubricants meet the performance requirements for use in the assembly of a wide range of industrial and domestic refrigerant and air conditioning systems. Miscibility of the ***Breox*** RFLs with a wide range of HFCs ensures their suitability for use with a range of refrigerants, including 1,1,1,2-tetrafluoroethane (R134a), R-404a, R-410a and R-407c.

Generally, a compression type refrigeration unit, such as found in automotive air-conditioning units, consists of a compressor, a condenser, expansion valves and an evaporator. In such a refrigeration unit, usually the temperature can rise to 40 °C, often 65 °C or more, while in the cooler the temperature may be as low as –40 °C.
Polyalkylene glycols for automotive air-conditioning units are well known, however they can suffer from two key problems. Firstly, one of phase separation with the Hydrofluorocarbon at temperatures close to room temperature and above. The resulting HFC-rich phase can result in poor lubrication and reduced compressor life, with separation of lubricant in critical temperature regions resulting in reduced compressor efficiency. For efficient lubrication of the compressor avoidance of phase separation is therefore crucial. Secondly, polyalkylene glycols are hygroscopic and the absorption of water above acceptable levels could potentially result in freezing out of water in the capillaries, resulting in reduced efficiency and lubrication.

Breox RFL lubricants, based on a new "capping" technology, provide efficient lubrication for compression type refrigeration units, with good refrigerant solubility over the full temperature range, and a substantially reduced tendency to absorb water. Improved lubricating properties as a result of the capping technology improves suitability for use in all applications.

Capped PAG Technology

The performance advantages associated with the use of ***Breox*** RFL grades as synthetic lubricants for HFC refrigerants are associated with the structural difference between the ***Breox*** RFL grades and standard polyalkylene glycols. A typical polyalkylene glycol generally consists of polymer chains with a hydroxyl group at one end which is chemically active, whereas a "capped" PAG has chemically inactive groups at both ends of the molecule.



This capping process results in specific performance attributes for the *Breox* RFL range:

Excellent Solubility in the principle HFC refrigerant R-134a over the compressor's temperature range of operation, resulting in an absence of lubricant pool forming and hence maintained compressor efficiency

Reduced Hygroscopicity. The water affinity of Breox RFL grades is significantly reduced compared to the tendancy towards water absorption demonstrated by standard PAGs. Hence use of Breox RFL grades ensures problems such as freezing of water resulting in blocked capillaries are reduced and any reductions in compressor efficiency are minimised.

Chemical and Thermal Stability. Exposure to high temperatures and high levels of moisture results in minimised product degradation, which in common competitor products such as polyol esters can release corrosive acids and cause a loss of performance and possible failure.

Improved Lubricity compared to uncapped PAGs and alternative capping technologies

Additional performance advantages characterising the *Breox* RFL range are as follows:

- Excellent viscosity index - Typically >200, The higher viscosity index of the RFL grades ensures that at higher temperatures there is the potential of further enhanced compressor life due to a greater lubricating film thickness in hydrodynamic conditions. Improved viscosity index also allows a compressor manufacturer to select a lower viscosity fluid than typically used, which offers power usage savings.

- Superior high temperature stability, resulting in reduced downtime and lower maintenance costs.

- Superior lubricity- Compared to competitor products such polyol esters, uncapped PAGs and alternative capping technologies, the wear protection offered by ***Breox*** RFL PAGs is exceptional, resulting in improved system efficiency. Lower maintenance costs result from reduced compressor wear.

