CO_2 PAG Lubricants

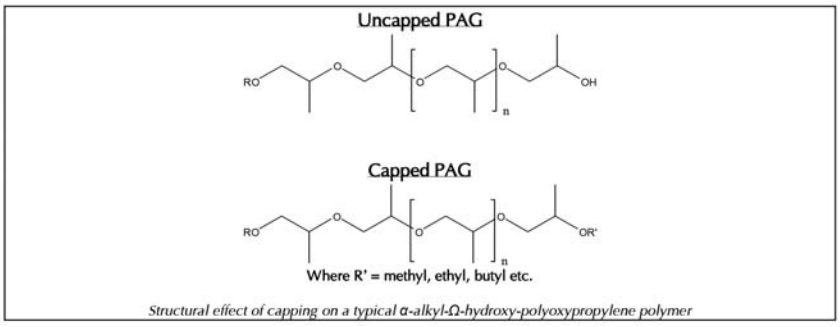
PAG are new Polyalkylene Glycol that guarantee high-performances in AC/R Systems with CO_2. CO_2 is a Refrigerant with a complex and delicate balance, which requires outstanding performances to the Lubricant.
PAG for CO_2 offer a better miscibility with CO_2 in a wide range of concentrations and temperatures. This means: excellent lubricating properties and higher efficiency for the Refrigeration System.
PAG for CO_2 have a reduced Hygroscopicity (if compared to normal PAG, which is unprotected to hydroxyl and used with other refrigerants). These Oils also have High Chemical Stability, Thermal and Hydrolysis Resistance.

CO_2 offers unfavorable characteristics in normal Refrigeration Applications, with a very high discharging pressure and a very low critical temperature (31°C - 74 bar). This situation requires sub and supercritical operating conditions in single-stage Systems with delivery pressure exceeding 100 bar. In addition, the energy performance is lower than the conventional vapor compression process.
However, in applications with potentially high rates of dispersion and where flammable refrigerants cannot be used for safety reasons, there are opportunities to use CO_2. For example, CO_2 is a valid option for Air Conditioning Systems in Automotive. For commercial and industrial refrigeration units, CO_2 can be used as a secondary fluid in a Cascade System.

Protection Terminals Technology and Protective Element Choice (Capped or Multi-capped)

Several performance advantages are associated with the use of PAG for CO_2 as Synthetic Lubricants for Refrigeration with CO_2. A typical Polyalkylene Glycol generally consists of Polymer chains terminated with a Hydroxyl group that is chemically active at one end. On the contrary, a protected PAG is a chemically inactive group at both ends of the molecule. PAG for CO_2, based on the "capped PAG" technology, provide effective lubrication for Refrigeration Units and compression. Protection technology ("capped" technology) also provides improved lubricity for CO_2 Systems.
High efficiency of the process typically results in ~ 95% for PAG for the CO_2 range.

- Miscibility with CO_2 in a wide range of lubricant concentration and temperature.
- Reduced hygroscopic than a PAG without protection in the process of absorbing water.
- High chemical stability to heat and hydrolysis.
- Excellent lubricating capacity.



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

PAG 46 for CO_2 features:

Property	Method	Value
Viscosity @ 40°C, cSt	ASTM D445	49.7
Viscosity @ 100°C, cSt	ASTM D445	10.7
Viscosity Index	-	213
Density @ 20°C, kg/m ^{3}	ASTM D1298	998
Pour point, °C	ASTM D97	-49
Flashpoint, COC, °C	ASTM D92	>200
Water Content , % mass	ASTM E284	<0.05
TAN, mgKOH/g	ASTM D974	<0.10
4-Ball wear scar -40kg/1hr (mm)	ASTM D4172	0.53
Cu corrosion test	ASTM D130	1a
Steam turbine corrosion test	ASTM D665(a)	Pass
Miscibility in CO_2:		
Upper CST: 1% RFL-X in CO_2	ASHRAE 86	30.9
5% RFL-X in CO_2		30.9
30% RFL-X in CO_2		26.0
50% RFL-X in CO_2		13.0
Density Inversion temp: 1% RFL-X in CO_2		-31.0
5% RFL-X in CO_2		-31.0
30% RFL-X in CO_2		-31.0
50% RFL-X in CO_2		-29.2

