

**Refrigeration Oils
2018/2019**



LUBRICANTS.
TECHNOLOGY.
PEOPLE.



LUBRICANTS. TECHNOLOGY. PEOPLE.

We are completely focused on high-quality lubricants and related specialties.

We develop innovative and reliable solutions for a wide variety of applications.

We value the high level of commitment of our employees and their trusting interaction with one another.

Facts and figures

FUCHS Group

Established 3 generations ago as a family-owned business

Position: No. 1 worldwide among the independent suppliers of lubricants

Companies worldwide: 58

Employees: Almost 5,000 employees

Product program: A full range of over 10,000 lubricants and related specialties

FUCHS SCHMIERSTOFFE GMBH

100% subsidiary of FUCHS PETROLUB SE

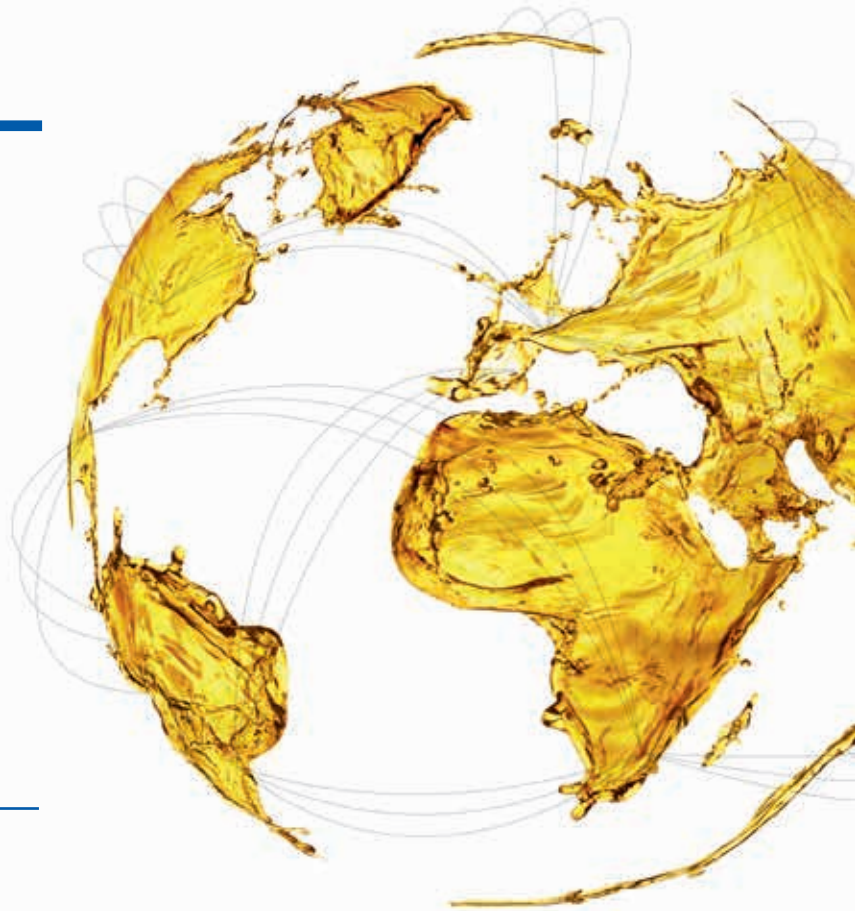
Headquarters: Mannheim

Further production plants Wedel, Kiel

Employees: More than 800 employees

Certifications: IATF 16949, DIN ISO 14001, BS OHSAS 18001, ISO 50001

References: Leading lubricant manufacturer for the German automotive industry



FUCHS is a global Group with German roots that develops, produces and distributes lubricants and related specialties.

We have more than 100,000 customers, including companies from the following fields: automotive suppliers, OEM, mining and exploration, metalworking, agriculture and forestry, aerospace, power generation, mechanical engineering, construction and transport, as well as steel, metal and cement industries, yet also companies in the food industry, glass production sector and the casting and forging industry – and many others.

Founded in 1931 as a family business in Mannheim today there are more than 58 operating companies with almost 5,000 employees in more than 40 countries under the umbrella of FUCHS PETROLUB SE. FUCHS is the world's largest provider among the independent lubricant manufacturers.

FUCHS SCHMIERSTOFFE GMBH works with a team of more than 800 specialists on 3 subsidiaries across Germany to guarantee the satisfaction of our customers.

In close contact with its customers FUCHS develops custom-made, innovative and reliable solutions for the most diverse applications. Whatever their requirements we have the ideal lubricant for their specific applications and processes. In our technology center we link interdisciplinary expertise in a quick and efficient way – and work on innovative lubricant solutions to meet the demands of today and tomorrow every single day.

FUCHS lubricants stand for performance and sustainability, for safety and reliability, for efficiency and cost savings. They represent a promise: technology that pays off.



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The FUCHS service program



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.

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The development of high-performance refrigeration oils

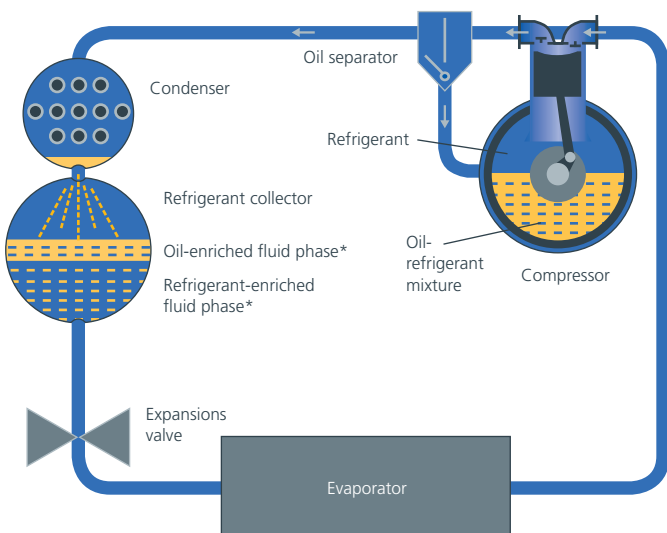
The interaction with other substances, in particular with the refrigerant, at fluctuating high and low temperatures creates very specific demands on the lubricant in the circuit.

The principal function of a refrigeration oil is to adequately lubricate 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.

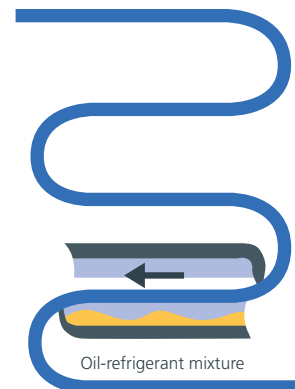
The compressor type, the efficiency of the oil separator, the design of the refrigeration system, the operating parameters, the refrigeration oil selection etc. are responsible for varying amounts of oil present in the refrigerant circuit. Oil content in the system usually can reach ranges from 1 to 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 satisfactory 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 then 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.

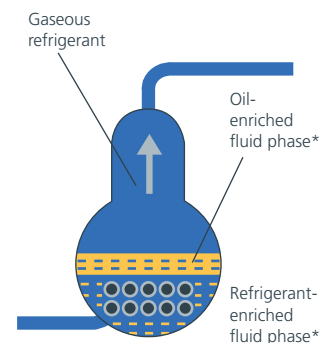
Scheme of refrigeration circuit



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 (GWP=1) and propane (GWP=3), but also synthetic fluorinated alternatives like R1234yf and R1234ze(E) (both GWP<1) are already increasing in their use. On the contrary 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 diverse refrigerants are performed. 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 setups can be examined and suitable lubricants can be selected and continuously improved.

Because of the new challenges also for refrigeration oils which are coming up owing to the commencement of 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 polyalphaolefins
- Synthetic refrigeration oils based on polyol esters
- Synthetic refrigeration oils based on polyalkylene glycols
- Synthetic refrigeration oils for CO₂ applications
- Synthetic refrigeration oils for HFO refrigerants

A photograph of two scientists, a man and a woman, in a laboratory. They are both wearing white lab coats with a logo on the chest and safety glasses. The man is holding a large white folder or document, and both are looking at it intently. The woman is also wearing blue gloves and holding a small vial. The background shows laboratory equipment and a window.

REQUIREMENTS AND CLASSIFICATION OF REFRIGERATION OILS

DIN 51503 describes the minimum requirements which 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 refrigerant 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 (2011) is in line with the refrigerants used in the refrigeration system

CAA

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 CAA products. Hydrogenated mineral oils and PAO get more and more important.

KAB

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

KB

Refrigeration oils for carbon dioxide (CO₂) – synthetic polyol esters (POE), polyalkylene glycols (PAG) or polyalphaolefins (PAO). POE oils generally offer good CO₂ miscibility. PAG oils and CO₂ only allow limited miscibility (larger miscibility gap with CO₂). Synthetic, polyalphaolefin-based refrigeration oils are not miscible with CO₂.

KC

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

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

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.

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. 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, 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 partly used 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 according to DIN ISO 2049:

Colour is product specific and can vary between crystal-clear (colour number 0) and dark brown (colour number 5).

Density according to DIN 51757:

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.

Neutralization number according to DIN 51558-1:

The neutralization 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 neutralization number is shown in mg KOH/g. A comparison with fresh oil values is essential when evaluating a used refrigeration oil. The neutralization numbers of refrigeration oils are very low compared to other lubricants. They are in the region of < 0.1 mg KOH/g.

The neutralization 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, 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 Part 2

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 when compared to other lubricants, refrigeration oils are normally used “ultra-dried”.

