FUCHS Industrial Lubricants

Innovative refrigeration oils need experienced application engineers

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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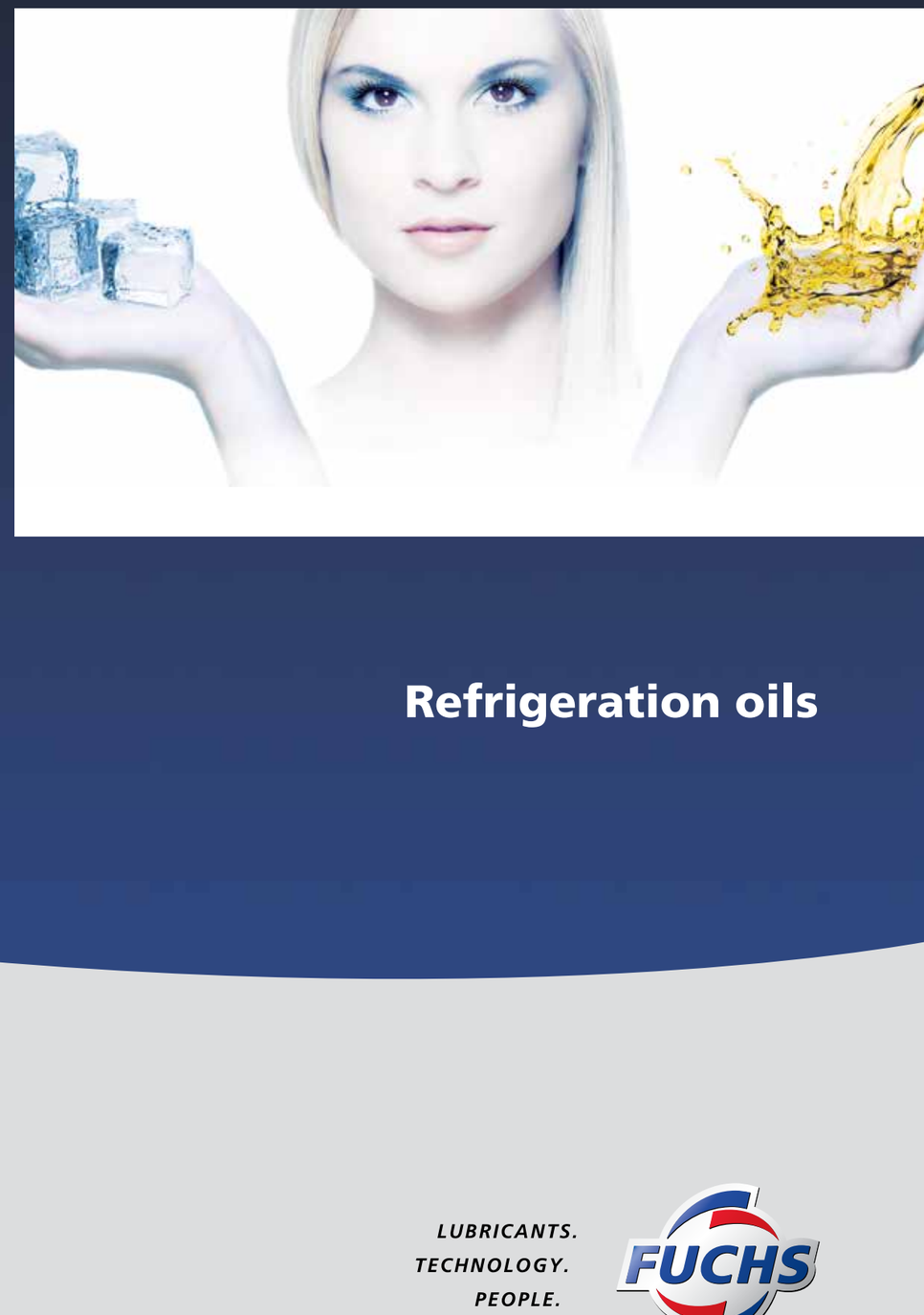
FUCHS Industrial Lubricants

RENISO

The right solution for every application



Refrigeration oils

LUBRICANTS.
TECHNOLOGY.
PEOPLE.

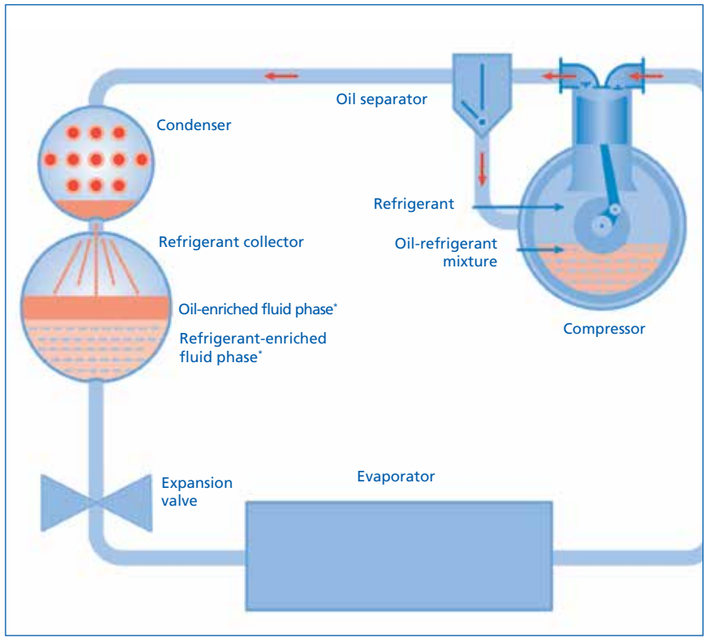
The complete product line of high-performance refrigeration oils.

