RENISO

Refrigeration Oils 2024/2025

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MOVING YOUR WORLD

FUCHS LUBRICANTS GERMANY

We don't just develop lubricants. For highly complex challenges in a wide range of industries, we develop innovative lubricant solutions that enable the mobility of tomorrow. Our goal: to keep our customers' world in motion. Efficient, sustainable, reliable. Today and tomorrow.

What can we move for you?

FUCHS LUBRICANTS GERMANY

Facts and figures

Company: FUCHS LUBRICANTS GERMANY GmbH, a company of the FUCHS Group

Locations: Mannheim, Dohna, Kaiserslautern, Kiel and Wedel; approx. 1,400 employees

Product range: A full range of more than 3,000 products for all application areas

Certifications i. a.: ISO 9001, IATF 16949, ISO 14001, ISO 45001, ISO 50001, ISO 21469, HALAL, KOSHER (detailed certifications at www.fuchs.com/de/en)

Gate-to-Gate* CO_2-compensated

FUCHS LUBRICANTS GERMANY is a subsidiary of FUCHS SE, the world's largest independent supplier of lubricant solutions. Around 1,400 specialists at the headquarters in Mannheim and the sites in Kaiserslautern, Wedel, Kiel and Dohna work with dedication on innovative lubricant solutions that enable the mobility of tomorrow.

The high level of technical consulting expertise combined with the largest nationwide network of its own technical contacts makes FUCHS LUBRICANTS GERMANY a reliable local partner. A comprehensive product range, supplemented by digital offerings and Smart Services, as well as many years of lubricant expertise and a high level of research competence are the foundations for the innovative FUCHS lubricant solutions. They reduce wear and energy requirements, extend the running times and service life of machines, and thus keep the world moving - from industrial motors and e-cars to wind turbines and washing machines. FUCHS LUBRICANTS GERMANY is certified to a wide range of standards and, as a technology leader and development partner, places the highest demands on quality management.

Customers in all industries benefit from this quality management: automotive suppliers and OEM, mechanical engineering, metal processing, mining and exploration, aerospace, energy, construction and transport, agriculture and forestry, as well as the paper, steel, metal, cement, forging and food industries, but also qualified lubricant dealers, car dealerships and workshops.

MOVING YOUR WORLD

*Gate-to-Gate Scope includes GHG-Protocol Scope 1, 2 and selected Scope 3 emissions (water, waste, business travel, commuting)

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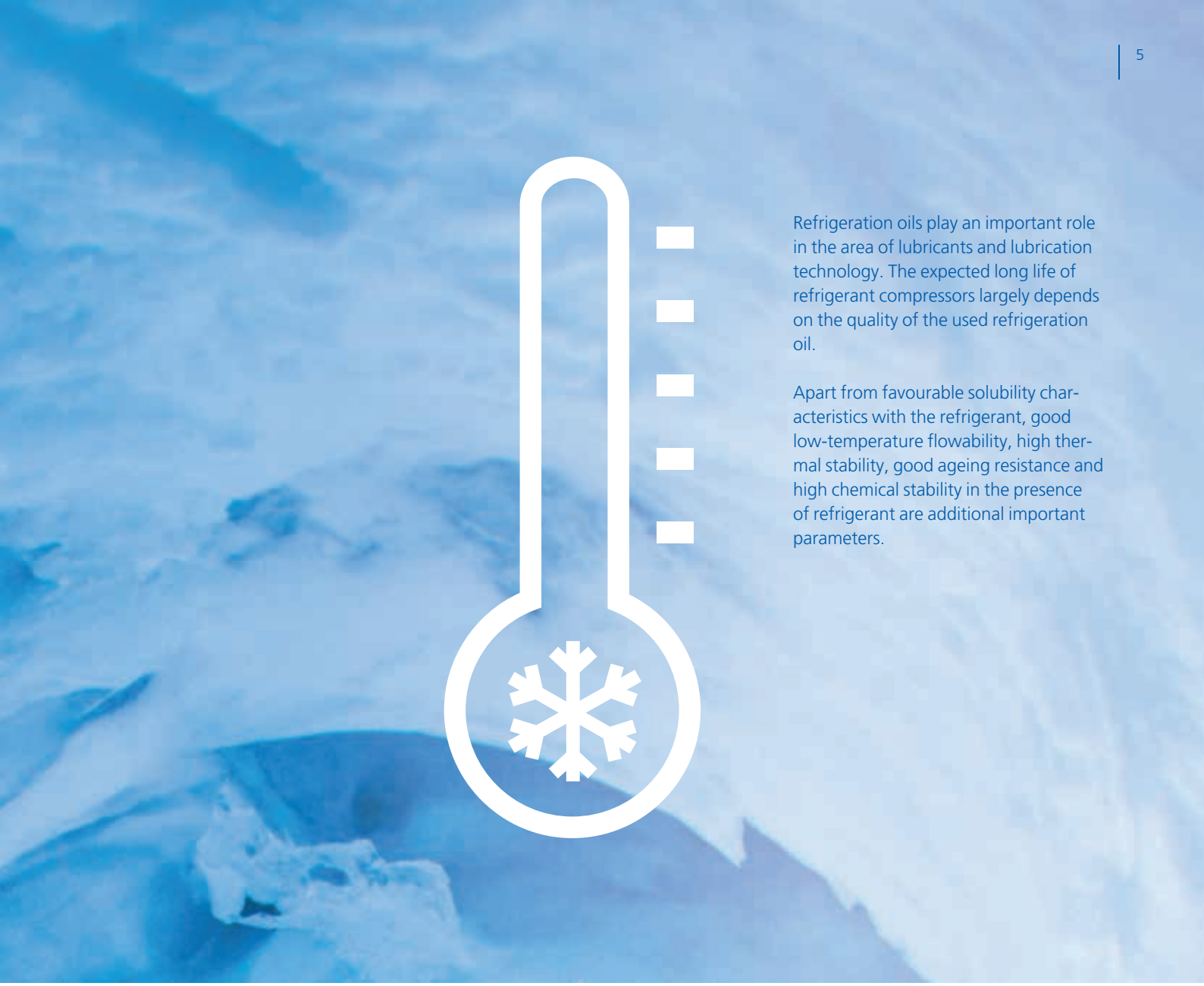


Refrigeration oils play an important role in the area of lubricants and lubrication technology. The expected long life of refrigerant compressors largely depends on the quality of the used refrigeration oil.

Apart from favourable solubility characteristics with the refrigerant, good low-temperature flowability, high thermal stability, good ageing resistance and high chemical stability in the presence of refrigerant are additional important parameters.

The development of high-performance refrigeration oils

The interaction with other substances, in particular with the used refrigerant, at fluctuating high and low temperatures creates very specific demands on the lubricant in the circuit.

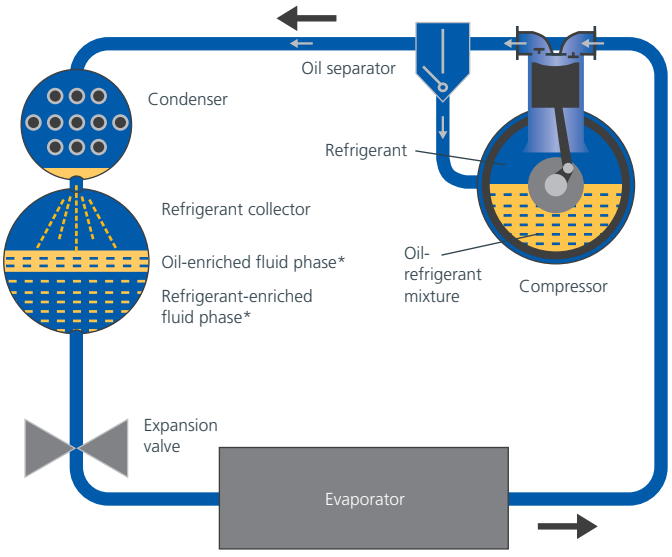
The main function of a refrigeration oil is to ensure the lubrication of all moving parts in the refrigerant compressor. Depending on the type of compressor, heat must also be dissipated and compression chambers and valves have to be sealed.

Depending on the compressor type, the efficiency of the oil separator, the design of the refrigeration system, the operating parameters, the refrigeration oil selection etc. different amounts of oil is in the refrigerant circuit. The oil content in the system usually can reach ranges from 1 to 5% and in special cases also higher values. To ensure reliable oil circulation and to ensure that the oil returns from the "cold" part of the circuit, refrigeration oils with good miscibility in the corresponding refrigerant are used.

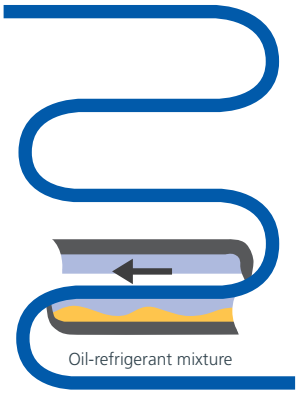
Particularly during start-up periods oil enrichment due to pronounced oil foaming as a result of dissolved refrigerant can occur. When the refrigerant evaporates the oil cools down. If the flowability of the remaining oil is not sufficient (due to high viscosity and/or poor refrigerant miscibility), reliable return to the compressor is not possible.

The compressor, on the other hand, requires a certain viscosity of the oil-refrigerant mixture. The optimum operating viscosity of the lubricant – subject to the influence of the refrigerant (pressure- and temperature-related dissolution of refrigerant) – thus represents a compromise between minimum viscosity required for reliable compressor lubrication and the necessary low-temperature flowing properties needed to ensure sufficient oil circulation in the circuit.

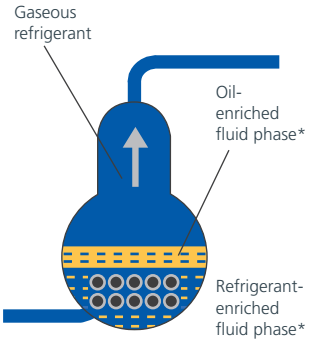
Scheme of refrigeration circuit



System 1: Dry evaporation



System 2: Flooded evaporator



*In the area of the miscibility gap: When the density of the refrigerant-enriched phase is greater than the density of the oil-enriched phase.

Research and Development – under the sign of climate protection

Our research and development department deals with comprehensive researches on refrigeration oils with all relevant refrigerants.

In general sustainable refrigerants are becoming more and more important. Low GWP refrigerants (GWP = Global Warming Potential = contribution of a refrigerant to the global warming) like e.g. carbon dioxide, R744 (GWP=1) and propane, R290 (GWP=3), but also synthetic fluorinated alternatives like R1234yf and R1234ze(E) (both GWP<1) are already increasing in their use. In contrast, the use of common refrigerants like R404A (GWP=3940) will decrease rapidly.

At FUCHS comprehensive stability tests are performed with the Sealed Tube apparatus in special laboratory equipment. Miscibility and solubility tests of refrigeration oils with several refrigerants are performed in refrigerant atmosphere. The very latest laboratory technology together with specially-constructed test rigs allow wear protection trials to be performed on refrigeration oil and refrigerant mixtures. Long-term trials of hermetically-sealed compressors in gas circuits can also be performed on FUCHS test rigs. The thermal and chemical stability of refrigerant-oil mixtures can be evaluated in special high-pressure autoclaves. These FUCHS in-house laboratory test rigs guarantee exceptional expertise: Specific customer set ups can be examined and suitable lubricants can be selected and improved continously.

Due to the new challenges also for refrigeration oils which are coming up with the European F-gases regulation (EU no. 517/2014) a reliable and innovative manufacturer of lubricants like FUCHS becomes a more and more important partner in refrigeration technology.

Product portfolio:

- Mineral oil-based refrigeration oils
- Synthetic refrigeration oils based on alkyl benzenes
- Synthetic refrigeration oils based on polyalphaolefines
- Synthetic refrigeration oils based on polyol esters
- Synthetic refrigeration oils based on polyalkylene glycols
- Synthetic refrigeration oils for CO_2 applications
- Synthetic refrigeration oils for NH_3 applications
- Synthetic refrigeration oils for hydrocarbon refrigerants
- Synthetic refrigeration oils for HFO refrigerants

4 good reasons for using RENISO refrigeration oils

Performance comparison RENISO TRITON SEZ 80 versus standard polyol ester (POE) refrigeration oils.

1 **High thermo-chemical stability**
e.g. in Sealed Glass Tube Test (ASHRAE 97-2007)

Standard POE refrigeration oils

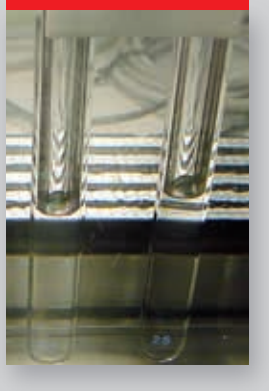
High stability

RENISO TRITON SEZ 80

2 **Very good miscibility**
with HFC/FC: e.g. in miscibility evaluation (DIN 51514)

Standard POE refrigeration oils

Good miscibility



RENISO TRITON SEZ 80

3 **Low varnish / low sludge formation**
e.g. in FUCHS In-house test (evaluation of oil sludge in beaker with bearing roller after 168h/135 °C)

Standard POE refrigeration oils

No sludge

RENISO TRITON SEZ 80

4 **Reliable wear protection**
e.g. in bearing wear testing (DIN 51819-3)

Standard POE refrigeration oils

No wear

RENISO TRITON SEZ 80


FUCHS
RENISO
TRITON SE/SEZ
Synthetisches Kältemaschinenöl
Synthetic Refrigeration Oil
Polyolester (POE) Schmierstoff für den Einsatz mit HFKW-, FKW- und HFO-Kältemitteln
Polyol ester (POE) lubricant suitable for the use with HFC, FC and HFO refrigerants
10l e
Made in EU
5l e
Made in EU
FUCHS LUBRICANTS GERMANY GmbH
Friesenheimer Str. 19 • 68169 Mannheim/Germany
Phone +49 621 3701-0 • www.fuchs.com/de/en
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RENISO
PAG 1234

REQUIREMENTS AND CLASSIFICATION OF REFRIGERATION OILS

DIN 51503 describes the minimum requirements refrigeration oils have to fulfil. This standard applies to oils which are used to lubricate and cool refrigerant compressors while under the influence of the refrigerant.

For hydrocarbon refrigerants also so called gas compressor oils can be applied, e.g. RENOLIN LPG 185 in combination with propane or propene. It has to be considered that these lubricants are not dried during production and therefore may have to undergo a drying procedure prior to be filled in refrigerant equipment.

The classification of refrigeration oils according to DIN 51503, part 1 (December 2021) is in line with the refrigerant used in the refrigeration system

KAA – for ammonia (R717)
Refrigeration oils not miscible with ammonia – mineral oils and/or synthetic oils – based on polyalphaolefin (PAO) or alkyl benzene (AB) or hydrogenated mineral oils.
In most cases, highly-refined, naphthenic refrigeration oils are used as KAA products. Hydrogenated mineral oils and PAO get more and more important.

KAB – for ammonia (R717)
Refrigeration oils miscible with ammonia – generally polyalkylene glycol (PAG). The water content of fresh PAG lubricants used in ammonia applications should not exceed 350 ppm.

KB – for carbon dioxide (R744)
Refrigeration oils for carbon dioxide (CO_2) – synthetic polyol esters (POE), polyalkylene glycols (PAG) or polyalphaolefins (PAO). POE oils generally offer good CO_2 miscibility. PAG oils and CO_2 only allow limited miscibility (larger miscibility gap with CO_2). Synthetic, polyalphaolefin-based refrigeration oils are not miscible with CO_2. Maximum water content (fresh oil): 50ppm to PAO, 100ppm for POE and 350ppm for PAG.

KC – for halogenated refrigerants
Refrigeration oils for partly and fully halogenated fluorinated and chlorinated hydrocarbons (CFC, HCFC) – as a rule, mineral oils and alkyl benzenes (in some cases ester oils also possible). Mostly highly-refined, naphthenic mineral oils and specially treated alkyl benzenes (alkylates) are used. The water content of fresh KC oils should be < 30 ppm. If the water content is higher, there is a danger of undesirable reactions with the refrigerant which can lead to the decomposition of the oil-refrigerant mixture.

KD – for fluorinated refrigerants
Refrigeration oils for partly and fully fluorinated hydrocarbons (HFC, FC) – as a rule, polyol esters (POE) or polyalkylene glycols (PAG). The refrigeration oils described in group KD are polar products with pronounced hygroscopic characteristics. For fresh polyol esters (POE) the water content should not exceed 100 ppm. Polyalkylene glycols (PAG) are often used in a/c systems. Their maximum fresh-oil water content should not exceed 350 ppm.

KE – for hydrocarbon refrigerants
Refrigeration oils for hydrocarbons (e.g. propane, isobutane) – mineral oils or synthetic oils based on alkyl benzene, PAO, POE or PAG. According to the oil group, the maximum permissible fresh oil water content should not exceed 30 ppm for mineral oils and alkyl benzene, 50 ppm for PAO, 100 ppm for POE and 350 ppm for PAG.

Abbreviations of the refrigerants

HC	Hydrocarbons	(e.g. R600a, R290)
PFC	Fluorocarbons	(e.g. R14, R116)
HFC	Hydrofluorocarbons	(e.g. R134a, R404A, R407A/C/F, R410A, R507A)
HFO	Hydrofluorolefines	(e.g. R1234yf, R1234ze(E))
HCFC	Hydrochlorofluorocarbons	(e.g. R22, R124)
HCFO	Hydrochlorofluorolefin	(e.g. R1233zd(E), R1224yd(Z))

PHYSICAL AND CHEMICAL DATA OF REFRIGERATION OILS

Additional information on the characteristics of refrigeration oils is included in the appendix to DIN 51503, part 1 (2021). Important parameters such as the flocculation point with corresponding refrigerants, copper corrosion, electrical conductivity in correlation with water content, Falex lubricity test or the modified Almen-Wieland test under refrigerant atmosphere are included. The appendix also names the corresponding pVT diagrams (Daniel Plots) of the oil-refrigerant combinations.

The water contents given in DIN 51503, part 1 (2021), are the maximum permissible values of the fresh oils. Refrigeration oils should be delivered in gas-tight metal packages which allow no moisture to ingress even after longer periods of storage. When handling refrigeration oils care should be taken that the containers are always resealed and that opened containers should be used up as soon as possible or alternatively stored with filled-in inert gas atmosphere.

Typical data to characterize a refrigeration oil

Colour number according to DIN ISO 2049:
The colour number is product specific and can vary between crystal-clear (colour number 0) and dark brown (colour number 5).

Density according to DIN 51757 (ASTM 4052):
Density refers to the mass of a fluid in relation to its volume. In general to characterize a refrigeration oil the density at 15 °C is reported. The density of a refrigeration oil is largely dependent on the temperature of the fluid because the volume increases with higher temperature. Density correspondingly falls at higher temperatures.

Acid number according to DIN ISO 6618 (formerly neutralization number according to DIN 51558):
The acid number serves to determine the amount of acidic components in a lubricant. Acids can corrode materials which come into contact with refrigeration oils. High levels of acids which can be created by oxidation, hydrolysis or ageing are therefore undesirable. The acid number is shown in mg KOH/g. A comparison with fresh oil values is essential when evaluating a used refrigeration oil. The acid numbers of refrigeration oils are very low compared to other lubricants. They are in the range of < 0.1 mg KOH/g.
The acid number is identical with the so called total acid number (TAN) acc. to ASTM D974.

Water content according to DIN 51777:
Determining water content according to Karl Fischer, (formerly DIN 51777, Part 1 – direct method, Part 2 – indirect method). Water content according to Karl Fischer shown as mg/kg (=ppm: parts per million) is determined by titration. The quantity of dissolved water in refrigeration oils can only be determined with this method. It is recommended to apply the indirect method acc. DIN 51777 because it is suitable for both, refrigeration oil without additives as well as refrigeration oil with additives. Undissolved water (free water) can also be determined using the Water-Xylol method (DIN ISO 3733). The content of water in refrigeration oils is very low compared to other lubricants. Refrigeration oils are normally used "ultra-dried".

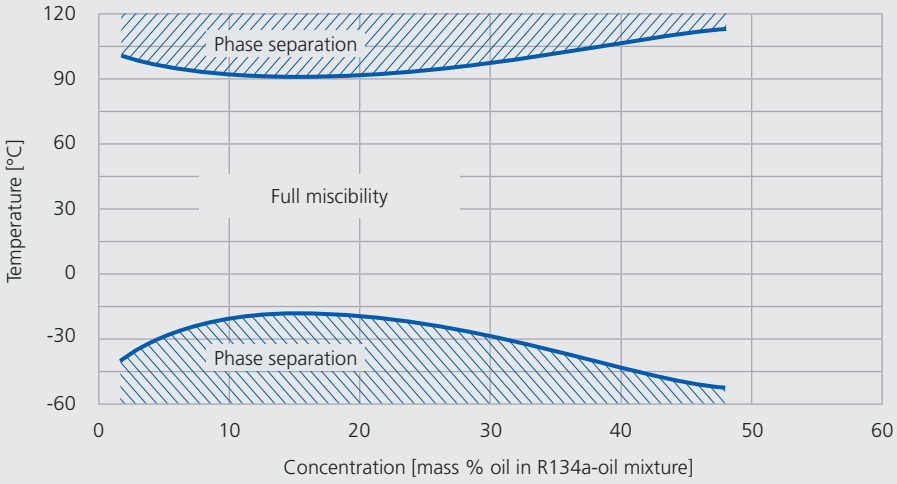
Pourpoint according to DIN ISO 3016:
The pourpoint shows the lowest temperature at which an oil still flows when it is cooled down under defined conditions. According to DIN ISO 3016 the sample is cooled down and its flowing behaviour is tested in 3K steps. The pourpoint and threshold viscosity define the lowest temperature at which a pure refrigeration oil can be used. However, the pourpoint and flowing characteristics of refrigeration oils are significantly affected by the proportion of dissolved refrigerant. Dissolved refrigerant significantly reduces the pourpoint, i.e. a refrigeration oil can be used at far lower evaporation temperatures (exception: flooded ammonia evaporation systems) than the pourpoint of the pure oil would suggest. The amount of refrigerant dissolved in refrigeration oil is given by pressure-viscosity-temperature charts (pVT diagrams) of oil-refrigerant mixtures, also known as Daniel Plots.

Flashpoint according to DIN ISO 2592:
The flashpoint of a refrigeration oil provides information on the base oil or base oil-mixtures used. The flashpoint can also be used to provide indirect information about the vapour-pressure behaviour of refrigeration oils. The lowest temperature at which a naked flame ignites the vapour above the surface of the fluid is called the flashpoint.

Typical data to characterize a refrigeration oil

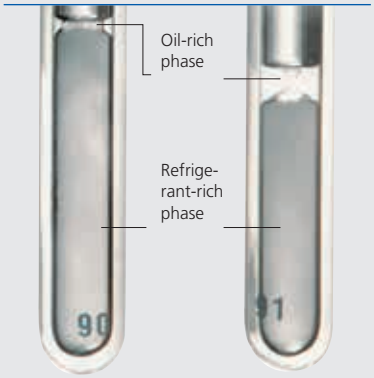
Miscibility gap diagram

Miscibility behaviour of FUCHS RENISO TRITON SEZ 32 with R134a



Phase separation

Oil-rich and refrigerant-rich phase (in glass tubes in FUCHS R&D)



Refrigerant miscibility according to DIN 51514:
The miscibility behaviour of the refrigeration oil with various refrigerants is shown in miscibility gap diagrams.

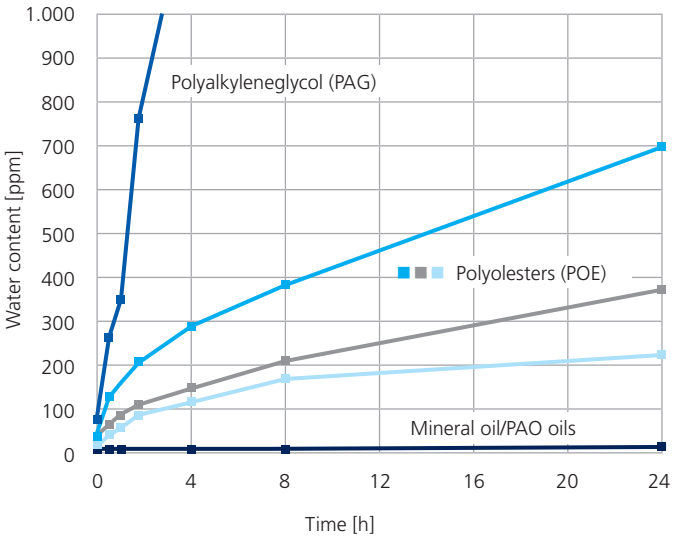
This behaviour is determined in pressure resistant glass tubes or in autoclaves. Different concentrations of oil-refrigerant mixtures are tested (mostly 3-5 mass % oil amount). The oil-refrigerant mixture is homogenized and cooled (respectively heated) in a defined way (in 3K steps). If the oil and refrigerant separate into two fluid phases (the phase separation is characterized by turbidity or emulsion formation in the initially clear fluid), this is the miscibility gap or the point of threshold solubility. These points from different concentrations form a phase diagram, more commonly known as the miscibility gap diagram.