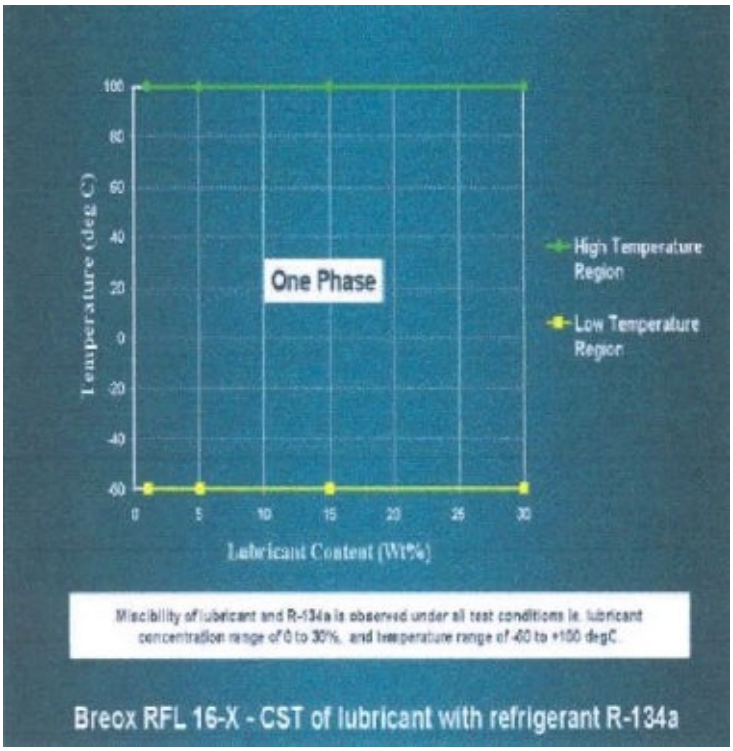
- Formulating Expertise - Fully formulated ***Breox*** RFL grades contain a complete additive system to protect the compressor from any problems relating to corrosion of white or yellow metals, to minimise the effects of wear and extreme pressure conditions, and to ensure long life for the fluids in use.

	Test Method	RFL 16-X	RFL 22-X	RFL 32-X	RFL 46-X	RFL 68-X	RFL 100-X	RFL 150-X
Viscosity cSt @ 40°C	ASTM D445	17.3	20.0	30.0	49.7	78.9	107.3	153.6
Viscosity cSt @ 100°C	ASTM D445	4.5	5.1	7.2	10.7	15.7	20.0	27.7
Viscosity Index	-	188	202	216	213	213	216	220
Density g/cm^3 @ 20°C	ASTM D1298	0.995	0.996	0.993	0.998	0.998	0.999	0.998
Pourpoint °C	ASTM D97	<-50	<-50	<-50	-49	-46	-43	-37
Flashpoint COC °C	ASTM D92	>200	>200	>200	>200	>200	>200	>200
Water Content % mass	ASTM E284	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
TAN mg KOH/g	ASTM D974	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
4-Ball Wear Test 40kg/1 hour (mm)	ASTM. D4172	0.65	0.65	0.61	0.53	0.52	0.58	0.58
Copper Corrosion 3hrs @ 100°C	ASTM D130	1a	1a	1a	1a	1a	1a	1a
Steam Turbine Corrosion	ASTM D665 (a)	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Miscibility: Two-phase Separation Temps (°C)	ASHRAE 86							
Upper: 1% RFL in 134a		>100	>100	93	87	83	60	-
Upper: 5% RFL in 134a		>100	>100	87	70	37	37	-
Lower: All RFL concs		<-60	<-60	<-60	<-60	<-60	<-60	-

Materials Compatibility

Common seal and gasket materials are unaffected by polyalkylene glycols, and ***Breox*** RFL grades are compatible with elastomers commonly found in R-134a systems. ***Breox*** RFL grades are incompatible with alkyd paints which soften in the presence of these products, internal system surfaces should ideally be unpainted or coated with a resistant material, such as epoxy resin based paints which are fully compatible.