PAG 68 for CO_2 features:

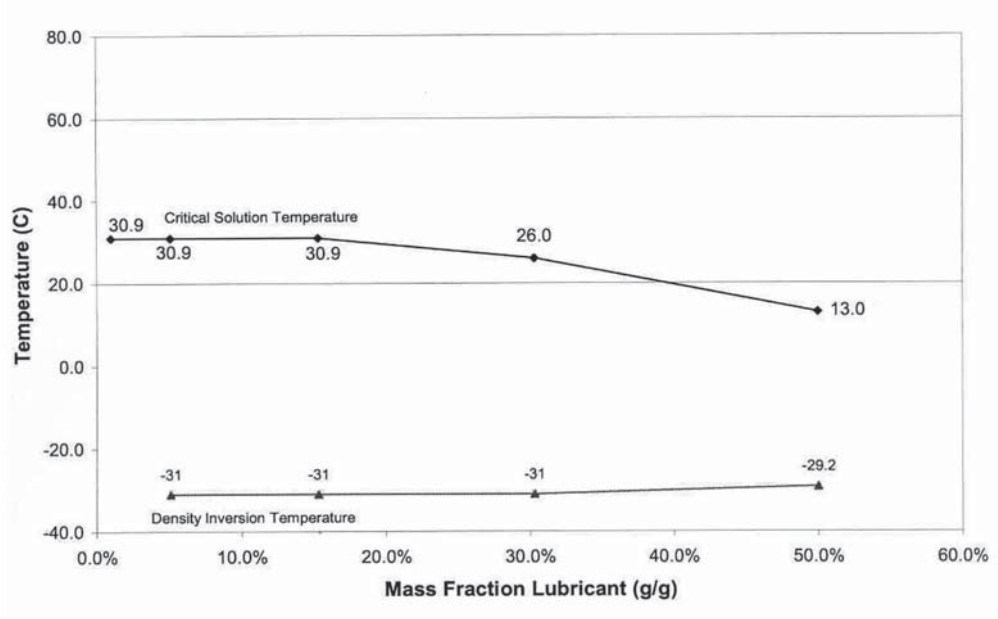
Property	Method	Value
Viscosity @ 40°C, cSt	ASTM D445	70
Viscosity @ 100°C, cSt	ASTM D445	14
Viscosity Index	-	210
Density @ 20°C, kg/m ^{3}	ASTM D1298	998
Pour point, °C	ASTM D97	-46
Flashpoint, COC, °C	ASTM D92	>200
Water Content , % mass	ASTM E284	<0.05
TAN, mgKOH/g	ASTM D974	<0.10
4-Ball wear scar -40kg/1hr (mm)	ASTM D4172	0.5
Cu corrosion test	ASTM D130	1a
Steam turbine corrosion test	ASTM D665(a)	Pass

Miscibility above and below the Critical Point of Carbon Dioxide (30.98°C).

Most of the conventional lubricants such as Mineral and Alkylbenzene oils are not soluble with CO_2. The Polyol Ester (POE) show good miscibility properties, however this may cause a drastic Viscosity reduction.
PAG shows partial miscibility with CO_2, but the viscosity properties of Polyalkylenglycols remain unchanged and the decrease of viscosity (observed with POE) does not happen in PAG lubricants under dilution with CO_2.
PAG for CO_2 show miscibility with CO_2 in a wide range of temperatures and lubricant concentrations.

FOCUS ON: CO_2 PAG 46

Miscibility of CO_2 PAG 46 in CO_2



Even the upper critical temperature remains constant over a wide range of lubricant concentrations. The lower critical temperature does not occur, even if an inversion of density in the liquid phases is observed in the tested range of concentration.