The refrigerant miscibility of the lubricating oil in the cooling circuit is of vital importance to oil transportation and to the overall efficiency of the refrigeration system as a whole. Phase separations can lead to operating malfunctions especially in heat exchangers, evaporators and in collectors. Insufficient oil return not only affects the function of control valves but can also lead to inadequate lubrication and compressor breakdowns.

Refrigerant compatibility according to ASHRAE 97-2007:
The compatibility of the refrigerant with the refrigeration oil is of fundamental importance. In the Sealed Tube Test acc. to ASHRAE 97-2007: "Method to test the chemical and thermal stability of materials for use within refrigerant systems" a test tube or autoclave is filled with a defined quantity of oil and fluid refrigerant and a catalyst (pieces of iron, copper, aluminium). The test is performed at 175 °C for 14 days. At the end of the test the oil is evaluated for changes, its acid number is tested and the surface of the metal pieces is examined for changes and corrosion.

Chemical stability:
The chemical stability of a refrigeration oil depends on a number of important factors including an extremely low water content in the system. Refrigeration oils with high water contents must be replaced. The diagram on page 13 shows the moisture absorption (hygroscopicity) of refrigeration oils. Different refrigeration oils have been stored in open containers at 20 °C and 60 % relative humidity and the increase in moisture in the refrigeration oils has been recorded: Non-polar lubricants such as mineral oil and polyalphaolefin which normally have water contents of less than 30 ppm do not show a significant increase of water content.

Water absorption (hygroscopicity) of refrigeration oils



Water content of refrigeration oils

		Time [h]			
		0	4	24	72
PAG ISO VG 46	Water content [ppm]	70	1,350	5,100	7,000
POE ISO VG 32		30	280	700	1.350
POE ISO VG 80		30	150	370	600
POE ISO VG 170		15	130	230	350
Mineral oil/ PAO ISO VG 68		10	15	20	20

Test conditions

20°C ambient temperature
60% relative humidity
Oil is stored in open can

Polyolesters (POE), which are described as polar, hygroscopic lubricants, display a continously rising water content. An increase to over 200 ppm water in the POE oil cannot be tolerated. The diagram also shows the increase in water content in relation to the viscosity. Low viscous ester oils absorb moisture more rapidly than high viscous ester oils. PAG refrigeration oils, which are mostly used in a/c systems with R134a and R1234yf, are even more hygroscopic. PAG lubricants absorb large quantities of moisture in relatively short time and thus rapidly exceed permissible thresholds of about 800 ppm water in used oils.

Thermal stability:

The exposure of lubricating oils to high temperatures over longer periods of time can lead to the formation of decomposition products which can cause serious problems. Ageing stability is an important lubricant selection criterion. Decomposition processes are generally complex chemical reactions which are catalyzed by metals such as copper, iron or aluminium. Also water in the system can lead to the formation of decomposition products.

Experience shows that an increase in temperature of 10K doubles the speed of ageing. Some refrigerants, especially HCFC, react chemically with water when subject to high temperatures and this can also reduce oil stability.

A well-known indicator of oil ageing is an increase of the acid number (formerly neutralization number) and copper plating. Copper plating means that copper (e.g. from the tubing) is chemically dissolved in the oil and then deposited elsewhere, usually on mechanically-stressed metal surfaces such as pistons, valves, etc. This can cause problems to machine parts with only small tolerances. Copper plating occurs when the oil acidifies. This process is accelerated by moisture in the system and with advanced oil ageing.

Testing the ammonia-stability of refrigeration oils according to DIN 51538:

An ammonia-saturated stream of air is passed through the refrigeration oil to be tested. This test lasts for 168 hours at 120 °C in the presence of a steel catalyst. The base number (in mg KOH/g) of the aged oil is used as a criteria to evaluate the stability of the refrigeration oil when in contact with ammonia and oxygen in the air (deviation from fresh oil value, measured acc. to ISO 3771).

Typical data to characterize a refrigeration oil

Kinematic viscosity according to DIN EN ISO 3104:
Viscosity (the "thickness of the oilfilm") is the most important characteristic describing the load-bearing capacity of an oil. Refrigeration oils along with other industrial lubricants, are classified according to their kinematic viscosity into ISO viscosity classes. The reference temperature is 40 °C and the official unit of kinematic viscosity is m^2/s but in the lubrication world, the units mm^2/s or cSt are more common. DIN 51519 defines 18 different viscosity classes from 2 to 1000 mm^2/s at 40 °C for fluid industrial oils. Every viscosity class is described by the medium viscosity at 40 °C and the permissible deviation of +/- 10 % of this value.

Dynamic & kinematic viscosity:

The arithmetical correlation between dynamic and kinematic viscosity is described by the following equation:

$\nu = \eta / \rho$

ν = kinematic viscosity
η = dynamic viscosity
ρ = fluid density

The viscosity of an oil decreases with rising temperature. The Viscosity Index (VI) describes this temperature dependence and is calculated according to DIN ISO 2909 from the kinematic viscosity at 40 °C and 100 °C. A suitably high lubricant viscosity is necessary to form a load-bearing lubricating film in the bearings, cylinders etc. of the compressor. However in the refrigerant circuit itself the oil should have the lowest possible viscosity to secure reliable oil transport. Refrigeration oils of various viscosities are used depending on the type of compressor and the application. The viscosity to be applied is normally specified by the compressor manufacturer.

This information is often not enough to evaluate the suitability of a refrigeration oil for a particular application. Additional, interesting information is provided by the corresponding pressure-viscosity-temperature charts (pVT charts, Daniel Plots) which are product and refrigerant specific. These diagrams show how much of a particular refrigerant dissolves in the oil under certain pressure and temperature conditions and how the kinematic viscosity of the refrigeration oil changes as a result. These figures form the basis for evaluating the compressor lubrication under operation conditions. pVT diagrams are specific for refrigeration oil/refrigerant systems.

In the past, refrigeration systems were operated with chlorinated CFC/HCFC refrigerants. The chlorine compounds in these products acted as anti wear (AW) additives. This additional protection is no longer available from chlorine-free refrigerants. Today's refrigerants thus need corresponding good lubricity.

To achieve reliable protection against wear the use of high-performance additives (so called AW- (Anti Wear) and/or EP- (Extreme Pressure) additives) in combination with selected suitable base fluids is essential.

Mixture viscosity and vapour pressure; Daniel Plot; pVT diagram
The influence of the refrigerant dissolved in the oil on viscosity is illustrated by pVT diagrams, otherwise known as Daniel Plots. In these, saturation vapour pressure and mixture viscosity at defined concentrations are shown against temperature. The lower diagram (see page 15) shows, for example, the amount of refrigerant dissolved in the oil at a certain temperature and the corresponding system pressure.

Example: Point A: 60 °C, 6 bar –> 90 % oil / 10 % refrigerant.

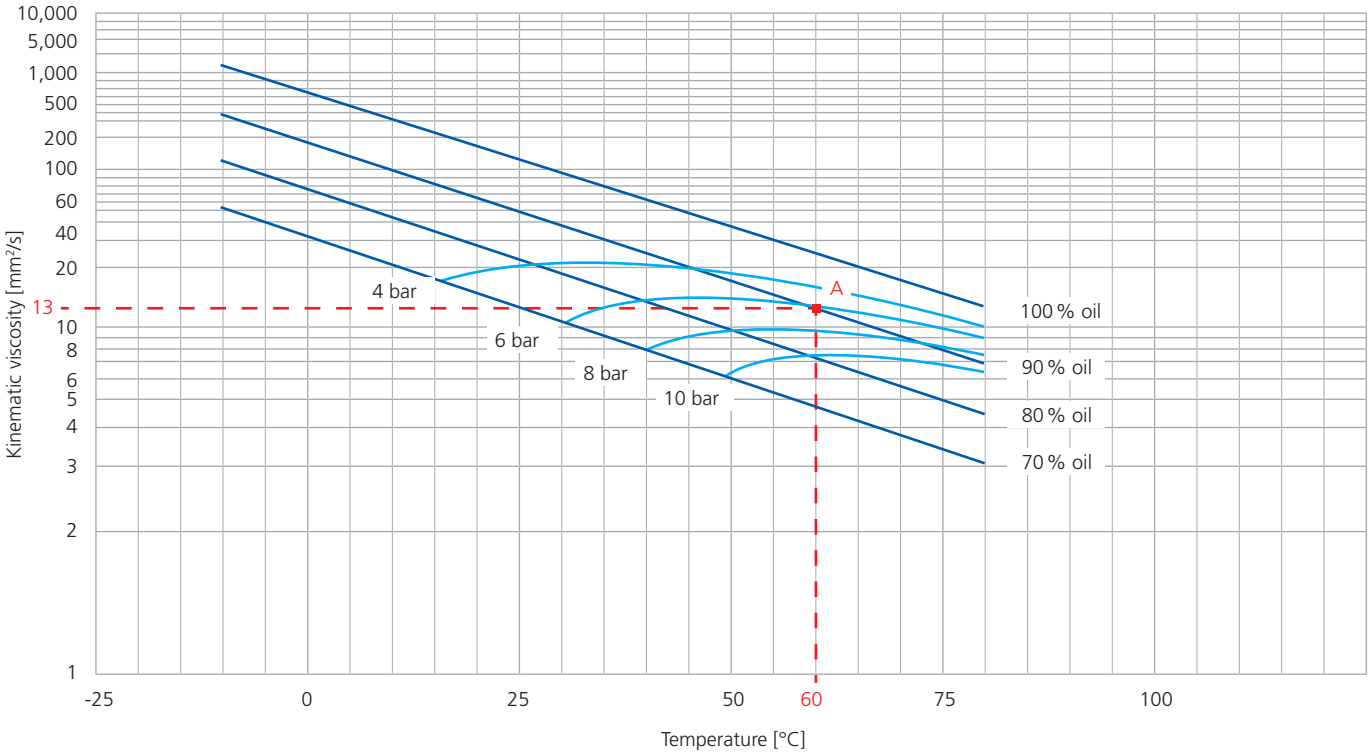
The resulting mixture viscosity can be taken from the upper diagram (see also next page) where the lines for the given temperature and for the corresponding percentage of oil dissolved in the refrigerant cross.

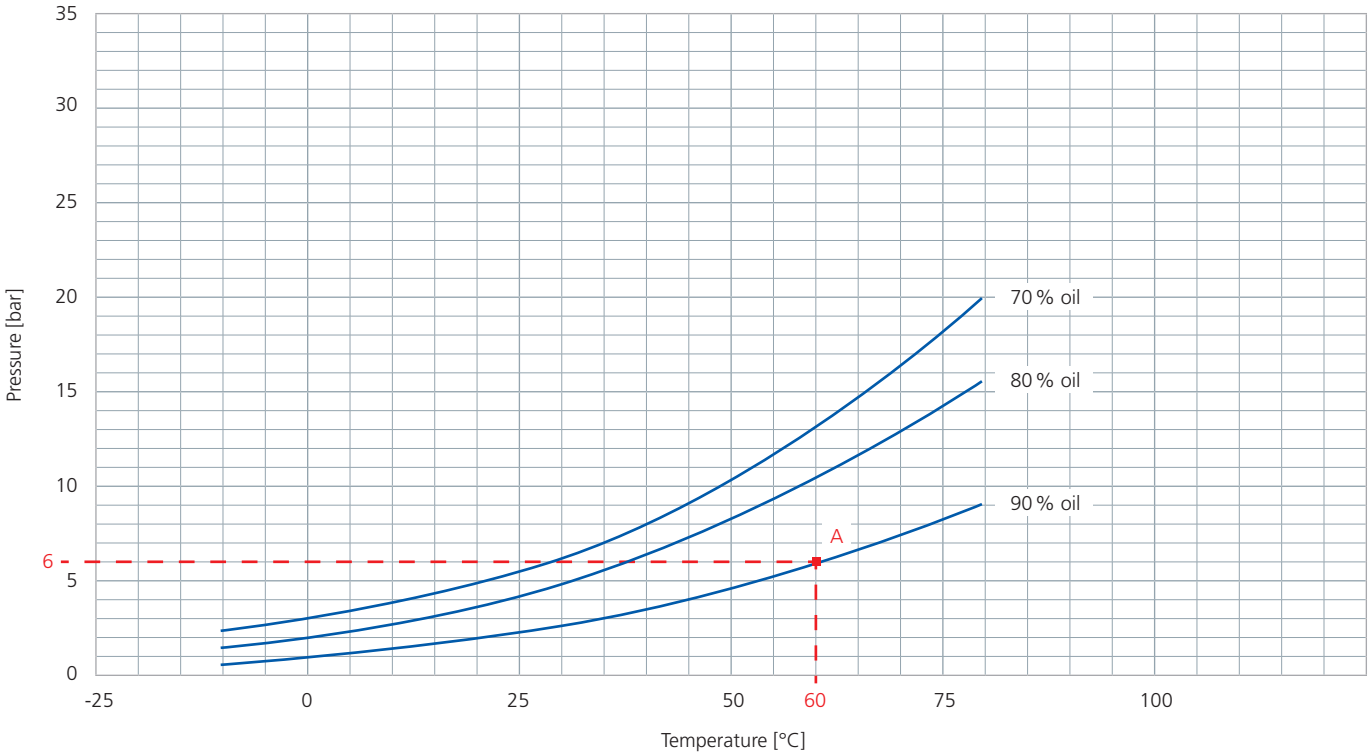
Example: Point A: 60 °C, 90 % –> 13 mm^2/s.

The resulting mixture viscosity at various pressures and temperatures shows the influence of refrigerant dissolved in the oil. This influence of refrigerant on oil viscosity is based on the suction pressure in the case of piston compressors and the outlet pressure (pressure in the oil separator) in the case of screw compressors.

Refrigeration Oils for applications using fluorinated refrigerants (e.g. R134a): RENISO TRITON SE / SEZ based on polyol esters (POE)

Example: Kinematic viscosity and vapour pressure (Daniel Plot) RENISO TRITON SE 55 - R134a - mixture





All % figures represent mass of oil in the refrigerant.

REFRIGERATION OIL PRODUCT GROUPS

Mineral oil based refrigeration oils

Miscibility gap diagram – Isobutane/R600a

Example: Miscibility of RENISO WF 5 A with R600a

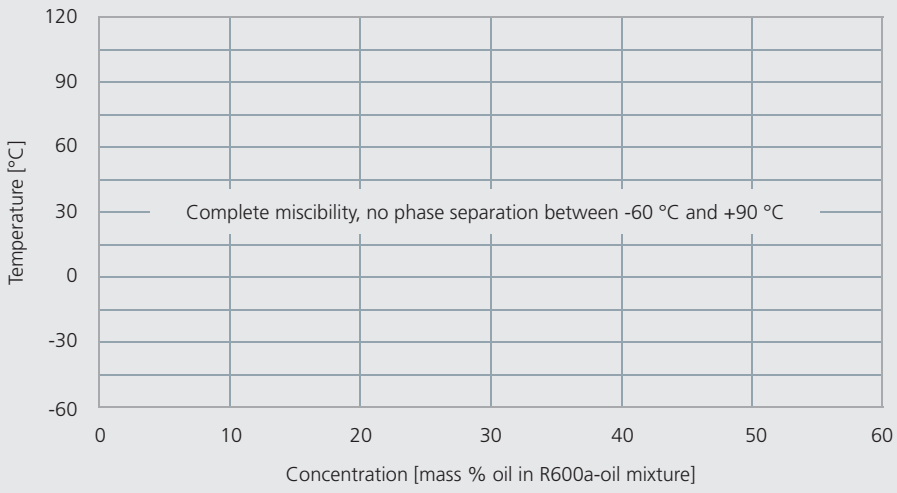


Photo: Nidec

RENISO K series
Highly refined, naphthenic mineral oils, free of additives. The RENISO K series can be used in NH_3 systems as well as for HCFC applications (e.g. for R22). As a result of their good ageing stability in the presence of ammonia and their worldwide availability, these oils play an important role in conventional NH_3 refrigeration systems.

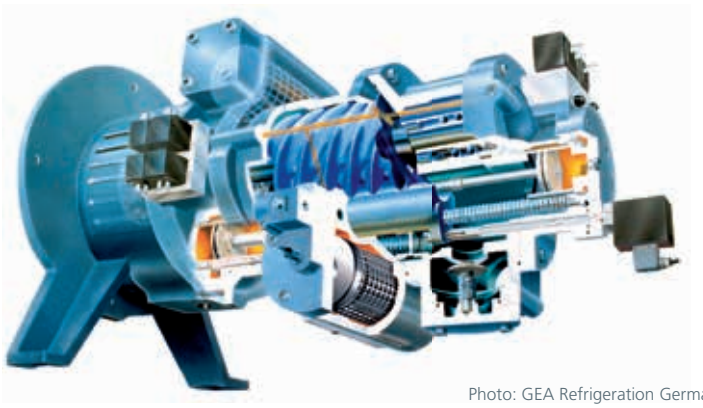


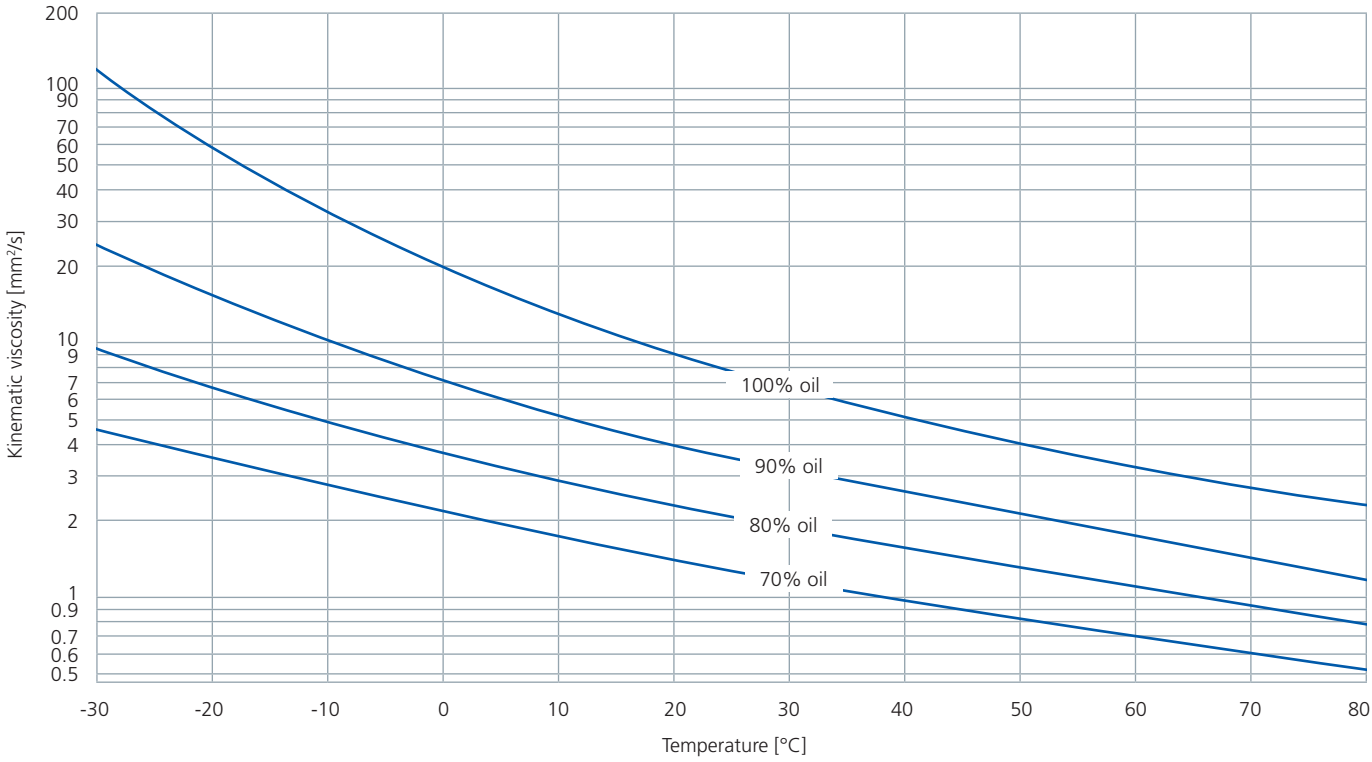
Photo: GEA Refrigeration Germany

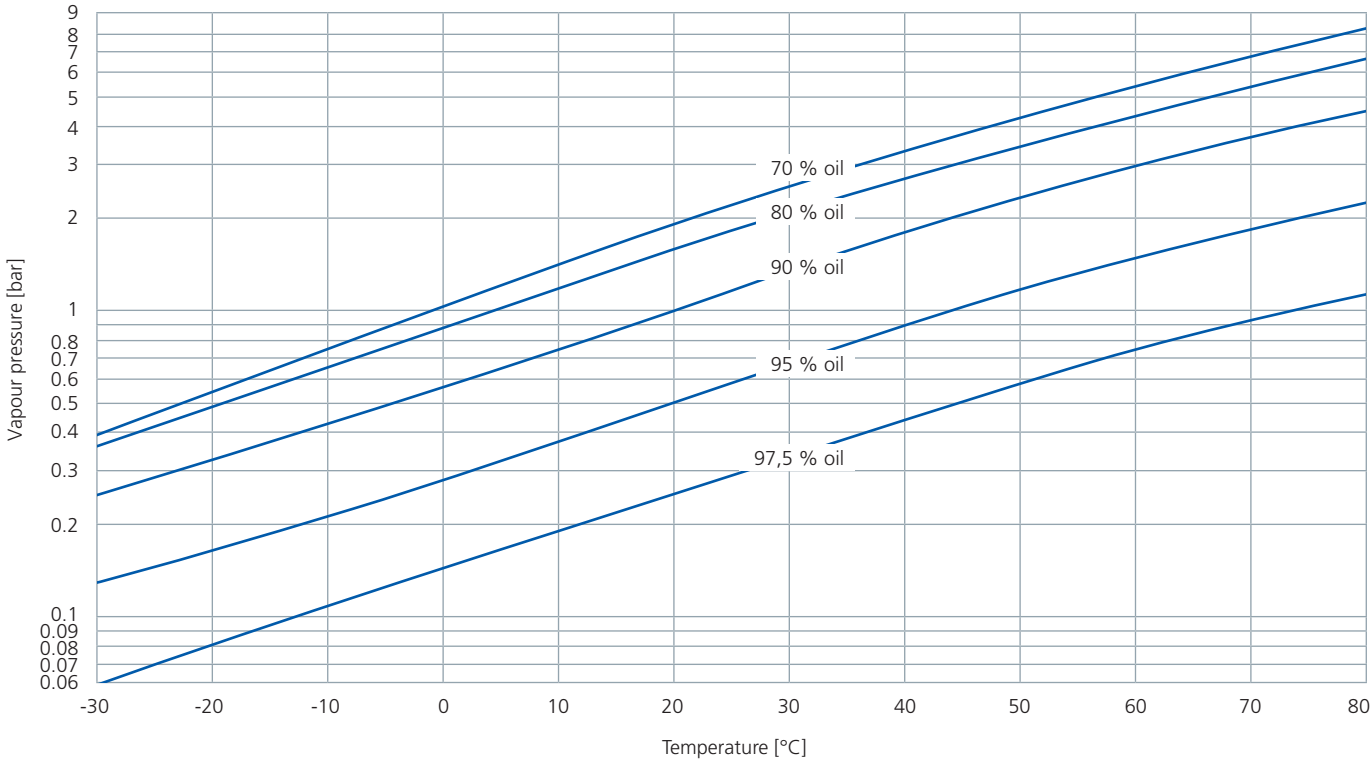
RENISO WF series
Selected, highly refined cuts with special anti-wear additives. The RENISO WF series – in the viscosity grades ISO VG 2 - 15 are perfect for the lubrication of hermetically sealed refrigerator compressors which use isobutane (R600a) as refrigerant. Diagrams of RENISO WF 5 A with isobutane (R600a) (see page 17).