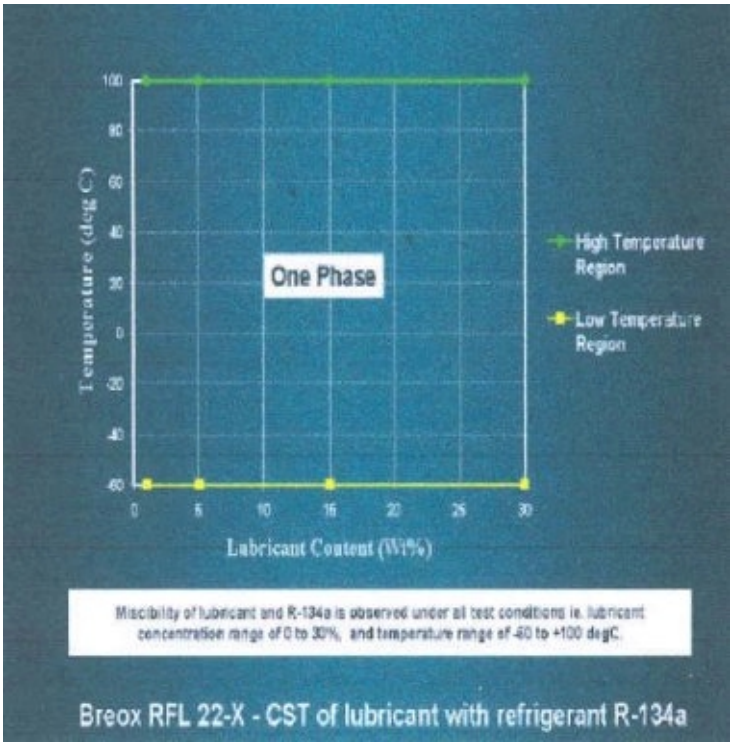
Miscibility in HFC Refrigerants



The miscibility of refrigeration lubricants may be measured by recording the Critical Solution Temperature (CST) at which immiscibility between the refrigerant and lubricant is first observed. ***Breox*** RFL PAG lubricants show CST values over a wide range of lubricant concentrations which exceed the requirements by most OEMs using R-134a.

Typically lubricants for refrigerant applications, including some uncapped PAGs, will demonstrate high temperature and low temperature separation of the lubricant from the refrigerant, with good miscibility generally observed between these extremes.

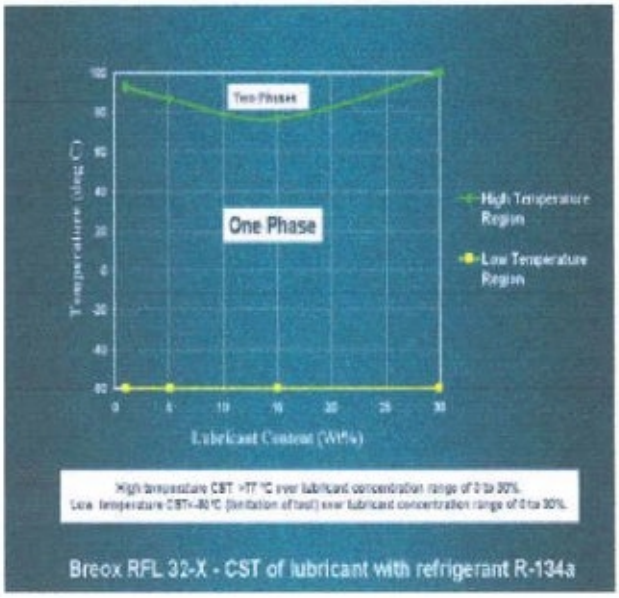
Breox **RFL-X ISO grades 16 & 22 demonstrating complete refrigerant miscibility within the test's temperature limtiations of -60 to +100°C over the full range of lubricant concentrations (1-30%) recorded.**

