Shrieve Product Information Sheet

ZEROL RFL-EP Series

High performance novel polyalkylene glycol lubricants for CO_2 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 NH_3 (R717), propane (R290), iso-butane (R600a) and carbon dioxide (R744).

Carbon dioxide (CO_2) 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 CO_2 until the introduction of the 'Safety Refrigerants' caused a decrease in the popularity of CO_2. Carbon dioxide offers unfavourable characteristics for usual refrigeration applications, with a very high discharge pressure and a very low critical temperature of 31°C (74 bar). This requires sub and supercritical operating conditions in single stage systems with discharge pressure above 100 bar, 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 CO_2. A number of development projects, primarily in the area of vehicle air conditioning are underway, and an additional application is in heat pumps for domestic water heating. Initial work indicates that CO_2 systems for automotive air conditioning and heat pumps show improved efficiency over traditional R134a technology. For larger commercial and industrial refrigeration units, CO_2 may be used as a secondary fluid in a cascade system and developments are also underway in this field.

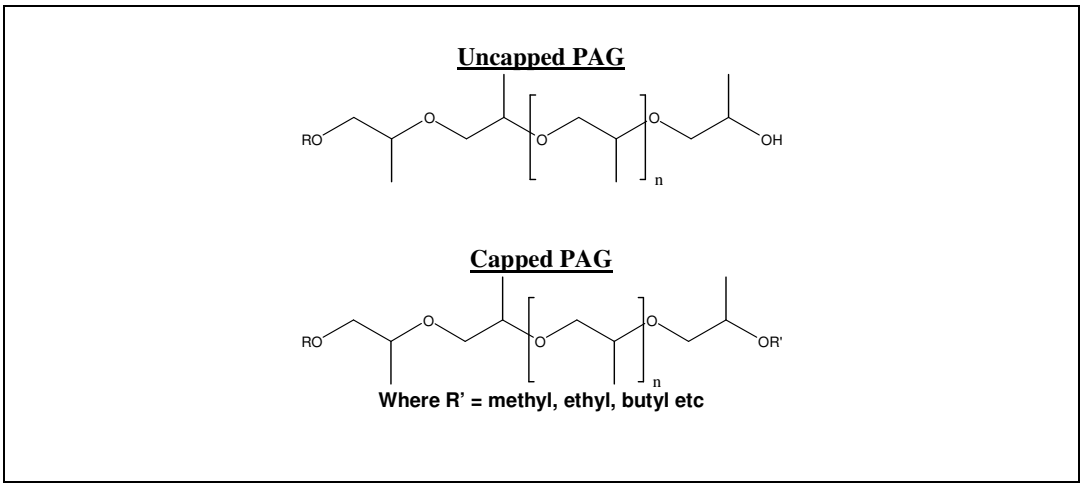
Capped PAG technology

Performance advantages are associated with the use of Shrieve ZEROL RFL-EP grades as synthetic lubricants for CO_2 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.
ZEROL RFL-EP lubricants, based on 'capped PAG' technology, provide efficient lubrication for compression type refrigeration units, improved lubricating properties for CO_2 systems are achieved as a result of the capping technology. High process efficiency typically results in ~95% capping for the RFL range.

Performance advantages characterising the ZEROL RFL-EP range include:

- Miscibility with CO_2 over a wide range of lubricant concentration and temperature
- Reduced hygroscopicity compared with water absorbing tendency of uncapped PAGs
- High chemical, thermal and hydrolytic stability
- Excellent lubricity.

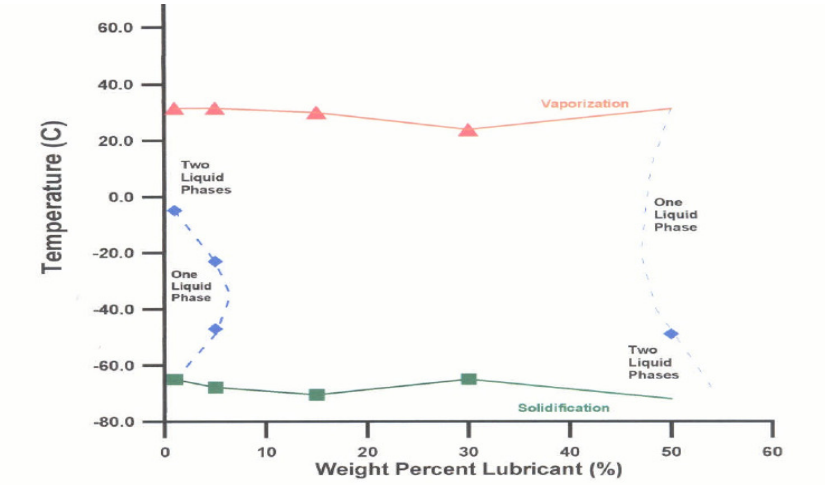
Structural effect of capping on a typical α-alkyl-Ω-hydroxy-polyoxypropylene polymer