The use of low viscous RENISO WF refrigeration oils in modern compressors can achieve significant improvements in energy efficiency.

Refrigeration oils for Isobutane (R600a) applications:
RENISO WF based on mineral oil

Example: Kinematic viscosity and vapour pressure (Daniel Plot): RENISO WF 5 A - R600a - mixture





All % figures represent mass of oil in the refrigerant.

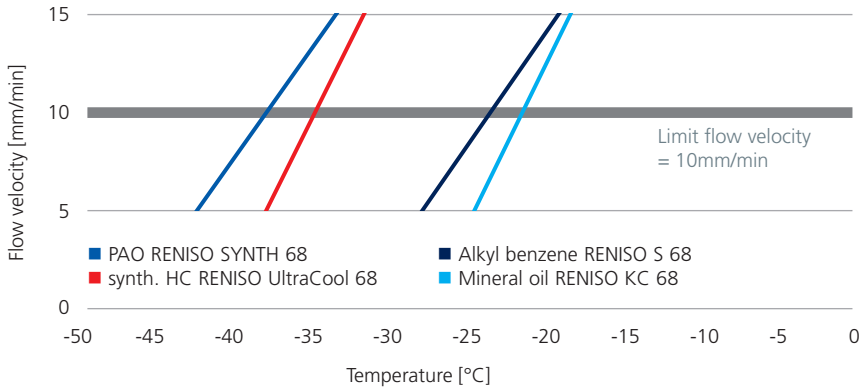
Synthetic refrigeration oils

Photos: Bock

NH_3 refrigeration oils

Determination of the flowability of refrigeration oils for NH_3 applications: U-Tube-Test (DIN 51568)

RENISO UltraCool 68 & RENISO SYNTH 68
significantly better low temperature flowability than mineral oils and alkyl benzenes
→ preferable for low evaporating temperatures



Alkyl benzenes (AB)

RENISO S / SP series

Chemical and thermal highly stable alkyl benzenes (AB-alkylate). A special refining treatment during the production process further improves the low temperature properties as well as the chemical and thermal stability of these oils. These products display outstanding additive solubility. Because of their favourable miscibility with HCFCs even at low temperature RENISO S/SP series products are recommended for R22 and its mixtures.

The RENISO SP grades containing AW additives are not suitable for NH_3 systems. The RENISO S series does not contain AW additives and is recommended for NH_3 applications.

Polyalphaolefins (PAO) / synthetic hydrocarbons

RENISO SYNTH 68

Thermally stable polyalphaolefins (PAO) with excellent cold flowing properties for NH_3 systems with highly stressed compressors and low evaporation temperatures. Due to its outstanding cold flow properties RENISO SYNTH 68 is also recommended for the use in plate evaporators with narrow tubing diameters – especially for low temperatures (t_0 <-50 °C), as shown in the above diagram.
RENISO SYNTH 68 can also be used as refrigeration oil for R723 (dimethyl ether-ammonia-mixture) and for CO_2 applications (not miscible with CO_2). Due to its beneficial solubility behaviour (low dilution) and its extraordinary viscosity-temperature-behaviour (high VI) RENISO SYNTH 68 is also very suitable for the use with hydrocarbons like propane (R290) or propylene (R1270).

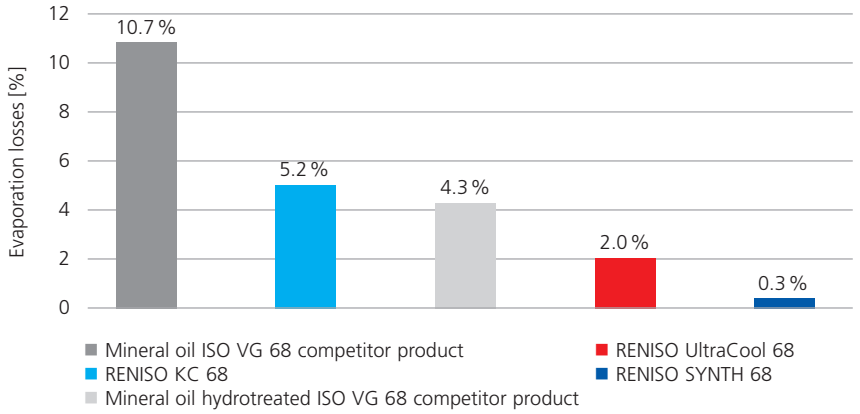
RENISO UltraCool 68 and RENISO UltraCool 100

RENISO UltraCool refrigeration oils are used for ammonia refrigeration plants with deep evaporation temperatures down to < -45 °C. Due to their thermal stability RENISO UltraCool oils avoid the formation of oil deposits and sludge in the compressor. According to this, maintenance costs of the refrigeration plant (filter replacement, inspection work etc.) can be considerably reduced. RENISO UltraCool oils show outstanding low evaporation rates (see diagram page 19) which are significantly lower than with conventional or hydrotreated mineral oils. In practice this means that there is less oil loss in the compressor (lower oil carry-over) which ends up in lower oil top-up volumes. This is also an important point with regard to cost savings in the refrigeration plant. RENISO UltraCool refrigeration oils combine the very good cold flow and high temperature properties of synthetic hydrocarbons with good elastomer properties (good compatibility with CR sealants) as they are only known from mineral oil products.

NH_3 refrigeration oils

Evaporation losses of refrigeration oils for NH_3 acc. ASTM D972 :
150° / 22h / air flow rate 2l/min

RENISO UltraCool 68 & RENISO SYNTH 68
significant lower evaporation loss in comparison to mineral oils and hydrotreated oils → less oil losses / less oil consumption



Photos: Bitzer

Polyolesters (POE)

RENISO TRITON SE / SEZ series

Synthetic refrigeration oils based on thermal and chemical highly stable polyolesters (POE), special mono- and/or dipentaerythritol esters.
Due to their good miscibility these polyolester oils are perfectly suited for applications with HFC/FC refrigerants such as R134a, R404A, R407C etc.. Comprehensive tests have been performed on the use of these products with R22 drop-in refrigerants such as R422A/D and R417A. Similarly RENISO TRITON SE/SEZ products are also recommended for use with partially-fluorinated propane and butane derivate (e.g. R245fa, R236fa, R227ea) in heat pumps and expanders (ORC systems, waste heat recovery).

RENISO TRITON SE/SEZ oils are already successfully introduced in applications with use for low GWP refrigerants of the HFO family (**H**ydrogenated **F**luorinated **O**lefins). Comprehensive laboratory tests as well as practical experiences with R1234yf, R1234ze(E) and numerous HFO/HFC mixtures already exist. FUCHS is a very dedicated lubrication partner in many projects with these new HFO and HFO/HFC refrigerants and will continuously develop its range of lubricants in this field.

RENISO TRITON SE/SEZ lubricants can also be used in cooling / refrigeration applications with hydrocarbon refrigerants like propane (R290) or propylene (R1270). Due to their high viscosity indices RENISO TRITON SE/SEZ products prove to have excellent cold flow properties and a highly stable lubricating film under high temperature conditions in hydrocarbon applications. All RENISO TRITON SE/SEZ products are characterized by excellent stability and outstanding lubricity.

All ester oils tend to absorb water. In extreme cases, hydrolytic decomposition reactions can occur if excessive water content in the oil and extreme stress combine. It is therefore necessary to ensure that these products do not come into contact with water or moisture during storage, handling or operation. All RENISO TRITON SE/SEZ products are ultra-dried and filled into gas-tight metal cans and drums in nitrogen atmosphere.

Synthetic refrigeration oils

Polyalkylene glycols (PAG)

RENISO PG 68
Synthetic, NH_3-miscible refrigeration oil based on special polyalkylene glycols (PAG) with an additive system designed to provide enhanced ageing stability.

The selected synthetic components display excellent viscosity-temperature behaviour and good thermal stability. RENISO PG 68 is specially developed for NH_3 systems which use the direct evaporation principle.

High water content in the ammonia refrigeration plant can lead to chemical reactions between PAG refrigeration oils and aluminium compressor parts. This PAG oil should therefore be used in ultra-dried form. Mixing with mineral oils should also be avoided. Suitable filter dryer systems to limit the water content are commercially available. Please contact the FUCHS application engineers before using RENISO PG 68.

RENISO PG 68 is also suitable for use with hydrocarbons. It displays minimal hydrocarbon solubility which guarantees that an effective lubrication film is formed even at high specific loads. RENISO PG 68 forms in contact with liquid hydrocarbons an own lubricant phase (attention: phase separation / miscibility gap!).

RENISO PAG 46 and RENISO PAG 100
Selected polyalkylene glycols (PAG) for automotive air conditioning systems which use R134a as refrigerant. Also recommended for the use in ammonia dry expansion (DX) systems (NH_3-miscible oils). RENISO PAG 46 and PAG 100 are also reliable lubricant solutions in systems with hydrocarbons as refrigerants (e.g. propane, propylene). (attention: phase separation / miscibility gap!)

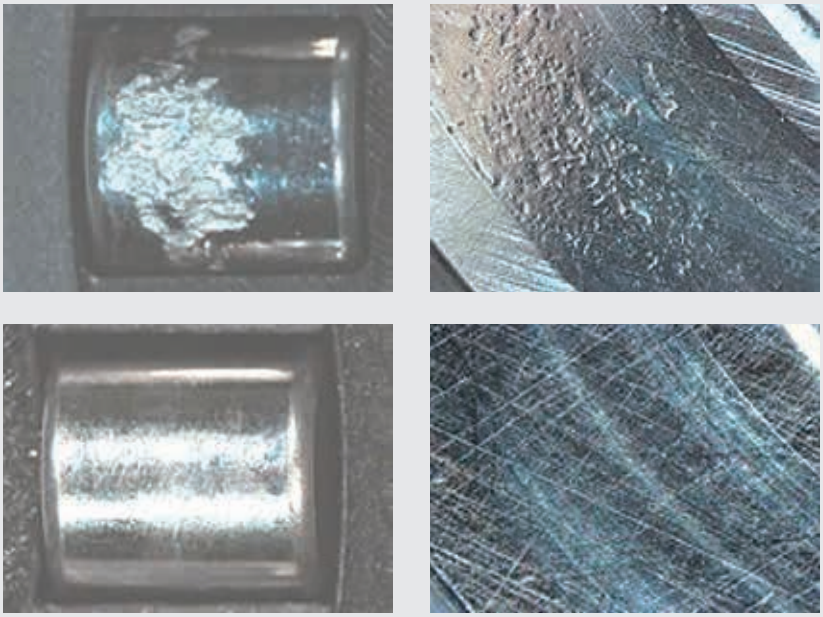
Lubricants for CO_2 applications

RENISO C series
RENISO C series products are based on special synthetic, thermally stable polyol esters. They have an excellent miscibility behaviour together with CO_2 which secures safe oil transport and proper heat transfer in the cooling circuit. RENISO C refrigeration oils contain a special additive system which reliably protects highly-stressed compressors – as often found in CO_2 systems – from wear (see pictures on page 21).

RENISO C series products can be used for both subcritical (e.g. low temperature cooling stages in supermarket cascade systems) and transcritical applications (e.g. in bus A/C systems and medium temperature cooling stages in supermarkets). RENISO C series products are already used successfully for more than 15 years in CO_2 refrigeration systems. Approvals from leading compressor manufacturers have been issued.

CO_2 refrigerant – anti wear additives

Test in FUCHS axial roller bearing test rig, mixed friction area in CO_2 atmosphere



Test conditions:
140 °C/50 bar CO_2/axial loading
8 kN/800 min^{-1}.
Comparison of roller and bearing surface wear after 20 hours.

(Photos above)
POE ISO VG 170 without additives: pitting, wear.

(Photos below)
RENISO C 170 E, POE ISO VG 170 with anti-wear additives: no wear.

RENISO ACC 68

RENISO ACC 68 was particularly developed for the use in transcritical CO_2 applications such as air conditioning applications and heat pump systems. RENISO ACC 68 is formulated on the basis of special double end-capped, thermally stable synthetic polyalkylene glycols (PAG). Highly effective additives ensure a reliable wear protection also under extreme operating conditions (high temperature, high pressure ratio).

RENISO ACC HV – for vehicle a/c systems

RENISO ACC HV (ISO VG 68) was developed in years of joint research work together with leading compressor manufacturers and OEMs for the use in CO_2 vehicle air conditioning systems.

RENISO ACC HV is based on double end-capped polyalkylene glycols (PAG) and contains an efficient additive system to increase the wear protection and the chemical-thermal stability.

RENISO ACC HV totally fulfills the high requirements on refrigeration oils for CO_2 vehicle air conditioning systems (transcritical CO_2 applications).

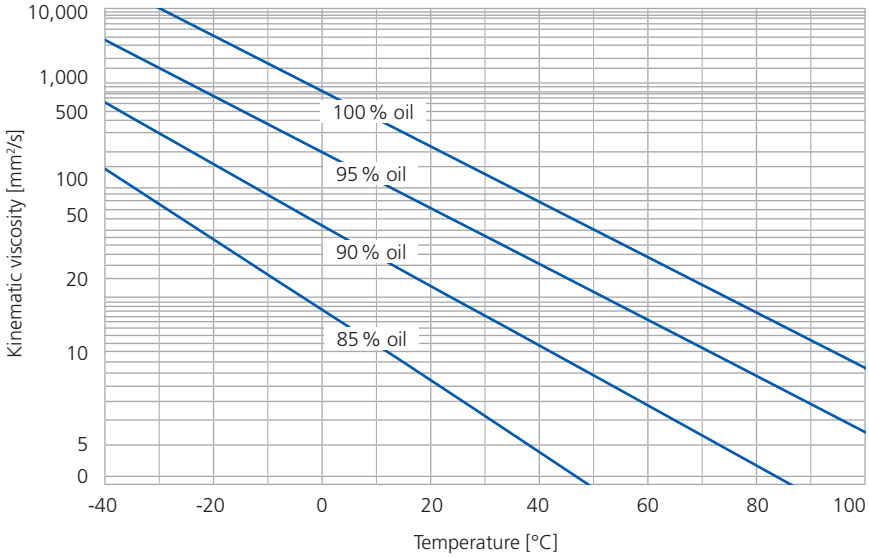
RENISO ACC HV is also suitable for electrically driven air compressors in electric vehicles - for both cooling and heat pump operation.

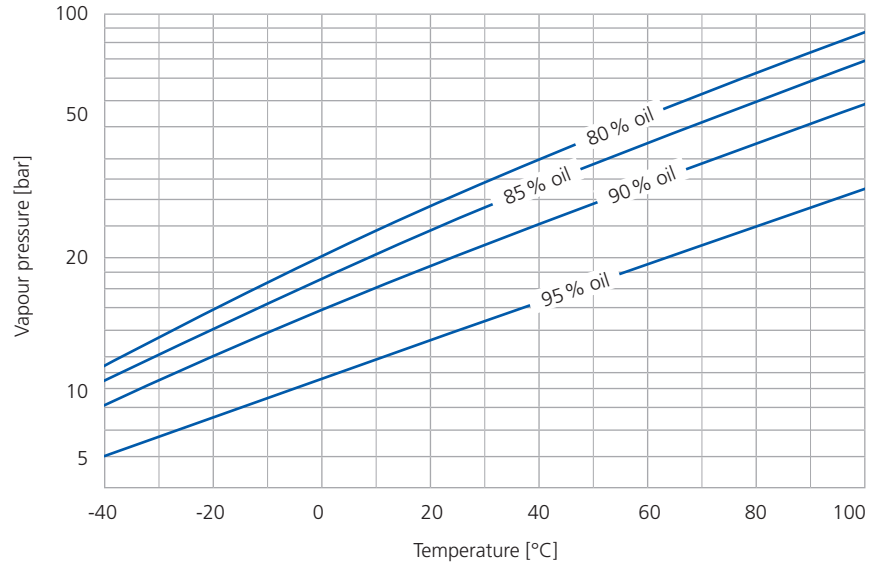
Synthetic refrigeration oils for CO_2 applications

Refrigeration oils for CO_2 (R744) applications:

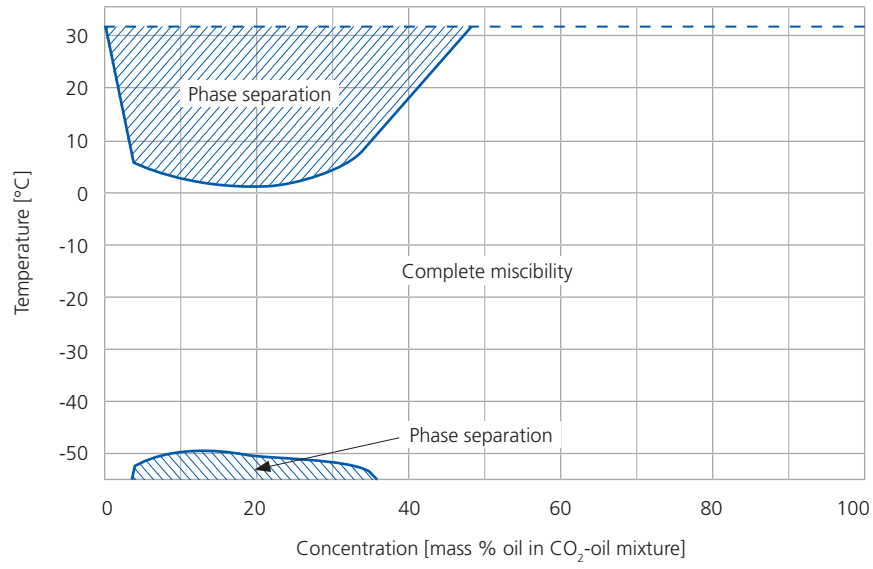
RENISO C
based on POE

Example:
Kinematic viscosity and vapour pressure (Daniel-Plot):
RENISO C 55 E - CO_2 - mixture





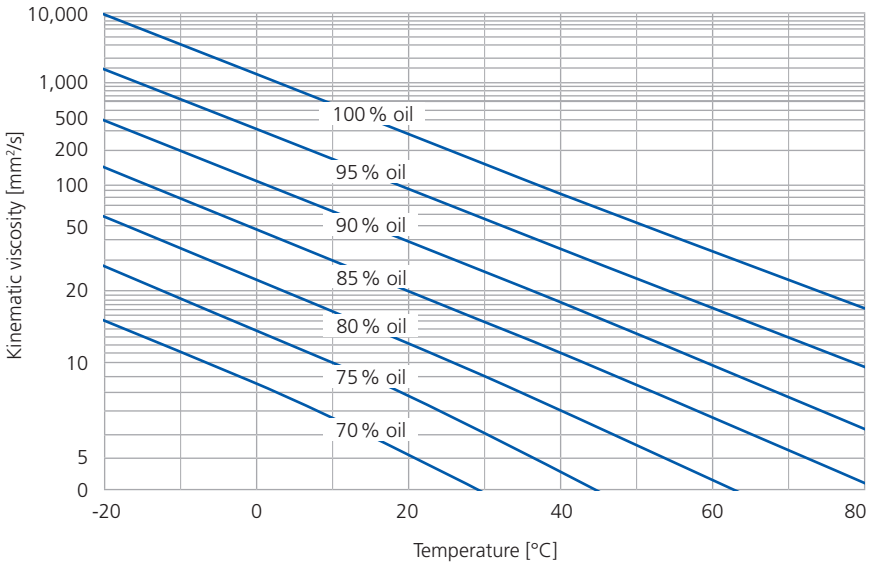
Example miscibility gap:
Miscibility of
RENISO C 55 E with CO_2 (R744)

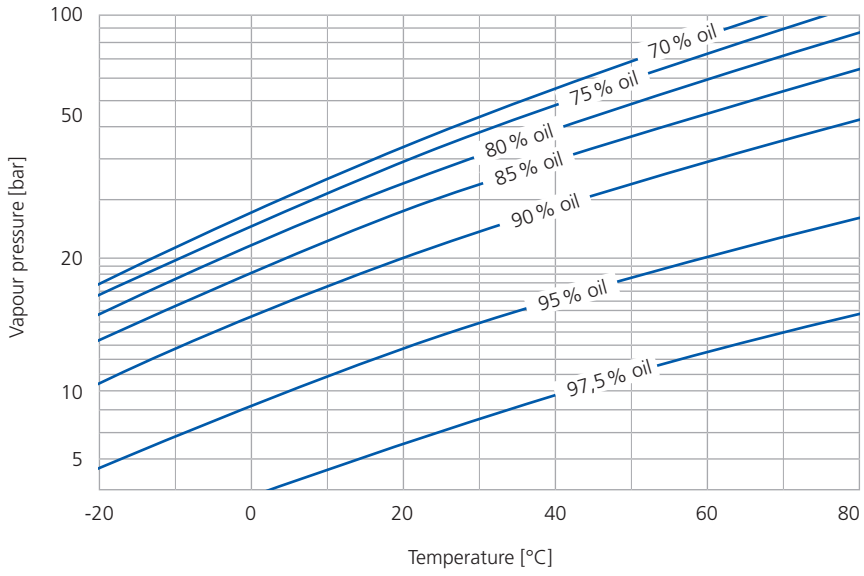


Refrigeration oils for CO_2 (R744) applications:

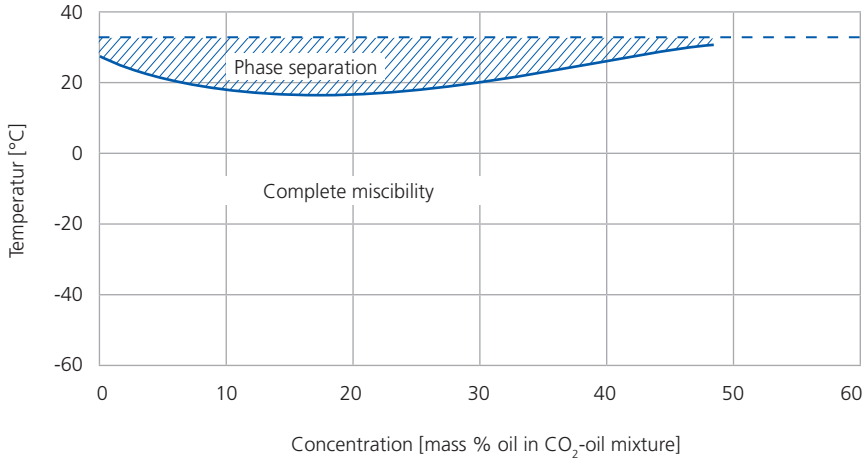
RENISO C based on POE

Example:
Kinematic viscosity and vapour pressure (Daniel-Plot):
RENISO C 85 E - CO_2 - mixture





Example miscibility gap:
Miscibility of
RENISO C 85 E with CO_2 (R744)



Lubricants for ammonia NH_3 applications

Natural refrigerants have been used for refrigeration since the middle of the 19th century - mainly in food production and storage. Ammonia (NH_3) in particular has proven itself in industrial refrigeration for over 120 years. Although the so-called safety refrigerants - for example CFCs, which are banned today - were increasingly used in new systems in the 50s and 60s of the 20th century, ammonia has always been able to maintain its dominance in industrial refrigeration technology. Also due to the environmental discussion about the greenhouse effect, the market share of ammonia refrigeration technology and its components is increasing again today.

Ammonia (R717) is a colorless gas that liquefies under pressure and has a pungent odor. The gas is generated synthetically for use in the refrigeration process, but is considered a natural refrigerant because it occurs in the earth's material cycles. Ammonia has no ozone depletion potential (ODP = 0) and no direct greenhouse effect (GWP = 0). Due to the high energy efficiency, the contribution to the indirect greenhouse effect is low compared to other refrigerants.

Ammonia is conditionally flammable. However, the required ignition energy is 50 times higher than that of natural gas, and ammonia does not continue to burn without a supporting flame. Ammonia is poisonous, but has a characteristic odor with a high warning effect and is already perceptible in the air from a concentration of 3 mg/m³, which means that the warning effect occurs long before a harmful concentration (> 1,750 mg/m³).