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. The interaction with other substances, in particular the refrigerant, at fluctuating high and low temperatures makes 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.

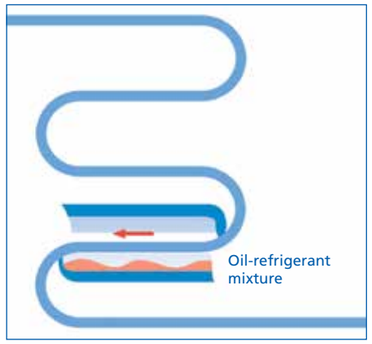
The compressor type, the efficiency of the oil separator, the design of the refrigeration system, the operating parameters, the refrigeration oil selection etc. are responsible for varying amounts of oil present in the refrigerant circuit. Oil content in the system usually can reach ranges from 1 to 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-ups, oil enrichment due to pronounced oil foaming as a result of dissolved refrigerant can occur. The oil then cools down when the refrigerant evaporates. If the flowability of the remaining oil is not sufficient (as a result of dissolved refrigerant), 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. 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.

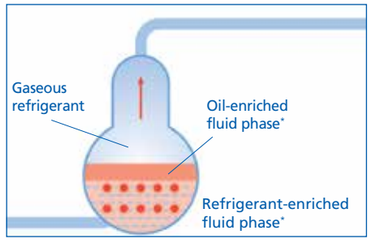
Scheme of refrigeration circuit



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 oil-enriched phase.

Research and Development – under the sign of climate protection

Our research and development department deals with comprehensive research 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 HFO-1234yf (GWP=4) are already increasing in their use. On the contrary the use of common refrigerants like R404A (GWP=3922) will decrease already in the medium term.

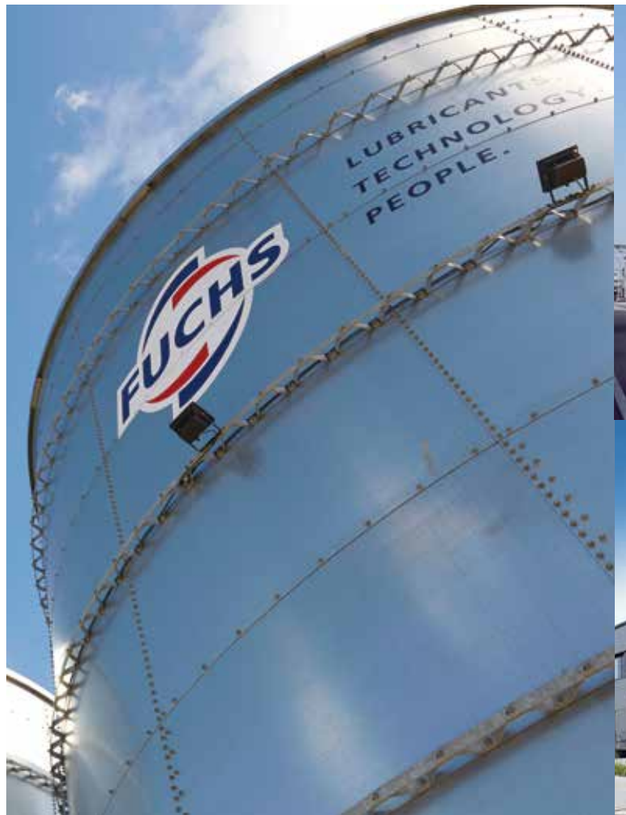
At FUCHS, stability tests are performed with the Sealed Tube apparatus and miscibility and solubility tests of refrigeration oils in diverse refrigerants are performed in special laboratory equipment. The very latest laboratory technology together with specially-constructed test rigs allow wear protection 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 on 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 further developed.

Because of the new challenges also for refrigeration oils which are coming up owing to the commencement of the new 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 benzene
- Synthetic refrigeration oils based on polyalphaolefin
- Synthetic refrigeration oils based on polyol esters
- Synthetic refrigeration oils based on polyalkylene glycol
- New refrigeration oils for CO_2 applications



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 protection 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 (January 2011) is alphabetic and in line with the refrigerants used in the following groups:

KAA Refrigeration oils not miscible with ammonia – mineral oils and/or synthetic oils – based on poly-alphaolefin (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 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 (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 described as not miscible with CO_2.

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) – as a rule, 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.