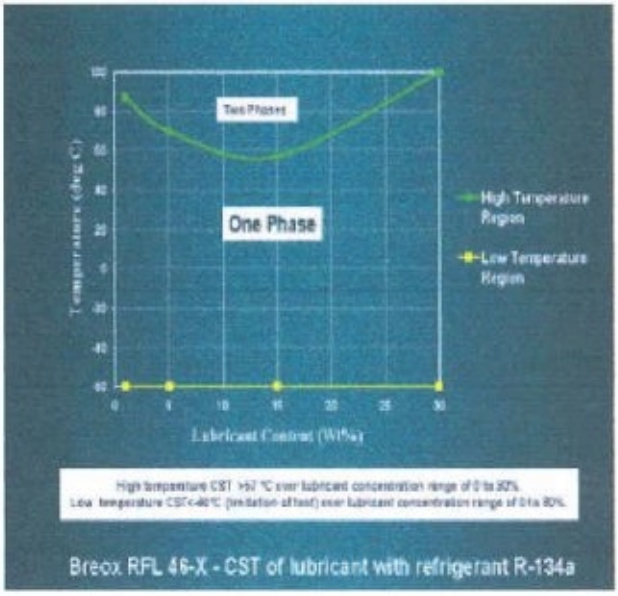


Breox RFL 22-X - CST of lubricant with refrigerant R-134a

Within the method's (ASHRAE 86) temperature limitations of -60°C to 100°C, lower ISO grade ***Breox*** RFL products remain fully miscible within these temperature limits over the full entire lubricant concentration range tested (1-30%), and therefore do not demonstrate any CST.

At higher viscosities, ***Breox*** RFL grades continue to show improved miscibility over uncapped PAGs, again demonstrating full miscibility at low temperatures to the lowest temperature range of the test (-60°C), with no low temperature CST recorded, again over the full range of lubricant concentrations tested. The higher viscosity RFL grades continue to show good miscibility at high temperatures over a wide range of lubricant concentrations, with CST values typically above those required by OEM manufacturers.