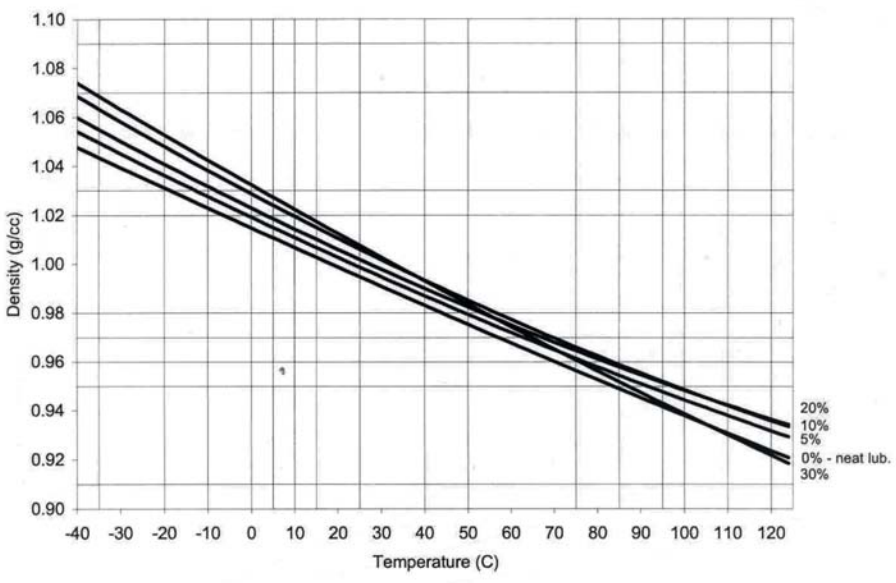
CO_2 PAG 46 Critic Solution and Inversion Density

% Composition Lubricant	Critical Solution Temperature (°C)	Density Inversion Temperature (°C)
1.0	30.9	Suspended droplets
5.1	30.9	-31.0
15.3	30.9	-31.0
30.3	26.0	-31.0
50.0	13.0	-29.2

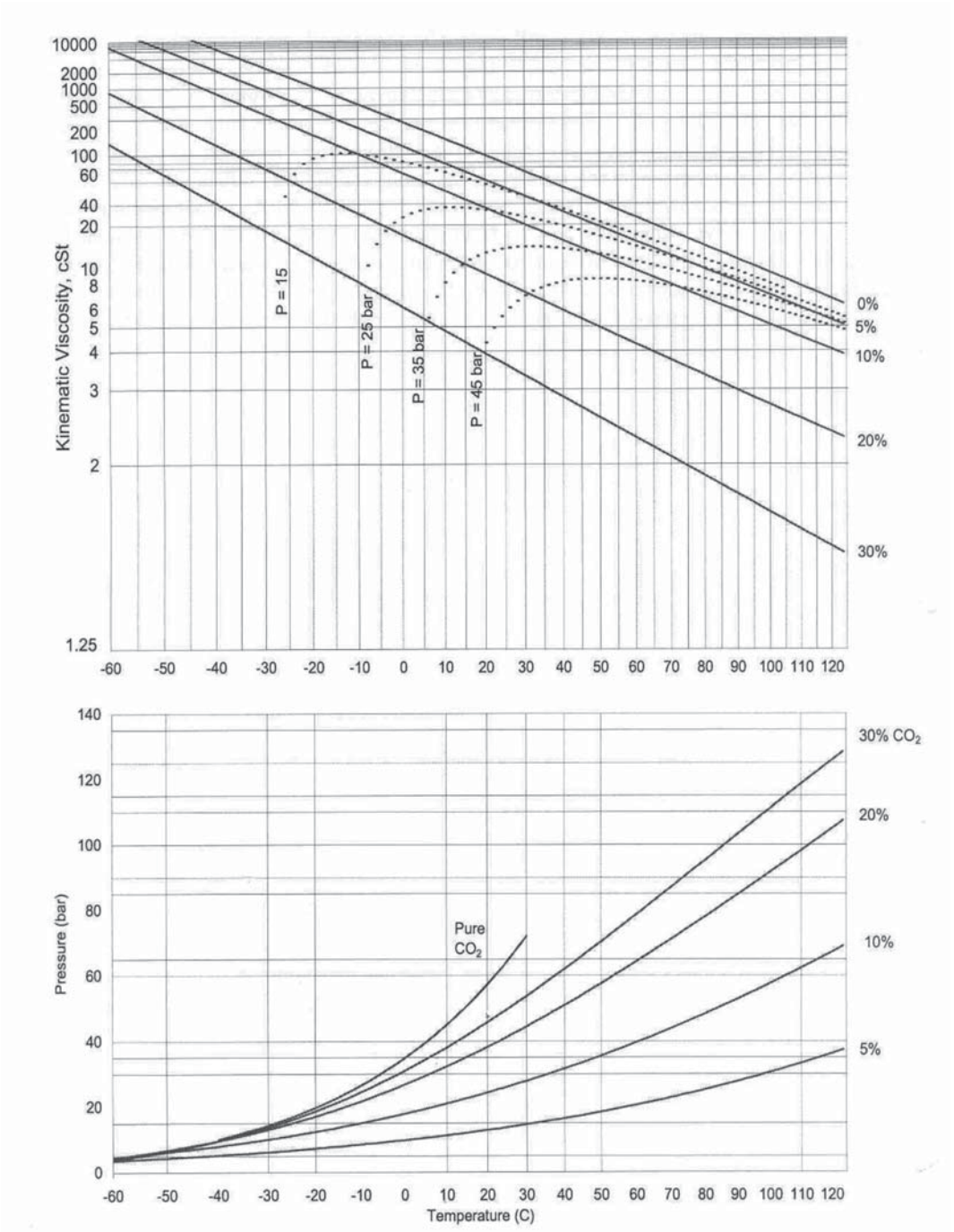
CO_2 PAG 46 Solubility, Density and Viscosity

