BREOX RFL-X for CO2 Refrigeration

Additional Technical Data

BREOX RFL-X GRADES FOR CO2 COMPRESSION

High performance novel polyalkylene glycol lubricants for CO2 based air-conditioning / refrigeration systems

Introduction

The refrigeration industry has recently realised a number of significant changes due to problems associated with ozone depletion. Until relatively recently the main refrigerants in use were ozone depleting types such as R12, R22 and R502. The use of these refrigerants , with the exception of R22, is now prohibited in developed countries, plans are also developing to phase out R22 as a result of the ozone depletion potential, albeit small, which is also associated with this gas. A number of significant alternative refrigerants have been established, including HFCs such as R134a, HFC blends such as R407c, R404a and R410a. Halogen-free refrigerants also offer significant possibilities as long-term refrigerants, with single substances including NH3 (R717), propane (R290), iso-butane (R600a) and carbon dioxide (R744).

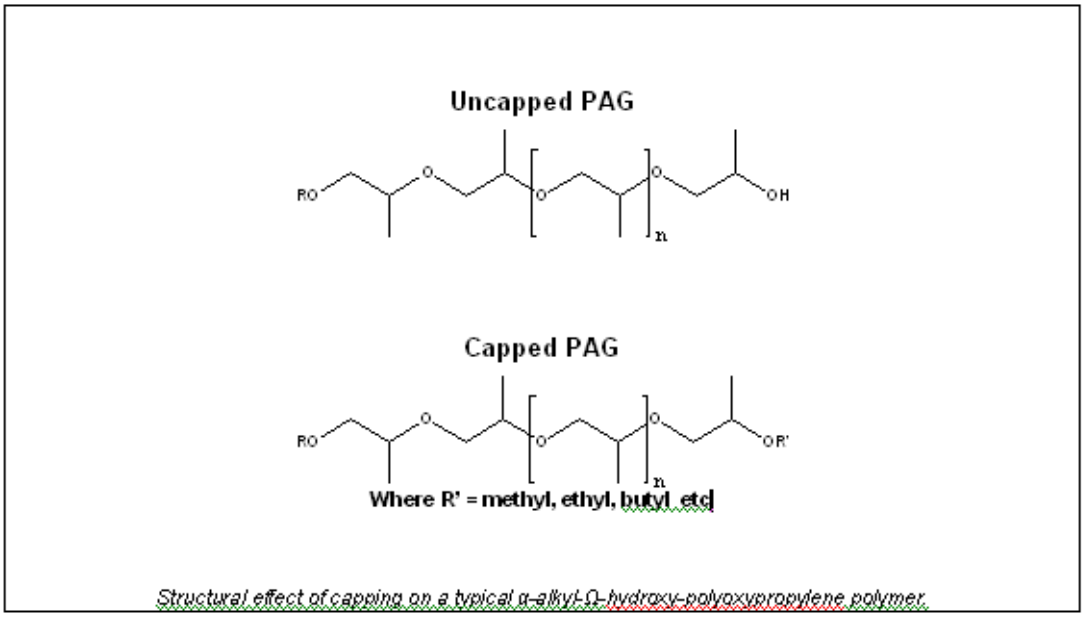
Carbon dioxide has no ozone depleting potential (ODP), is non-flammable and chemically very stable. It is only harmful to health in very high concentrations and is inexpensive, hence eliminating any need for recovery and disposal. These safety characteristics were the main reason for the widespread use of CO2 until the introduction of the “Safety Refrigerants” caused a decrease in the popularity of CO2. Carbon dioxide offers unfavourable characteristics for usual refrigeration applications, with a very high discharge pressure and a very low critical temperature of 31C (74 bar). This requires sub and supercritical operating conditions in single stage systems with discharge pressure above 100 bars, and in addition the energy efficiency is lower compared to the traditional vapour compression process. However, in applications with potentially high leakage rates and where flammable refrigerants cannot be accepted for safety reasons, there exist opportunities for CO2.

A number of development projects, primarily in the area of vehicle air-conditioning are underway, and an additional potential application is in heat pumps for sanitary water heating. Initial work indicates that CO2 systems for automotive air-conditioning and heat pumps show improved efficiency over traditional R134a technology. For larger commercial and industrial refrigeration units, CO2 may be used as a secondary fluid in a cascade system and developments are also underway in this field.