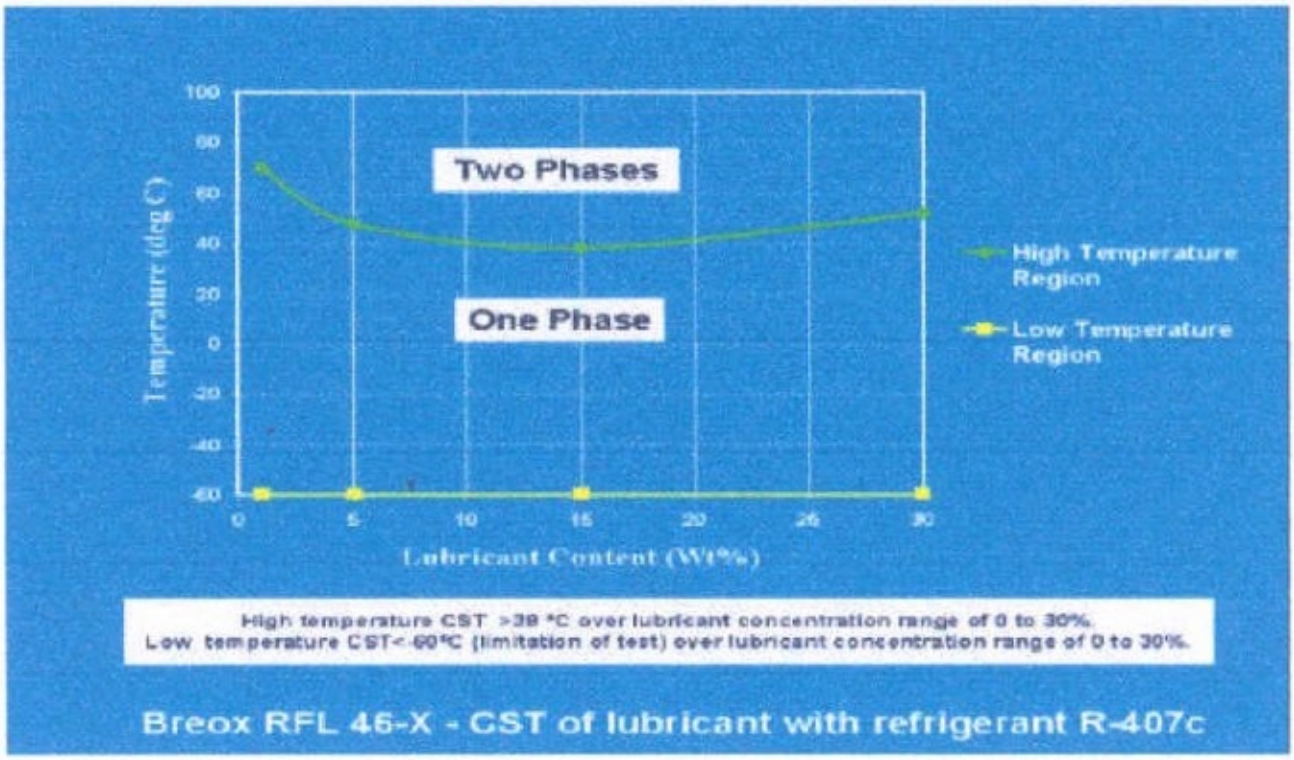




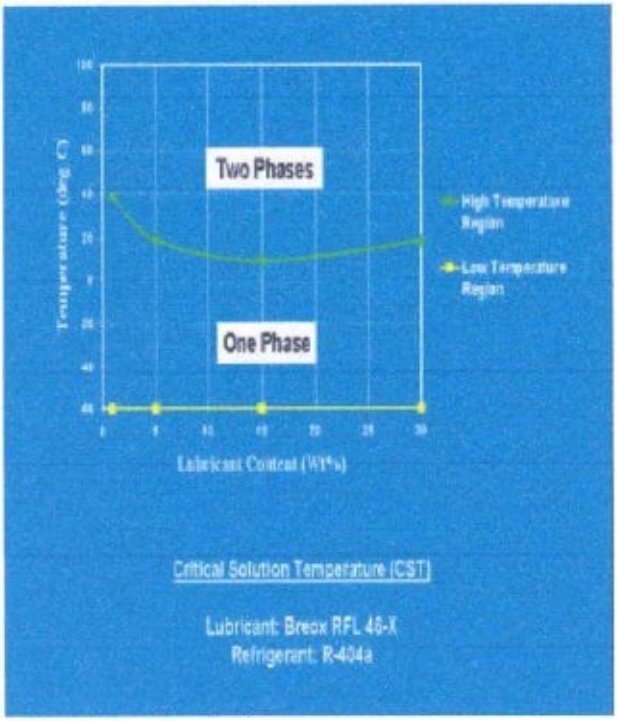
Breox **RFL-X ISO grades 32 & 46, demonstrating excellent refrigerant miscibility at low CST test temperatures, good miscibility over a wide range of lubricant concentrations, and high CST values observed at higher temperatures.**

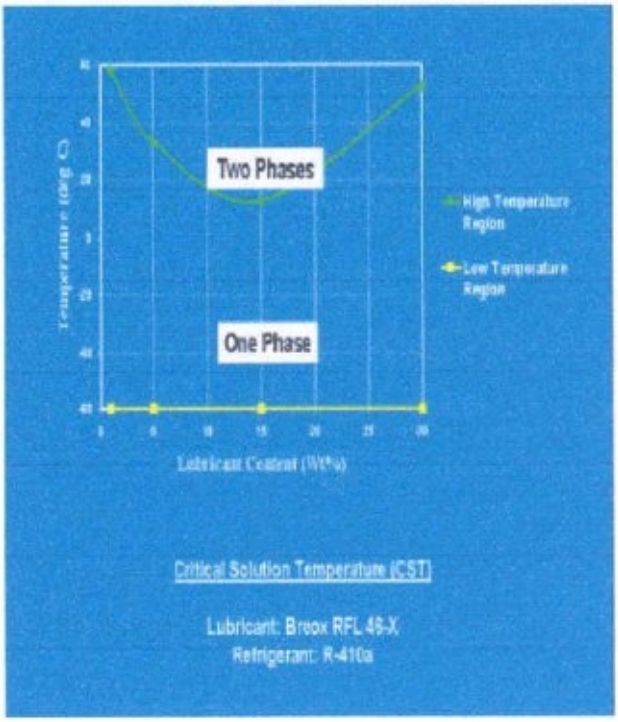
The ***Breox*** RFLs demonstrate extensive miscibility with a wide range of HFCs, ensuring their suitability for use with a range of refrigerants.