Well over 90 % of ammonia refrigeration systems use so-called immiscible oils according to DIN 51503 group KAA as refrigeration oils. These oils include mineral oils, alkylbenzenes and polyalphaolefins. In most refrigeration systems, there are heat exchangers that work on the principle of flooded evaporation. With the time, the oil is deposited at the bottom of these devices and is either discarded or, in rarer cases, transported back to the compressor.
Refrigeration oils based on PAG are at least partially miscible with ammonia (DIN 51503 group KAB), but only play a subordinate role in practice and are only used in systems with dry evaporation (DX systems).

Lubricants for ammonia NH_3 properties

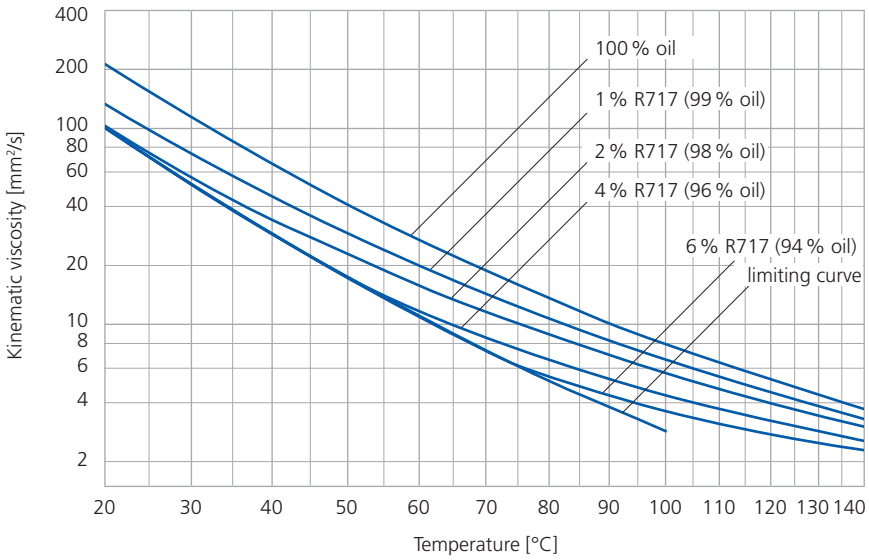
Lubricants for ammonia NH_3	Properties
RENISO K series (ISO VG 32 to 100) Naphthenic mineral oils with very good lubricity and low-temperature flowability (low pour points). Very good material compatibility (e.g. with the elastomer types CR, NBR) (see also page 16ff).	▪ Naphtenic base oils. ▪ Worldwide, assured availability. ▪ Excellent elastomer compatibility. ▪ Reliable wear protection.
RENISO UltraCool 68 and RENISO UltraCool 100 Synthetic refrigeration oils based on synthetic hydrocarbons / PAO with an excellent price-performance ratio: very high thermal and aging resistance, extremely low oil evaporation loss in the compressor, good CR compatibilty. Also perfectly suitable for heat pump applications (see also page 18f). Very good low temperature flowability.	▪ Synthetic base oils. ▪ Significantly higher aging resistance than mineral oils. ▪ Reduced tendency towards deposits and varnish. ▪ Good compatibility with sealing materials, especially CR elastomers. ▪ RENISO UltraCool 100 – especially suitable for heat pumps.
RENISO SYNTH 68 Synthetic premium refrigeration oil based on high-purity polyalphaolefins (PAO). For NH_3 refrigeration systems with heavily loaded compressors and low evaporation temperatures. Unsurpassed in cold flowability and thermal and aging stability. RENISO SYNTH 68 can also be used as refrigeration oil for R723 (dimethyl ether-ammonia mixture) (see also page 18f). For food industry.	▪ Synthetic base oils. ▪ For significantly longer oil change and service intervals. ▪ Extremely low evaporation losses and thus minimized oil consumption. ▪ Suitable for the lowest evaporation temperatures (pour point -57 °C). ▪ Food grade lubricant with NSF H1 registration.
RENISO PG 68 Synthetic, ammonia-miscible refrigeration oil based on polyalkylene glycol (PAG). For NH_3 direct evaporation systems (see also page 20). Due to the special PAG chemistry, please contact FUCHS application engineering before using RENISO PG 68 with NH_3 – especially before refilling.	▪ Synthetic PAG base oils. ▪ Good ammonia miscibility. ▪ High viscosity index (VI = 210) for reliable lubrication. ▪ Specially dried.

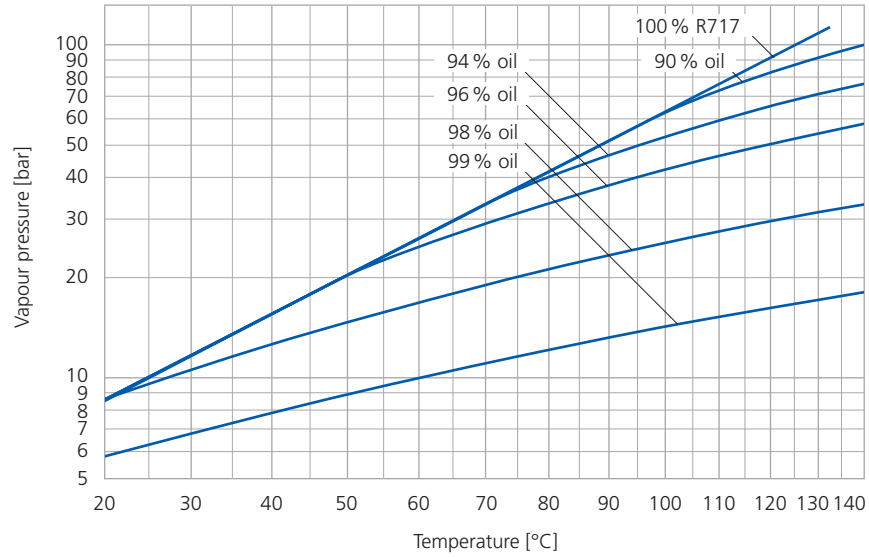
Synthetic refrigeration oils for ammonia NH_3 applications

Refrigeration oil for ammonia NH_3 (R717) applications:

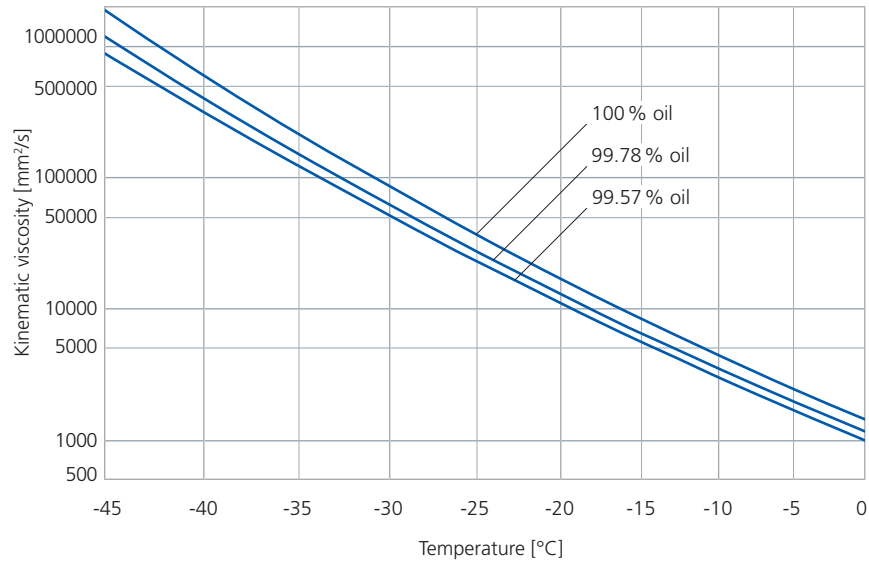
RENISO KC 68

Example:
Kinematic viscosity and vapour pressure (Daniel-Plot): RENISO KC 68 and ammonia (R717, NH_3)





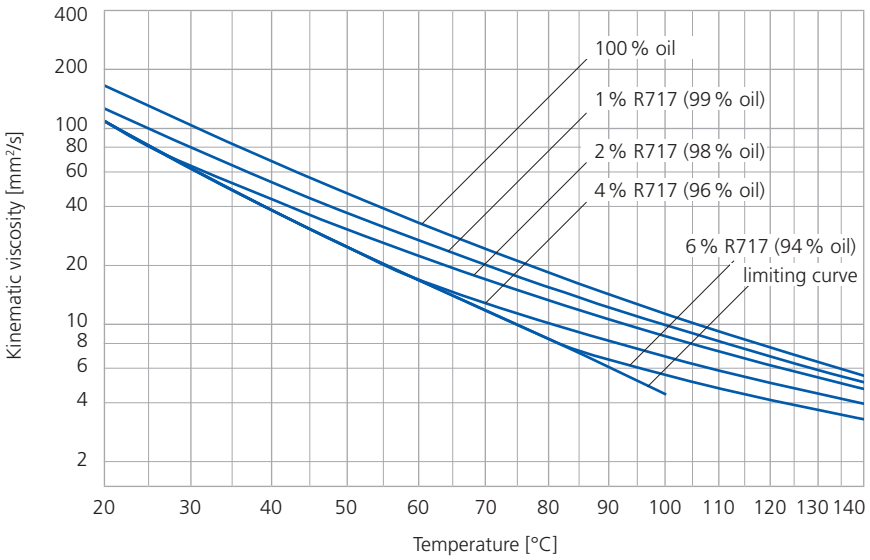
Example:
Low temperature viscosity of RENISO KC 68 with dissolved ammonia (R717, NH_3)

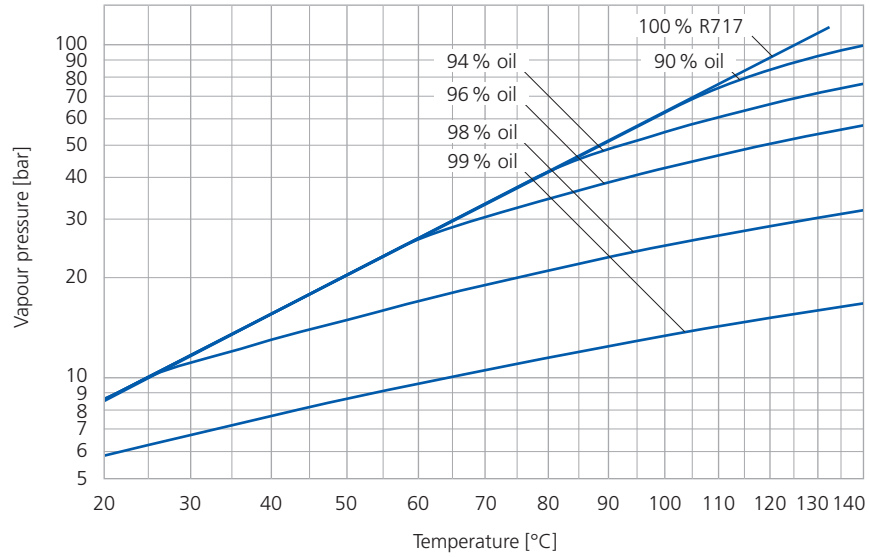


Refrigeration oil for ammonia NH_3 (R717) applications:

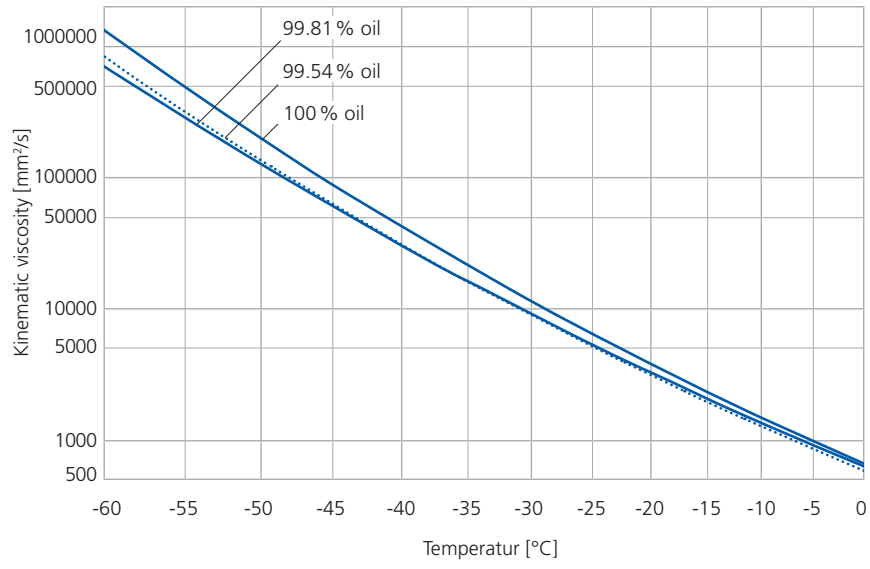
RENISO SYNTH 68

Example:
Kinematic viscosity and vapour pressure (Daniel-Plot): RENISO SYNTH 68 and ammonia (R717, NH_3)





Example:
Low temperature viscosity of RENISO SYNTH 68 with dissolved ammonia (R717, NH_3)



Synthetic lubricants for hydrocarbon HC refrigerants (e.g. R290) – RENISO LPG series

As natural refrigerants, hydrocarbons have a number of advantages over fluorinated refrigerants. Typical representatives such as Propane R290, propylene R1270, isobutane R600a have a high thermal resistance, are chemically stable, show good material compatibility and are relatively cheap. Their main advantage, however, is the very low GWP of 3 to 6. This means that they are not subject to any restrictions in terms of use under the F-Gas Regulation.

A major disadvantage of hydrocarbons is their flammability, which brings special design requirements (explosion-proof design of systems), filling volume limits and, in many cases, the need for a risk assessment for the end user.

When assessing the lubricant management in the hydrocarbon refrigeration application, there are different perspectives. First of all, the general and very good miscibility of the hydrocarbon refrigerants with conventionally used refrigeration oil types should be mentioned. Homogeneous mixtures are formed over a wide temperature and concentration range with both mineral oil and synthetic lubricants such as PAO or POE oils. The solubility of hydrocarbons in mineral oil is the largest (strong dilution), while that in ester oil is lower (smaller decrease in viscosity). There is no separate oil phase here. As a result, there are generally no problems with oil transport or heat transfer in the heat exchangers with these refrigeration oils.
The use of hydrocarbon refrigerants may lead to foaming when there is a decrease in pressure or to mixed friction.

A special feature of hydrocarbon refrigeration applications with regard to the oil management is the high solubility of hydrocarbons in refrigeration oils. The strong dissolution in the oil results in a significant dilution of the lubricant, which can drastically reduce the load-bearing properties of the lubricating film under certain circumstances. As a result of this dilution and the associated decrease in the thickness of the lubricating film in the lubrication gaps, increased wear in the compressor and a reduction in the lifetime of the compressor can occur. In addition to measures in the area of compressor design (more powerful oil heaters to evaporate the refrigerant component from the oil), care must be taken to select a lubricant with a higher initial viscosity for use in hydrocarbon applications.

RENISO LPG series – synthetic, based on PAG

For hydrocarbon refrigerants, special refrigeration oils with reduced refrigerant dissolution have a clear advantage in terms of the lubricating film thickness. RENISO LPG was developed with precisely this aim in mind.

The RENISO LPG series is based on a special synthetic polyalkylene glycol (PAG) fluid. When choosing the base liquid, the focus was on the low hydrocarbon dissolution and thus the lowest possible dilution under the influence of refrigerant. The latest additive technology ensures high aging and thermal stability, reliable wear protection and a reduced tendency to foam. In particular, the suppression of the foaming of oil when the pressure drops is an important criterion for reliable wear protection.

The RENISO LPG series has good miscibility with hydrocarbon refrigerants. For this reason, with the RENISO LPG series a safe oil transport and an unimpaired heat transfer in the circuit can be guaranteed.

The RENISO LPG series is suitable as refrigeration oils for all hydrocarbon refrigerants - including propane R290, propylene R1270 or isobutane R600a / butane R 600. Both reciprocating and screw compressors are reliably lubricated with RENISO LPG.

The RENISO LPG series is used in refrigeration / air conditioning applications as well as in heat pumps. The products of the RENISO LPG series can also be recommended for the transport and compression of natural gas.

Foaming behavior of PAG hydrocarbon mixtures

The RENISO LPG series is characterized by its favorable foaming behavior during outgassing of the refrigerant.

Left picture:
Conventional PAG refrigeration oil: Strong foaming

Right picture:
FUCHS refrigeration oils RENISO LPG series: Reduced foaming during out-gassing of propane

Properties of the RENISO LPG series:

- Synthetic, based on PAG.
- Good miscibility with hydrocarbon refrigerants such as propane.
- Reduced refrigerant dissolution and thus less dilution and lower viscosity loss.
- Favourable foaming behaviour during outgassing of the refrigerant.
- Reliable wear protection.
- High resistance to aging.
- High thermal resistance.
- Very favourable viscosity-temperature behaviour: very high viscosity index (VI = 186): for increased lubricant film thickness.

Further documentation on hydrocarbon refrigerants and RENISO products, on request, e.g.

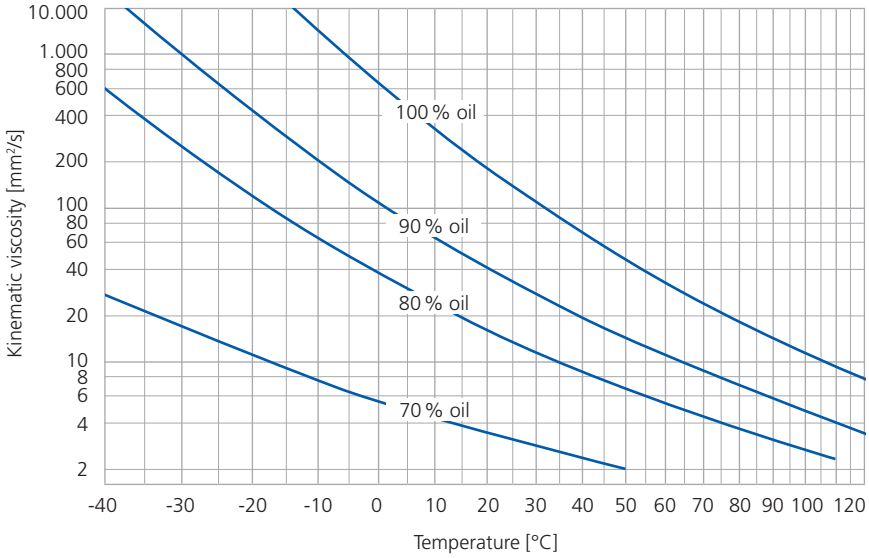
- R290 propane
- R600 butane
- R600a isobutane
- R601a isopentane
- R1150 ethylene
- R1270 propylene

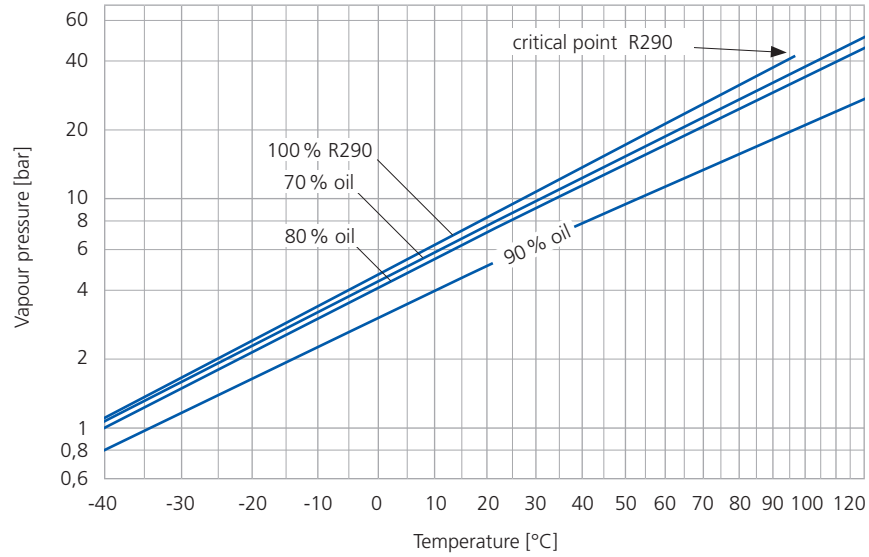
Synthetic refrigeration oils for hydrocarbon refrigerants

Refrigration oil for hydrocarbons:

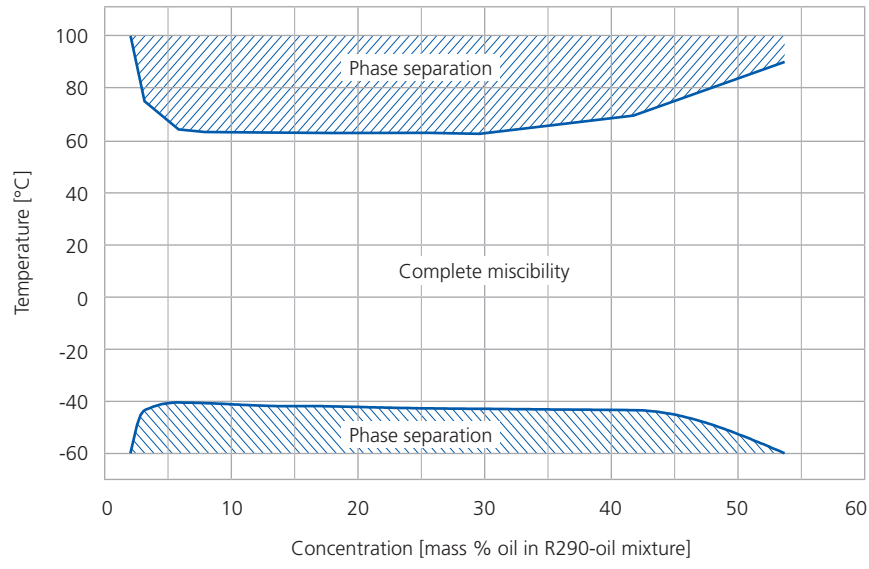
RENISO LPG 68 based on PAG

Example:
Kinematic viscosity and vapour pressure (Daniel-Plot): RENISO LPG 68 - R290 (propane) - mixture





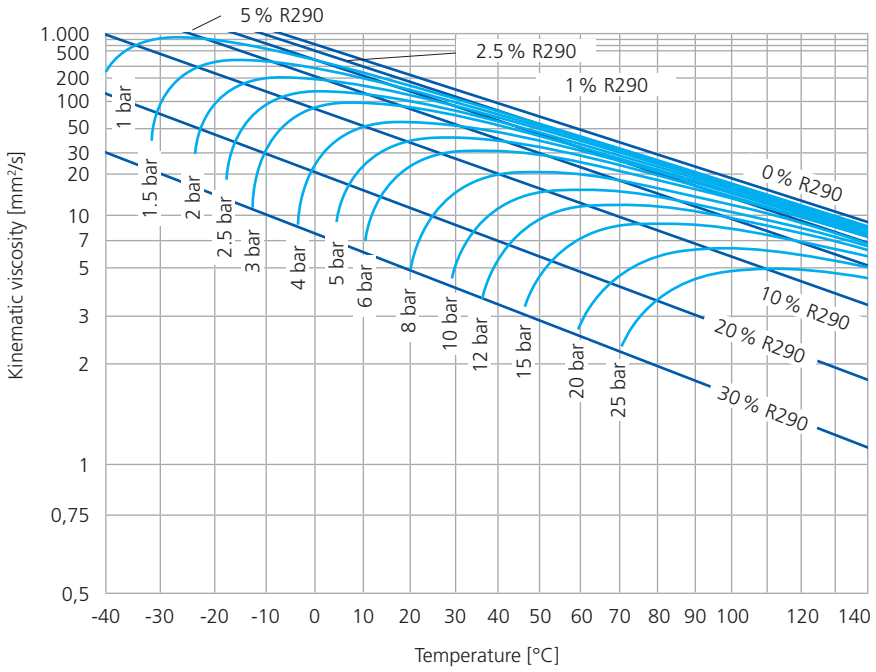
Example miscibility gap:
Miscibility of RENISO LPG 68 with propane (R290)