The following typical properties are given to characterise a refrigeration oil:

Colour	**DIN ISO 2049**
Viscosity	**DIN EN ISO 3104**
Density	**DIN 51757**
Neutralisation number	**DIN 51558-1**
Water content	**DIN 51777-1/-2**
Pourpoint	**DIN ISO 3016**
Flashpoint	**DIN ISO 2592**
Refrigerant miscibility	**DIN 51514**
Refrigerant stability (Sealed-Tube-Test)	**ASHRAE 97-2007**

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 in an inert gas atmosphere.

Physical and chemical data of refrigeration oils.

The following typical data is used to characterise a refrigeration oil:

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

Density according to DIN 51757:
Density refers to the mass of a fluid in relation to its volume. In general to characterise 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.

Neutralisation number according to DIN 51558:
The neutralisation 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 neutralisation number is shown in mg KOH/g. A comparison with fresh oil values is essential when evaluating a used refrigeration oil. The neutralisation numbers of refrigeration oils are very low compared to other lubricants. They are in the region of < 0.1 mg KOH/g.
The neutralisation 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 (ISO 3733 / IP 74). The content of water in refrigeration oils is very low when compared to other lubricants, refrigeration oils are normally used in “ultra-dried” form.

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 than the pourpoint of the pure oil would suggest. An estimation of 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.

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 homogenised and cooled respectively heated in a defined way (3K steps). If the oil and refrigerant separate into two fluid phases (the phase separation is characterised 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.

Miscibility behaviour of FUCHS RENISO TRITON SEZ 32 with R134a

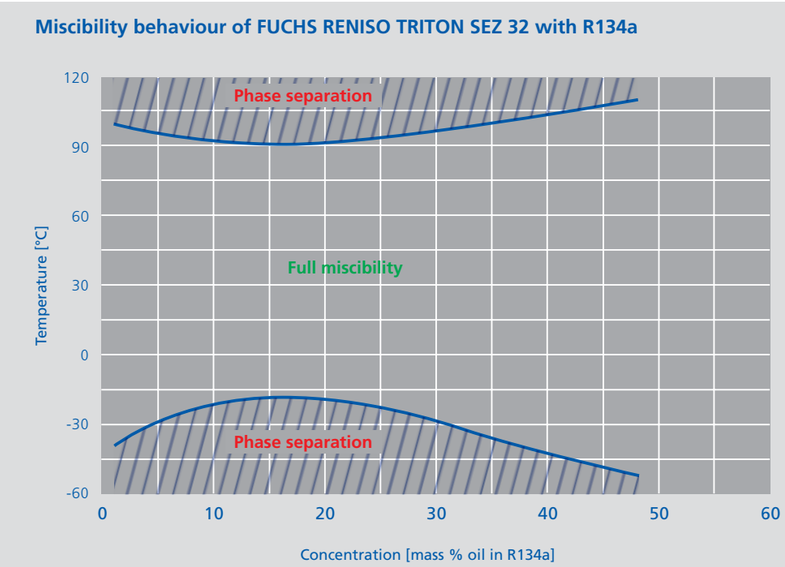
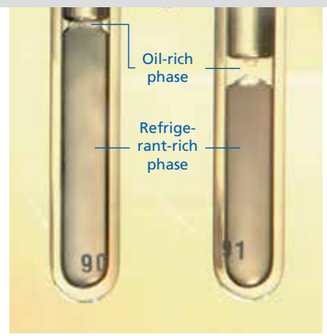


Photo: Phase separation into oil-rich and refrigerant-rich phase (in glas tubes in FUCHS R&D)

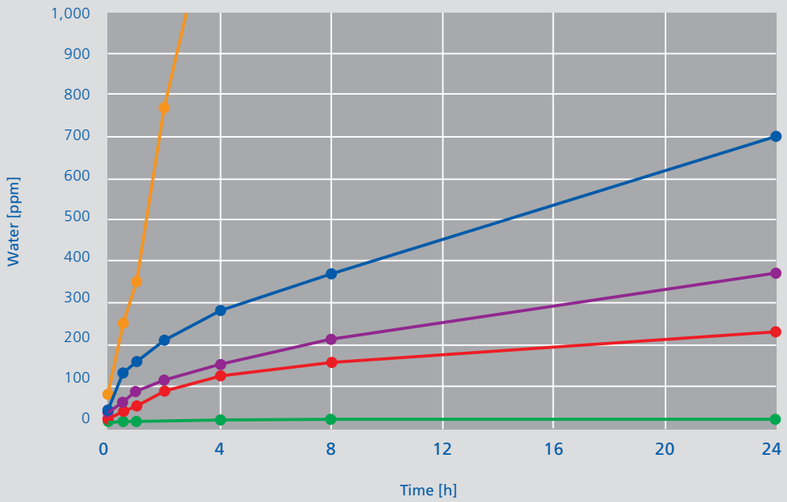


Physical and chemical data of refrigeration oils.