Capped PAG Technology

Performance advantages are associated with the use of Breox RFL grades as synthetic lubricants for CO2 refrigeration. A typical polyalkylene glycol generally consists of polymer chains with a terminating hydroxyl group at one end which is chemically active, whereas a “capped” PAG has chemically inactive groups at both ends of the molecule.
Breox RFL lubricants, based on “capped PAG” technology, provide efficient lubrication for compression type refrigeration units, improved lubricating properties for CO2 systems are achieved as a result of the capping technology. High process efficiency typically results in ~95% capping for the *Breox* RFL range.
Peformance advantages characterising the *Breox* RFL range include:

Miscibility with CO2 over a wide range of lubricant concentration and temperature.
Reduced hygroscopicity compared with water absorbing tendancy of uncapped PAGs.
High chemical, thermal and hydrolytic stability.
Excellent lubricity.

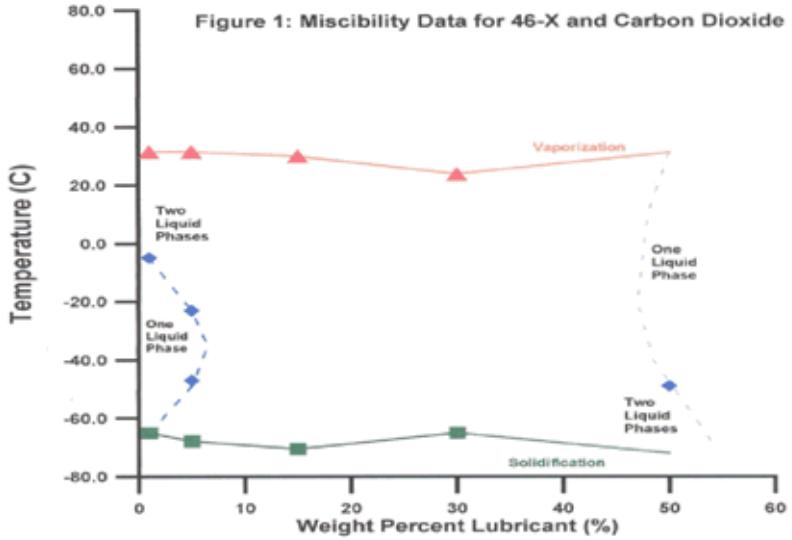


Structural effect of capping on a typical α-alkyl-Ω-hydroxy-polyoxypropylene polymer.

Typical Properties

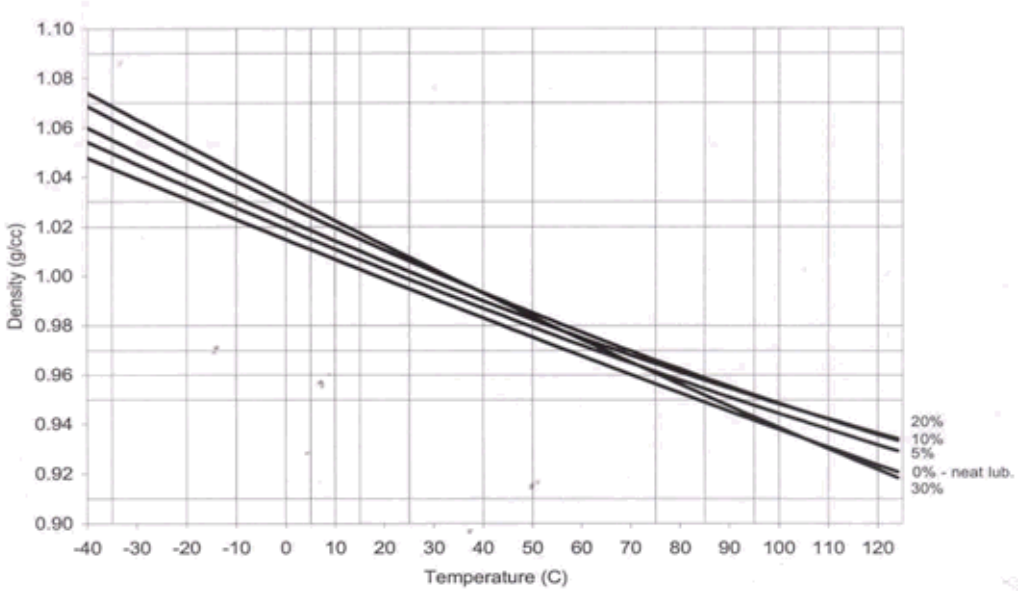
Property	Method	RFL 46-X	RFL 68-X	RFL 100-X
Viscosity 40°C (cSt)	ASTM D445	46	68	100
Viscosity 100°C (cSt)	ASTM D445	10.7	15.7	20.0
Viscosity Index	-	213	213	216
Density (gcm^{-3} at 20 °C)	ASTM D1298	0.998	0.998	0.999
Pourpoint (°C)	ASTM D97	-49	-46	-43
Flashpoint COC (°C)	ASTM D92	>200	>200	>200
Water Content (%mass)	ASTM E284	<0.05	<0.05	<0.05
TAN (mgKOH/g)	ASTM D974	<0.10	<0.10	<0.10
4-Ball wear scar -40kg/1hr (mm)	ASTM D4172	0.53	0.52	0.58
Cu corrosion test	ASTM D130	1a	1a	1a
Steam turbine corrosion test	ASTM D665(a)	Pass	Pass	Pass