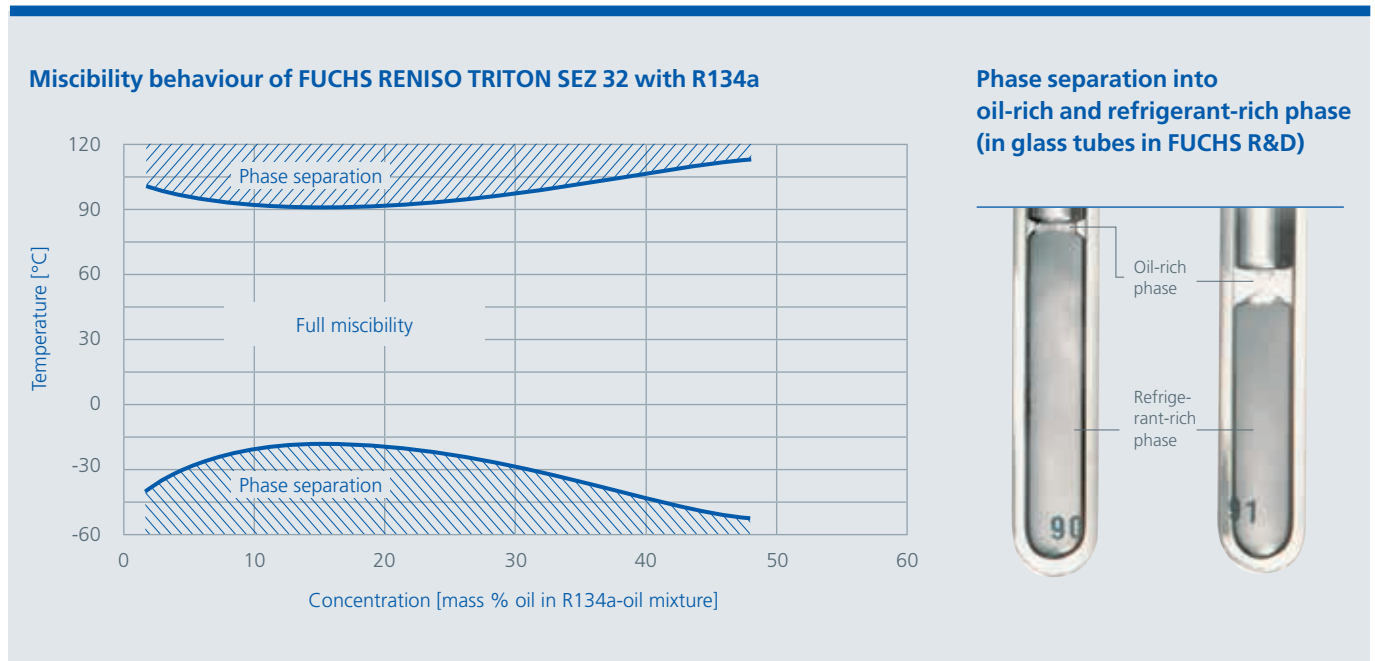
Pourpoint according to DIN ISO 3016:

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



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. 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 decisive 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.

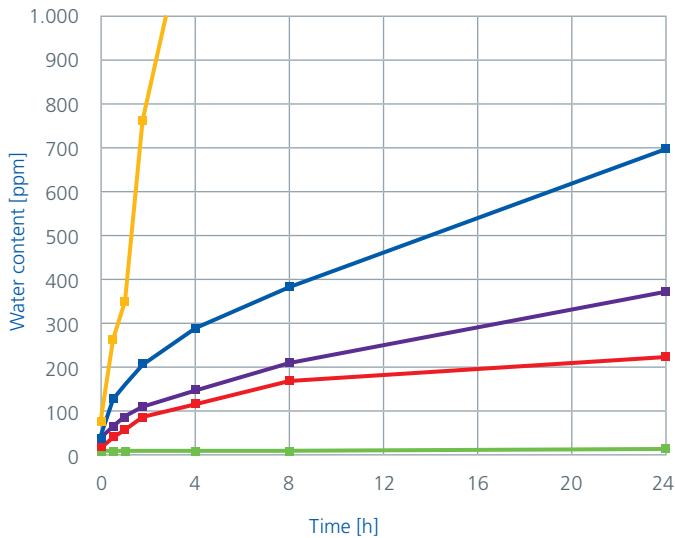
Refrigerant compatibility according to ASHRAE 97-2007:

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 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 neutralization number is tested and the surface of the metal pieces is examined for changes.

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 present 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 show no significant increase in water content.

Water absorption (hygroscopicity) of refrigeration oils



Water content according to DIN 51777-2

		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

Polyol esters (POE), which are described as polar, hygroscopic lubricants, display a continuously 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 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 thus 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.

Well-known indicators of oil ageing are an increase in neutralization number (acid 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 thus aged oil is used as a criterion 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 DIN 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 Grades. The reference temperature is 40 °C and the official unit of kinematic viscosity is m²/s but in the lubrication world, the units mm²/s or cSt are more common. DIN 51519 defines 18 different viscosity grades from 2 to 1000 mm²/s at 40 °C for fluid industrial oils. Every viscosity grade is described by the mean 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 falls 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 in question. The viscosity to be applied is normally specified by the compressor manufacturer.

This information alone 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.

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 correspondingly good lubricity.

To achieve reliable protection against wear the use of high-performance additives (AW 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 next page) 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.

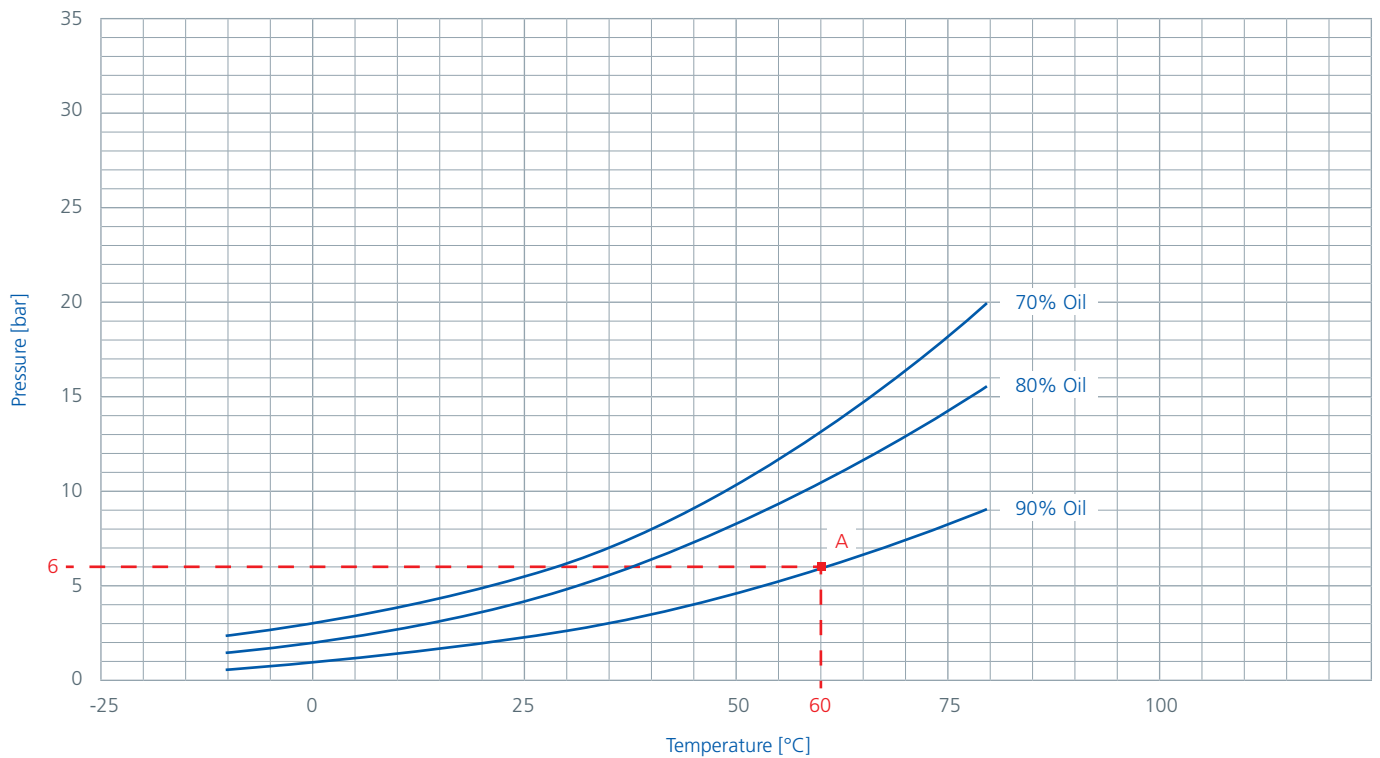
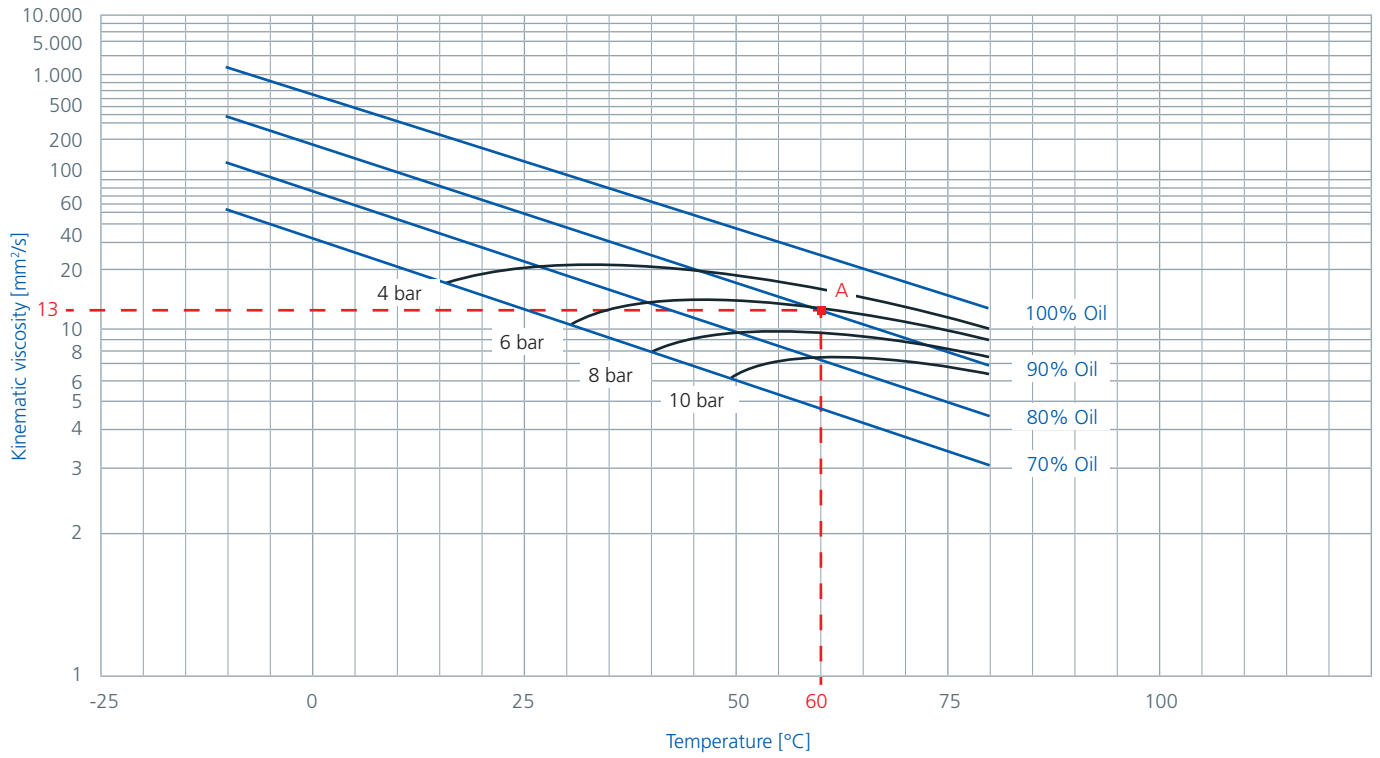
The resulting mixture viscosity can be taken from the upper diagram (see also next page) where the lines for the given temperature and for the corresponding percentage of oil dissolved in the refrigerant cross.