ZEROL RFL-EP range typical properties

			Shrieve ZEROL		
		Method	**RFL 46-EP**	**RFL 68-EP**	**RFL 100-EP**
Typical physical properties	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
	Pour point (°C)	ASTM D97	-49	-46	-43
	Flash point 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

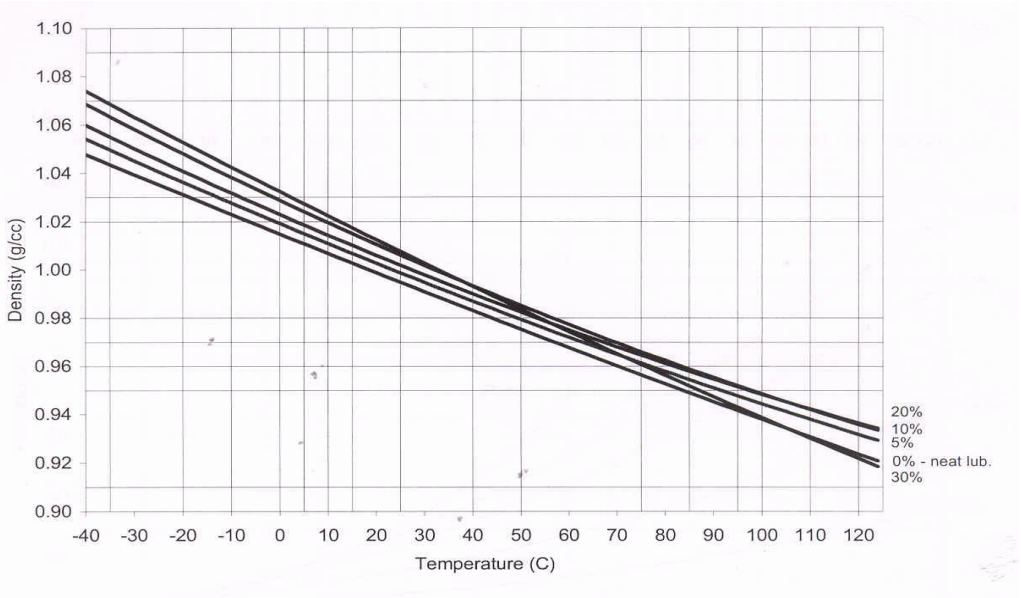
Miscibility of ZEROL RFL 46-EP with CO_2:



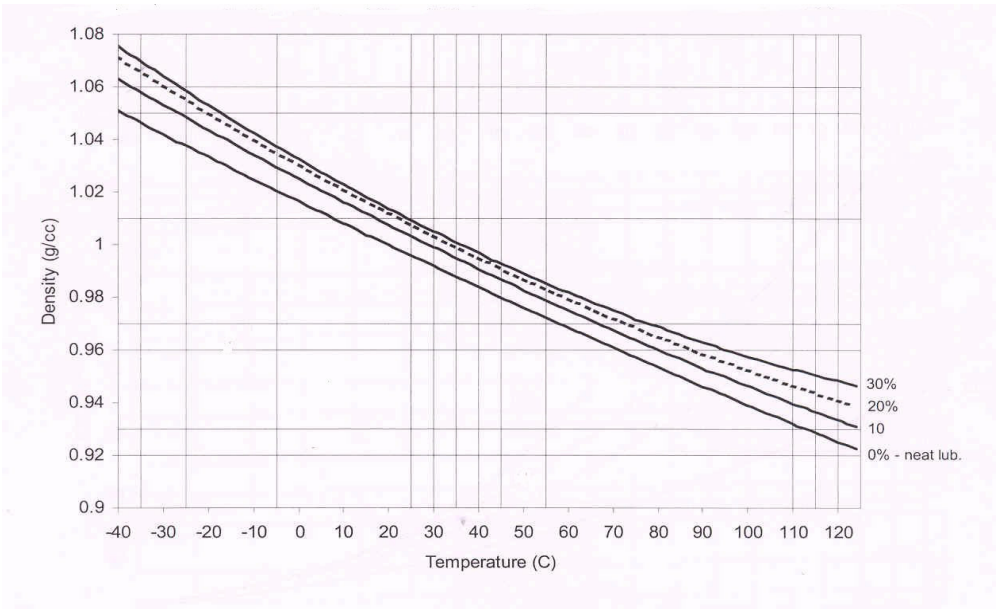
Miscibility data recorded for the ZEROL RFL-EP series with CO_2 indicates a very similar miscibility profile across the viscosity range ISO 46 – ISO 150.