Miscibility with CO2

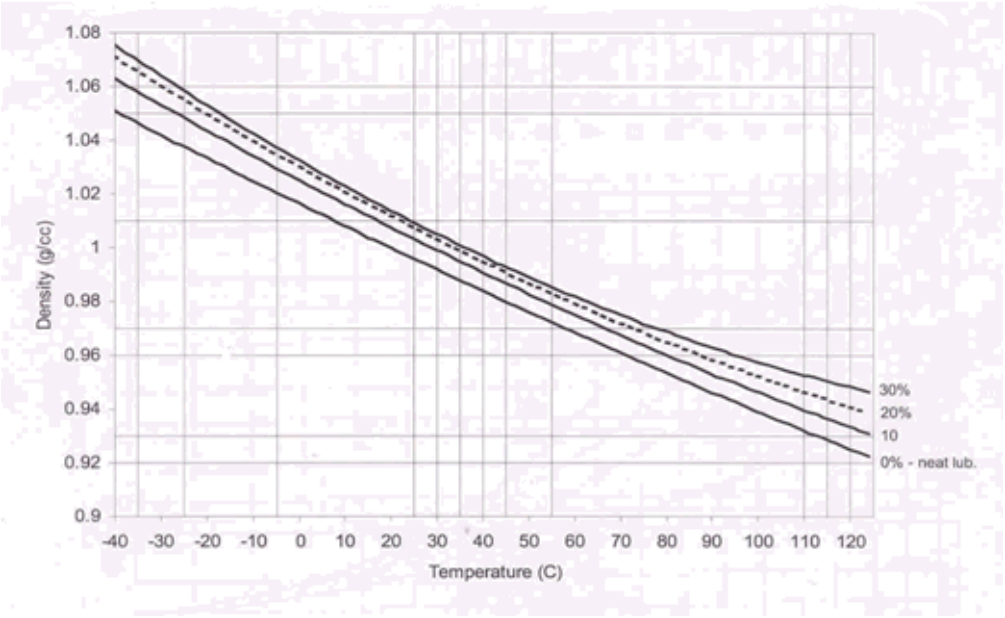


Miscibility data recorded for the Breox RFL-X range with CO2 indicates the same miscibility profile across the viscosity range ISO 46 – ISO 150.
The majority of conventional lubricants such as mineral oils and alkylbenzenes are not soluble with CO2. Polyol ester (POE) synthetic lubricants show good miscibility properties, however this can result in a dramatic reduction in lubricant viscosity. PAGs show partial miscibility with CO2, however the viscometric properties of polyalkylene glycols remain unaffected and the decrease in viscosity observed with POEs is not observed for PAGs under CO2 dilution, thus good wear protection properties are retained with PAGs.