Refrigerant compatibility according to ASHRAE 97-2007:
The compatibility of the refrigerant with the refrigeration oil used 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 neutralisation 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, but above all, on an extremely low water content in the system. Refrigeration oils with excessive water contents must be replaced. The diagram below 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 (compared to the fresh oil values) 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. Polyol esters (POE), which are described as polar, hygroscopic lubricants, display a marked increase in 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-viscosity ester oils absorb moisture more rapidly than high-viscosity ester oils. PAG refrigeration oils, which are mostly used in a/c systems with R134a, are even more hygroscopic. PAG lubricants absorb large quantities of moisture in relatively little time and thus rapidly exceed permissible thresholds of about 800 ppm water in used oils.

Water absorption (hygroscopicity) of refrigeration oils



Test conditions:

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

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

Thermal stability:
The exposure of lubricating oils to high temperatures over longer periods of time can lead to the formation of decomposition products and these can cause serious problems. Ageing stability is thus an important lubricant selection criterion. Decomposition processes are generally complex chemical reactions which are catalysed 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 neutralisation 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 close tolerances. Copper plating occurs when the oil acidifies and is accelerated by moisture in the system along 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 (shown 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 in line with DIN ISO 3771).

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

Kinematic viscosity according to DIN EN ISO 3104:
Viscosity (the thickness of the oil) 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 m^2/s but in the lubrication sector, the units cSt or mm^2/s are more common. DIN 51519 lays down 18 different viscosity grades from 2 to 1000 mm^2/s at 40 °C for fluid industrial lubricants. Every viscosity grade is described by the mean viscosity at 40 °C and the permissible deviation of +/- 10 % of this value.

The thickness or 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. 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 (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.

Physical and chemical data of refrigeration oils.

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 (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 (next page) where the given temperature and the corresponding percentage of oil dissolved in the refrigerant meet.

Example:
Point A: 60 °C, 90 % –> 14 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.

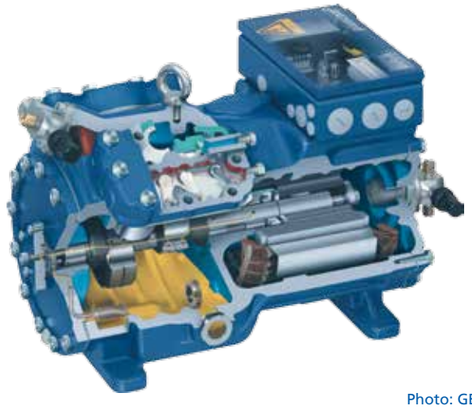


Photo: GEA Bock

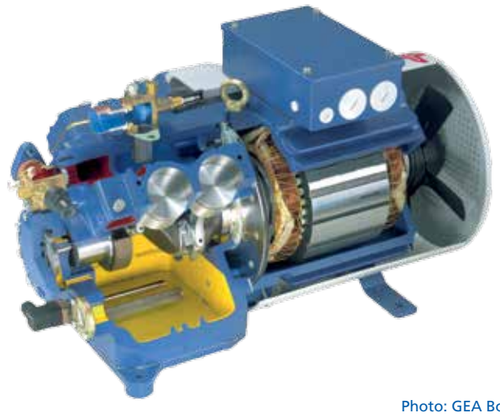
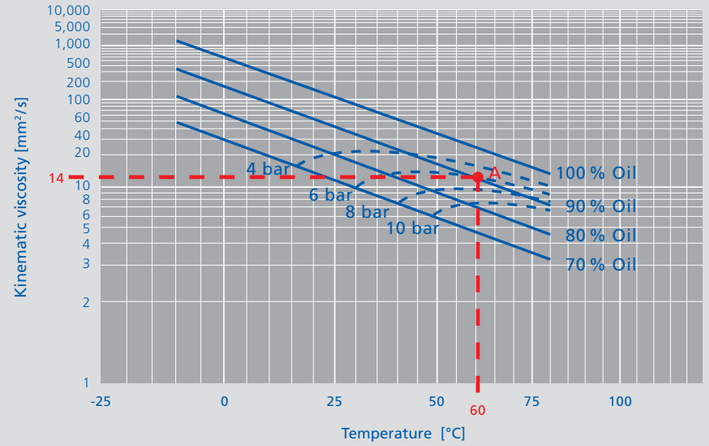
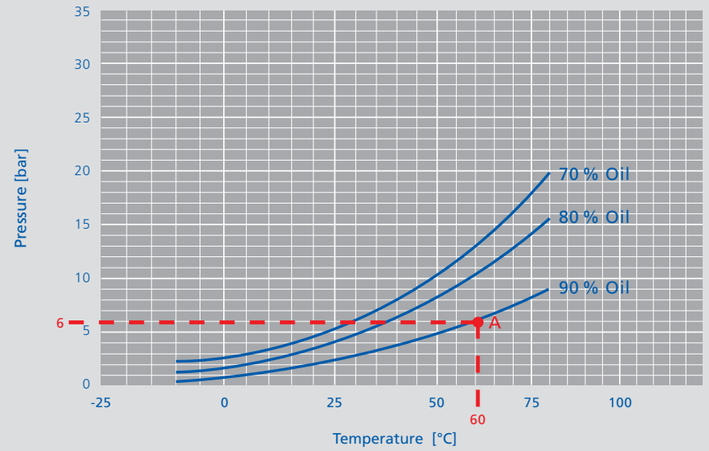


Photo: GEA Bock

Refrigeration Oils for application 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

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. R22 systems). 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 systems.