Miscibility of ZEROL RFL 46-EP with CO_2 (continued):
The majority of conventional lubricants such as mineral oils and alkyl benzenes are not soluble with CO_2. 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 CO_2, however the viscometric properties of polyalkylene glycols remain unaffected and the decrease in viscosity observed with POEs is not observed for PAGs under CO_2 dilution, thus good wear protection properties are retained with PAGs.

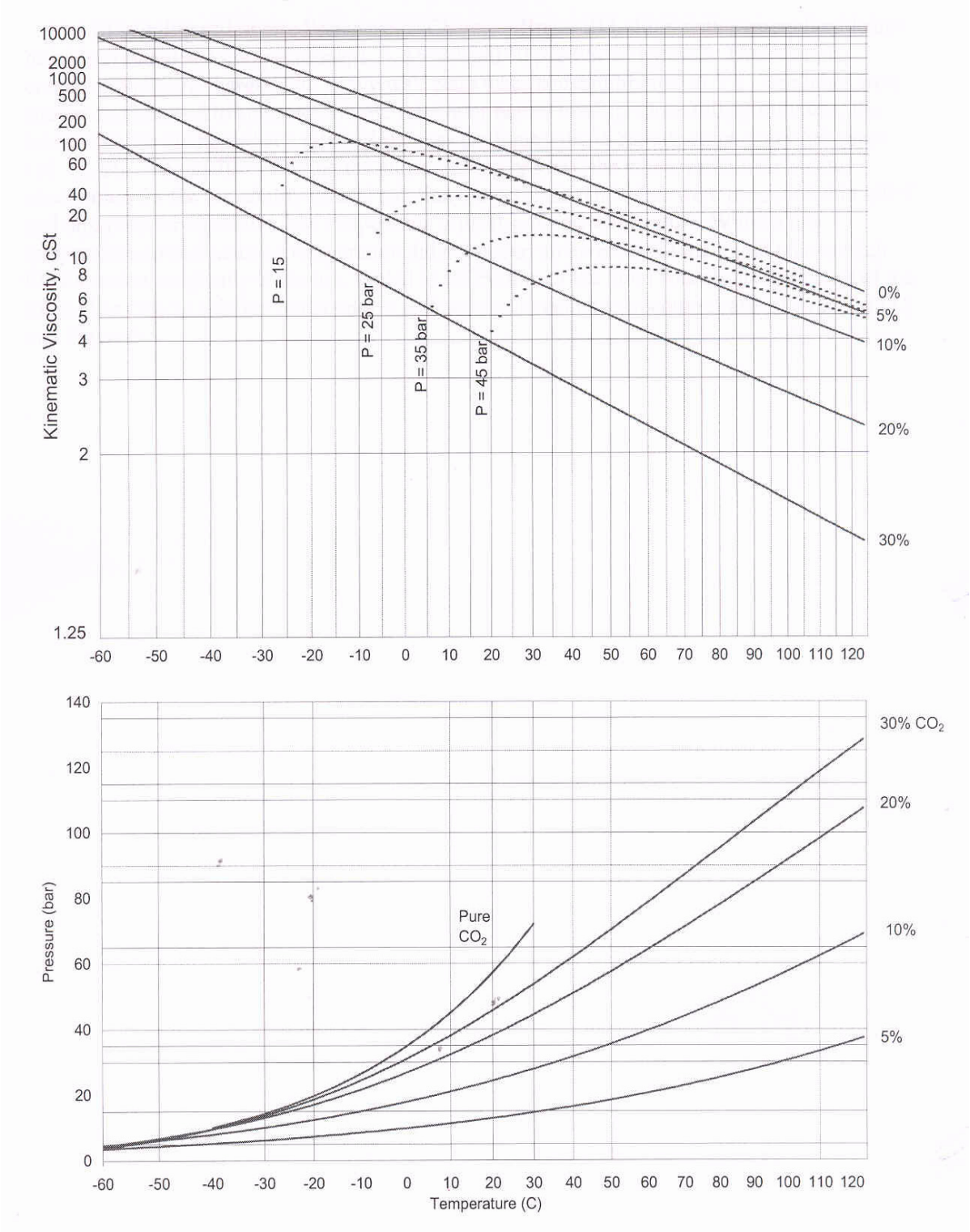
Density vs. Temperature, ZEROL RFL 46-EP/CO_2