Experimental measurements of the liquid density, vapor pressure (solubility) and the viscosity of the liquid were recorded for PAG 46 for CO_2 concentrations in 70, 80, 90 and 95% of weight, in a temperature range -40 °C to +125 °C.

CO_2 PAG 46 Density



CO_2 PAG 46 Viscosity and Vapour Pressure



Lubricant properties

The development of the trans-critical CO_2 Systems requires special Lubricants because of High Pressure and subsequently higher load on the bearings. The extreme PAG pressure and antiwear properties are superior to those of POE and other synthetic materials, such as PVEs.

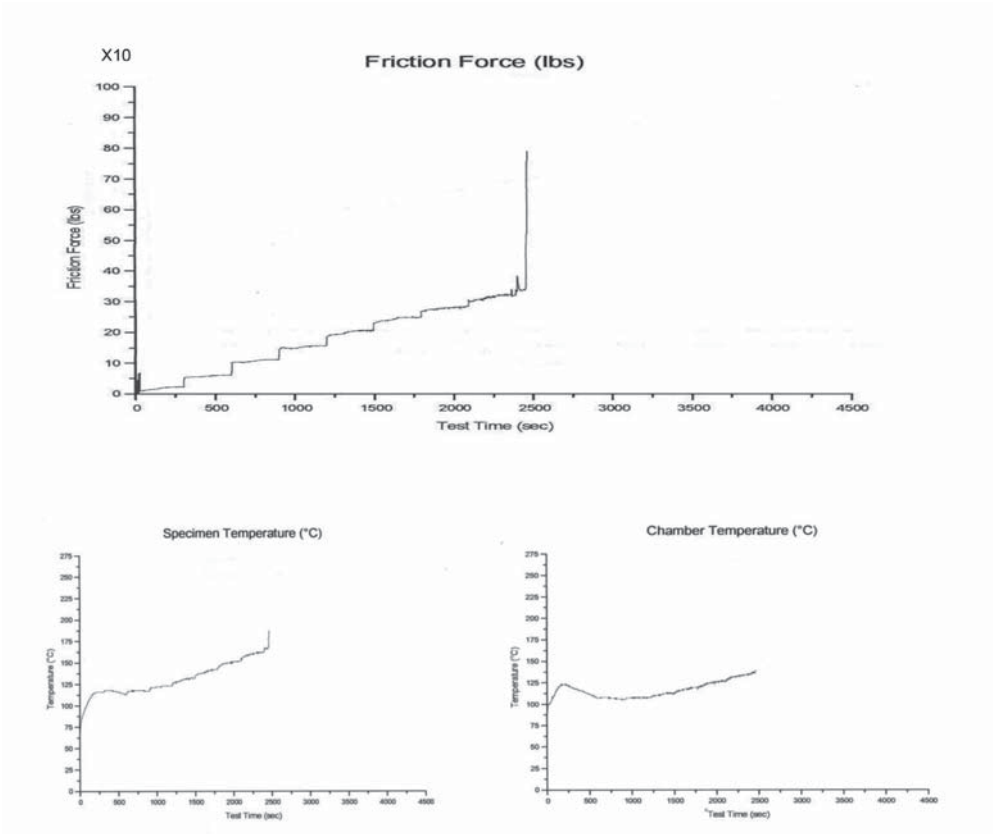
These lubricating properties are kept under High-Pressure conditions. PAG 46 for CO_2 ("capped" technology based), provides efficient lubrication for refrigeration units.