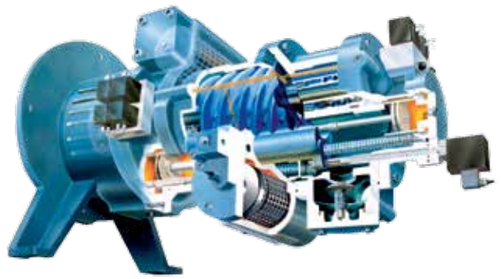


Photo: GEA Refrigeration Germany

RENISO WF series

Selected, highly refined cuts with special anti-wear additives. The RENISO WF series – in the viscosity grades ISO VG 5-22 are perfect for the lubrication of hermetically sealed refrigerator compressors which use isobutane (R600a) as refrigerant. Diagrams of RENISO WF10A with isobutane (R600a) see page 15.

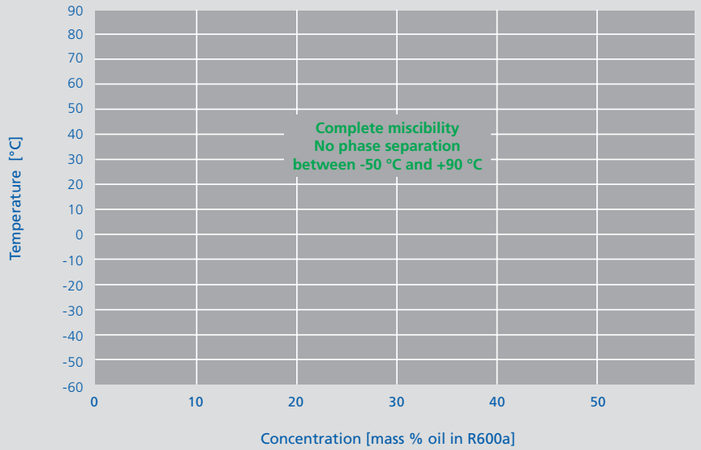
The use of low viscous RENISO WF refrigeration oils in modern compressors can achieve significant improvements in energy efficiency.

Photo: SECOP

RENISO TES 100

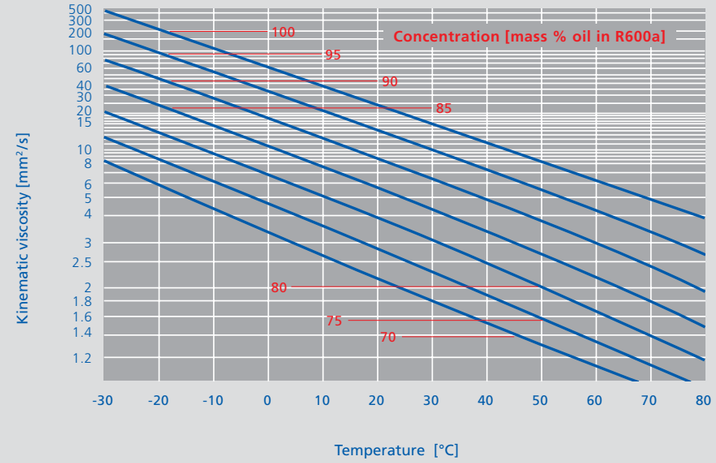
Special paraffinic mineral oil. Due to its good viscosity-temperature behaviour, RENISO TES 100 is particularly suitable for older turbo-compressors which were designed for use with refrigerants containing chlorine.

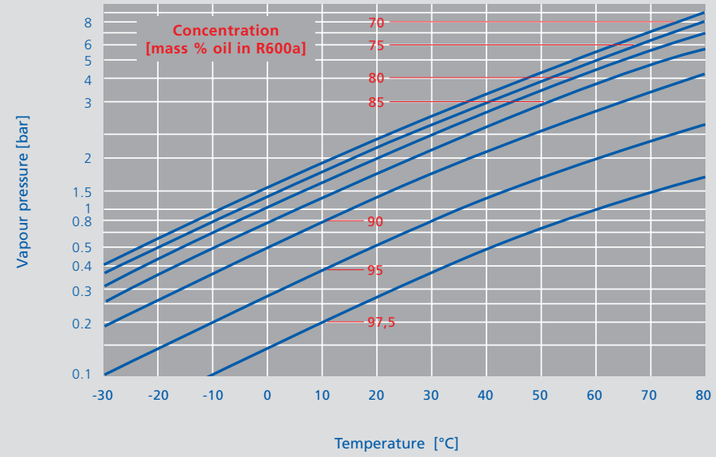
Example:
Miscibility of
RENISO WF 10 A with R600a



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

Example:
Kinematic viscosity and
vapour pressure (Daniel Plot)
RENISO WF 10 A –
R600a mixture





Refrigeration oil product groups.