Example: Point A: 60 °C, 90 % → 13 mm²/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:
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

Example: Miscibility of RENISO WF 5 A with R600a (miscibility gap diagram)

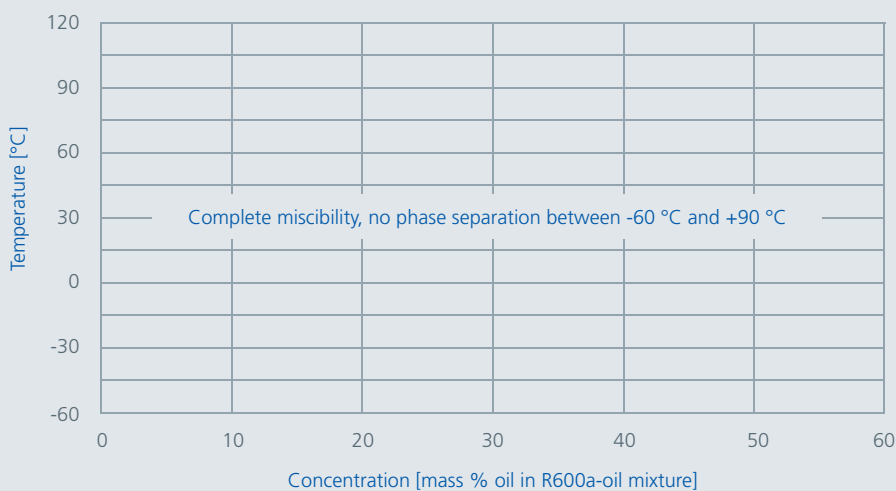


Photo: Nidec

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.

RENISO WF series

Selected, highly refined cuts with special anti-wear additives. The RENISO WF series – in the viscosity grades ISO VG 5-15 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 please.

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

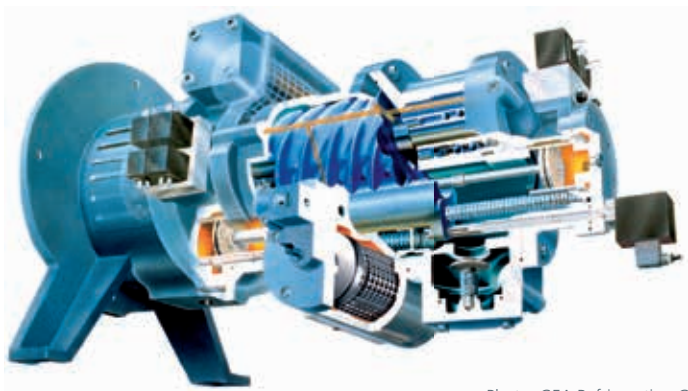
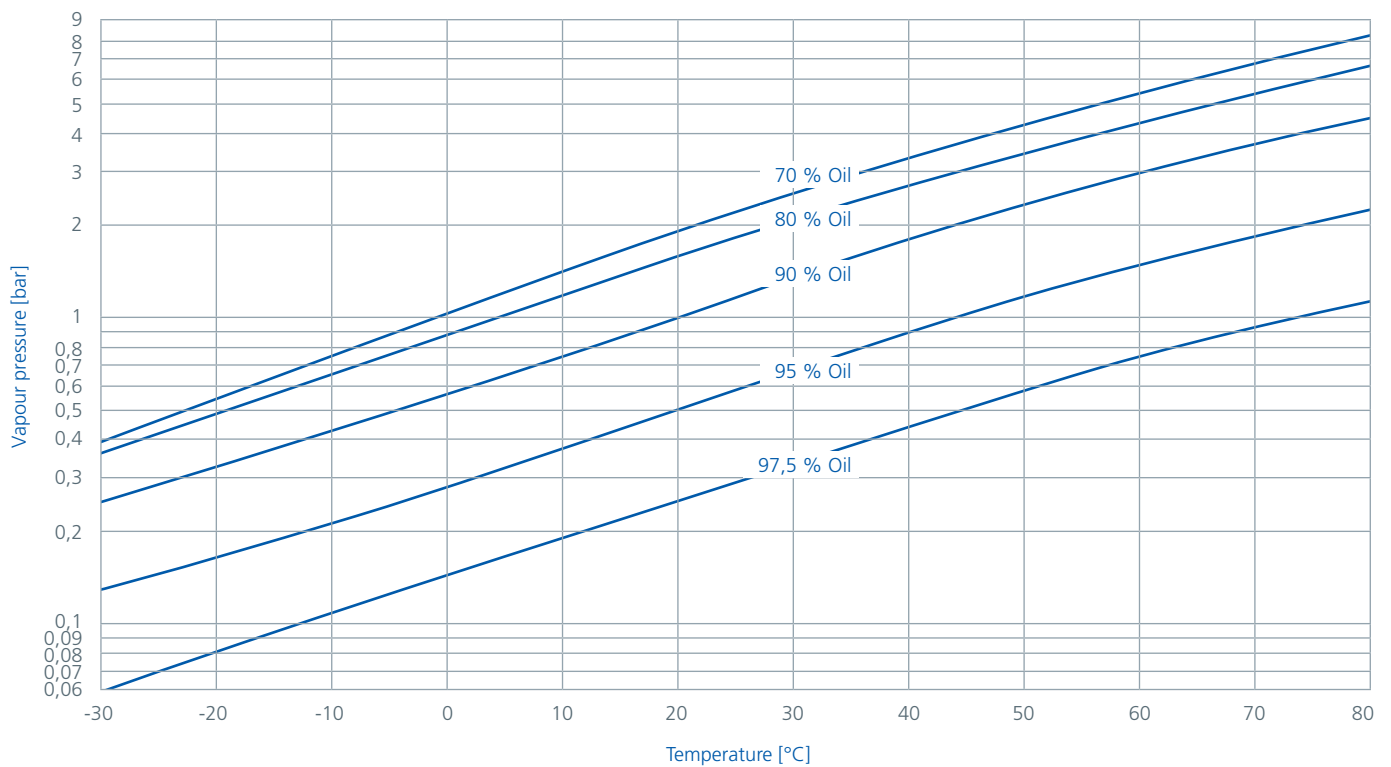
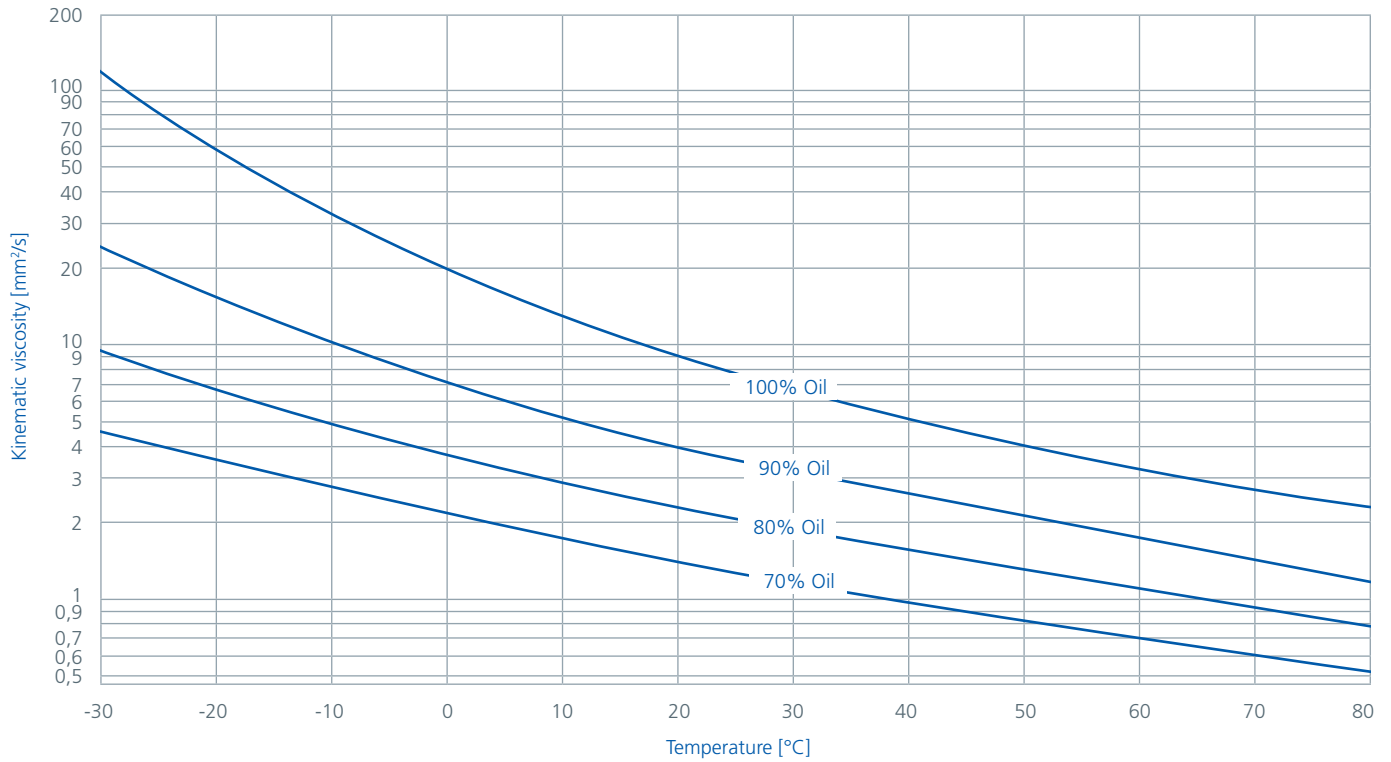