These improved lubricating properties for CO_2 Systems are obtained as a result of the terminals protection technology (capped technology).

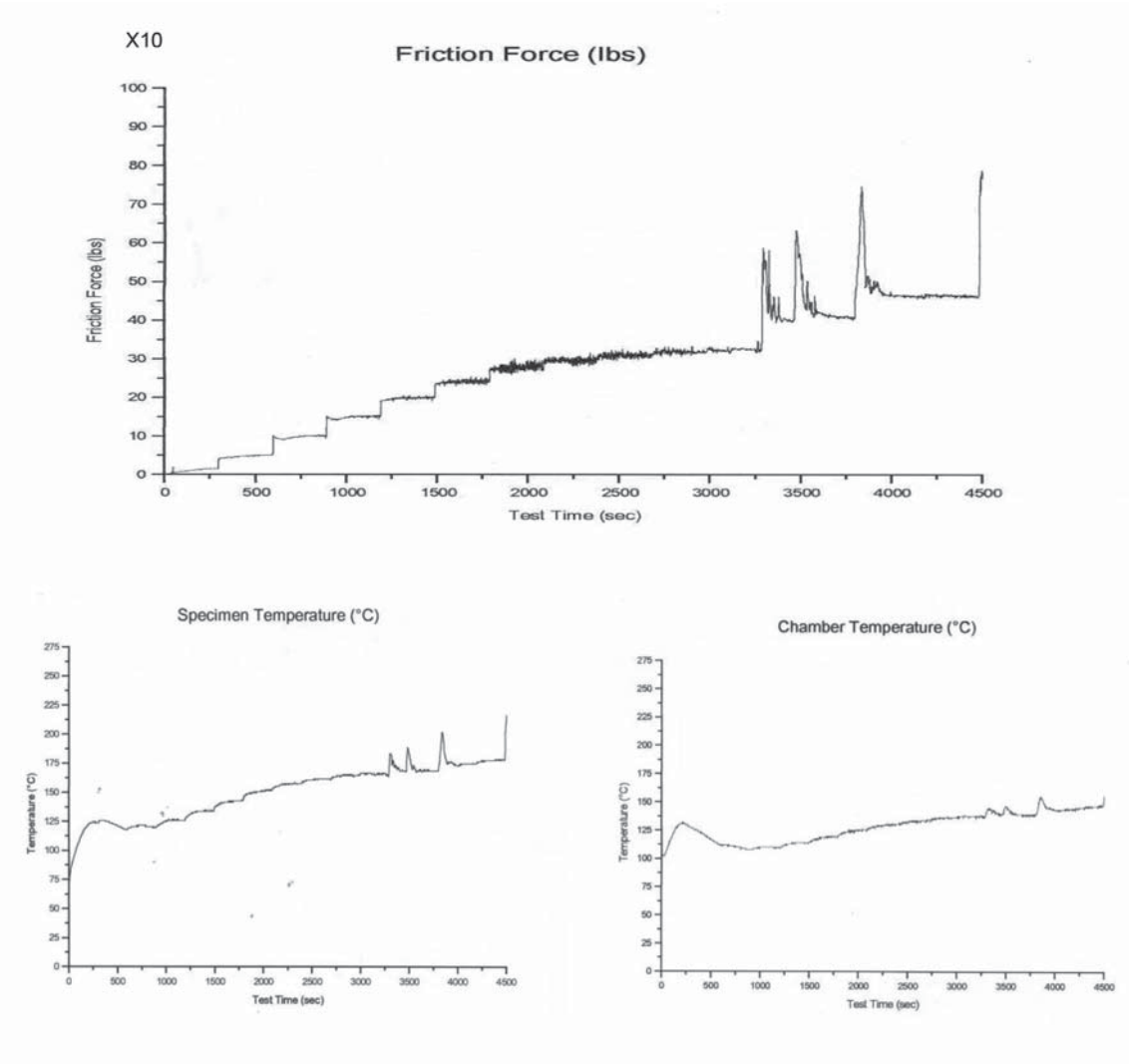
In order to simulate as accurately as possible the CO_2 pressurized environment, Falex Block-on-Ring test was used to evaluate the effect on the PAG 46 for CO_2 properties using the following parameters:

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 6-12 rms
Blocks	Falex H-30, SAE 01 steel, Rc 27-33, 4-8 rms

The load pressure (lbs) and estimated wear (mm) were recorded for PAG 46 for the CO_2 (and with the addition of additives EP / AW - PAG 46 for CO_2):



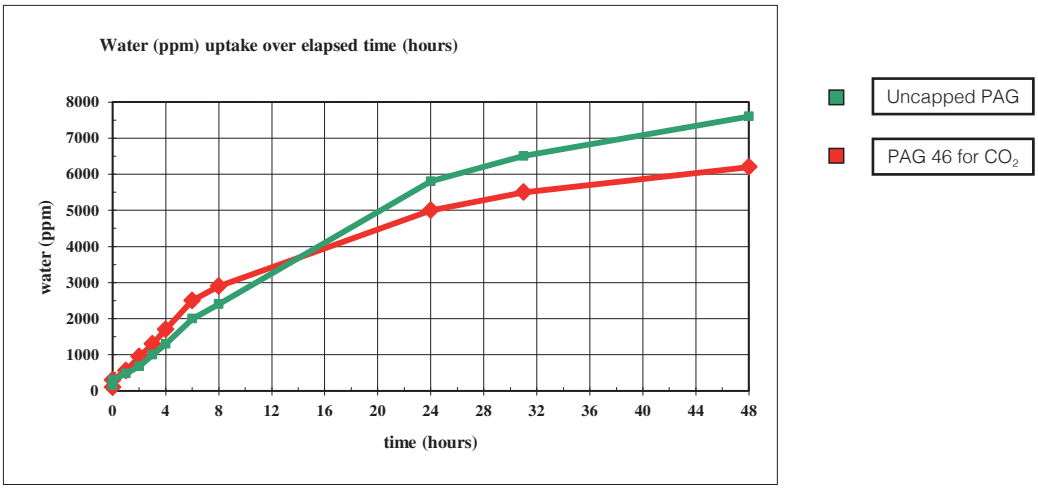
20 lbs increase:



Stability to hydrolysis

Unprotected Polyalkylenglycols Hydroxyl are very Hygroscopic and can absorb thousand ppm of water if exposed to humid conditions. Despite this PAG lubricants do not hydrolyze under normal operating conditions. Therefore problems related to water consumption in alternative synthetic lubricants (such as esters of polyols) cannot be caused - problems such as corrosion or ice formation in the expansion/capillary valve.
Due to the replacement of the hydroxyl terminal group with an alkyl species in the PAG 46 for CO_2, the hygroscopicity is lower than in a free PAG.

CO_2 PAG 46 Moisture Absorption Levels



While the water absorbed by the PAG is not free (but linked to PAG) and does not cause problems that may be associated with the free moisture, the reduced hygroscopicity exhibited by PAG 46 for CO_2 can be obtained through a careful choice of the end-capped hydroxyl. A maximum water content (0.05%) has been defined for PAG 46 for CO_2.

FOCUS ON: CO_2 PAG 68

In order to simulate as accurately as possible the CO_2 pressurized environment, Falex Block-on-Ring test was used to evaluate the effect on the PAG 68 for CO_2 properties using the following parameters:

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 6-12 rms
Blocks	Falex H-30, SAE 01 steel, Rc 27-33, 4-8 rms

Lubricant Properties

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These lubricating properties are kept under high-pressure conditions. PAG 68 for CO_2 ("capped" technology based), provides efficient lubrication for refrigeration units.