Synthetic refrigeration oils

Alkyl benzene (AB)

- **RENISO S series**
- **RENISO 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 additives are not suitable for NH_3 systems. The RENISO S series is recommended for NH_3 applications. RENISO S series products can also be used with HCFCs refrigerants such as R22 (the RENISO S series does not contain AW additives).

Polyalphaolefin (PAO) / synthetic hydrocarbons

- **RENISO SYNTH 68**

Thermally stable polyalphaolefin (PAO) with excellent cold-flowing properties for NH_3 systems with highly-stressed compressors and low evaporation temperatures. Due to its outstanding cold-flowing properties, RENISO SYNTH 68 is also recommended for use in plate evaporators operating at low temperature and with narrow tubing diameters.

RENISO SYNTH 68 can also be used, as a refrigeration oil for R723 (dimethyl ether-ammonia-mixture) and CO_2 applications (not miscible with subcritical CO_2). Due to its beneficial solubility behaviour (low dilution) and its extraordinary viscosity-temperature-behaviour (high VI) RENISO SYNTH 68 is especially suitable for the use with hydrocarbons like propane (R290) or propylene (R1270).

- **RENISO UltraCool 68**

RENISO UltraCool 68 is used for ammonia refrigeration plants with deep evaporation temperatures down to < -45°C. Due to its thermal stability RENISO UltraCool 68 avoids 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 68 shows an outstanding low evaporation rate which is significantly lower than that of conventional and that of hydro treated 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 68 combines 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.

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 lubricants can also be used in cooling / refrigeration applications with hydrocarbon refrigerants like propane (R290) or propylene (R1270). These POE refrigeration oils show good lubricity under hydrocarbon atmosphere.
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**lefin). Comprehensive laboratory tests as well as initial practical experiences with e.g. HFO-1234yf and HFO-1234ze already exist. FUCHS is a very dedicated lubrication partner in many projects with these new HFO refrigerants and refrigerant mixtures and will continually develop its range of lubricants in this field.

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 characterised 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.

Photo: Bitzer

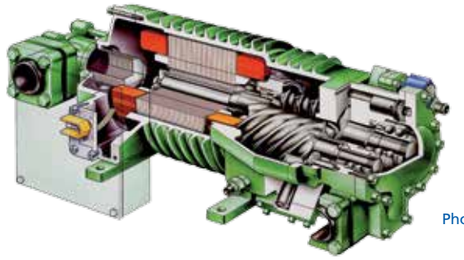
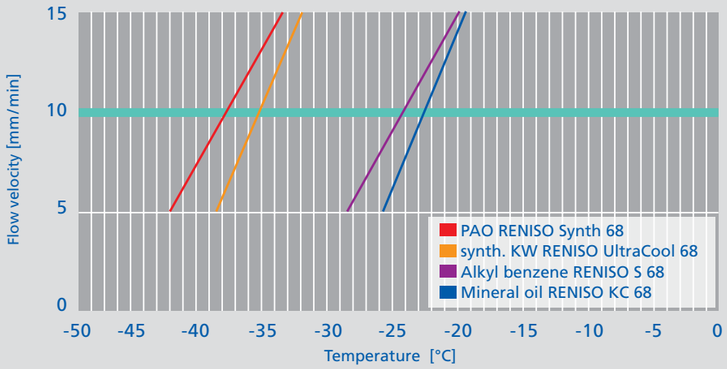


Photo: Bitzer

Determination of the flowability of refrigeration oils for NH_3: U-Tube-Test (DIN 51568) – without refrigerant (low temperature flowability)

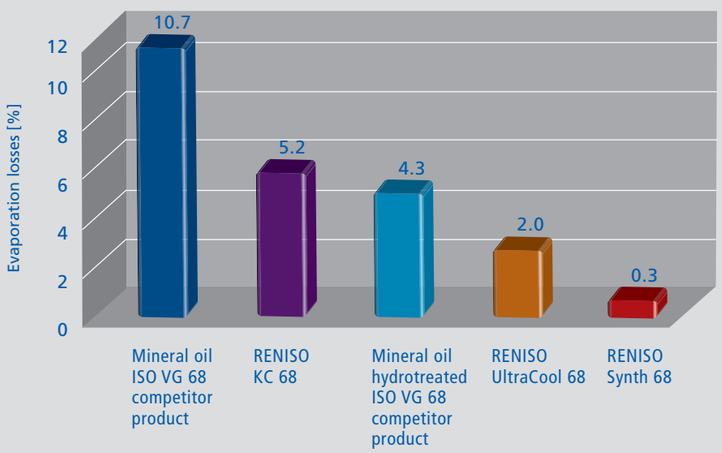


RENISO UltraCool 68 & RENISO SYNTH 68
- significantly better low temperature flowability than mineral oils and alkylbenzenes

→ preferable for low evaporating temperatures

Limit flow velocity = 10mm/min

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 oil and hydrotreated oill

→ less oil losses / less oil consumption

Refrigeration oil product groups.