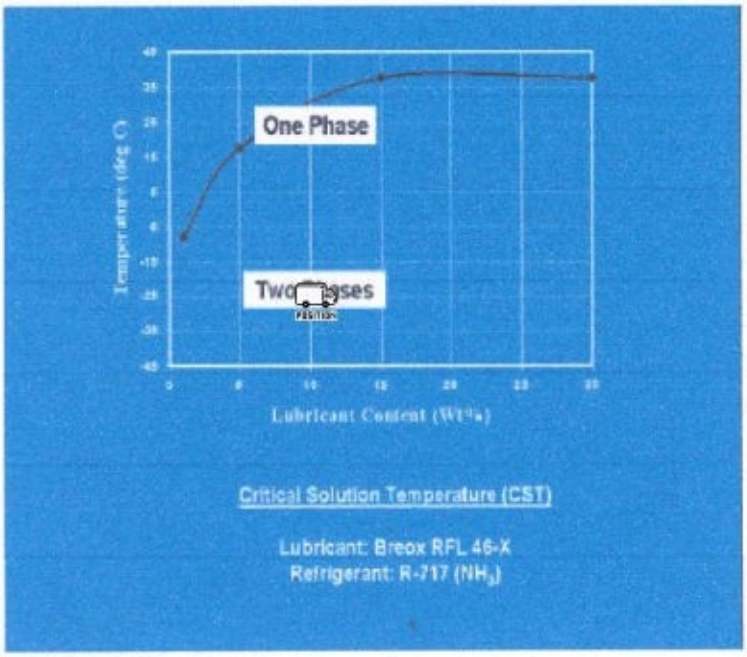
Breox RFL grades also show suitable compatibility with other refrigerants such as hydrocarbons, ammonia and carbon dioxide. ***Breox*** RFL grades are also generally observed to be compatible with other lubricating oils used in refrigeration compressors, such as polyol esters.



CST data provided demonstrates the miscibility characteristics of *Breox* RFL 46-X with R-407c, a zero ozone depletion blend of HFCs (R134a, R125 & R32), which has properties closely matching those of R22, a single component HCFC which has been used extensively in a wide variety of air conditioning and refrigeration applications.







PAG synthetic lubricants typically demonstrate the adjacent miscibility characteristics with ammonia, allowing the use of ***Breox*** PAGs in ammonia refrigeration systems where such solubility properties are desired. Furthermore, the limited miscibility temperature region demonstrated by the RFL-X grades offers certain advantages in flooded evaporator systems. Limited miscibility indicates the RFL-X grades' suitability for traditional ammonia systems where immiscible synthetic oils with good low temperature properties allow operation at very low temperatures.