Density vs Temperature, RFL 46-X / CO2

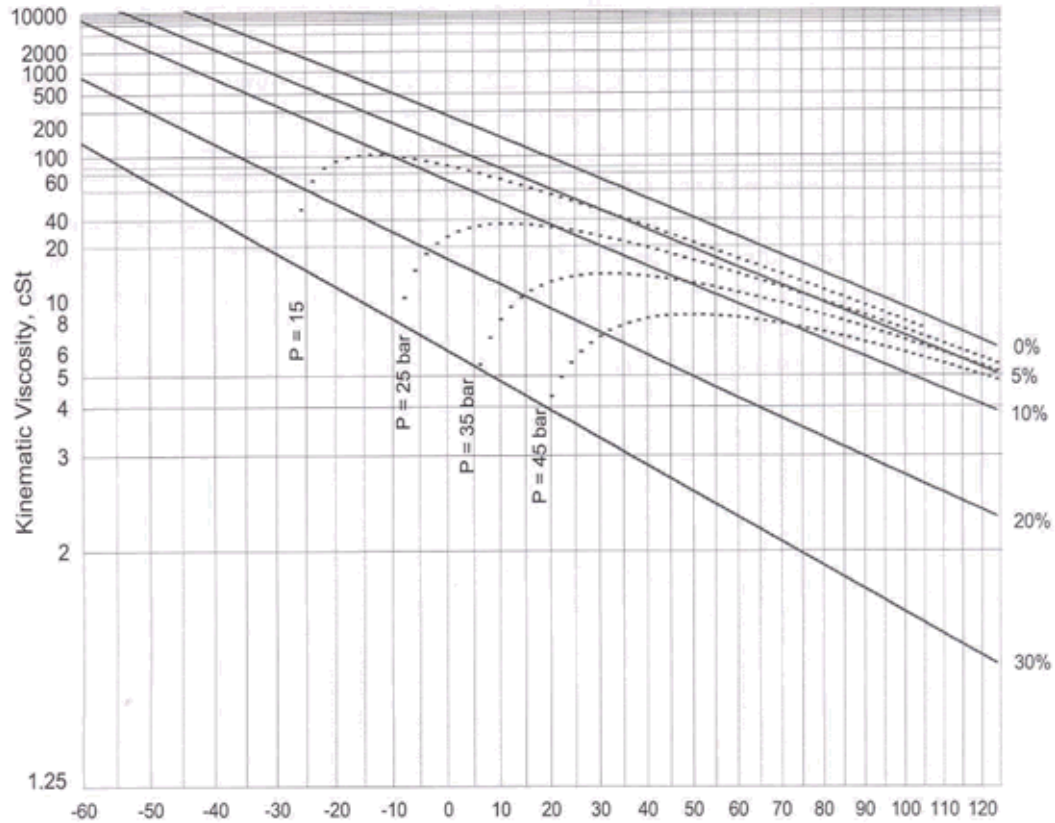


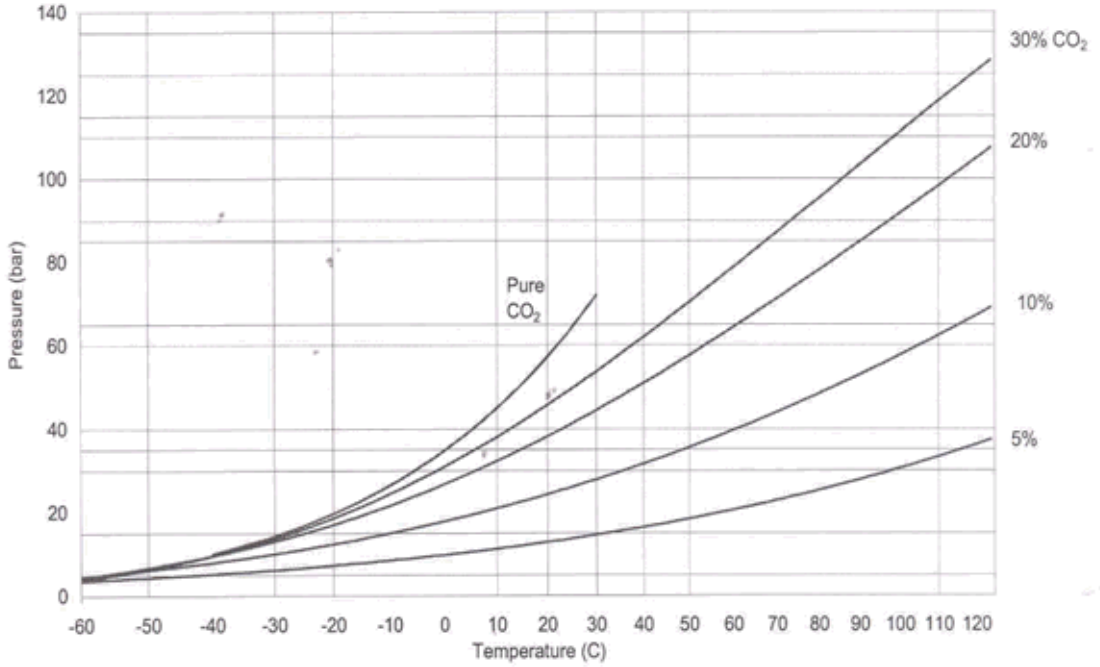
Density vs Temperature, RFL 100-X / CO2