Polyalkylene glycol (PAG)

RENISO PG 68, 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 220C – R134a applications

Synthetic, high-viscous refrigeration oil based on special polyalkylene glycols (PAG), which offer excellent miscibility with R134a. RENISO PAG 220 C was specially developed for use in R134a screw compressors. Its main application is in heat pumps and expanders.
RENISO PAG 220 C can also be used with the refrigerants R236fa, R227ea, R245fa and R744 (CO_2).

RENISO PAG 46 and PAG 100

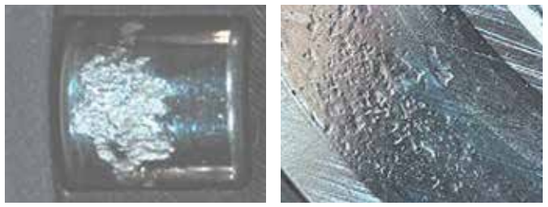
Selected polyalkylene glycols (PAG) for automotive air-conditioning systems which use R134a refrigerants. Also recommended for the use in ammonia dry expansion (DX) systems. PAG refrigeration oils like RENISO PAG 46 and RENISO PAG 100 belong to the group KAB according DIN 51503 (with ammonia miscible oils).

Lubricants for CO_2 applications

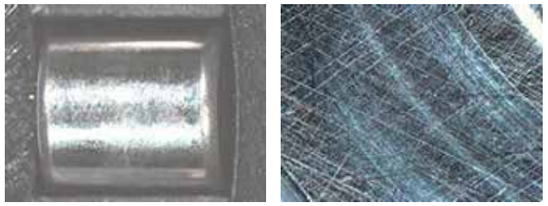
RENISO C series

RENISO C series products are based on special synthetic, thermally stable ester oils. 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 below).

Test in FUCHS axial roller bearing test rig
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.



POE ISO VG 170 without additives:
pitting, wear



RENISO C 170 E, POE ISO VG 170,
with anti-wear additives:
no wear

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.

RENISO ACC 68

RENISO ACC 68 was particularly developed for the use in trans-critical CO_2 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 46 and RENISO ACC HV – for vehicle a/c systems

RENISO ACC 46 and RENISO ACC HV (ISO VG 68) were developed in years of joint research work together with leading compressor manufacturers and OEMs for the use in CO_2 vehicle air conditioning systems.
The RENISO ACC products are based on double end-capped polyalkylene glycols (PAG) and are containing an efficient additive system to increase the wear protection and the chemical-thermal stability.

RENISO ACC 46 and RENISO ACC HV totally fulfill the high requirements on refrigeration oils for CO_2 vehicle air conditioning systems.

Lubricants for HFO refrigerants

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 refrigerant HFO-1234yf (GWP=4) is already in use in air conditioning systems of new vehicle types as successor refrigerant for R134a (GWP=1300). But HFO-1234yf is at least disputed because of its flammability (classification A2L).
HFO-1234ze (GWP=6) which has the same chemical composition but a different molecular structure has also thermodynamic properties which are making a use as refrigerant possible. But the volumetric refrigerating capacity is appr. 25% below the capacity of HFO-1234yf resp. R134a.
Beside these pure substances mixtures of HFO refrigerants with HFC are also offered for having an efficient refrigeration medium available which has a distinctly lower flammability as HFO-1234yf.

Initial promising experiences with these new HFO refrigerants and 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 POE oils (RENISO TRITION SE/SEZ) 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 numerously 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.

Refrigeration oil product groups.

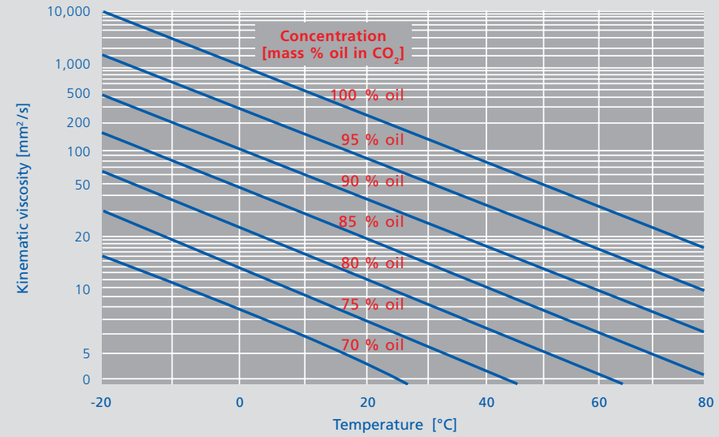
Lubricants for sustainable vehicle air conditioning