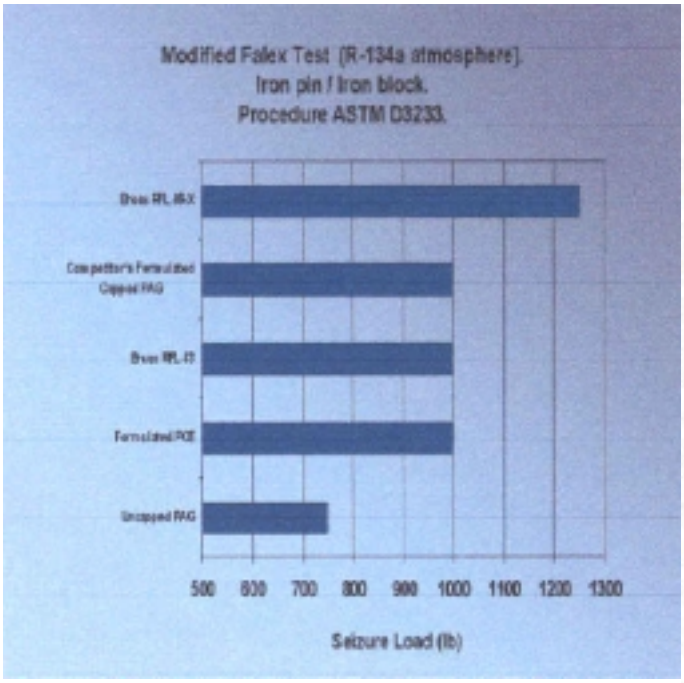
Chemical Stability

The chemical stability of lubricants intended for use with refrigerants is commonly tested using the Sealed Glass Tube (SGT) method (ASHRAE std. 97-1983), a procedure which has been used extensively for the evaluation of materials used in refrigeration systems.

The chemical stability of ***Breox*** RFL grades in comparison with fully-formulated POE, in the presence of refrigerant R-134a, has been recorded using the SGT method. The ***Breox*** RFL grades are observed to demonstrate good stability even in the presence of 1% water, whilst the POE product shows a lack of stability in the same environment.

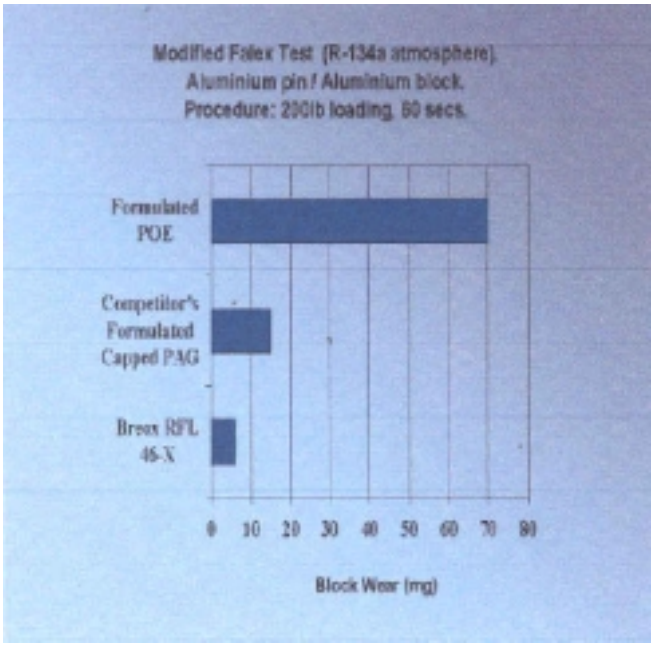
Sample	Acid Value Prior to SGT (mgKOH/g)	Acid Value After SGT (mgKOH/g
Breox RFL 46-X	0.04	0.03
POE	0.22	26.0

Lubricity Properties



Data generation by the Falex pin and V-block test is heavily dependant on specific test conditions and additive technology, and it is possible to formulated capped or uncapped PAGs to generate test data which appears to favour one type of PAG over another. The data provided considers the lubricity of uncapped and capped PAG basefluids with no additive inclusion, thus demonstrating the lubricity advantage directly attributable to the capping process. The formulating technology used for the ***Breox*** RFL-X grades is shown to result in a further improvement in falex performance, which is not equalled by competitive formulated capped PAG technology.

The excellent wear properties of PAGs can be demonstrated effectively by block wear Falex tests, where significant improvements in wear properties can be observed with ***Breox*** RFL-X grades compared with POE technology. Lubricity advantages over non-Breox capped PAGs are also demonstrated.