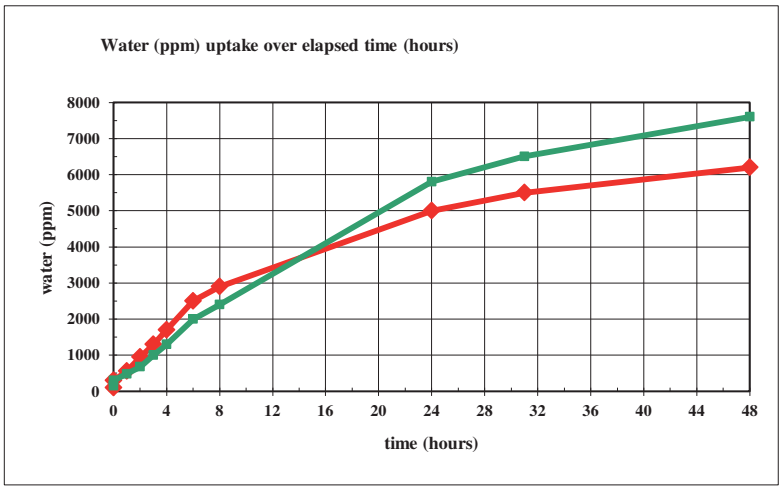
These improved lubricating properties for CO_2 systems are obtained as a result of the terminals protection technology (capped technology).

Stability to Hydrolysis

Unprotected polyalkylenglycols hydroxyl are very hygroscopic and can absorb thousand ppm of water if exposed to humid conditions. Despite this PAG lubricants do not hydrolyze under normal operating conditions. Therefore problems related to water consumption in alternative synthetic lubricants (such as esters of polyols) cannot be caused - problems such as corrosion or ice formation in the expansion/capillary valve.

Due to the replacement of the hydroxyl terminal group with an alkyl species in the PAG 68 for CO_2, the hygroscopicity is lower than in a free PAG.

CO_2 PAG 68 Moisture Absorption Levels



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CO_2 PAG Lubricants

PAG Lubricants for AC/R Systems with CO_2

ISO 46

Method and Reference Unit	VALUE	Reference Method
ISO VG	46	
Kinematic viscosity @ 40°C (cSt)	49,7	ASTM-D445
Kinematic viscosity @ 100°C (cSt)	10,7	ASTM-D445
Viscosity Index	213	ASTM-D2270
Pour point (°C)	-49	ASTM-D 97
Flash point (°C)	>200	ASTM-D 92
Density @ 15°C (g/cm³)	998	ASTM-D4052
Humidity content (ppm)	300	ASTM-E1064
Total acidity (mg KOH/g)	0,02	ASTM-D 974
Color (APHA)	20	ASTM-D1209
Capping efficiency (%)	95	IM

ISO 68

Method and Reference Unit	VALUE	Reference Method
ISO VG	68	
Kinematic viscosity @ 40°C (cSt)	70	ASTM-D445
Kinematic viscosity @ 100°C (cSt)	14	ASTM-D445
Viscosity Index	210	ASTM-D2270
Pour point (°C)	-46	ASTM-D 97
Flash point (°C)	>200	ASTM-D 92
Density @ 15°C (g/cm³)	998	ASTM-D4052
Humidity content (ppm)	300	ASTM-E1064
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Capping efficiency (%)	95	IM

Packaging References

ISO 46

Art.-Nr.	Description		
OL6036.Q.P2	250 mL (8.5 fl oz) Plastic Tank	24	2880
OL6036.M.P2	500 mL (17 fl oz) Plastic Tank	12	1080
OL6036.K.P2	1 Litre (34 fl oz) Plastic Tank	12	756
OL6036.P.P2	5 Litres (1.32 GAL) Plastic Tank	02	140

ISO 68

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OL6037.Q.P2	250 mL (8.5 fl oz) Plastic Tank	24	2880
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OL6037.P.P2	5 Litres (1.32 GAL) Plastic Tank	02	140

**80x120xH200 cm (31,50x47,25xH78,75 inch.)

AVAILABLE IN:

250 mL (8.5 fl oz) - 500 mL (17 fl oz)
1 Litre (34 fl oz) - 5 Litres (1.32 GAL)