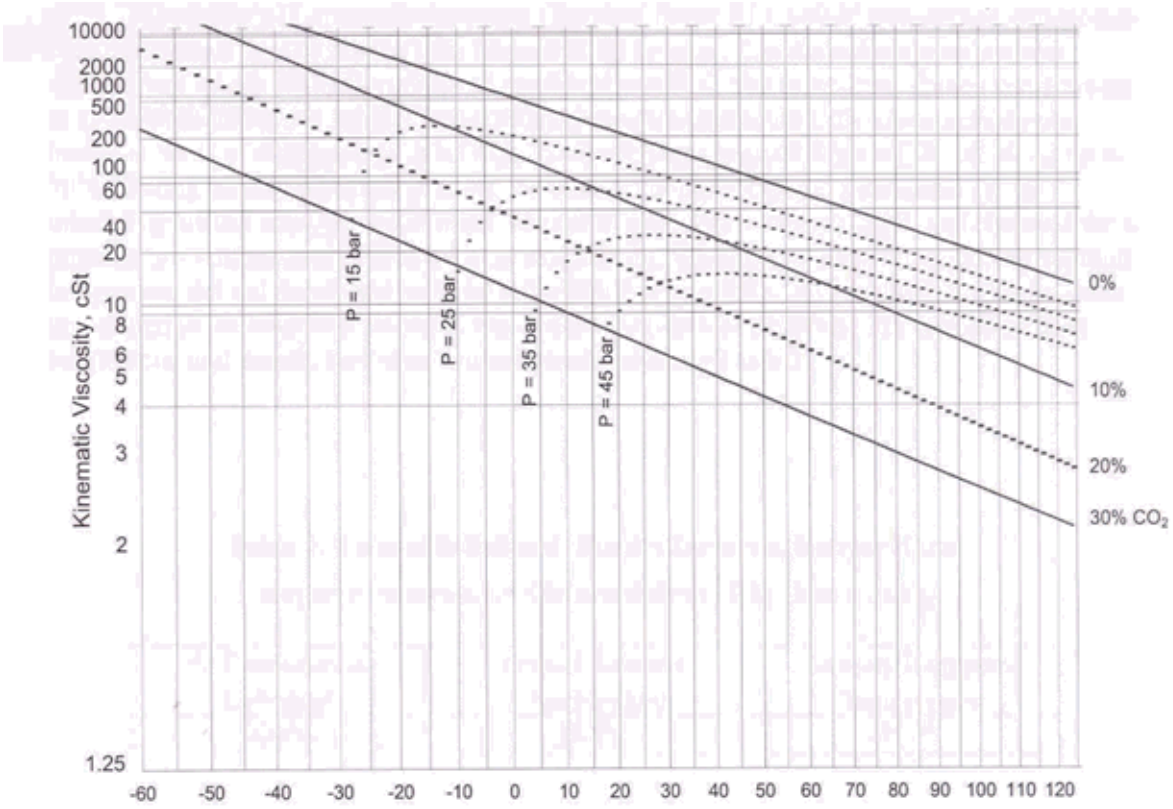
Experimental measurements of liquid density were recorded at ***Breox*** RFL-X concentrations of 70, 80, 90 and 100wt%, over a temperature range of –40 to +125C.