Photo: GEA Refrigeration Germany

**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: GEA Bock



Alkyl benzenes (AB)

RENISO S / SP series

Chemically and thermally highly stable alkyl benzene (AB) oils. 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 SP series products are recommended for R22 and its mixtures.

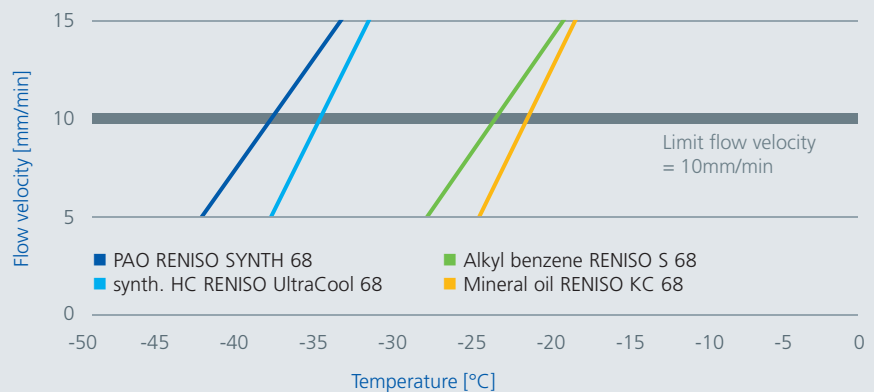
The RENISO SP grades containing AW additives are not suitable for NH₃ systems. The RENISO S series does not contain AW additives and is recommended for NH₃ applications.

RENISO S / SP series products can also be used with HCFCs refrigerants such as R22.

Determination of the flowability of refrigeration oils for NH₃: 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



Polyalphaolefins (PAO) / synthetic hydrocarbons



RENISO SYNTH 68

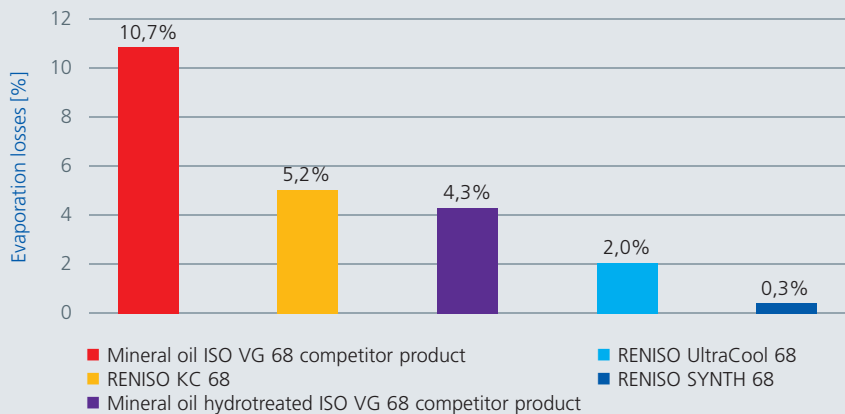
Thermally stable polyalphaolefin (PAO) with excellent cold flowing properties for NH₃ systems with highly stressed compressors and low evaporation temperatures. Due to its outstanding cold flow properties RENISO SYNTH 68 is also recommended for the use in plate evaporators with narrow tubing diameters – especially for low temperatures. RENISO SYNTH 68 can also be used as a refrigeration oil for R723 (dimethyl ether-ammonia-mixture) and for CO₂ applications (not miscible with CO₂). 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 which are significantly lower than that of conventional and that of 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.

Evaporation losses of refrigeration oils for NH₃ 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

Polyol esters (POE)



RENISO TRITON SE / SEZ series

Synthetic refrigeration oils based on thermally and chemically highly stable polyol esters (POE), special mono- and/or dipentaerythritol esters. Due to their good miscibility these polyol ester 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 (Hydrogenated Fluorinated Olefins). 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 continually 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 and RENISO GL 68

Synthetic, NH_3 -miscible refrigeration oils 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 and RENISO GL 68 were specially developed for NH_3 systems which use the direct evaporation principle (RENISO PG 68 and GL 68: with ammonia miscible oils).

High water content in the ammonia refrigeration plant can lead to chemical reactions between PAG refrigeration oils and aluminium compressor parts. These PAG oils 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.

RENISO PG 68 and RENISO GL 68 are also suitable for use with hydrocarbons. They display minimal hydrocarbon solubility which guarantees that an effective lubrication film is formed even at high specific loads. RENISO PG 68 and RENISO GL 68 form in contact with liquid hydrocarbons an own lubricant phase (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).



Lubricants for CO_2 applications

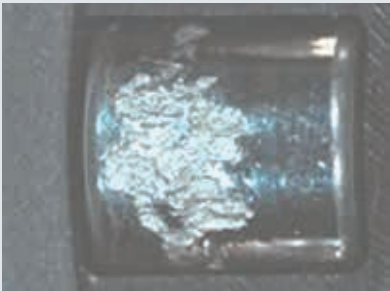


RENISO C series

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 next page please).

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.

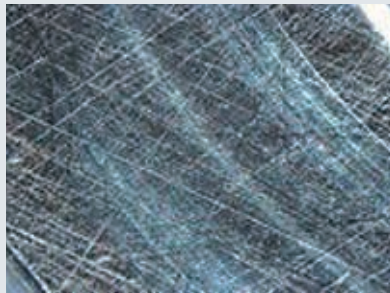
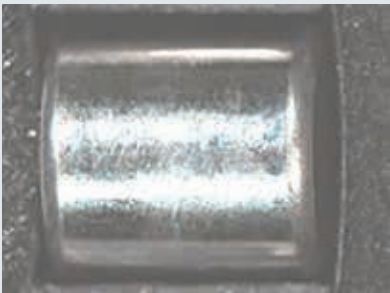
Test in FUCHS axial roller bearing test rig



Test conditions:
140 °C/50 bar CO₂/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 trans-critical CO₂ applications such as air conditioning applications and heat pump systems. RENISO ACC 68 is formulated on the basis of special thermally-stable synthetic polyalkylene glycols. 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 CO₂ 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 CO₂ vehicle air conditioning systems.