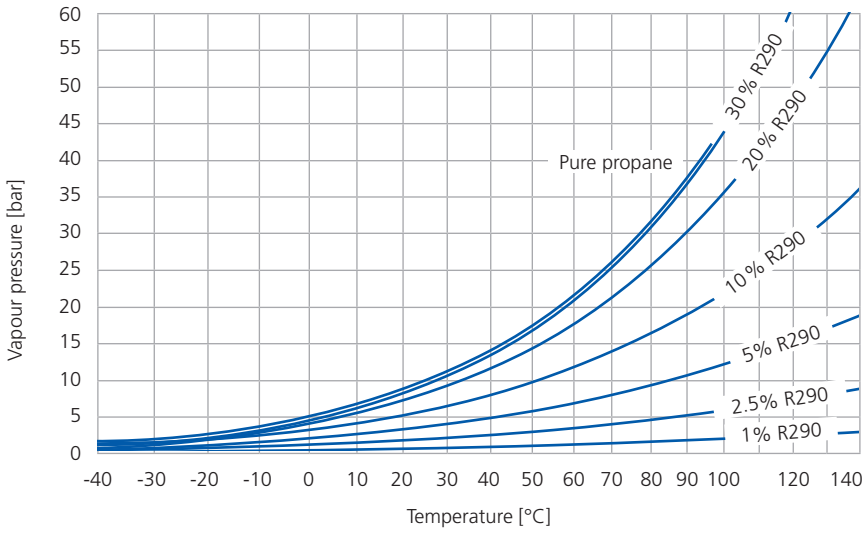


Refrigration oil for hydrocarbons:

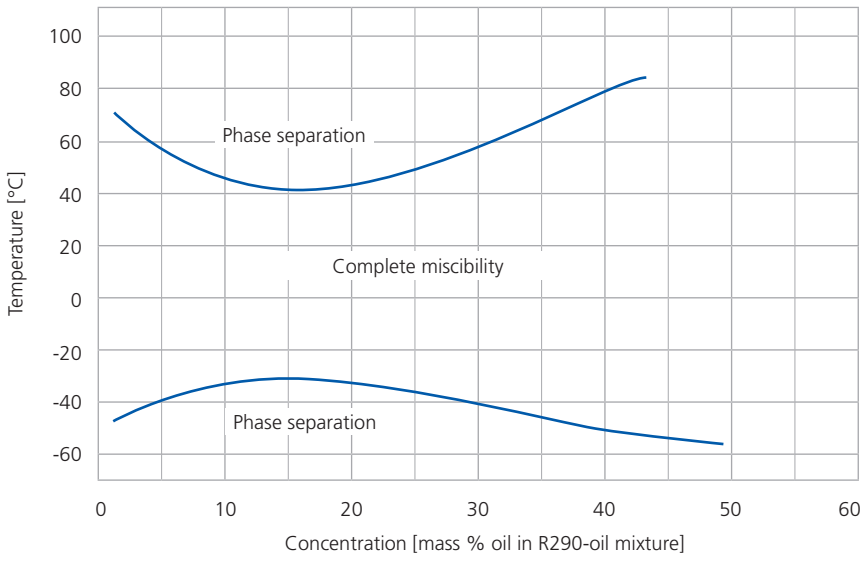
RENISO LPG 100 based on PAG

Example:
Kinematic viscosity and vapour pressure (Daniel-Plot): RENISO LPG 100 - R290 (propane) - mixture





Example miscibility gap:
Miscibility of RENISO LPG 100 with propane (R290)

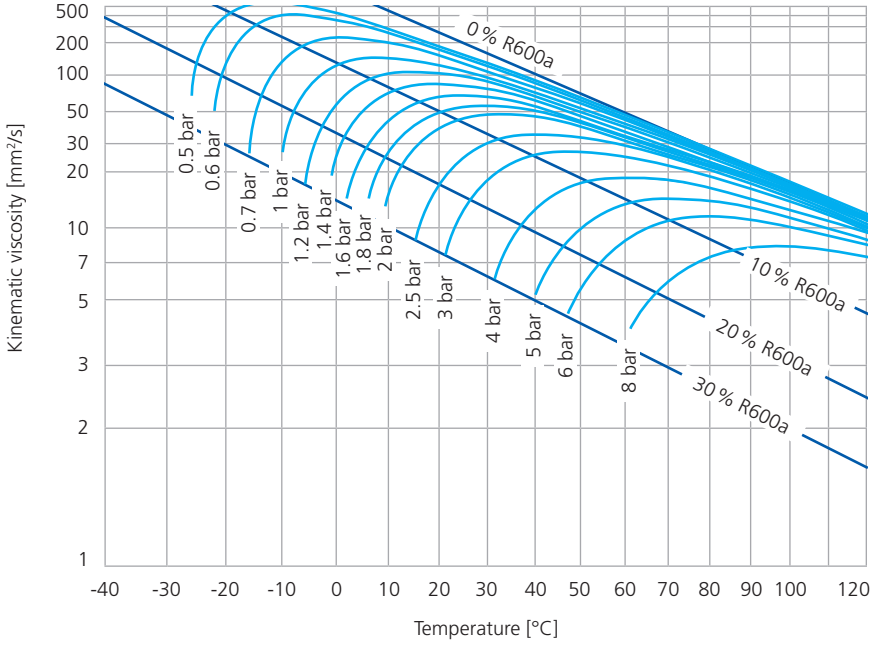


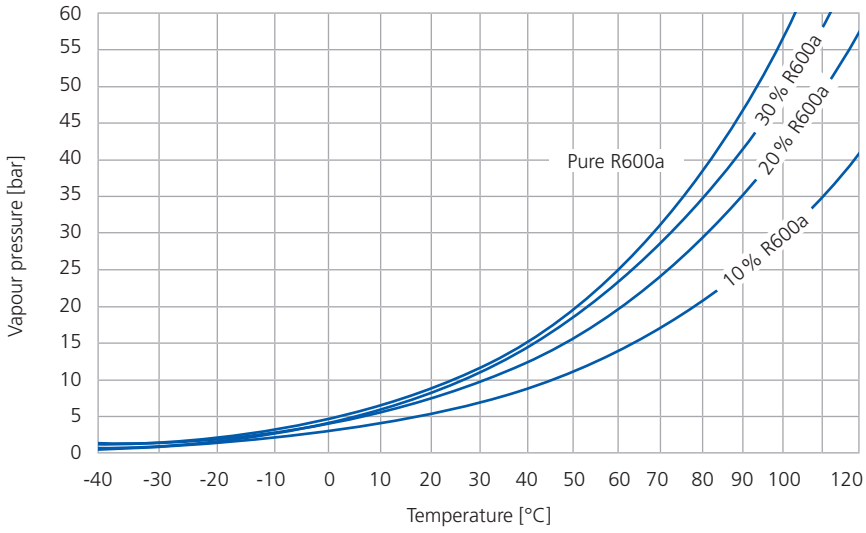
Synthetic refrigeration oils for hydrocarbon refrigerants

Refrigration oil for hydrocarbons:

RENISO LPG 100 based on PAG

Example:
Kinematic viscosity and vapour pressure (Daniel-Plot): RENISO LPG 100 - R600a (isobutane) - mixture

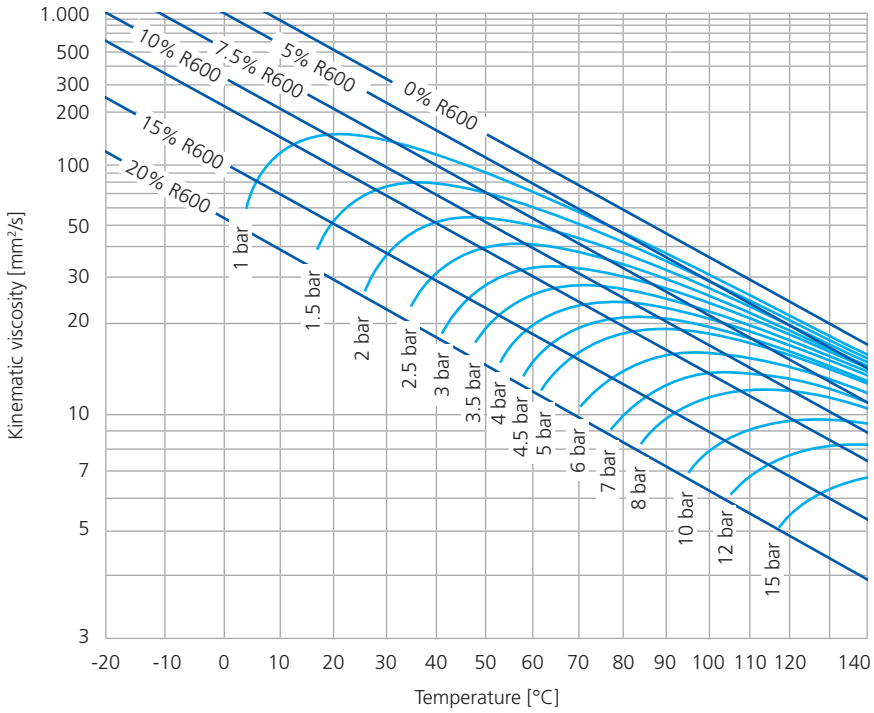


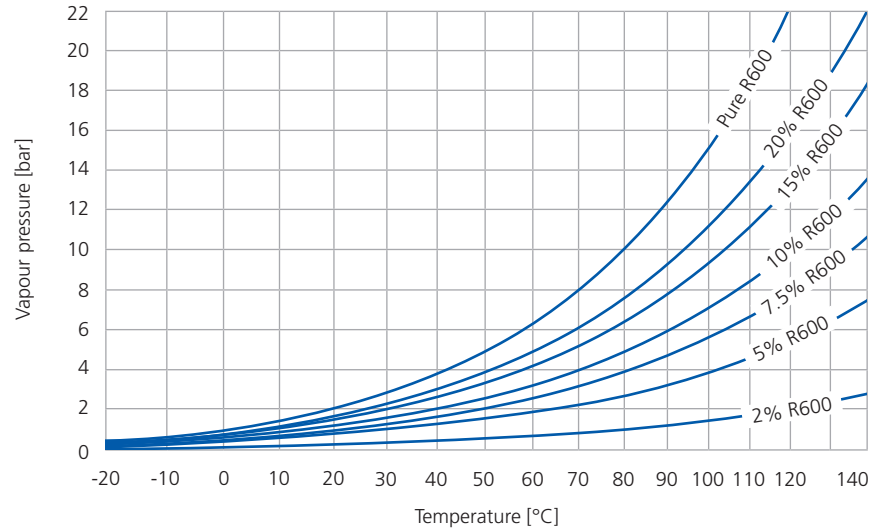


Refrigration oil for hydrocarbons:

RENISO LPG 220 based on PAG

Example:
Kinematic viscosity and vapour pressure (Daniel-Plot): RENISO LPG 220 - R600 (butane) - mixture



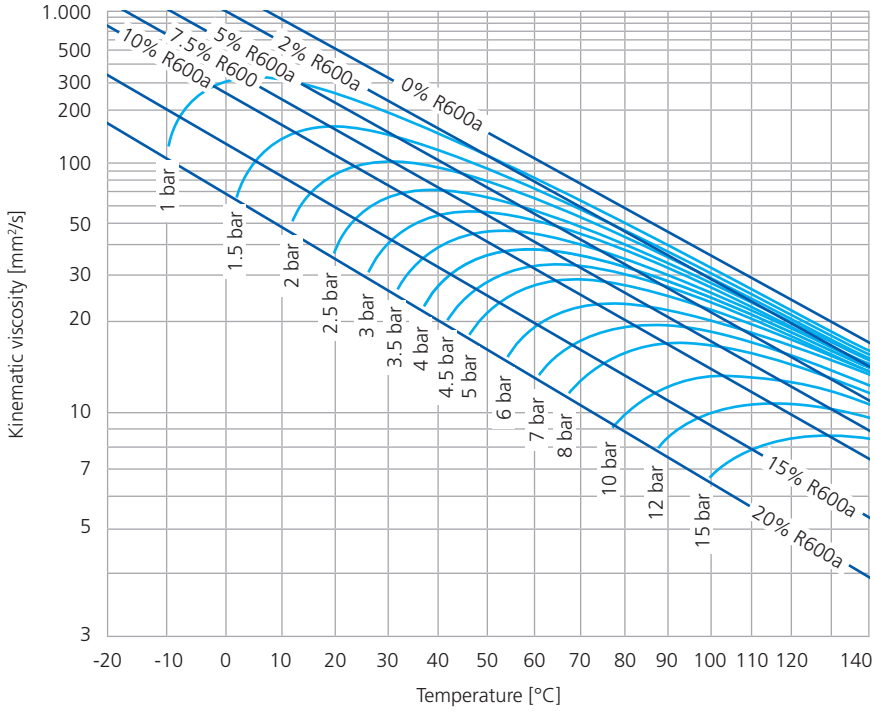


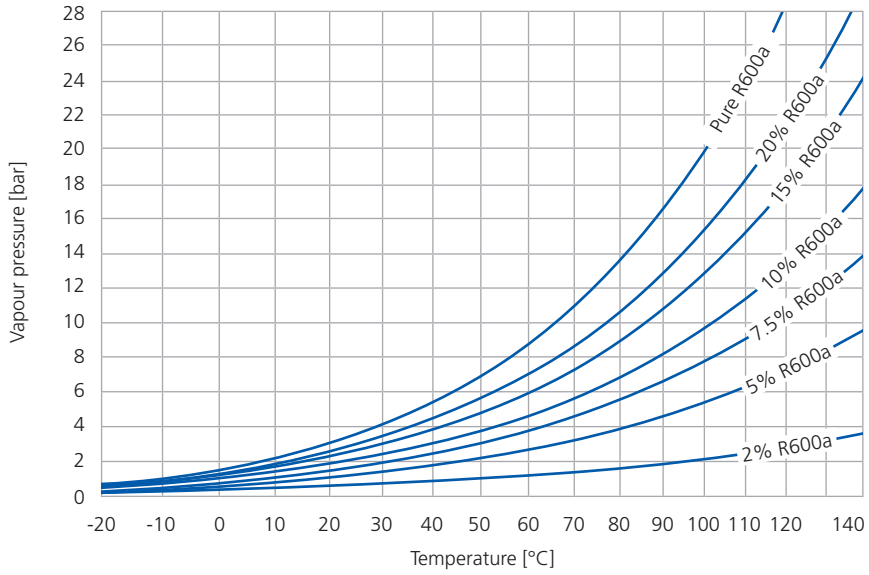
Synthetic refrigeration oils for hydrocarbon refrigerants

Refrigration oil for hydrocarbons:

RENISO LPG 220 based on PAG

Example:
Kinematic viscosity and vapour pressure (Daniel-Plot): RENISO LPG 220 - R600a (isobutane) - mixture



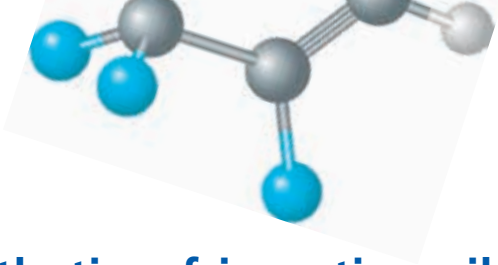


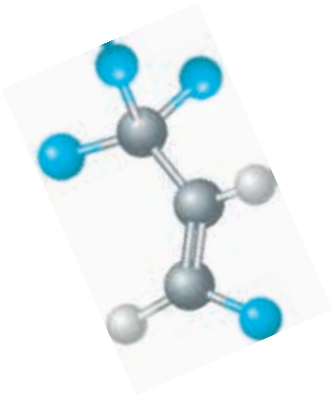
In addition to the products of RENISO LPG series, the following refrigeration oils are successfully in use for hydrocarbon refrigerants for more than 10 years:

RENISO TRITON SE/SEZ series (POE) – also for hydrocarbon refrigerants
Synthetic refrigeration oils based on chemically and thermally extremely stable polyol esters (POE). Their polar structure also reduces the refrigerant dissolution and thus the decrease in viscosity compared to mineral oils.

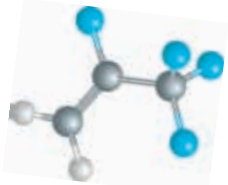
RENISO SYNTH 68 (PAO) – also for hydrocarbon refrigerants
Highly pure polyalphaolefins (PAO) as base oils for very good cold flow properties and a favorable viscosity-temperature behavior (high VI). RENISO Synth 68 has been firmly established in the field of hydrocarbon refrigerants for over 10 years and has very good practical experience.

RENISO WF series (Mineral oil) – for R600a applications
RENISO WF refrigeration oils based on selected hydrogenated mineral oils, so-called isodewaxed base oils, with an effective additive system for increased wear protection. Low-viscosity RENISO WF oils have been used by well-known manufacturers for over 20 years to increase efficiency in fully hermetic R600a refrigerator compressors.





Synthetic refrigeration oils for HFO refrigerants / refrigerant mixtures



Lubricants for HFO refrigerants

RENISO TRITON SE / SEZ series

The use of environmentally acceptable refrigerants – i.e. refrigerants with a reduced contribution to the global warming potential, so-called Low-GWP refrigerants (GWP = Global Warming Potential) – is becoming even more important. In the meantime, with the EU regulation no. 517/2014 the legal framework to reduce the impact of HFC refrigerants to the worldwide greenhouse effect is given.

To fulfill the valid emission limits during the next years (reducing step by step the emission of HFC refrigerants to 21% of the initial value until 2030) the application of refrigerants with a high GWP value will become more and more difficult. Beside natural refrigerants like carbon dioxide, ammonia and hydrocarbons the use of partly fluorinated olefins, so-called HFO (**H**ydrogenated **F**luorinated **O**lefin) refrigerants, will increase.

The HFO-refrigerant R1234yf (GWP <1) is already in use in air conditioning systems of new vehicle types as successor refrigerant for R134a (GWP=1300). But R1234yf is at least disputed because of its flammability which leads to a classification into safety group A2L. R1234ze(E) (also GWP <1 and safety group A2L) has the same chemical composition but a different molecular structure and has also thermodynamic properties which are making a use as refrigerant possible. But the volumetric refrigerating capacity is approximately 25% below the capacity of R1234yf respectively R134a.

Beside these pure substances, mixtures of HFO refrigerants with HFC are also offered for having efficient refrigeration media available which have a distinctly lower flammability than R1234yf/R1234ze(E).

Initial promising experiences with these new HFO refrigerants and HFO/HFC refrigerant mixture do already exist. As refrigeration oils for this substance group the new developed PAG oils (RENISO PAG 1234) for vehicle air conditioning systems and the POE based RENISO TRITION SE/SEZ oils for stationary applications have proven to be reliable lubricants.

But for sure the steadily increasing practical experiences will be crucial for the evaluation of this new refrigerant class in the future. FUCHS is involved in numerous projects and field tests with HFO refrigerants and has thereby established itself as a reliable partner for the lubrication system in these sustainable low GWP applications.

The new F-gases regulation brings up challenging climate protection targets to the European refrigeration sector. Pure HFO substances and their blends with HFC refrigerants will play an important role due to their low GWP values (GWP = Global Warming Potential) together with natural refrigerants. The HFO/HFC blends which are meanwhile available commercially (or in some cases only in laboratory scale) include a large number of new refrigerants. Actually not all of these gases are classified by ASHRAE.

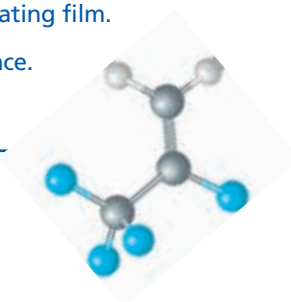
The new blends are not only different with regard to their climate compatibility (their GWP) but also in their flammability properties.

For FUCHS as innovation leader new developments in the area of refrigerants are a challenge that we strive to master: Evaluation of miscibility behaviour, stability tests and solubility and viscosity measurements of our RENISO refrigeration oils in combination with the new HFO/HFC blends are in the focus of our FUCHS R&D department. Extensive research results are already available and new oil-refrigerant data are constantly gained. Please have a look on page 36/37 for example. Here you can find the solubility and viscosity measurements of RENISO TRITON SE 170 with R1234yf and R1234ze(E). On request FUCHS customers can get more information on solutions for HFO and HFO/HFC refrigerants by our experienced application engineers.

The following table on page 34 shows relevant HFO/HFC refrigerants which substitute the pure HFC refrigerants R134a, R404A, R507, R407C and R410A. To have a better overview and because of the amount of published refrigerant blends this is only an extract of the complete product range.

Properties of RENISO TRITON SE/SEZ:

- Synthetic, based on POE (Polyolester)
- Excellent miscibility properties with HFO refrigerants.
- High viscosity index (VI) for a stable lubricating film.
- High aging and high temperature resistance.
- Reliable wear protection.



Synthetic refrigeration oils – RENISO TRITON (POE)