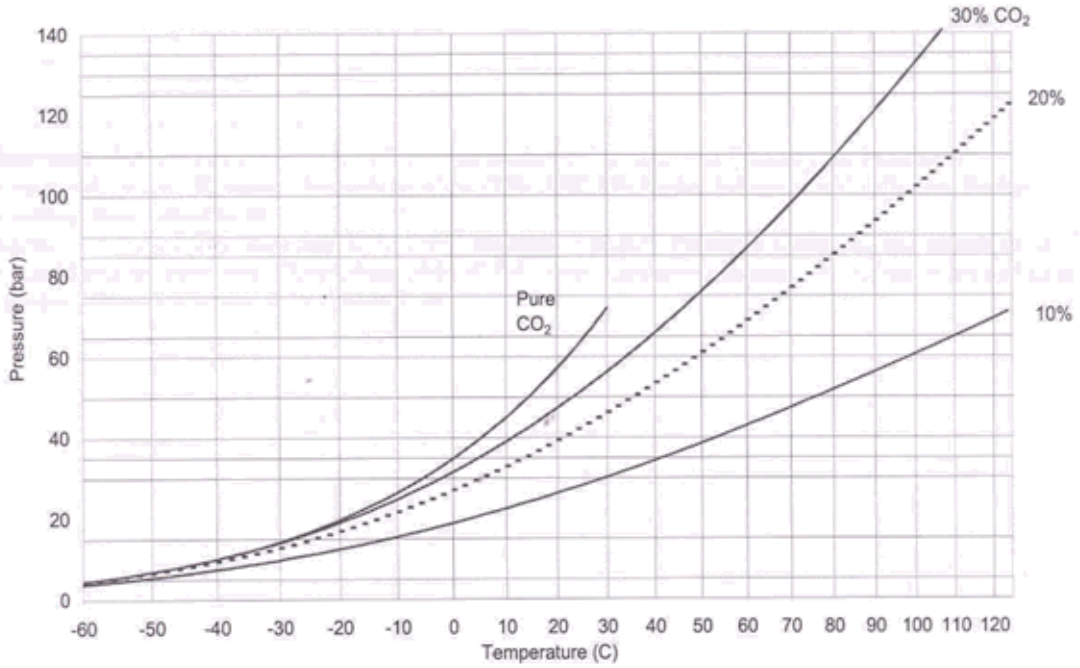
Breox RFL 46-X Daniel plot





Breox RFL 100-X Daniel plot





Lubricity Properties

The development of trans-critical CO2 systems requires speciality lubricants due to the high pressure and subsequently higher loading on bearings. The extreme pressure and anti-wear properties of PAGs are superior to POEs and other synthetics such as PVEs, with such lubricating properties being retained under high pressure CO2 conditions. ***Breox*** RFL-X lubricants, based on "capped PAG" technology, provide efficient lubrication for compression type refrigeration units, improved lubricating properties for CO2 systems are achieved as a result of the capping technology.

To simulate as accurately as possible the CO2 pressurised environment, Falex Block-on-Ring testing has been used to assess the load carrying properties of the ***Breox*** RFL-X grades using the following test parameters:

Load Steps	+50 lbs, followed by +20lbs
Rotation Speed	600 rpm
Atmosphere	CO2
Overpressure	10 bar (150 psi)
Step Duration	5 minutes
Temperature	Min 90C
Ring	Falex S10, SAE 4620 steel, Rc5 8-63 6-12rms
Blocks	Falex H-30, SAE 01 steel, Rc 27-33, 4-8 rms

Measured at increasing steps of 20lbs:

EP Load (lbs) – RFL 46-X	380

Hydrolytic Stability

Uncapped polyalkylene glycols are very hygroscopic and may absorb several thousand ppm of water when exposed to humid conditions, however despite this PAGs will not hydrolyse under any conditions and water absorbed by the PAG is not free (but bound to the PAG) and therefore cannot result in problems typically associated with absorbed water in alternative synthetic lubricants such as polyol esters, such as corrosion, ice formation in the expansion valve / capillaries, or acidic species generation.
Due to the replacement of the terminal hydroxyl group by an alkyl species in the ***Breox*** RFL-X grades, hygroscopicity is reduced below that of an uncapped PAG and ensures low requirements for the water content of a system can be achieved through a choice of capped PAG. A maximum water content of 0.05% water is defined for the ***Breox*** RFL-X grades.

Remarks

Handling & Safety: A Material Safety Data Sheet (MSDS) has been issued describing the health, safety and environmental characteristics of the Breox RFL 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 grades do not have adverse effects on health when handled and used properly.

Storage:

Revision-No. 1.1-07.2005 Effective July 21, 2005

The product can be stored for at least 2 years at ambient storage conditions and temperature without any deterioration.

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