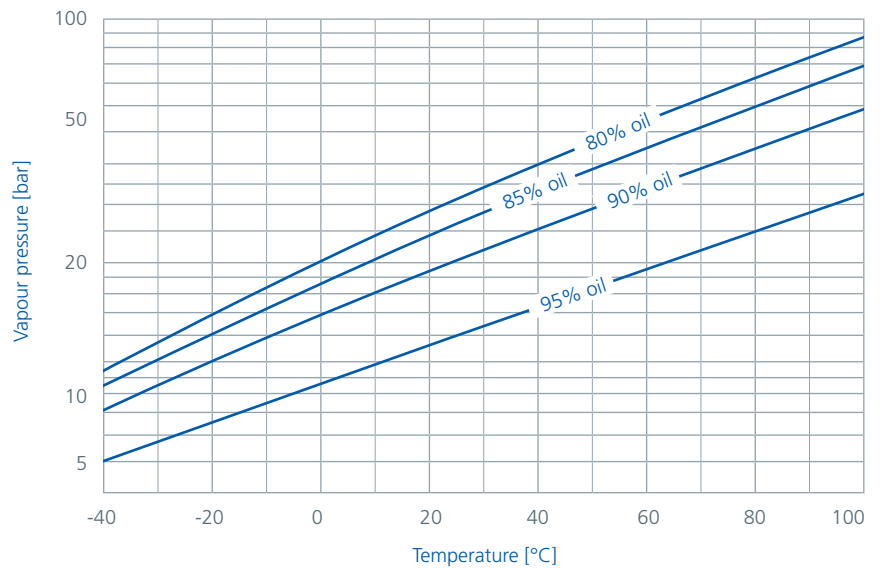
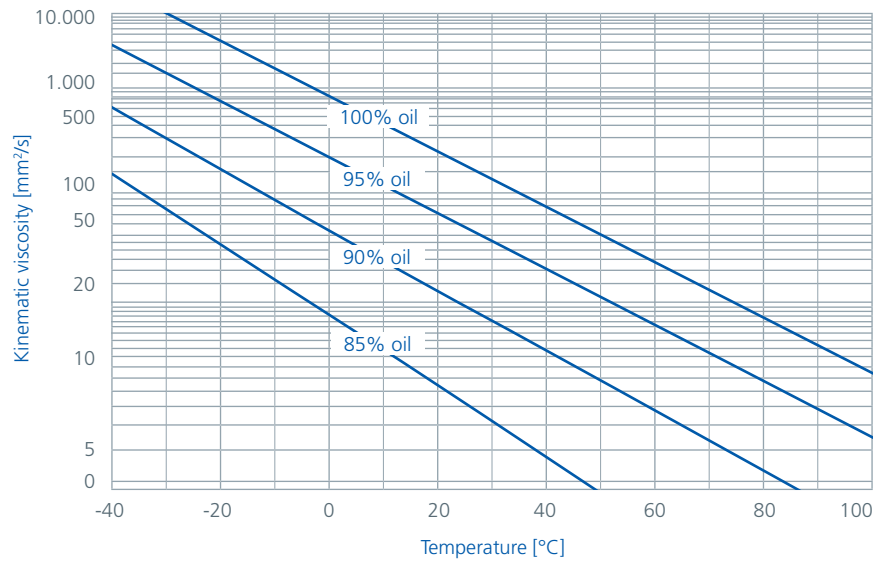
RENISO ACC HV is also suitable for electrically driven air compressors in electric vehicles - for both cooling and heat pump operation.

Synthetic refrigeration oils

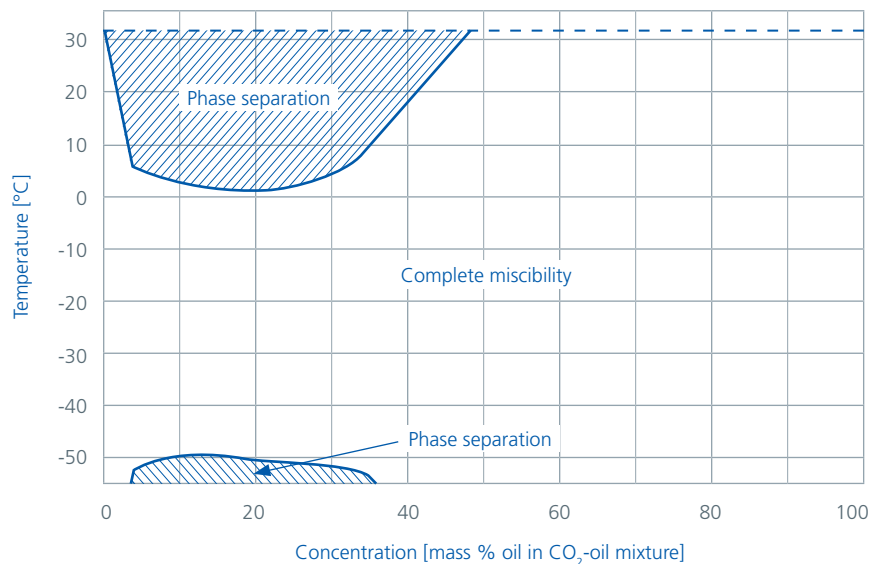
Lubricants for CO₂ applications

Refrigeration oils for CO₂ (R744) applications:
RENISO C based on POE

Example:
 kinematic viscosity and vapour pressure (Daniel-Plot):
 RENISO C 55 E – CO₂ mixture

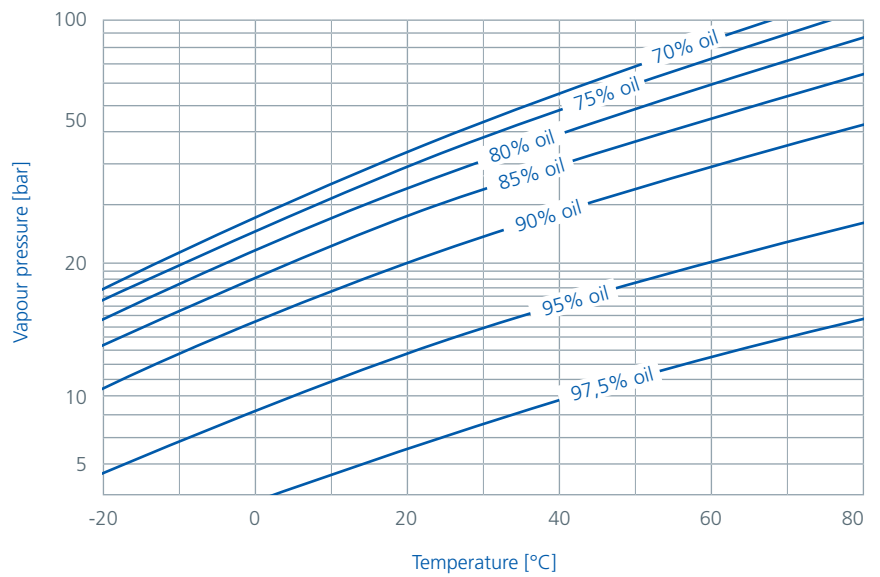
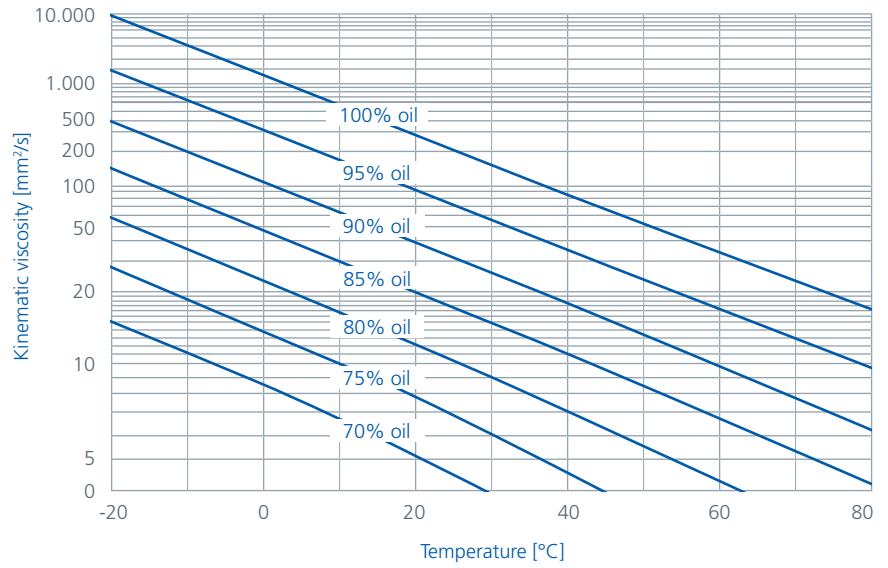


Example:
 Miscibility of RENISO C 55 E with CO₂
 (miscibility gap)