Lubricants for HFO refrigerants – polyolester RENISO TRITON

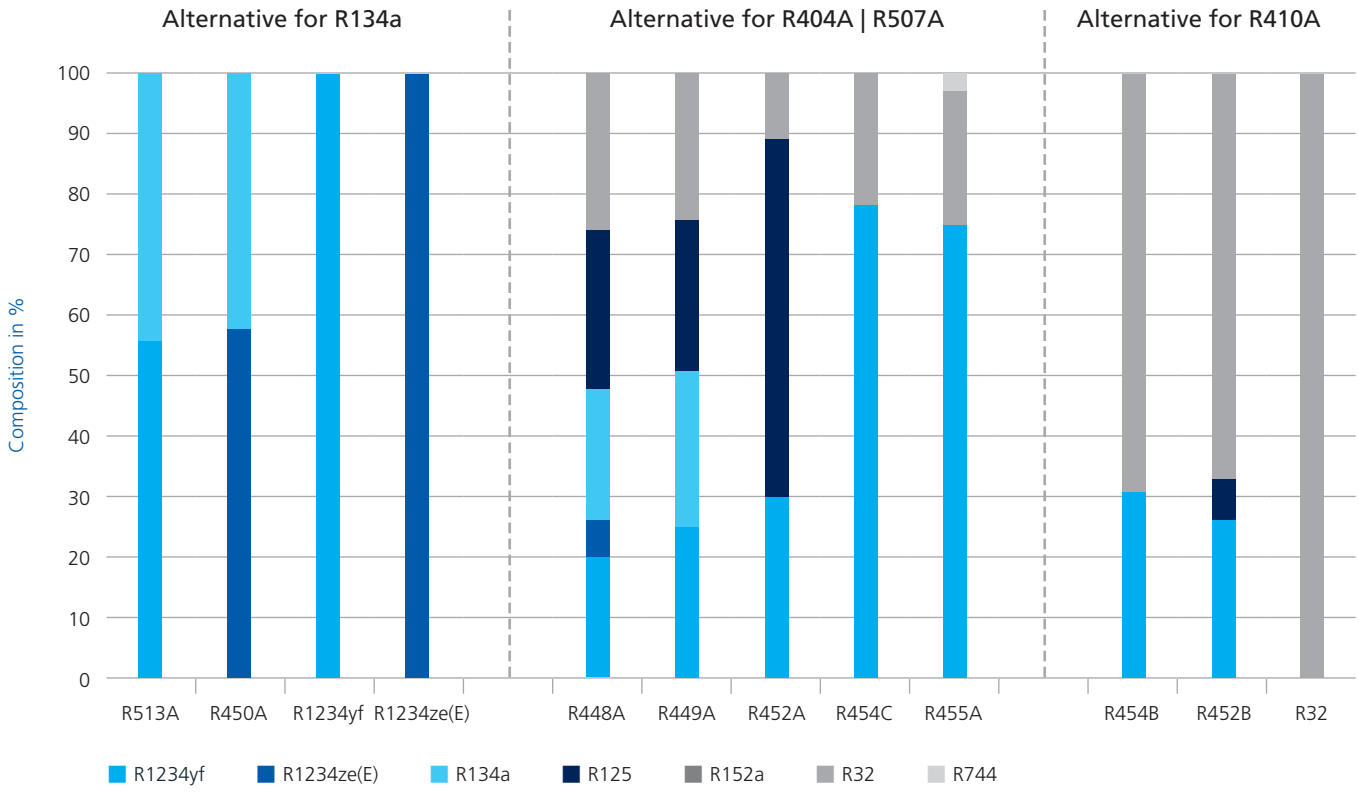
HFO and HFO/HFC mixtures

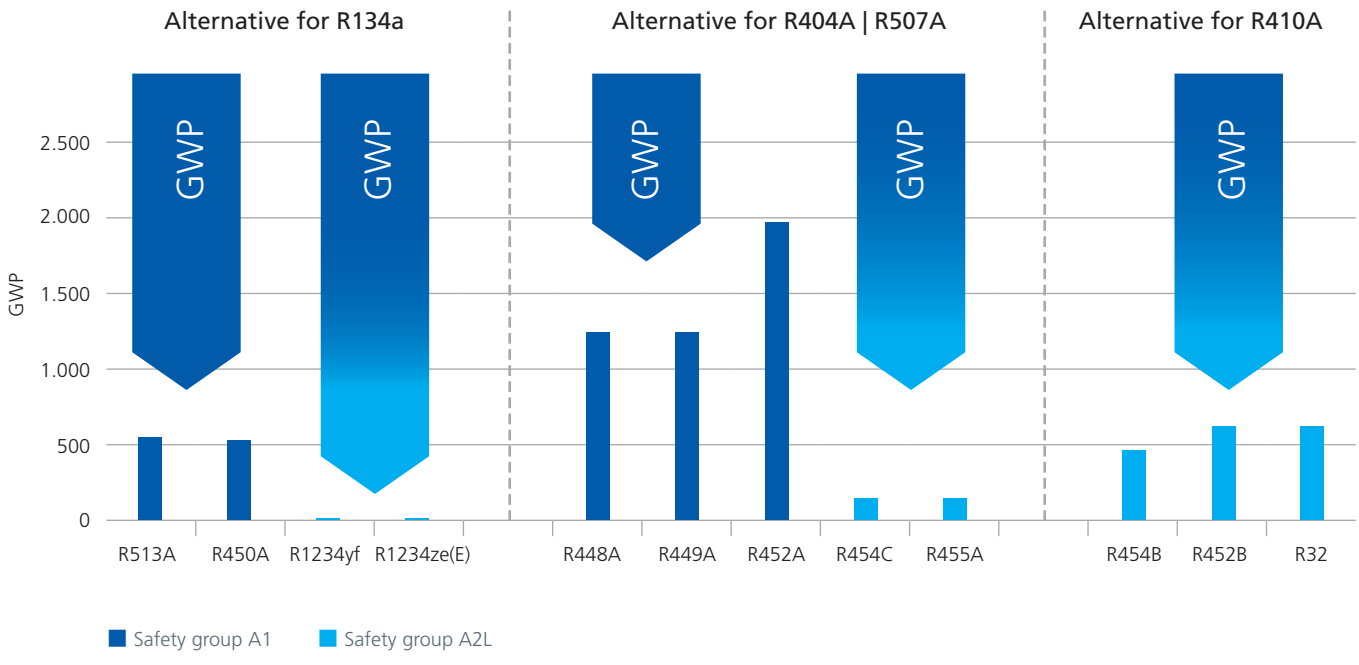
Refrigerant HFO / HFC	GWP*	Replacement for refrigerant HFC	GWP*	Composition	Safety group**
R1233zd(E)	1	R123 / R245fa	858	Trans-1-chloro-3,3,3-Trifluorpropen	A1
R1234yf	< 1	R134a	1300	2,3,3,3-Tetrafluorpropen	A2L
R1234ze(E)	< 1	R134a	1300	Trans-1,3,3,3-Tetrafluorprop-1-en	A2L
R1336mzz(Z)	2	R245fa	858	1,1,1,4,4,4-Hexafluor-2-buten	A1
R444B	295	R22 / R407C	1760 / 1620	R32 / R152a / R1234ze(E)	A2L
R448A	1270	R404A / R507A	3940 / 3990	R32 / R125 / R134a / R1234ze(E) / R1234yf	A1
R449A	1280	R404A / R507A	3940 / 3990	R32 / R125 / R134a / R1234yf	A1
R450A	547	R134a	1300	R134a / R1234ze(E)	A1
R452A	1945	R404A / R507A	3940 / 3990	R32 / R125 / R1234yf	A1
R452B	676	R410A	1920	R32 / R125 / R1234yf	A2L
R454A	238	R404A / R507A	3940 / 3990	R32 / R1234yf	A2L
R454B	467	R410A	1920	R32 / R1234yf	A2L
R454C	146	R404A / R507A	3940 / 3990	R32 / R1234yf	A2L
R455A	146	R404A / R507A	3940 / 3990	R1234yf / R32 / R744	A2L
R513A	573	R134a	1300	R134a / R1234yf	A1
R514A	2	R123	79	R1336mzz(Z) / t-DCE	B1

* GWP = Global Warming Potential acc. to IPCC AR5, time horizon 100 years
** Safety group acc. to ASHRAE 34: A1 = non-flammable; A2L = mildly flammable

Low GWP refrigerants

Alternatives for the change to low GWP refrigerants



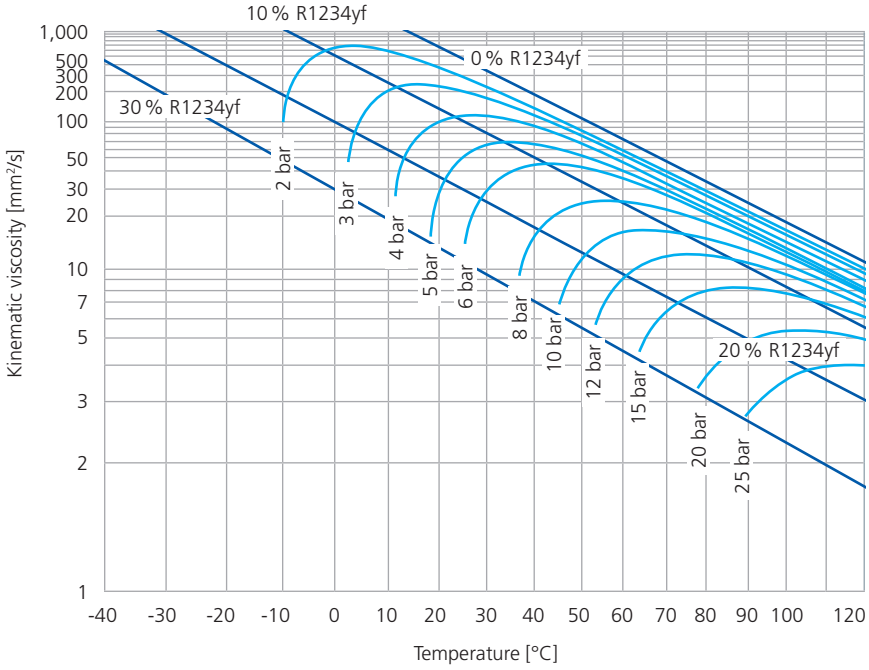


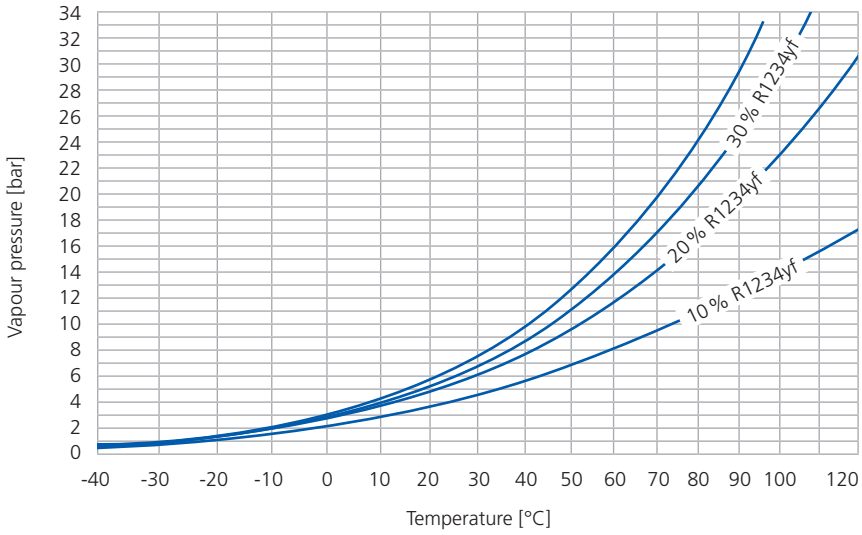
Synthetic refrigeration oils for HFO refrigerants

Refrigeration oils for HFO applications:

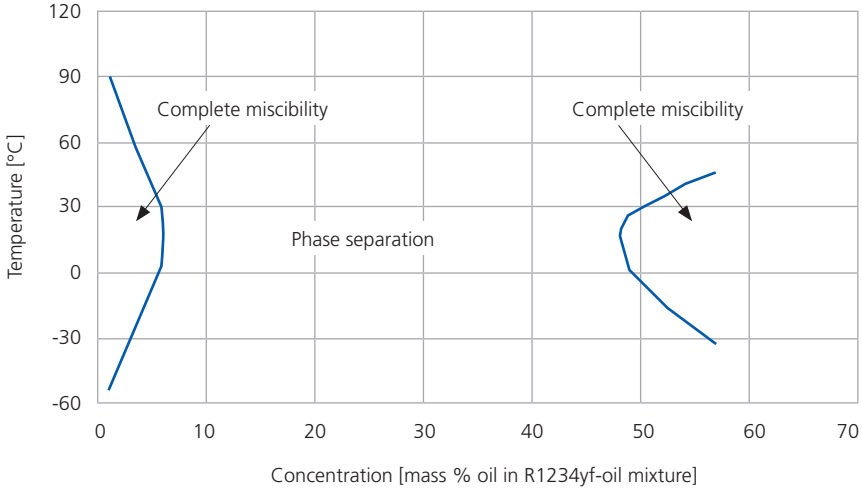
RENISO TRITON SE/SEZ based on POE

Example:
Kinematic viscosity and vapour pressure (Daniel-Plot):
RENISO TRITON SE 170 - R1234yf - mixture





Example miscibility gap:
Miscibility of
RENISO TRITON SE 170
with R1234yf

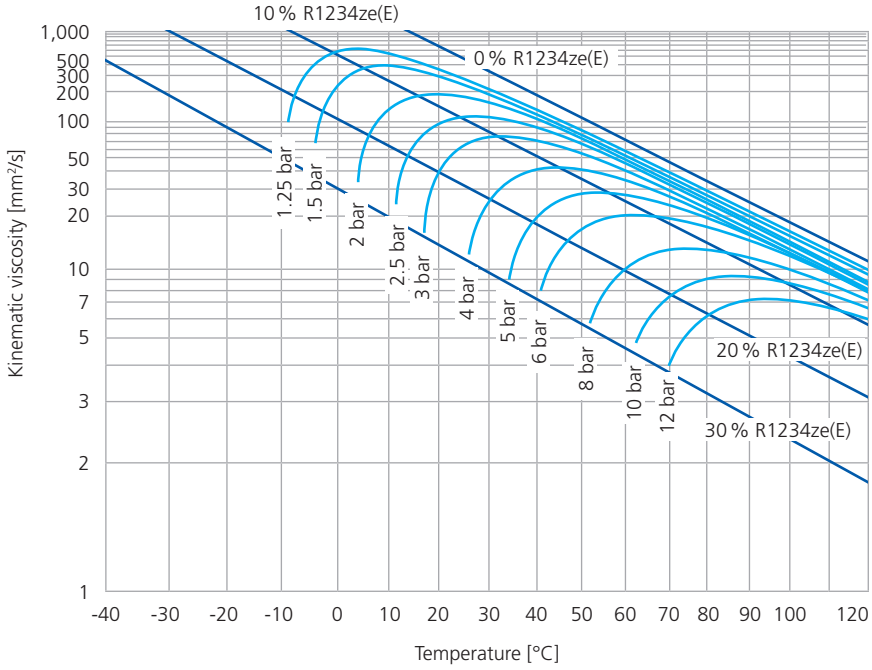


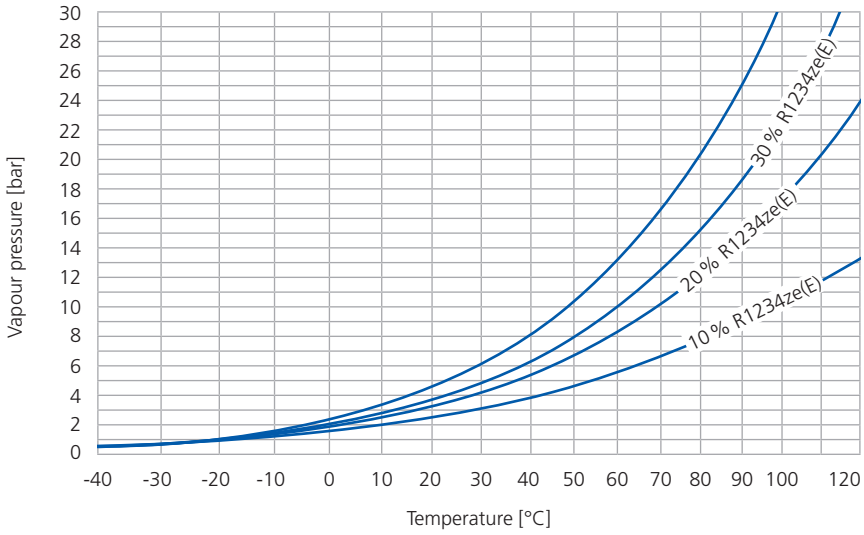
Synthetic refrigeration oils for HFO refrigerants

Refrigeration oils for HFO applications:

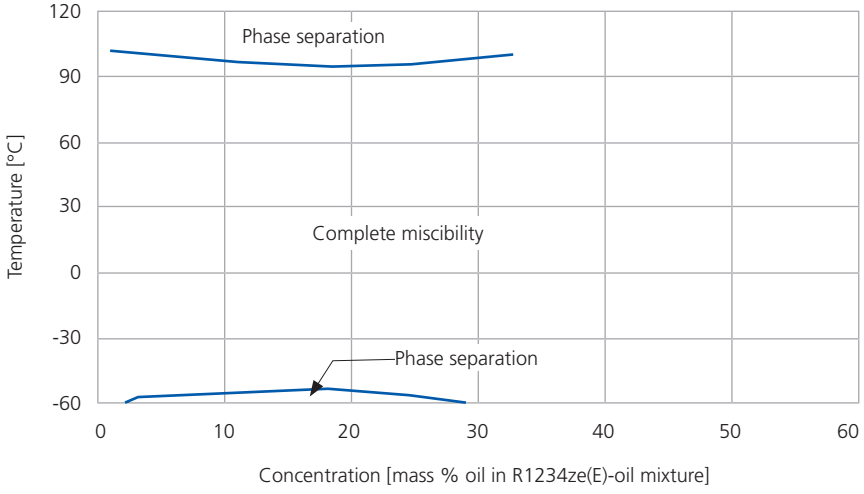
RENISO TRITON SE/SEZ based on POE

Example:
Kinematic viscosity and vapour pressure (Daniel-Plot):
RENISO TRITON SE 170 - R1234ze(E) - mixture





Example miscibility gap:
Miscibility of
RENISO TRITON SE 170
with R1234ze(E)



Synthetic refrigeration oils based on PAG for A/C with R1234yf

Lubricants for mobile air conditioning (MAC) systems with R1234yf

RENISO PAG 1234 – for R1234yf
Using R1234yf as successor of R134a in automotive a/c systems means a lot of challenges for the refrigeration oil in the compressor. RENISO PAG 1234 on the basis of double-end-capped polyalkylene glycols (PAG) is characterized by a good miscibility with R1234yf. Due to its newly developed additivation RENISO PAG 1234 ensures reliable compressor lubrication and excellent wear protection. The high thermo-chemical stability of RENISO PAG 1234 in combination with R1234yf guarantees a stable long-term operation of the a/c system. Moreover RENISO PAG 1234 can be used without any restriction in R134a a/c systems as well.

Due to their comparatively polar structure PAGs absorb water rapidly. This means that corresponding care must be taken when handling these products. The RENISO PAG series of products are ultra-dried and filled into gas-tight containers (e.g. 250 ml cans) in nitrogen atmosphere.

Synthetic refrigeration oils for e-mobility

Challenge e-mobility

The development of vehicles with completely or partly electrical engines (hybrid vehicles) leads to higher requirements in terms of thermal management. Besides of the passenger area the battery in electrical vehicles also has to be cooled or heated. Only a permanently tempered battery guarantees a reliable power supply and thus an optimized range of the vehicle.

Because of the absence of engine heat in electrical vehicles the heating operation becomes clearly more important. Instead of conventional electrical heating systems the use of heat pump cycles is reasonable to increase efficiency and the range of the vehicles.

FUCHS is working on many projects dealing with the thermal management of modern electrical vehicles and is already offering diverse lubricants and refrigeration oils for different refrigerants and system options.

For this purpose you can directly contact our FUCHS application engineering.

RENISO ACC HV is succesfully used in automotive a/c systems / combined heat pump systems with the refrigerant carbon dioxide, R744, CO_2 for applications in e-mobility.

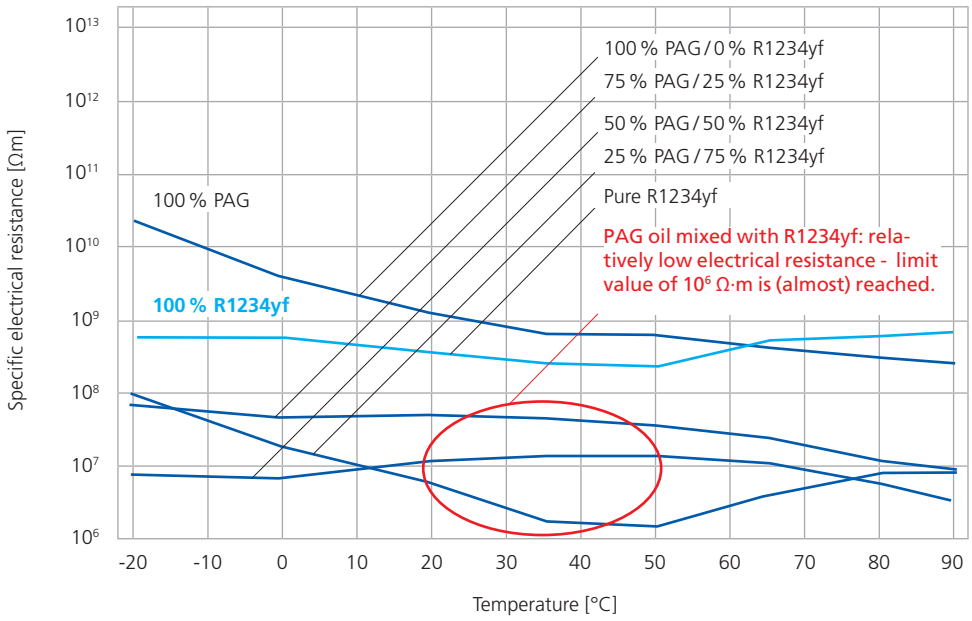
Synthetic refrigeration oils for electric a/c-applications with the refrigerant R1234yf

Hybrid and electric vehicles already have electrically driven hermetic refrigerant compressors as part of the air conditioning system. Because of the contact that occurs between the refrigerant-oil mixture and the compressor winding, it is important that the oil has a high insulating effect in order to avoid short circuits. Classical PAG-based refrigeration oils usually only have inadequate insulation properties.

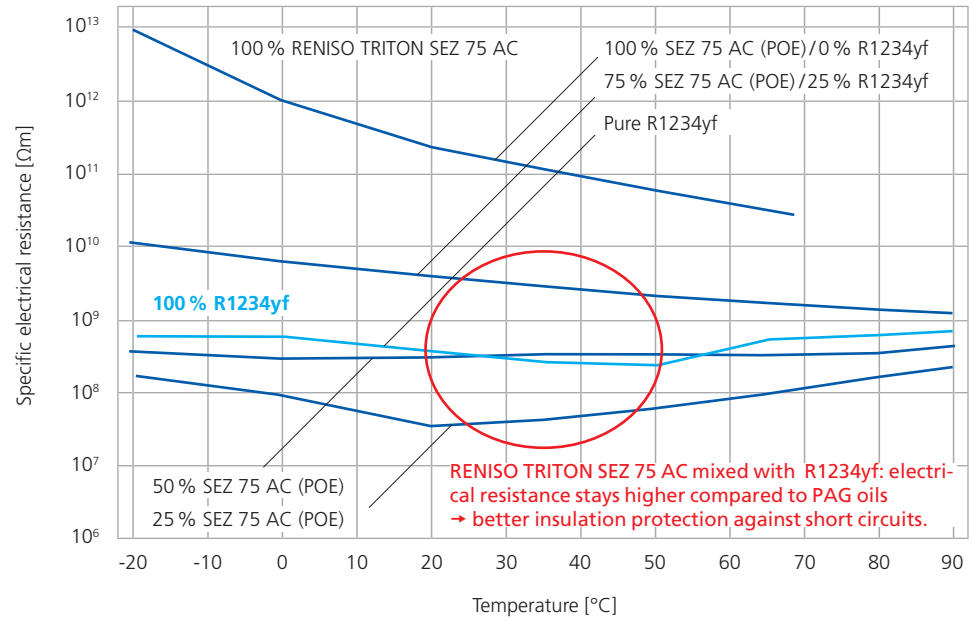
The **POE-based refrigeration oil RENISO TRITON SEZ 75 AC** was developed for exactly this application. Due to the high specific resistance of RENISO TRITON SEZ 75 AC, the insulation of the electrical compressor parts is ensured at all times. In addition, the use of RENISO TRITON SEZ 75 AC in R1234yf air conditioning systems guarantees reliable lubrication of the electrical compressor and perfect oil transport in the refrigeration circuit.

RENISO TRITON SEZ 75 AC is also suitable for use in electric R134a compressors.

Specific electrical resistance of PAG oils mixed with R1234yf



Specific electrical resistance of RENISO TRITON SEZ 75 AC (POE based) mixed with R1234yf



Sealing compatibility of RENISO refrigeration oils

Refri-gerant	Type refrigeration oil	FUCHS product	Sealing materials				
			CR chlorine butadiene rubber, e.g. neo-prene	NBR* Acrylonitrile butadiene rubber	HNBR* Hydrogenated acrylonitrile butadiene rubber	EPDM Ethylene propylene diene rubber	FKM Fluorine rubber, e.g. Viton
NH_3	MO - Mineral oil	RENISO K series	•	(•)	(•)	–	–
	AB - Alkylbenzene	RENISO S series	•	(•)	(•)	–	–
	PAO - Polyalphaolefine	RENISO SYNTH 68	(•)/–	(•)	•	–	–
	Synth. hydrocarbon	RENISO UltraCool 68	•	(•)	•	–	–
	PAG - Polyalkyleneglycol	RENISO PG 68	–	•	•	•	–
HFC, HFO e.g. R134a, R404A	POE - Polyolesters	RENISO TRITON SE/SEZ series	–	•	•	•	–
	PAG - Polyalkyleneglycol	RENISO PAG (A/C)	–	•	•	•	–
CO_2	POE - Polyolesters	RENISO C series	–	–	•	•	•
	PAG - Polyalkyleneglycol	RENISO ACC HV (A/C)	–	–	•	•	•
	PAO - Polyalphaolefine	RENISO SYNTH 68	–	–	•	–	•
Hydro-carbons e.g. R290, R1270, R600a, R601a	MO - Mineral oil	RENISO WF series (Hermetic) (RENISO K series)	• (•)	• (•)	• (•)	– –	• (•)
	AB - Alkylbenzene	(RENISO S/SP series)	(•)	(•)	(•)	–	(•)
	PAO - Polyalphaolefine	RENISO SYNTH series	•	•	•	–	•
	POE - Polyolesters	RENISO TRITON SE/SEZ series	–	•	•	–	•
	PAG - Polyalkyleneglycol	RENISO LPG series	–	•	•	–	•
HCFC e.g. R22	MO - Mineral oil	RENISO K series	•	–	(•)	–	–
	AB - Alkylbenzene	RENISO MS series RENISO S/SP series	• •	– –	(•) (•)	– –	– –
	Esters	RENISO TRITON SEZ 32	(•)	–	–	•	–

• = suitable; (•) = conditional; – = not suitable
* Nitrile content >36%

GENERAL SEALING COMPATIBILITY

Elastomers from different manufacturers can differ significantly, e.g. in terms of chemical composition, degree of cross-linking, degree of saturation and the use of processing aids. Therefore, the properties of elastomers of one type - manufactured by different companies - can sometimes vary considerably.