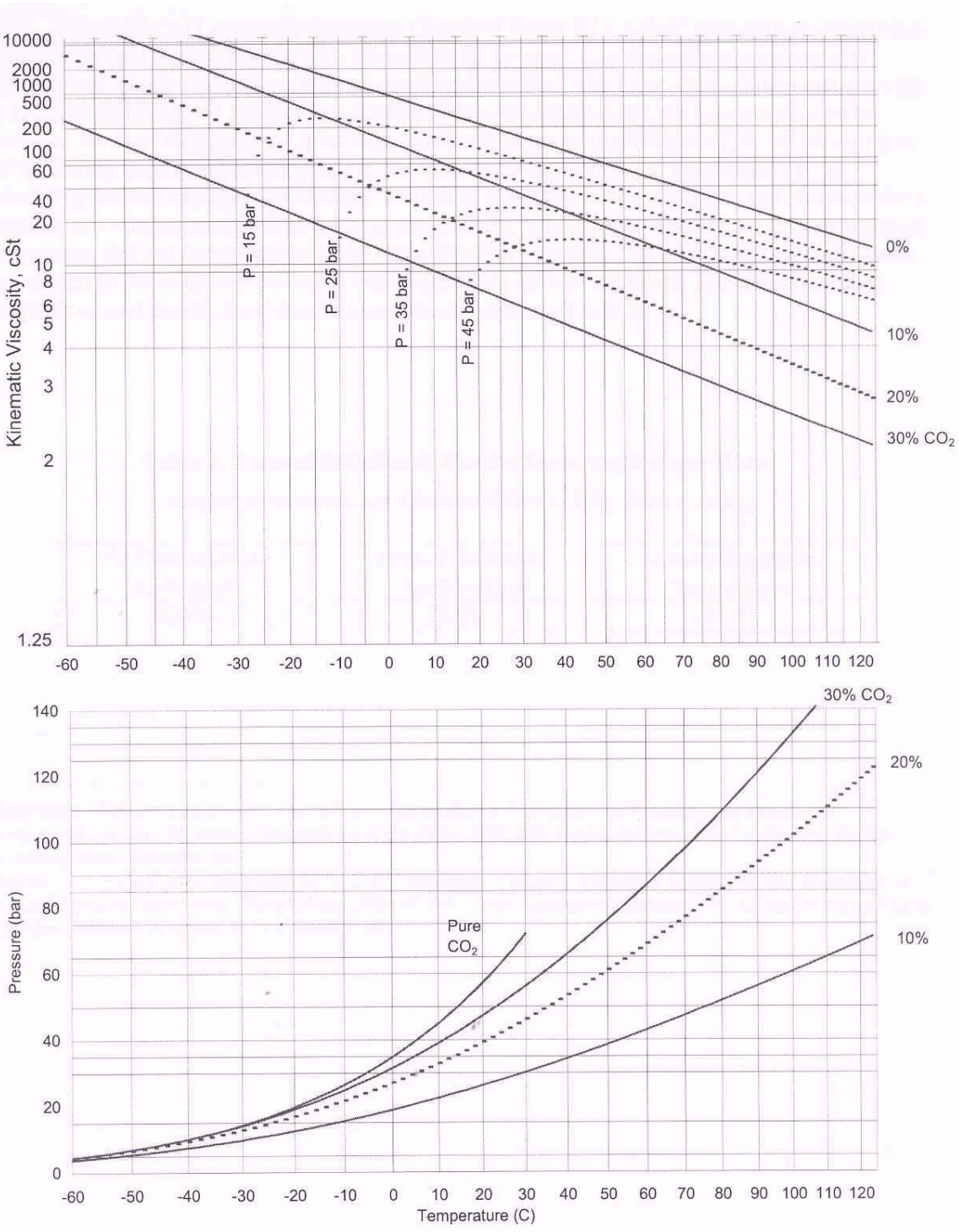
Density vs. Temperature, ZEROL RFL 100-EP/CO_2



ZEROL RFL 46-EP Daniel plot



ZEROL RFL 100-EP Daniel plot



Lubricity properties
The development of trans-critical CO_2 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 CO_2 conditions. ZEROL RFL-EP lubricants, based on 'capped PAG' technology, provide efficient lubrication for compression type refrigeration units, improved lubricating properties for CO_2 systems are achieved as a result of the capping technology.

To simulate as accurately as possible the CO_2 pressurised environment, Falex Block-on-Ring testing has been used to assess the load carrying properties of the ZEROL RFL-EP grades using the following test parameters:

Parameter	
Load Steps	+50 lbs, followed by +20lbs
Rotation Speed	600 rpm
Atmosphere	CO_2
Overpressure	10 bar (150 psi)
Step Duration	5 minutes
Temperature	Min 90°C
Ring	Falex S10, SAE 4620 steel, Rc5 8-63 6-12rms
Blocks	Falex H-30, SAE 01 steel, Rc 27-33, 4-8 rms

Result
(measured at increasing steps of 20lbs):

EP Load (lbf) – RFL 46-EP	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 hydrogen 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 ZEROL RFL-EP grades, hygroscopicity is reduced below that of an un-capped 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 ZEROL RFL-EP grades.

For further information on our complete ZEROL range of lubricants, including Health and Safety data, please contact us at any of the following international locations:

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