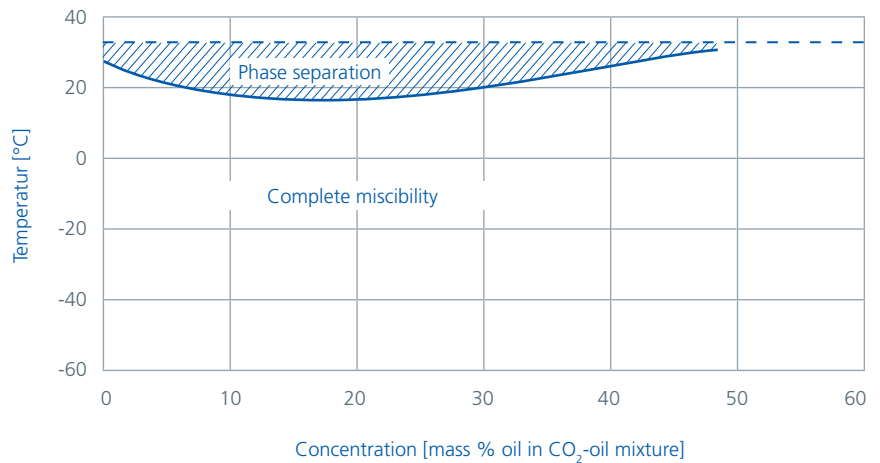


**Refrigeration oils for CO₂ (R744) applications:
RENISO C based on POE**

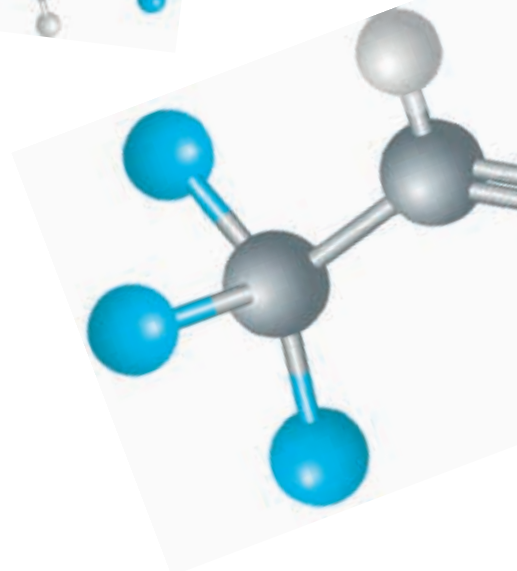
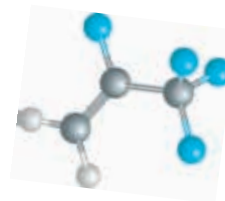
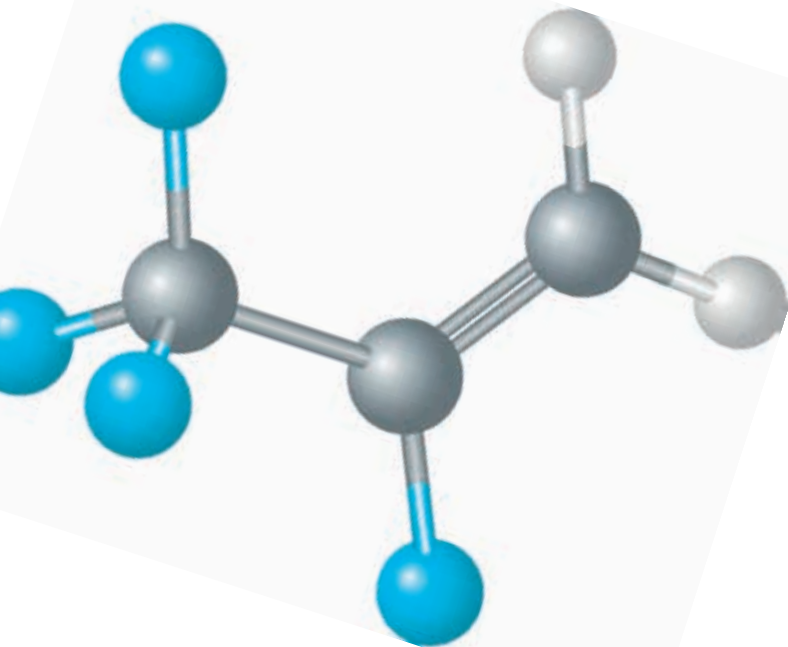
Example:
kinematic viscosity and vapour pressure (Daniel-Plot):
RENISO C 85 E – CO₂ mixture



Example:
Miscibility of RENISO C 85 E with CO₂
(Miscibility gap)



Synthetic refrigeration oils



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 (Hydrogenated Fluorinated Olefin) refrigerants, will increase.

The 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) which has the same chemical composition but a diffe-

rent molecular structure has also thermodynamic properties which are making a use as refrigerant possible. But the volumetric refrigerating capacity is approx. 25% below the capacity of R1234yf resp. 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 as 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 TRITON 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-gas regulation brings up challenging climate protection targets to the European refrigeration sector. Pure HFO substances and their blends with HFC refrigerants thus 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 28/29 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 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 refrigerants blends this is only an extract of the complete product range.

Synthetic refrigeration oils

Lubricants for HFO refrigerants

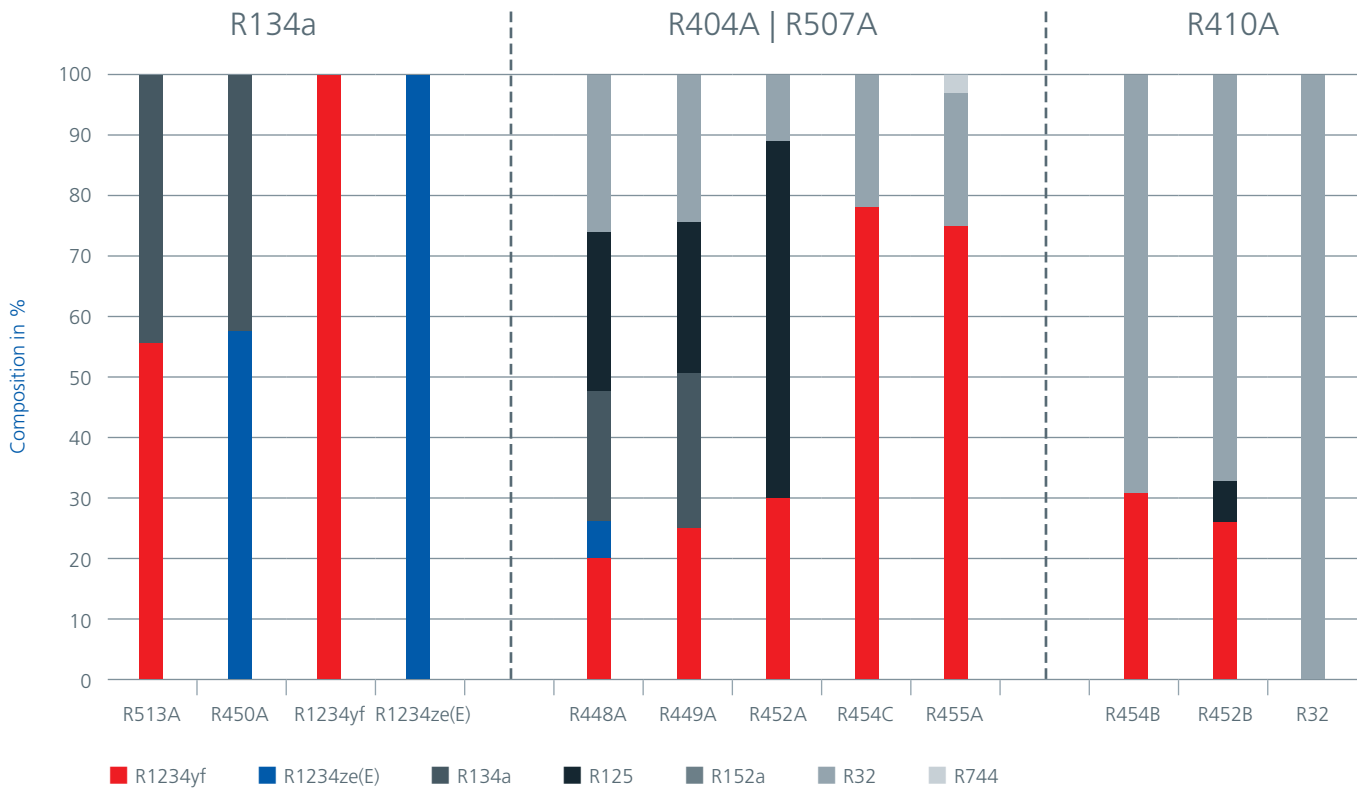
HFO and HFO/HFC mixtures

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

Alternatives for the change to low GWP refrigerants

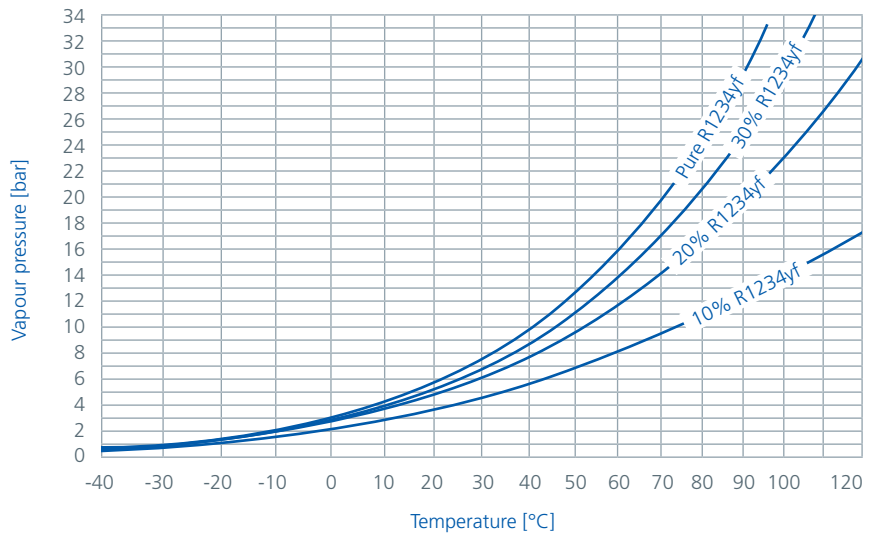
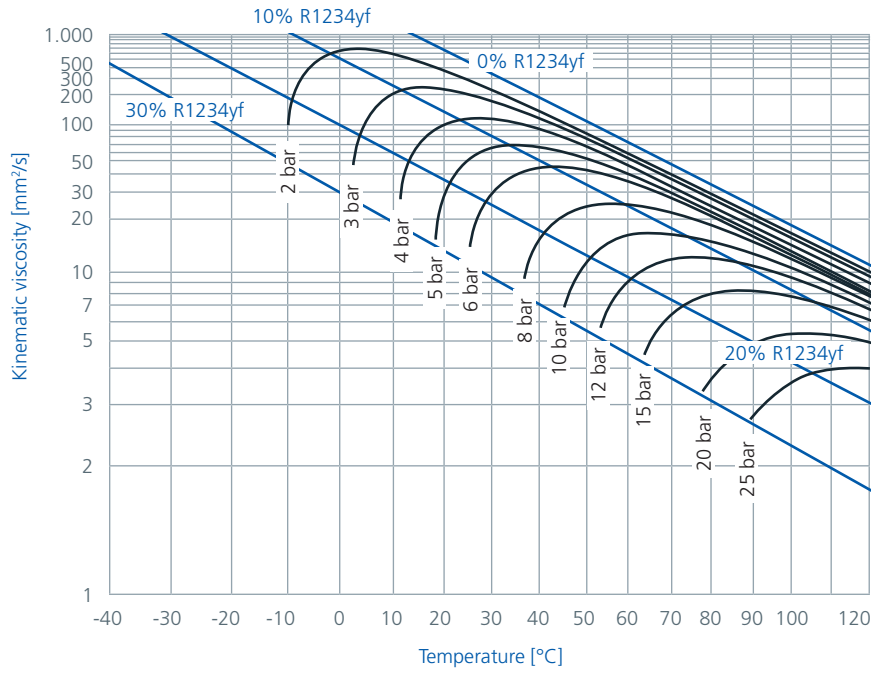