Hydrolytic Stability

Uncapped polyalkylene glycols are very hygroscopic and may absorb several thousand ppm of water when exposed to humid conditions. In the absence of adequate inhibitors, such water absorption could potentially lead to corrosion of bearings. Freezing of absorbed water, potentially leading to ice formation in the expansion valve or capillaries within the units is another problem associated with high moisture content. However, polyalkylene glycols will bind with water and prevent both corrosion and ice formation problems, even at minimal temperatures. Alternative lubricant technologies available for refrigeration systems such as polyol esters are also hygroscopic, though the presence of moisture may result in chemical instability due to the hydrolysis of the ester to form acidic species, potentially leading to accelerated metallic corrosion problems, device blockage and reduced compressor efficiency. Rapid acid number increase in POEs may be catalysed by metal contamination such as some types of brazing flux and also plated system components.

Despite their hygroscopicity, PAGs **will not** hydrolyse under any conditions and demonstrate very high water tolerance.

Due to the replacement of the terminal hydroxyl group by an alkyl species in the ***Breox*** RFL grades, hygroscopicity is reduced below that of an uncapped PAG:

Water Absorption Properties

Lubricants in a 52% relative humidity environment

Note: (1) sample stirring speed: 500 rpm, (2) temp: 20 °C,
(3) initial sample size: 30 g, (4) surface area: 3.1 cm

Whilst water absorbed by the PAG is not free (but bound to the PAG) and hence does not result in the usual problems associated with free moisture, the reduced hygroscopicity exhibited by the ***Breox*** RFL grades ensures low requirements for the water content of a system can be met through a choice of capped PAG lubricant.

A maximum water content of 0.05% water is defined for ***Breox*** RFL grades, with care taken during packaging and handling to ensure low water content is retained by minimising the amount of water absorbed from the atmosphere. Correct handling of the ***Breox*** RFL grades consists of storing bulk

volumes in nitrogen blanketed vessels (or equipping them with vent driers), handling of smaller volumes requires simply ensuring that the lubricant container is closed when not in use and minimising the time taken to transfer the lubricant from container to the system. The use of filter-dryers in the system will assist in minimising moisture content of the lubricant.

Electric Properties

For lubricant application in hermetic and semi-hermetic systems, where the lubricant is in direct contact with the motor windings, the electric properties such as dielectric strength and motor winding / insulation compatibility are of importance. Good electrical insulation may be retained by minimising moisture levels, with the dielectric breakdown voltage routinely used to detect free water in refrigeration oils.
Specific Resistivity measurements (IEC 247) made for the Breox RFL-X grades indicate the resistivity to typically be 10^8 Ωm, with Breakdown Voltages (IEC 156) being recorded as 50-70 kV eff. Efficient operation in hermetic and semi-hermetic systems has indicated that the Breox RFL-X grades have suitable electrical properties for such systems.

Miscibility and stability in R-12

The miscibility of Breox RFL-X grades with R-12 has been evaluated using CST testing over a temperature range of –40 to +80°C, over a lubricant concentration range of 1-30% in the R-12. Over the full range of temperature and lubricant concentration the Breox grades demonstrate complete R-12 miscibility. Systems using R-12 as refrigerant typically use mineral oil as the lubricant. Hence when retrofitting systems from R-12 to R-134a the Breox RFL-X grades show miscibility with any residual R-12, are stable in the presence of residual levels of R-12, and are also miscible with residual mineral oil.

Remarks

Handling & Safety: A Material Safety Sheet (MSDS) has been issued describing the health, safety and environmental Charcteristics of BREOX RFL-X range, together with advice on handling precautions and emergency procedures. This must be consulted and fully understood before storage, handling and use. Based on current information, the BREOX RFL-X grades do not have adverse effects on health when handled and used properly.

Storage:

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