Further typical technological tests for refrigeration oils

Properties	Reliable test methods
Flocculation point with the respective refrigerant	DIN 51351
Copper strip test (3 h, 100 °C)	DIN EN ISO 2160
Electric discharge voltage	DIN EN 60156 (VDE 0370-5)
Four ball wear test, procedure A (1 h / 150 N) without refrigerant	DIN 51350-3
Falex-test without refrigerant	ASTM D2670
Modified Almen-Wieland-Test in refrigerant atmosphere	–
pVT diagrams/Daniel-plots Kinematic viscosity of the oil-refrigerant mixtures depending on pressure and temperature, to be specified for an oil amount of 70% to 100% (mass fraction)	–
Ashrae Sealed Glass Tube Test – Testing the chemical and thermal stability of refrigerant / oil mixtures / 175 °C / 2 weeks / Cu, Fe, Al	Ashrae-Standard 97

Sealed tube test – ASHRAE 97 - 2007

Warning values for used refrigeration oils and explanations acc. to DIN 51503-2 (2015 – is currently being reviewed (July 2022))

* In the case of kinematic viscosity manufacturer's specifications should always be observed.
** Larger deviations from fresh oil values are possible in the case of ammonia refrigeration oils – acceptable in the direction of a higher viscosity.

The lubricant / compressor / installation manufacturer should be consulted if the warning values are exceeded.

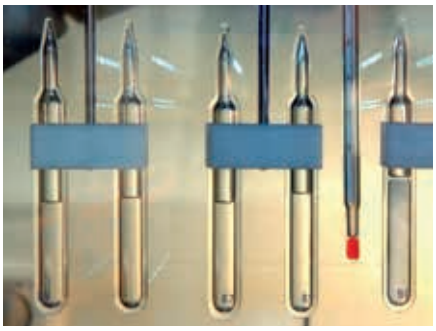
KAA – Ammonia refrigeration oils (not miscible: e.g. mineral oils, alkyl benzenes, polyalphaolefins)
KAB – Ammonia refrigeration oils (miscible: e.g. polyalkylene glycols)
KB – CO_2 refrigeration oils (CO_2 miscible: e.g. polyol esters, polyalkylene glycols, CO_2 non-miscible: e.g. polyalphaolefins)
KC – HCFC refrigeration oils (e.g. mineral oils, alkyl benzenes, complex and polyol esters)
KD – HFC/FC refrigeration oils (e.g. polyol esters, polyalkylene glycols)
KE – Hydrocarbon refrigeration oils (e.g. mineral oils, alkyl benzenes, polyalphaolefins, polyalkylene glycols, polyol esters)

Determining water content according to Karl Fischer

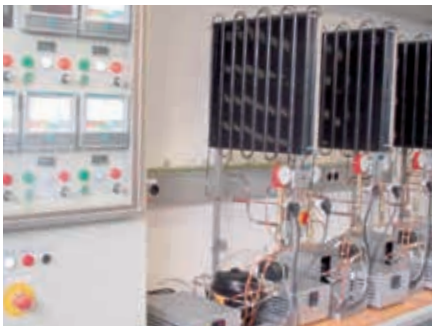
DIN 51777:
for refrigeration oils with and without additives

The FUCHS Service program

High pressure autoclaves



Miscibility behaviour, miscibility gap



Compressor test rig, gas cycle

FUCHS laboratory analysis system for refrigeration oils

Focused on the specific requirements of refrigerants FUCHS offers a laboratory service which is designed to monitor the condition of refrigeration oils in use. This support service helps to guarantee the reliable operation of refrigeration plants.

The determination of viscosity, water content, concentration of wear particles, additive content and the acid number (for ammonia systems: Determination of the base number) enables the monitoring of refrigerating systems.

Thus, by means of the FUCHS laboratory analysis system, maintenance costs can be reduced. This service also allows to react in time if deviations in the used oil compared to the fresh oil values are registered.

Warning values for used RENISO refrigeration oils (acc. to FUCHS experience)

Brand name	Group	Deviation in kinematic viscosity at +40 °C [mm^2/s]	Max. water content [mg H_2O/kg oil]	Acid number / Delta [mg KOH/g]
		DIN EN ISO 3104	DIN 51777	DIN ISO 6618
RENISO K Mineral oils	KAA KC KE	– ± 15% of fresh oil value ± 15% of fresh oil value	100 60 80	– 0,2 0,2
RENISO SYNTH **RENISO UltraCool** Polyalphaolefins (PAO)	KAA KB KE	– ± 15% of fresh oil value ± 15% of fresh oil value	100 80 80	– 0,2 0,2
RENISO S/SP Alkyl benzenes (AB)	KAA KC KE	– ± 15% of fresh oil value ± 15% of fresh oil value	100 60 80	– 0,2 0,2
RENISO PAG/ACC **RENISO PG/LPG** Polyalkylene glycols (PAG)	KAB KB KD KE	– ± 15% of fresh oil value ± 15% of fresh oil value ± 15% of fresh oil value	500 800 800 800	– 0,2 0,2 0,2
RENISO TRITON SE/SEZ **RENISO C** Ester oils (POE, complex esters)	KB KC KD KE	± 15% of fresh oil value ± 15% of fresh oil value ± 15% of fresh oil value ± 15% of fresh oil value	150 150 200 200	0,2 0,2 0,2 0,2

The FUCHS Service program

Logistic systems for refrigeration oils

RENISO refrigeration oils are ultra-dried. PAG and POE are hygroscopic, i.e. they tend to absorb water more rapidly than hydrocarbon-based non-polar refrigeration oils such as mineral oils, alkyl benzenes and PAOs.

Our RENISO refrigeration oils are available in a variety of user-friendly containers ranging from 1 litre cans through to 1 m³ containers and special road tankers. All containers have passed long-term trials to test their ability to seal out moisture.

Prior to shipping our logistics concept involves all 1 m³ containers and tankers being permanently pressurized (with dried nitrogen) to stop the ingress of moisture. A sophisticated method of emptying and filling containers guarantees that the water content in fresh deliveries is absolutely low. If required this can be certified on a document which details key data such as product quantity, water content and container pressure. We will be glad to supply you with further information about our logistics system along with technical product documentation.

FUCHS high-tech lubricants

The use of innovative refrigeration oils requires experienced and individual consultation. A detailed consultation should therefore precede every change of application parameters. This guarantees that the optimum lubricant system is selected. FUCHS lubrication specialists have the experience and technical expertise to give qualified lubricant recommendations as well as helping to solve problems.

A broad overview over the field of refrigeration oils – including a lot of application engineering data and diagrams for numerous oil-refrigerant-mixtures.

Available only in German from VDE Verlag: ISBN 978-3-8007-3271-5

The advantages of our RENISO refrigeration oils:

- Highest quality standards
  RENISO products use the highest quality raw materials. Development, production and filling are all subject to highest quality standards and controls.
- Joint product development
  Customers often need special solutions. We accept this challenge and together we develop suitable solutions which satisfy your applications and requirements.
- Individual problem-solving
  All RENISO refrigeration oils have been carefully developed, tested and formulated with years of acquired know-how. For the customer, this means more reliability and greater economy.
- Personal consulting – contact us now!
  What can FUCHS do for you in terms of products and service? Your personal contact person can tell you more.

Refrigeration oils – our expertise

- R&D
  – Experienced refrigeration oil development department
- Test rigs
  – Compressor test rigs
  – Component test rigs
- Laboratories
  – High pressure autoclaves
  – Low temperature baths
  – Stability test rigs (autoclaves, Sealed Tube Test)
  – Miscibility gap and flocculation point apparatus
  – Range of all common HFC / HFO refrigerants and natural refrigerants
- Logistics/Production
  – Stainless steel components and N_2 (inert gas) atmosphere during manufacturing and filling
  – Special containers
- Service
  – Testing of used refrigeration oils and evaluation of results
  – Intensive consulting / application engineering

Overview of RENISO products

Brand name	Description	Density at 15 °C [kg/m³]	Flashp., Clev. [°C]	Kin. Visc. at 40 °C [mm²/s]	Kin. Visc. at 100 °C [mm²/s]	VI (Viscosity Index)	Pour-point [°C]	Main application area
RENISO WF – Mineral oil based refrigeration oils								
RENISO WF 2,3 A	Special refrigeration oils for use with the refrigerant isobutane (R600a) – for hermetic compressors, highly refined, low flocculation point with R600a, containing additives to improve wear protection and ageing stability. DIN 51503: KC, KE	823	100	2.4	–	–	-42	RENISO WF refrigeration oils are recommended for the lubrication of hermetic refrigerator compressors with the refriger-ant isobutane (R600a). Due to special additive systems, the RENISO WF refrigeration oils ensure the formation of a wear-protecting lubricating film at all operating temperatures. RENISO WF refrigeration oils are fully miscible with R600a and also with all other hydrocarbon refrigerants like R290. **Based on special mineral oils**
RENISO WF 5 A (on request)		827	134	5.0	1.7	95	-45	
RENISO WF 7 A (on request)		832	158	7.2	2.2	97	-42	
RENISO WF 10 A (on request)		835	172	9.6	2.6	97	-42	
RENISO WF 15 A (on request)		883	164	15	3.1	–	-51	
RENISO K – Mineral oil based refrigeration oils								
RENISO KM 32 (20 x 1 L)	Highly refined, naphthenic mineral oils with high ageing stability, low pourpoint, excellent low-temperature behaviour and particularly good compatibility with the following refrigerants: ammonia (NH3), HCFCs (e.g. R22), hydrocarbons (e.g. propane R290, propylene R1270). DIN 51503: KAA, KC, KE	881	202	32	4.9	63	-45	For all refrigeration systems using ammonia (NH_3) or HCFC refrigerants. RENISO KES 100 is suitable for applications with high evaporation and condensation temperatures, such as air-conditioning applications, heat pumps - especially recommended also for turbo compressors. **Based on naphthenic base oils**
RENISO KS 46 (4 x 5 L, 20 L)		894	204	46	5.8	47	-42	
RENISO KC 68		894	223	68	7.4	58	-39	
RENISO KES 100		912	218	100	8.4	20	-33	

RENISO

Brand name	Description	Density at 15 °C [kg/m³]	Flashp., Clev. [°C]	Kin. Visc. at 40 °C [mm²/s]	Kin. Visc. at 100 °C [mm²/s]	VI (Viscosity Index)	Pour-point [°C]	Main application area
RENISO S/SP – Fully synthetic refrigeration oils based on alkyl benzenes								
RENISO SP 32	Fully synthetic refrigeration oils based on chemically and thermally stable alkyl benzenes. RENISO SP 32, 46 and 100 contain highly effective AW* additives **(not suitable for NH_3 applications)**. Excellent miscibility and excellent stability with HCFC refrigerants (e.g. R22). DIN 51503: KC, KE	870	186	32	4.6	31	-51	Particularly good miscibility with HCFC refrigerants, such as R22. Suitable for very low evaporation temperatures down to -80° C. Due to their excellent stability RENISO S / SP – products are suitable for the lubrication of highly stressed refrigerant compressors. **Based on alkyl benzene**
RENISO SP 46 (4 x 5 L)		869	190	46	5.3	26	-42	
RENISO SP 100		869	208	95	8.0	11	-33	
RENISO S 3246	RENISO S 3246 and RENISO S 68 do not contain AW (anti wear) -additives and are suitable for use with HCFC refrigerants, hydrocarbons and NH_3. DIN 51503: KAA, KC, KE	876	184	40	5.0	17	-42	RENISO S 3246 and RENISO S68 – suitable for R22, hydrocarbons as well as NH_3 applications.
RENISO S 68		871	192	68	6.6	-30	-36	

Overview of RENISO products

Brand name	Description	Density at 15 °C [kg/m³]	Flashp., Clev. [°C]	Kin. Visc. at 40 °C [mm²/s]	Kin. Visc. at 100 °C [mm²/s]	VI (Viscosity Index)	Pour-point [°C]	Main application area
RENISO TRITON SE/SEZ – Fully synthetic refrigeration oils based on polyol esters (POE)								
RENISO TRITON SEZ 22 (20 x 1 L) (4 x 5 L)	Fully synthetic refrigeration oils based on synthetic polyol esters - especially suitable for non-ozone depleting FC / HFC refrigerants, such as R134a, R404A, R507, R410A, R407C. Also suitable for hydrocarbon refrigerants. As polyol ester oils strongly tend to absorb water (hygroscopic behaviour), the contact of these lubricants with air (atmospheric humidity) has to be limited to a minimum. DIN 51503: KD, KE SE/SEZ is also suitable for the use with HFO and HFO/HFC refrigerants.	1003	248	20	4.4	133	-57	The RENISO TRITON SE/SEZ products are perfectly suited for all refrigeration circuits in which chlorine-free refrigerants (HFCs / FCs), e.g. R134a are used. RENISO TRITON SE/SEZ-refrigeration oils are recommended for hermetic, semi-hermetic and open piston compressors, as well as for screw and turbo compressors (depending on viscosity). Comprehensive tests have been performed with the use of RENISO TRITON SE/SEZ products with new refrigerants designed to replace R22, such as R422A/D and R417A. Comprehensive laboratory tests as well as practical experiences with HFO and HFO/HFC refrigerants already exist. **Based on polyol ester**
RENISO TRITON SEZ 32 (20 x 1 L) (4 x 5 L) (3 x 10 L) 		1004	250	32	6.1	141	-57	
RENISO TRITON SE 55 (20 x 1 L) (4 x 5 L) (3 x 10 L) 		1009	286	55	8.8	137	-48	
RENISO TRITON SEZ 68 (20 x 1 L) (4 x 5 L) (3 x 10 L) 		972	258	68	8.9	104	-39	
RENISO TRITON SEZ 80 (20 x 1 L)		992	251	80	10.6	118	-42	
RENISO TRITON SEZ 100 (4 x 5 L)		970	266	100	11.4	100	-30	
RENISO TRITON SE 170 (20 x 1 L) (4 x 5 L) (3 x 10 L) 		972	260	173	17.1	106	-27	
RENISO TRITON SE 220 (4 x 5 L)		976	294	220	19.0	98	-27	
RENISO TRITON SEZ 320 	Fully synthetic refrigeration oil based on saturated ester, suitable for ORC systems and HFO applications e.g. R1233zd. Also suitable for PFC and HCFC refrigerants.	1016	278	310	33.3	148	-42	
RENISO TRITON SEZ 35 SC (4 x 5 L)	For HFC/FC refrigerants. Specially developed for scroll compressors. DIN 51503: KD	1015	256	34	6.3	138	-51	RENISO TRITON SEZ 35 SC has a specific performance specification which is aligned on the use in scroll compressors. Suitable for all HFC/FC and HFO refrigerants. **Based on polyol ester**

RENISO

Brand name	Description	Density at 15 °C [kg/m³]	Flashp., Clev. [°C]	Kin. Visc. at 40 °C [mm²/s]	Kin. Visc. at 100 °C [mm²/s]	VI (Viscosity Index)	Pour-point [°C]	Main application area
RENISO SYNTH 68 / RENISO UltraCool – Fully synthetic refrigeration oils based on synthetic hydrocarbons (PAO)								
RENISO SYNTH 68	Synthetic refrigeration oil based on polyalphaolefins (PAO). For NH_3 applications and hydrocarbon refrigerants. Also suitable for CO_2 (not miscible with CO_2). DIN 51503: KAA, KB, KE NSF-H1-approved, acceptable as a lubricant with incidental food contact, for use in and around food processing areas.	835	260	68	10.5	142	-57	RENISO SYNTH 68 has been developed especially for the lubrication of highly stressed NH_3 compressors. Excellent stability with NH_3. Excellent low temperature flowability, suitable for evaporation temperatures below -50°C. Very good thermal stability. Very good lubricity also in hydrocarbon (propane R290, propylene R1270, etc.) and CO_2 applications (not miscible with CO_2). **Based on PAO**
RENISO UltraCool 68	Refrigeration oils based on synthetic hydrocarbons. Particularly developed for ammonia applications. DIN 51503: KAA	854	250	62	9.1	124	-48	RENISO UltraCool 68 and UltraCool 100 combine high thermal stability (no varnish, no sludge) and low evaporation rate (low oil carry-over/ low oil loss) with good elastomer compatibility (CR, HNBR, NBR).
RENISO UltraCool 100 Packages on request		857	239	108	14.4	136	-45	
RENISO PG 68 – Fully synthetic refrigeration oil based on polyalkylene glycols (PAG) for NH_3 applications								
RENISO PG 68 (4 x 5 L)	Fully synthetic refrigeration oil based on polyalkylene glycols (PAG), miscibility gap 10% oil / 90% NH_3: separation of phase at -35 °C. NH_3 – partly miscible refrigeration oil, also suitable for hydrocarbon applications. DIN 51503: KAB, KE	1,044	250	70	14.0	210	-52	RENISO PG 68 is an ultra-dried, synthetic refrigeration oil based on PAG for NH_3 systems which operate on the principle of direct expansion. Suitable for screw and reciprocating piston compressors. **Warning:** - PAG oil is not compatible / miscible with mineral oil. - PAG oil is hygroscopic. Avoid any contamination with water or ambient air. Please contact our FUCHS application engineers. **Based on polyglycol**

Overview of RENISO products

Brand name	Description	Density at 15 °C [kg/m³]	Flashp., Clev. [°C]	Kin. Visc. at 40 °C [mm²/s]	Kin. Visc. at 100 °C [mm²/s]	VI (Viscosity Index)	Pour-point [°C]	Main application area
RENISO PAG – Fully synthetic refrigeration oils based on polyalkylene glycols (PAG) for car a/c systems								
RENISO PAG 46 (24 x 250 ml) (20 x 1 L) (on request)	Synthetic refrigeration oils based on special polyalkylene glycols (PAG) for automotive air conditioning units with R134a. NH_3 – partly miscible refrigeration oils. Also suitable for hydrocarbon applications. DIN 51503: KAB, KD, KE	992	240	55	10.6	187	-45	Refrigeration oils based on polyalkylene glycols for application with the refrigerant R134a used in car and truck air conditioning systems (a/c systems). RENISO PAG 100 is especially suitable for vane compressors. RENISO PAG 46 and PAG 100 are also recommended for the use with hydrocarbon refrigerants and ammonia. **Based on polyglycol**
RENISO PAG 100 (24 x 250 ml) (20 x 1 L) (on request)		996	240	120	21.0	202	-45	
RENISO PAG 1234 (24 x 250 ml)	Synthetic refrigeration oil on the basis of double-end-capped polyalkylene glycols (PAG). For vehicle a/c systems with R1234yf. Also suitable for R134a. DIN 51503: KD	993	224	44	9.8	218	-45	RENISO PAG 1234 has been newly developed for car air-conditioning systems with R1234yf. The product combines both good miscibility properties and high thermo-chemical stability in contact with the refrigerant. Basic fluid and additivation of RENISO PAG 1234 guarantee best lubrication properties and wear protection. **Based on polyglycol**
Fully synthetic refrigeration oil based on POE for car a/c systems in electric and hybrid cars								
RENISO TRITON SEZ 75 AC Packages on request	Synthetic refrigeration oil for electrically driven, hermetic compressors in R1234yf car a/c systems. Also suitable for R134a. DIN 51503: KD	992	246	75	9.9	113	-42	RENISO TRITON SEZ 75 AC was developed to lubricate electric compressors in car a/c systems. Due to its high electrical resistivity RENISO TRITON SEZ 75 AC is the ideal lubricant to secure the insulation of the electrical compressor parts at any time. Beyond that RENISO TRITON SEZ 75 AC guarantees reliable lubrication, excellent wear protection and safe oil transport in the refrigeration circuit.

RENISO

Brand name	Description	Density at 15 °C [kg/m³]	Flashp., Clev. [°C]	Kin. Visc. at 40 °C [mm²/s]	Kin. Visc. at 100 °C [mm²/s]	VI (Viscosity Index)	Pour-point [°C]	Main application area
RENISO ACC 68, RENISO ACC HV – Fully synthetic refrigeration oils based on polyalkylene glycols (PAG) for CO_2 applications								
RENISO ACC 68 (4 x 5 L)	Synthetic refrigeration oil based on special, double-end capped PAGs for for transcritical CO_2 applications (industrial and commercial applications). DIN 51503: KB	992	>220	68	14.1	215	-42	Refrigeration oil based on thermally very stable, double-end capped PAGs for industrial transcritical CO_2 applications (particularly for air-conditioning and heat pump applications). Contains special additives to improve wear protection and ageing stability. **Based on polyglycol**
RENISO ACC HV (24 x 250 ml) (on request)	Refrigeration oils for the use in mobile A/C systems with CO_2 as refrigerant. Base oil: double end-capped PAG. DIN 51503: KB	991	229	68	14.0	216	-45	RENISO ACC HV was developed in close collaboration with leading compressor manufacturers and OEMs specifically for CO_2 air conditioning systems in vehicles. RENISO ACC HV is based on a chemical and thermal extremely stable double end-capped PAG fluid with efficient additivation – especially with regard to wear protection. **Based on polyglycol**
RENISO C – Fully synthetic refrigeration oils based on polyol esters (POE) for CO_2 applications								
RENISO C 55 E (20 x 1 L) (4 x 5 L) (on request)	Synthetic refrigeration oils based on special polyol esters with anti-wear additives for use with the refrigerant CO_2 (subcritical and transcritical applications). Also suitable for HFC / FC refrigerants. DIN 51503: KB, KD	1,009	286	55	8.8	137	-48	The RENISO C products were especially developed for use in applications with the refrigerant CO_2. Application fields: supermarket refrigeration equipment (subcritical deep-freeze stage of cascade systems & transcritical applications), ship cooling, as well as nearly all fields of industrial and commercial refrigeration. **Based on polyol ester**
RENISO C 85 E (20 x 1 L) (4 x 5 L) (3 x 10 L) (on request)		993	246	80	10.6	118	-42	
RENISO C 170 E (3 x 10 L) (on request)		976	286	172	18.0	116	-33	
NEW **Fully Synthetic Refrigeration Oils based on Polyalkylene Glycols (PAG) for Hydrocarbon Refrigerants Applications**								
RENISO LPG 68 (4 x 5 L)	**Range RENISO LPG** Synthetic refrigeration oil **based on polyalkylene glycols (PAG)**. For the application area of hydrocarbon refrigerants like propane (R290), propene (R1270). Synergetic acting additives improve the properties of the used base oils. Depending on the field of application and type of compressor, different viscosities are used. Controlled hydrocarbon solvency for less viscostiy reduction. DIN 51503 - KE	990	226	68	12.7	189	-48	For piston, scroll and screw compressors (observe operating conditions, e.g. pressure, temperature) **Based on polyglycol**
RENISO LPG 100 (4 x 5 L) (on request)		992	228	100	18.1	201	-45	
RENISO LPG 220 (4 x 5 L) (on request)		999	240	220	36.9	219	-42	

New innovative RENISO refrigeration oils by FUCHS – heat pump applications

NEW!

Heat pumps are gaining in importance. Thereby optimized compressors are used in the different performance ranges. The biggest field of application are heat pumps for heating systems and for hot and used water treatment. Heat pump dryers additionally are of high importance. The field of industrial large-scale heat pumps, especially high-temperature heat pumps, are gaining in their importance. Different designs and performance classes are carried out. Besides turbo compressors, screw compressors and piston compressors are used in this field. The applied refrigerants, refrigerant gases, in the range of the heat pumps vary greatly. For high temperature heat pumps synthetic refrigerants like R1234ze, R1336mzz or HFO refrigerants and their mixtures are applied. Fully synthetic refrigerants, e.g. R1233zd, are also used for ORC systems (Organic-Rankine-Cycle systems).

Additionally, hydrocarbon refrigerants are considered, designed and qualified (iso-pentane, pentane) for this field of application. A broad range of hydrocarbon refrigerants are discussed, e.g. high temperature heat pumps with the working substance pentane (R601). In these high temperature heat pumps, temperatures of up to 150 °C and 160 °C are reached at the corresponding pressure. Special refrigeration oils for the different fields of application, compressor types, pressure and temperature levels were developed to meet the requirements of high temperature heat pumps and heat pump applications.

RENISO TRITON CE 500

A fully synthetic refrigeration oil based on saturated, synthetic ester (POE) for high temperature heat pumps for the refrigerant R1234ze, R1336mzZ.

Density at 15 °C [kg/m³]	Flashpoint, Clev. [°C]	Kin. Viscosity at 40 °C [mm²/s]	Kin. Viscosity at 100 °C [mm²/s]	VI (Viscosity Index)	Pourpoint [°C]	Water content [ppm]
950	221	505	52.1	166	–33	< 50

New innovative RENISO refrigeration oils by FUCHS

RENISO PAG 460
Special fully synthetic refrigeration oil based on special polyalkylene glycol (PAG), for the use in high temperature heat pump systems with hydrocarbon refrigerants, e.g. pentane (R601), iso-pentane (R601a).