Synthetic refrigeration oils

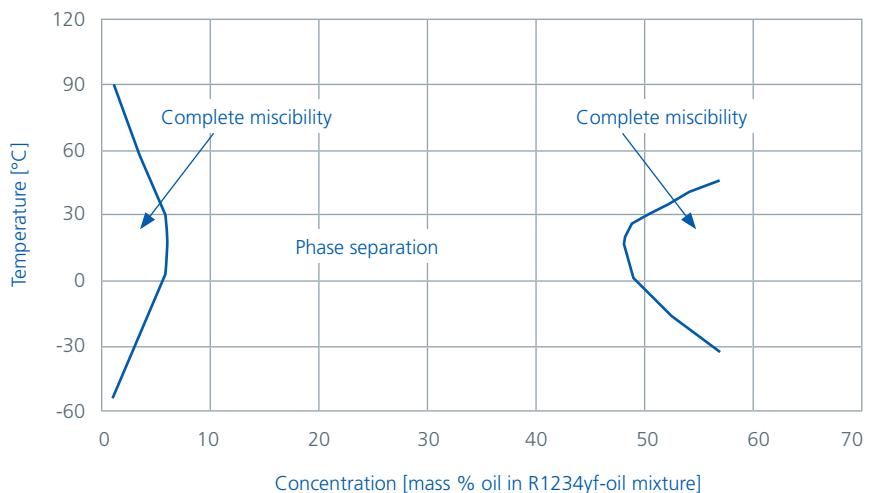
Lubricants for HFO refrigerants

Refrigeration oils for HFO applications:
RENISO TRITON SE 170 based on POE

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

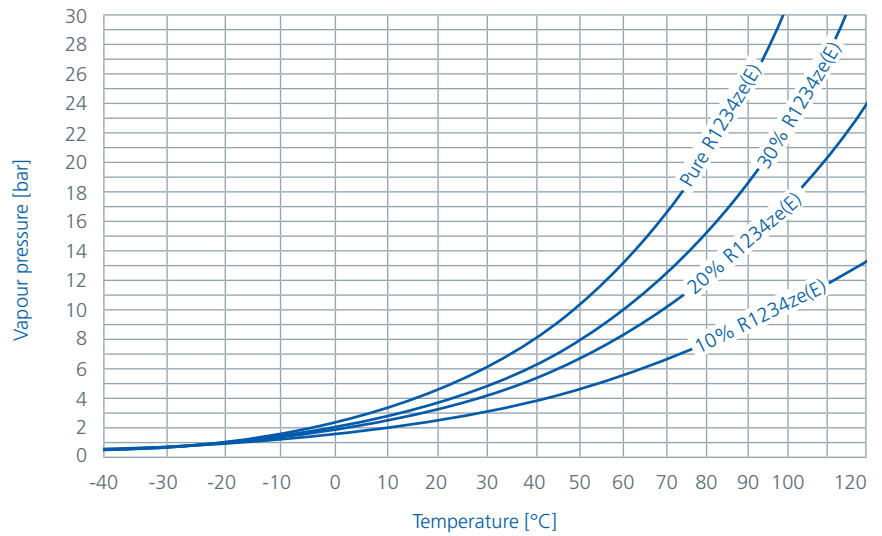
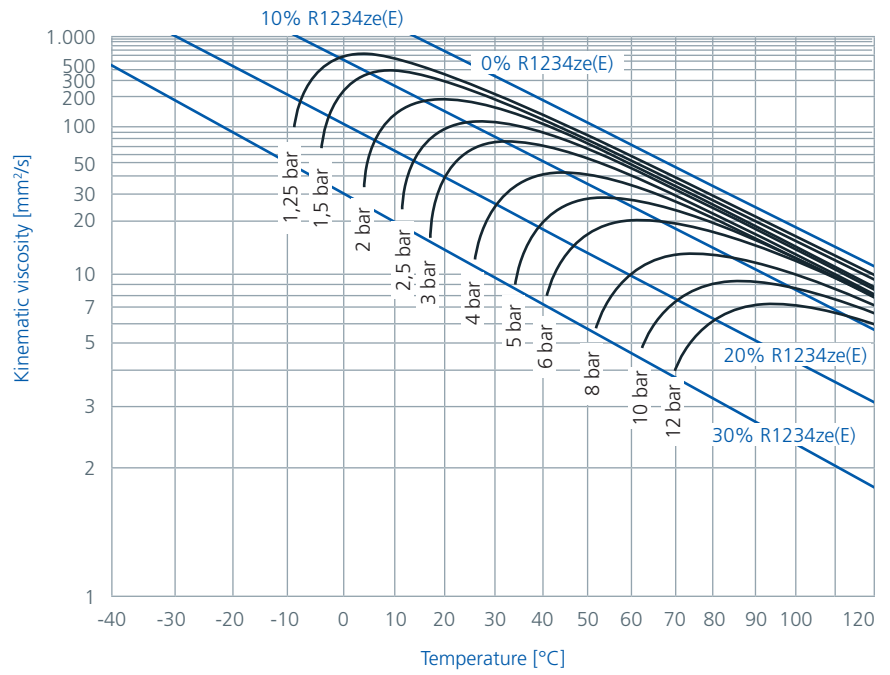


Example:
 Miscibility of RENISO TRITON SE 170 with R1234yf (miscibility gap)

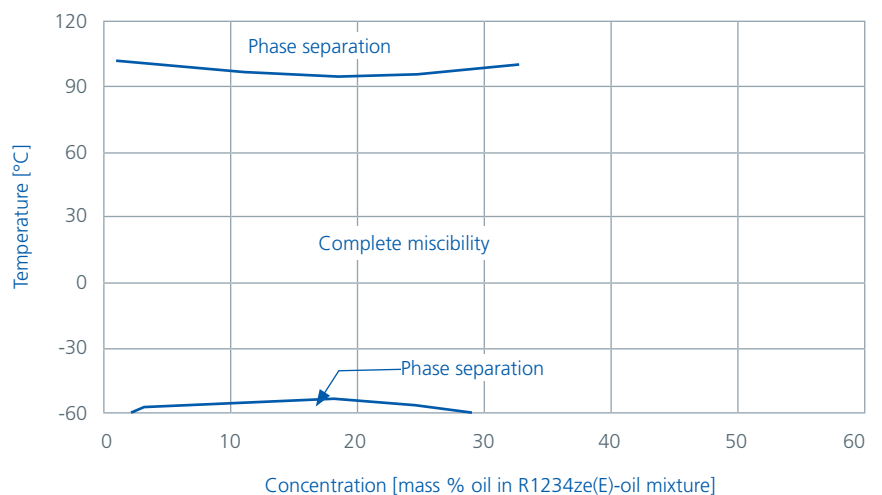


**Refrigeration oils for HFO applications:
RENISO TRITON SE 170 based on POE**

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



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



Synthetic refrigeration oils



Lubricants for sustainable mobile air conditioning (MAC) systems with HFO refrigerants



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

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 usage 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.





Sealed tube test

Warning values for used refrigeration oils and explanations acc. to DIN 51503-2 (2015)

- * 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 – CO₂ refrigeration oils (CO₂ miscible: e.g. polyol esters, polyalkylene glycols, CO₂ 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

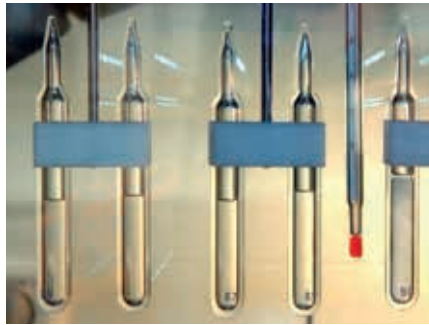
DIN 51777-1 (direct):
for refrigeration oils without additives

DIN 51777-2 (indirect):
for refrigeration oils with and without additives

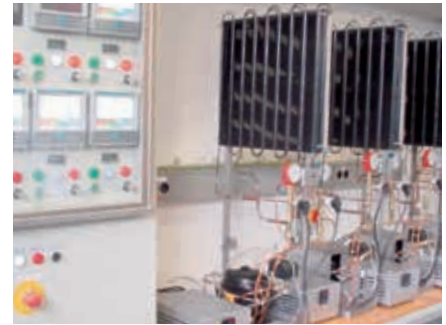
The FUCHS service program



High pressure autoclaves



Miscibility behaviour



Compressor test rig

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 neutralization 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 DIN 51503-2, 2015)

Brand name	Group	Deviation in kinematic viscosity at +40 °C [mm ² /s]*	Max. water content [mg H ₂ O/kg oil]	Neutralization number [mg KOH/g]
		DIN EN ISO 3104	DIN 51777-1 DIN51777-2	DIN 51558-1
RENISO K Mineral oils	CAA KC KE	** ± 15% of fresh oil value ± 15% of fresh oil value	100 60 80	– 0,07 0,1
RENISO SYNTH Polyalphaolefins (PAO)	CAA KB KE	** ± 15% of fresh oil value ± 15% of fresh oil value	100 80 80	– 0,1 0,1
RENISO S/SP Alkyl benzenes (AB)	CAA KC KE	** ± 15% of fresh oil value ± 15% of fresh oil value	100 60 80	– 0,07 0,1
RENISO PAG/ACC RENISO PG/GL 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 0,1 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 N₂ (inert gas) atmosphere during manufacturing and filling
 - Special containers
- **Service**
 - Testing of used refrigeration oils and evaluation of results
 - Intensive consulting / application engineering