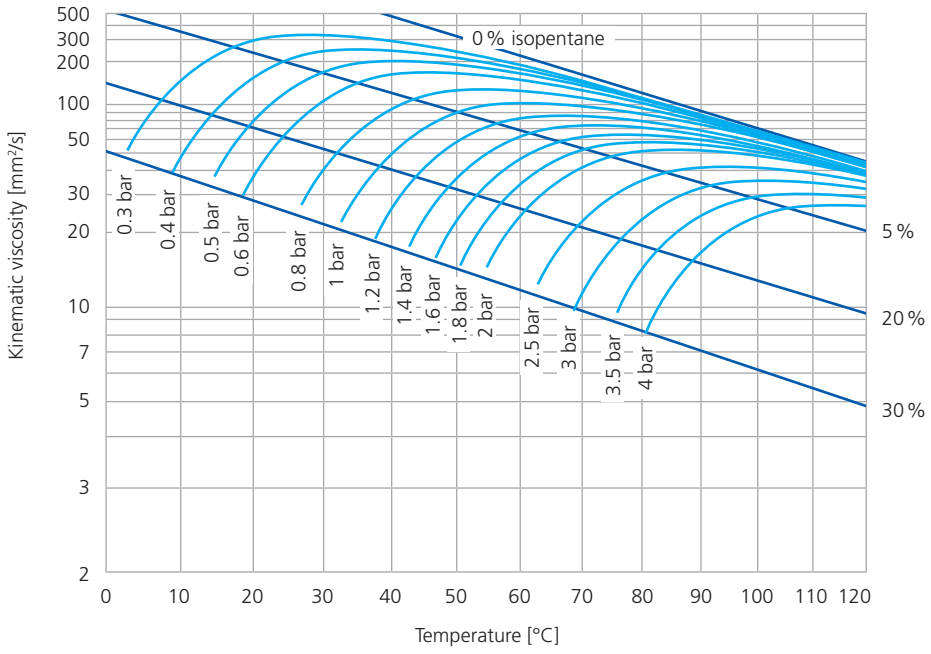
On request

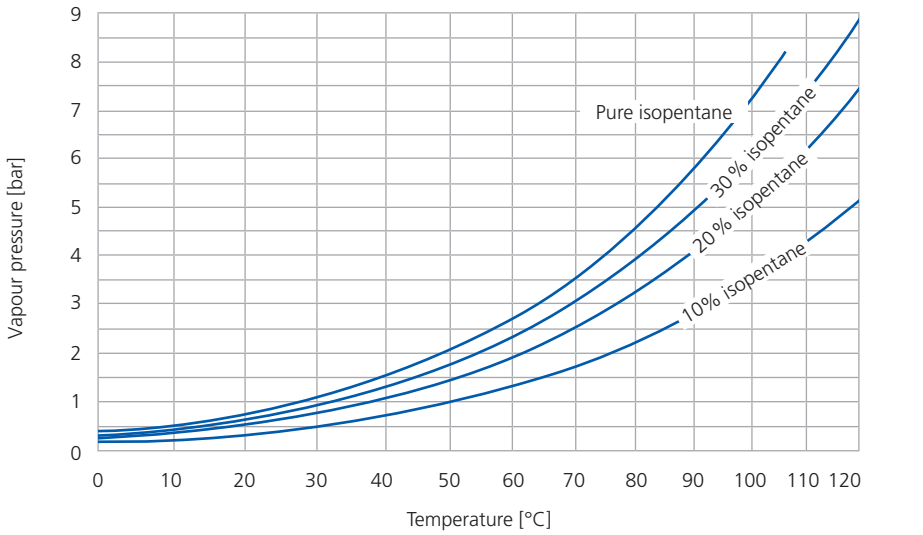
Density at 15 °C [kg/m³]	Flashpoint, Clev. [°C]	Kin. Viscosity at 40 °C [mm²/s]	Kin. Viscosity at 100 °C [mm²/s]	VI (Viscosity Index)	Pourpoint [°C]	Water content [ppm]
1077	250	460	79	255	–36	< 350

Refrigeration oil for hydrocarbons:

RENISO PAG 460 based on PAG

Example:
kinematic viscosity and vapour pressure (Daniel-Plot): RENISO PAG 460 - R601a (i-pentane) - mixture





NEW!

RENISO TRITON SEZ 320

Fully synthetic refrigeration oil based on saturated ester, suitable for ORC systems and HFO applications e.g. R1233zd. Also suitable for PFC and HCFC refrigerants.

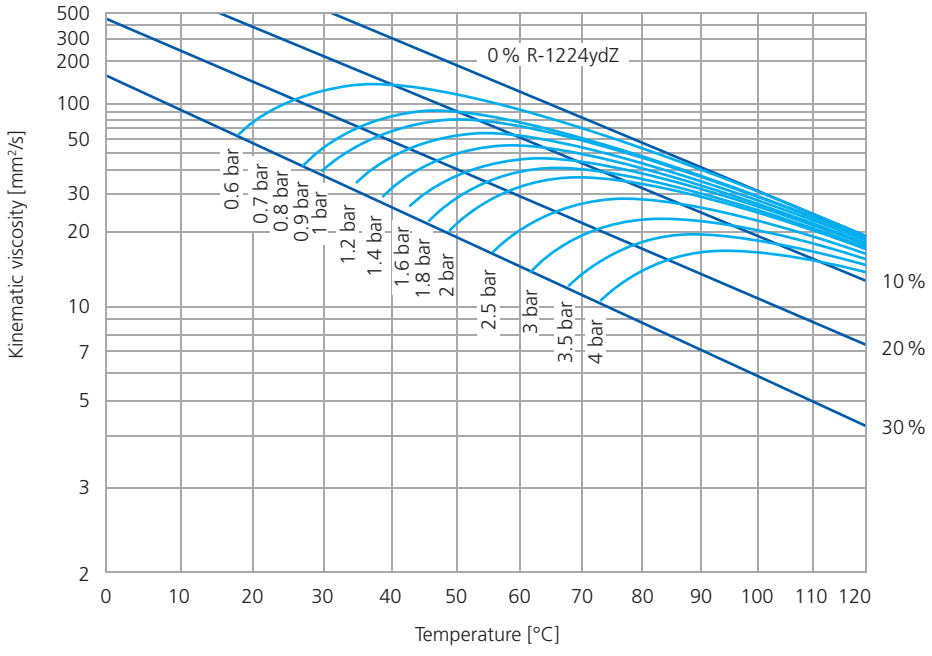
On request

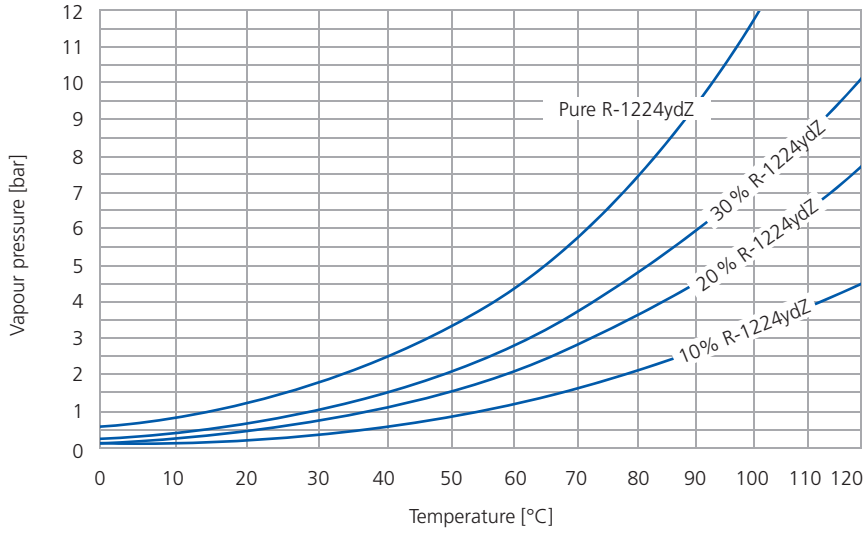
Density at 15 °C [kg/m³]	Flashpoint, Clev. [°C]	Kin. Viscosity at 40 °C [mm²/s]	Kin. Viscosity at 100 °C [mm²/s]	VI (Viscosity Index)	Pourpoint [°C]	Water content [ppm]
1016	278	310	33.3	148	–42	< 50

Refrigeration oils for HFO-applications:

RENISO TRITON SEZ 320 based on POE

Example:
kinematic viscosity and vapour pressure (Daniel-Plot): RENISO TRITON SEZ 320 - R1224yd - mixture





New innovative RENISO refrigeration oils by FUCHS

RENISO LPG

For the application area of hydrocarbon refrigerants like propane (R290), propene (R1270) special refrigeration oils based on polyalkylene glycols (PAG) were developed.

Synergetic acting additives improve the properties of the used base oils. Depending on the field of application and type of compressor, different viscosities are used.

RENISO LPG 68

for piston, scroll and screw compressors (observe operating conditions, e.g. pressure, temperature) (4 x 5 L)

Density at 15 °C [kg/m³]	Flashpoint, Clev. [°C]	Kin. Viscosity at 40 °C [mm²/s]	Kin. Viscosity at 100 °C [mm²/s]	VI (Viscosity Index)	Pourpoint [°C]	Water content [ppm]
990	226	68	12.7	189	–48	300

RENISO LPG 100

for piston, scroll and screw compressors (observe operating conditions, e.g. pressure, temperature) (4 x 5 L),

Density at 15 °C [kg/m³]	Flashpoint, Clev. [°C]	Kin. Viscosity at 40 °C [mm²/s]	Kin. Viscosity at 100 °C [mm²/s]	VI (Viscosity Index)	Pourpoint [°C]	Water content [ppm]
992	228	100	18.1	201	–45	300

RENISO LPG 150

for piston, scroll and screw compressors (observe operating conditions, e.g. pressure, temperature) On request

Density at 15 °C [kg/m³]	Flashpoint, Clev. [°C]	Kin. Viscosity at 40 °C [mm²/s]	Kin. Viscosity at 100 °C [mm²/s]	VI (Viscosity Index)	Pourpoint [°C]	Water content [ppm]
994	238	149.9	26.2	211	–42	300

RENISO LPG 220

for piston, scroll and screw compressors (observe operating conditions, e.g. pressure, temperature) (4 x 5 L),

Density at 15 °C [kg/m³]	Flashpoint, Clev. [°C]	Kin. Viscosity at 40 °C [mm²/s]	Kin. Viscosity at 100 °C [mm²/s]	VI (Viscosity Index)	Pourpoint [°C]	Water content [ppm]
999	240	220	36.9	219	–42	–

Higher viscosities on request

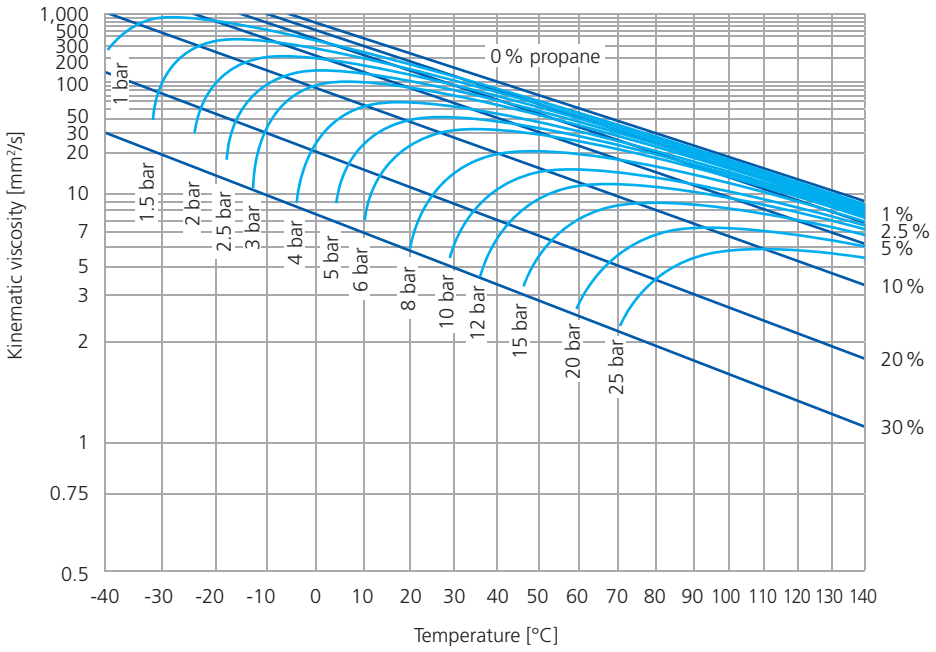
NEW!

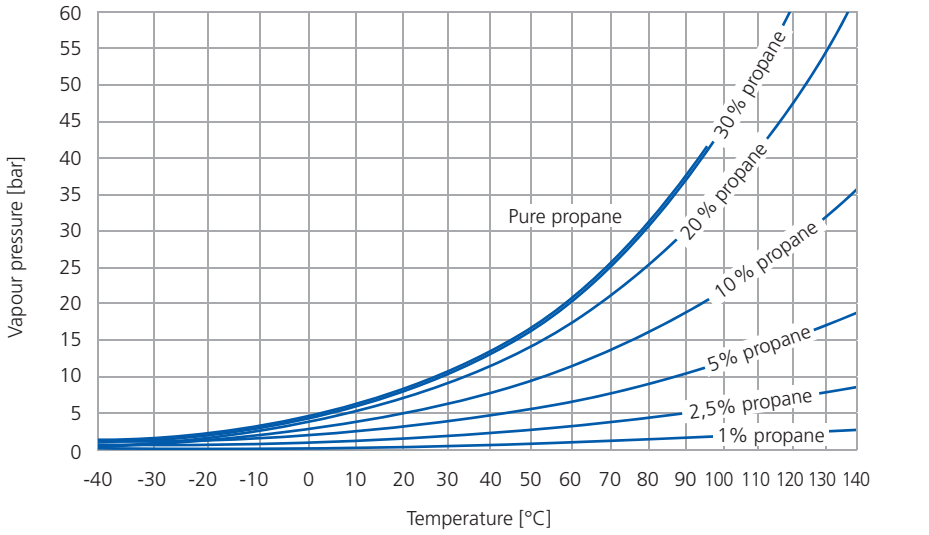
Refrigeration oil for hydrocarbons:

RENISO LPG 100 based on PAG

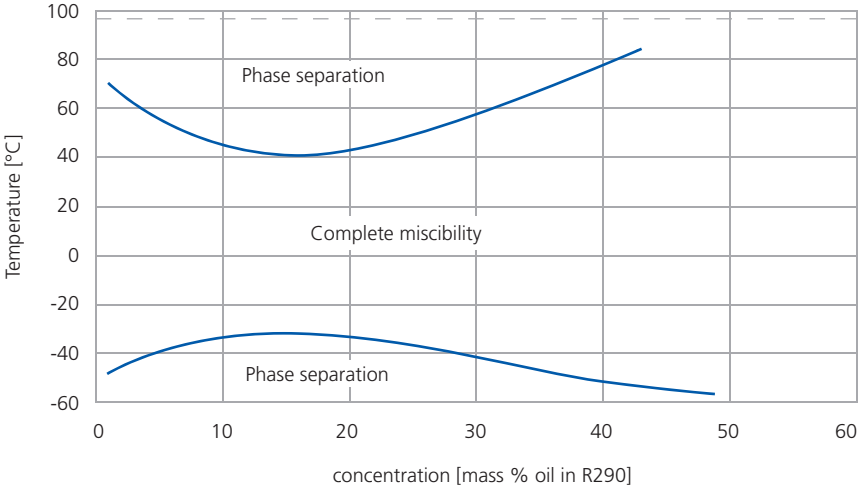
Example:
kinematic viscosity and vapour pressure (Daniel-Plot):
RENISO LPG 100 - R290 - mixture

(Further diagrams on page 32-36)





Example miscibility gap:
miscibility of
RENISO LPG 100 with R290



Which refrigeration oil for which refrigerant?

Refrigeration oil selection guide: RENISO refrigeration oils for industrial and commercial refrigeration systems

HCFC refrigerant applications – selection of viscosity

Refrigerant		Evaporation temperature		Compressor type							
ASHRAE name	Type	from (°C)	to (°C)	Piston (viscosity grade)			Screw (viscosity grade)			Centrifugal (viscosity grade)	
R22	HCFC	-50	+10	32/46 ▲	32/46 **P**		68 ▲	68/100 **P**		68 ▲	68
R401A	HCFC	-20	+10	32/46				100			68
R402A	HCFC	-50	-30	32			100				
R408A	HCFC	-50	-30	32			100				
R409A	HCFC	-20	+10	32/46			100				

Natural refrigerant applications, e.g. HC, NH_3, CO_2

Refrigerant		Evaporation temperature		Compressor type							
ASHRAE name	Type	from (°C)	to (°C)	Piston (viscosity grade)			Screw (viscosity grade)			Centrifugal (viscosity grade)	
R290	Propane	-30	+20	68 **P**	68 **P**	80 **P**	* **P**	* **P**		*	* **P**
R1270	Propylene	-30	+20	68 **P**	68 **P**	80 **P**	* **P**	* **P**		*	* **P**
R600	Butane	-30	+20	68 **P**	68 **P**	80 **P**	* **P**	* **P**		*	* **P**
R600a	Isobutane	-30	+20	68 **P**	68 **P**	80 **P**	* **P**	* **P**		*	* **P**
R717	NH_3	-50	+10	68 ▲	68 **P**	68	46/68	46/68 **P**	46/68	68	
R717	NH_3 - DX	-50	+10	68 **P**	68			68			
R744	CO_2 - subcritical	-50	-10	55/80 **P**	68			170			
R744	CO_2 - transcritical	-50	-10	80 **P**	68			170			

HCFC = Hydrochlorofluorocarbon
HFC = Hydrofluorocarbon
HFO = Hydrofluoro-Olefin

RENISO SYNTH 68 / RENISO UltraCool based on PAO / synthetic hydrocarbon
RENISO K series based on mineral oils (MO)
RENISO S/SP series based on alkyl benzenes (AB)
RENISO TRITON SE/SEZ series based on polyol esters (POE)
RENISO PG/LPG/PAG based on polyalkylene glycols (PAG)
RENISO C series based on polyol ester for CO_2 (POE-CO_2)
RENISO ACC 68 based on polyalkylene glycols for CO_2 (PAG-CO_2)

P = Preferred recommendation
* Selection of viscosity grade acc. to recommendation of compressor manufacturer
▲ = Mineral oil with restricted suitability for very low evaporation temperatures (restricted cold flowability)

HFC & HFO refrigerant applications

Refrigerant		Evaporation temperature		Compressor type		
ASHRAE name	Type	from (°C)	to (°C)	Piston (viscosity grade)	Screw (viscosity grade)	Centrifugal (viscosity grade)
R23	HFC	-100	-40	22/32		
R134a	HFC	-30	+10	32/55	100/170/220	68
R32	HFC	-15	+15	32/55	170/220	
R404A	HFC	-50	-30	32/55	100/170/220	68
R407C	HFC	0	+10	55/68	170/220	
R410A	HFC	-45	+10	32/55	100/170/220	68
R410B	HFC	-25	+10	32/55	170/220	68
R417A	HFC	-15	+15	55/68	170/220	68
R422A	HFC	-45	-5	22/32/55	100/170/220	68
R422D	HFC	-45	+10	32/55	100/170/220	68
R427A	HFC	-40	+10	22/32/55	100/170/220	68
R507	HFC	-40	0	32/55	100/170/220	68
R1233zd(E)	HFO	-10	+100	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*
R1234yf	HFO	-30	+10	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*
R1234ze(E)	HFO	-10	+25	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*
R1336mzz(Z)	HFO	-10	+150	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*
R444B	HFO/HFC	-30	+15	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*
R448A	HFO/HFC	-40	+15	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*
R449A	HFO/HFC	-40	+25	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*
R450A	HFO/HFC	-25	+15	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*
R452A	HFO/HFC	-40	+15	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*
R452B	HFO/HFC	-25	+15	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*
R454A	HFO/HFC	-40	+15	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*
R454B	HFO/HFC	-25	+15	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*
R454C	HFO/HFC	-40	+15	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*
R455A	HFO/HFC	-40	+15	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*
R513A	HFO/HFC	-25	+25	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*
R514A	HFO/t-DCE	-10	+100	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*	RENISO TRITON SE/SEZ*

* Selection of viscosity grade acc. to recommendation of compressor manufacturer

The RENISO product portfolio

Product group	Refrigerant	Refrigeration oil
Mineral oils (MO)	for NH_3 and R22	RENISO KM 32 RENISO KS 46 RENISO KC 68 RENISO KES 100
	for isobutane (e.g. R600a - hermetic compressors)	RENISO WF 2,3 A RENISO WF 5 A RENISO WF 7 A RENISO WF 10 A RENISO WF 15 A
Synthetic hydrocarbons	for NH_3	RENISO UltraCool 68 RENISO UltraCool 100
Polyalphaolefin (PAO)	for NH_3, CO_2 (not miscible) and hydrocarbons	RENISO SYNTH 68
Polyalkylene glycols (PAG)	for NH_3 (miscible with NH_3) and hydrocarbons	RENISO PG 68
	for hydrocarbons, e.g. propane R290, propylene R1270, isobutane R600a	RENISO LPG 68 RENISO LPG 100 RENISO LPG 150 RENISO LPG 220
Alkyl benzenes (AB)	for R22 and hydrocarbons	RENISO SP 32 RENISO SP 46 RENISO SP 100
	for R22, hydrocarbons and NH_3	RENISO S 3246 RENISO S 68
Polyol esters (POE)	for HFC/FC, e.g. R134a, R404A, R507, R410A, R407C for HFO and HFO/HFC refrigerants	RENISO TRITON SEZ 22 RENISO TRITON SEZ 32 RENISO TRITON SEZ 35 SC RENISO TRITON SE 55 RENISO TRITON SEZ 68 RENISO TRITON SEZ 80 RENISO TRITON SEZ 100 RENISO TRITON SE 170 RENISO TRITON SE 220 RENISO TRITON SEZ 320
Special polyol esters (POE)	for CO_2 (subcritical and transcritical)	RENISO C 55 E RENISO C 85 E RENISO C 170 E
Special polyalkylene glycol (PAG)	for CO_2 transcritical systems in stationary application (heat pumps, a/c systems). Industrial and commercial applications.	RENISO ACC 68
Special polyalkylene glycols (PAG) for mobile a/c systems	for R134a in mobile a/c systems, for hydrocarbons and for NH_3 (miscible with NH_3, industrial application)	RENISO PAG 46 RENISO PAG 100
	for R1234yf and R134a mobile a/c systems	RENISO PAG 1234
	for CO_2 mobile a/c systems	RENISO ACC HV
Special polyol esters (POE) for mobile a/c systems in electric and hybrid cars	for R1234yf and R134a mobile a/c systems with electric compressor	RENISO TRITON SEZ 75 AC

Notes

Note
The information contained in this product brochure is based on the experience and know-how of FUCHS LUBRICANTS GERMANY GmbH in the development and manufacturing of lubricants and represents the current state-of-the-art. The performance of our products can be influenced by a series of factors, especially the specific use, the method of application, the operational environment, component pre-treatment, possible external contamination, etc. For this reason, universally-valid statements about the function of our products are not possible.

Our products must not be used in aircraft or spacecraft. Our products may be used in the manufacture of components for aircraft or spacecraft if they are removed without residue from the components prior to assembly into the aircraft or spacecraft.

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FUCHS Lubricants

Innovative lubricants need experienced application engineers

Every lubricant change should be preceded by expert consultation on the application in question. Only then can the best lubricant system be selected. Experienced FUCHS engineers will be happy to advise on products for the application in question and also on our full range of lubricants.

Contact:

FUCHS LUBRICANTS GERMANY GmbH
Friesenheimer Straße 19
68169 Mannheim/Germany
Phone +49 621 3701-0
Fax +49 621 3701-7000
E-mail zentrale-flg@fuchs.com
www.fuchs.com/de/en

Export Division
Friesenheimer Straße 19
68169 Mannheim/Germany
Phone +49 621 3701-1703
Fax +49 621 3701-7719
E-mail export-flg@fuchs.com
www.fuchs.com/de/en

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