RENISO Overview of products

Brand name	Description	Density at 15 °C [kg/m ³]	Flashp., Clev. [°C]	Kin. Visc. at 40 °C [mm ² /s]	Kin. Visc. at 100 °C [mm ² /s]	VI (Viscosity Index)	Pour-point [°C]	Main application area
RENISO WF – Mineral oil based refrigeration oils								
RENISO WF 5 A	Special refrigeration oils for use with the refrigerant isobutane (R600a) – highly refined, low flocculation point with R600a, containing additives to improve wear protection and ageing stability. DIN 51503 - KC, KE.	827	134	5.0	1.7	95	-45	RENISO WF refrigeration oils are recommended for the lubrication of hermetic refrigerator compressors with the refrigerant 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.
RENISO WF 7 A		832	158	7.2	2.2	97	-42	
RENISO WF 10 A		835	172	9.6	2.6	97	-42	
RENISO WF 15 A		883	164	15	3.1	9	-51	
RENISO K – Mineral oil based refrigeration oils								
RENISO KM 32	Highly refined, naphthenic mineral oils with high ageing stability, low pourpoint, excellent low-temperature behaviour and particularly good compatibility with the following refrigerants: ammonia (NH ₃), 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.
RENISO KS 46		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 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, 100 and 220 contain highly effective AW* additives (not suitable for NH₃ applications). Excellent miscibility and excellent stability with HCFC refrigerants (e.g. R22). DIN 51503 - KC, KE.	881	172	32	4.6	31	-39	Particularly good miscibility with HCFC refrigerants, such as R22. Suitable for very low evaporation temperatures down to -80° C. RENISO SP products are also recommended for use with Drop-In refrigerants (R402A/B, R401A/B, etc.). Due to their excellent stability RENISO S / SP – products are suitable for the lubrication of highly stressed refrigerant compressors. RENISO SP 220 is especially designed for the lubrication of screw compressors.
RENISO SP 46		875	199	46	5.6	26	-42	
RENISO SP 100		871	190	100	7.9	11	-24	
RENISO SP 220		872	192	220	13.2	13	-27	
RENISO S 3246	RENISO S 3246 and RENISO S 68 do not contain AW* additives and are suitable for use with HCFC refrigerants, hydrocarbons and NH ₃ . DIN 51503 - KAA, KC, KE.	877	180	40	5.1	17	-39	RENISO S 3246 and RENISO S 68 – suitable for R22, hydrocarbons as well as NH ₃ applications.
RENISO S 68		869	188	68	6.2	-30	-33	

* AW = Anti-Wear additives: additives to enhance the wear protection of the refrigeration oil under mixed friction conditions.

Brand name	Description	Density at 15 °C [kg/m ³]	Flashp., Clev. [°C]	Kin. Visc. at 40 °C [mm ² /s]	Kin. Visc. at 100 °C [mm ² /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	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. NEW: RENISO TRITON SE/SEZ is also suitable for the use with HFO and HFO/HFC refrigerants.	1,003	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 on 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.
RENISO TRITON SEZ 32		1,004	250	32	6.1	141	-57	
RENISO TRITON SE 55		1,009	286	55	8.8	137	-48	
RENISO TRITON SEZ 68		972	258	68	8.9	104	-39	
RENISO TRITON SEZ 80		992	251	80	10.6	118	-39	
RENISO TRITON SE 100		970	266	100	11.4	100	-30	
RENISO TRITON SE 170		972	260	173	17.6	111	-27	
RENISO TRITON SE 220		976	294	220	19.0	98	-27	
RENISO TRITON SEZ 320 (complex ester)	RENISO TRITON SEZ 320 was developed especially for application with R22. DIN 51503 – KC, KD.	1,016	278	310	33.0	148	-42	RENISO TRITON SEZ 320 is used for the lubrication of screw compressors combined with mainly R22 (also suitable for HFC).
RENISO TRITON SEZ 35 SC	For HFC/FC refrigerants. Specially developed for scroll compressors. DIN 51503 – KD.	1,015	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.
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).
RENISO UltraCool 68	Refrigeration oils based on synthetic hydrocarbons. Particularly developed for ammonia applications.	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 NEW	DIN 51503-KAA.	857	239	108	14.4	136	-46	

RENISO Overview of products

Brand name	Description	Density at 15 °C [kg/m ³]	Flashp., Clev. [°C]	Kin. Visc. at 40 °C [mm ² /s]	Kin. Visc. at 100 °C [mm ² /s]	VI (Viscosity Index)	Pour-point [°C]	Main application area
RENISO GL 68, RENISO PG 68 – Fully synthetic refrigeration oils based on polyalkylene glycols (PAG) for NH₃ applications								
RENISO GL 68	Fully synthetic refrigeration oil based on polyalkylene glycols (PAG), miscibility gap 10% oil / 90% NH ₃ : -22°C. NH ₃ – partly miscible refrigeration oil (Linde), also suitable for hydrocarbon applications. DIN 51503 - KAB, KE.	1,010	270	68	10.5	140	-42	RENISO PG 68 and GL 68 are ultra-dried, synthetic refrigeration oils based on PAG for NH ₃ systems which operate on the principle of direct expansion. They differ in their miscibility with NH ₃ . Suitable for screw and reciprocating piston compressors. RENISO PG 68 and GL 68 are also recommended for the use with hydrocarbon refrigerants.
RENISO PG 68	Fully synthetic refrigeration oil based on polyalkylene glycols (PAG), miscibility gap 10% oil / 90% NH ₃ : -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	Warning: - PAG oils are not compatible / miscible with mineral oil. - PAG oils are hygroscopic. Avoid any contamination with water or ambient air. Please contact our FUCHS application engineers.
RENISO PAG – Fully synthetic refrigeration oils based on polyalkylene glycols (PAG)								
RENISO PAG 46	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.
RENISO PAG 100		996	240	120	21.0	202	-45	
RENISO PAG 1234 NEW	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.

Brand name	Description	Density at 15°C [kg/m ³]	Flashp., Clev. [°C]	Kin. Visc. at 40°C [mm ² /s]	Kin. Visc. at 100°C [mm ² /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 CO₂ applications								
RENISO ACC 68	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.
RENISO ACC HV NEW	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	65	13.5	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.
RENISO C – Fully synthetic refrigeration oils based on polyol esters (POE) for CO₂ applications								
RENISO C 55 E	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.
RENISO C 85 E		993	246	80	10.6	118	–42	
RENISO C 170 E		976	286	178	18.5	116	–33	
RENISO LPG – Fully synthetic gas compressor oils based on polyalkylene glycols (PAG)								
RENOLIN LPG 100	Synthetic gas compressor oils based on polyalkylene glycols (PAG). Suitable for process gases, refinery gases (petroleum gases) and other hydrocarbon-based gases (propane, propylene, butane, etc.) and their blends. Attention: For RENOLIN LPG 100 and LPG 185 a drying process has to be applied prior to using them as refrigeration oils.	1,007	225	100	17.2	190	–37	RENOLIN LPG 100 and LPG 185 are characterized by a low solubility of hydrocarbon gases in the oil. Due to the use of special PAG base oils, the dilution of the lubricant in operation (drop in viscosity) is minimized. Thus, reliable wear protection and excellent lubricating properties are guaranteed. Selected additives provide additional security in terms of thermal-oxidative stability and wear protection of the lubricant under gas atmosphere.
RENOLIN LPG 185		1,002	229	185	30.1	205	–45	

Refrigeration oil selection guide for industrial and commercial refrigeration systems

HCFC refrigerant applications

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

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	68 P	80 P	*	* P		*	* P
R1270	Propylene	-30	+20	68	68 P	80 P	*	* P		*	* P
R600	Butane	-30	+20	68	68 P	80 P	*	* P		*	* P
R600a	Isobutane	-30	+20	68	68 P	80 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 P	68			
R744	CO ₂ - subcritical	-50	-10	55/80 P	68			170			
R744	CO ₂ - transcritical	-50	-10	80 P	68						

HCFC = Hydrochlorofluorocarbon

HFC = Hydrofluorocarbon

HFO = Hydrofluoro-Olefin

RENISO SYNTH 68 / RENISO UltraCool 68 based on PAO / synthetic hydrocarbon

RENISO K series / RENISO TES 100 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/GL/PAG based on polyalkylene glycols (PAG)

RENISO C series based on polyol ester for CO₂ (POE-C)

RENISO ACC 68 based on polyalkylene glycols for CO₂ (PAG-C)

HFC & HFO refrigerant applications

Refrigerant		Evaporation temperature		Art des Verdichters		
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
R507A	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*

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)

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

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



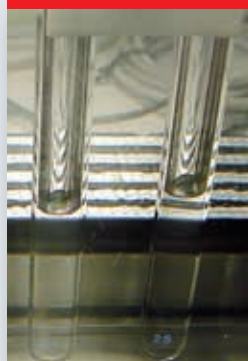
RENISO TRITON SEZ 80

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



Standard POE
refrigeration oils

Good miscibility



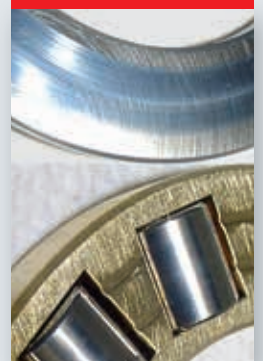
RENISO TRITON SEZ 80

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



Standard POE
refrigeration oils

No wear



RENISO TRITON SEZ 80

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 hydrocarbons (e.g. R600a - hermetic compressors)	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 NEW
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 RENISO GL 68
Alkyl benzenes (AB)	for R22 and hydrocarbons	RENISO SP 32 RENISO SP 46 RENISO SP 100 RENISO SP 220
	for R22, hydrocarbons and NH ₃	RENISO S 3246 RENISO S 68
Polyol esters (POE)	for HFC/FC, e.g. R134a, R404A, R507 NEW: 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 and for NH ₃ (miscible with NH ₃ , industrial application) and hydrocarbons	RENISO PAG 46 RENISO PAG 100
	for R1234yf and R134a mobile a/c systems	RENISO PAG 1234 NEW
	for CO ₂ mobile a/c systems	RENISO ACC HV NEW



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Experienced consultation

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

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