■ RENISO PAG 1234 – for HFO-1234yf

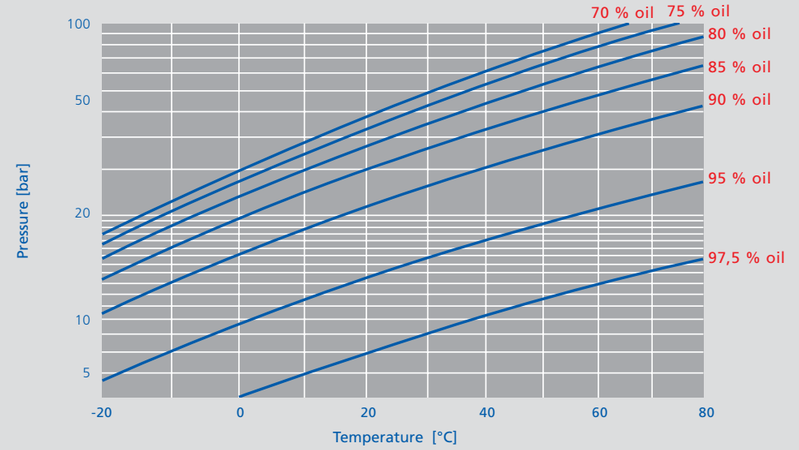
Using HFO-1234yf as successor of R134a in automotive a/c systems brings a lot of challenges for the refrigeration oil in the compressor. RENISO PAG 1234 on the basis of double-end-capped polyalkylene glycols (PAG) is characterised by a good miscibility with HFO-1234yf. Due to its newly developed additivation RENISO PAG 1234 ensures reliable compressor lubrication with excellent wear protection. The thermo-chemical stability of RENISO PAG 1234 in combination with HFO-1234yf guarantees a stable long-term operation of the a/c system.

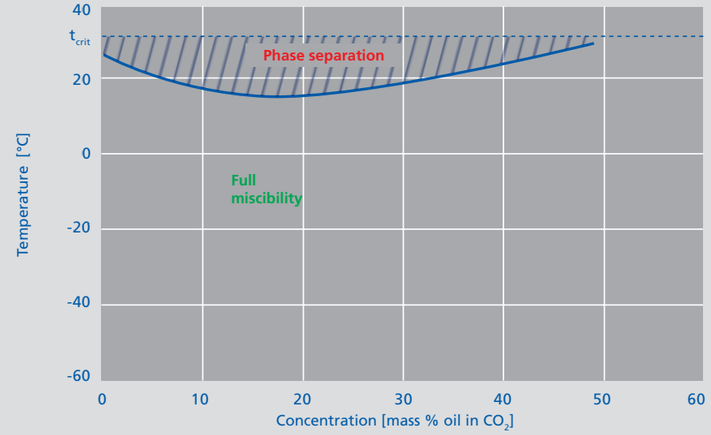
Due to their comparatively polar structure, PAGs absorb water rapidly. This means that corresponding care must be taken when handling these products. The RENISO PAG series of products are ultra-dried and filled into gas-tight containers (e.g. 250 ml cans) in nitrogen atmosphere.

Example:
Daniel Plot:
Kinematic viscosity and vapour pressure
RENISO C 85 E – CO_2 mixture



Example:
Miscibility gap
Miscibility of
RENISO C 85 E with CO_2





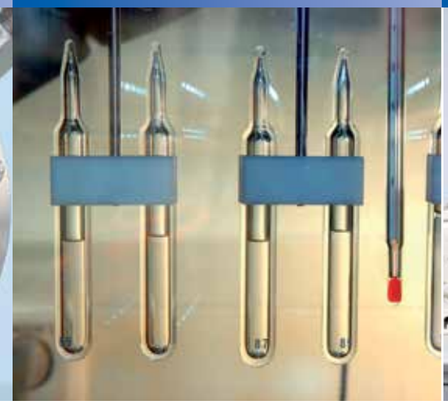
All % figures represent mass of oil in the refrigerant.

The service program.


Advanced development laboratories


Sealed-Tube-Test


High pressure autoclaves


Miscibility behaviour


Oil refrigerant compatibility


Compressor test rig

LAS – 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 LAS kit contains all the necessary equipment for 5 analyses in the FUCHS laboratories. The determination of viscosity, water content, concentration of wear particles, additive content and the neutralisation number (for ammonia systems: Determination of the base number) enables the on-going monitoring of refrigerating systems.

The LAS can help reduce maintenance costs and allow countermeasures to be taken in good time if danger signs are registered. Our “LAS for Refrigeration Oils” information pack describes the scope of the tests and the analyses performed.

Threshold values for used RENISO refrigeration oils (in line with DIN 51503-2, draft version)

Product	Group	Deviation in kinematic viscosity at +40 °C, mm²/s	Max. water content, mg H_2O/kg oil	Neutralisation number, mgKOH/g
		DIN EN ISO 3104	DIN 51777-1 DIN 51777-2	DIN 51558-1
Mineral oil	KAA	**	100	–
RENISO K	KC	± 15% of fresh oil value	60	0.07
	KE	± 15% of fresh oil value	80	0.1
Polyalphaolefin (PAO)	KAA	**	100	–
RENISO SYNTH	KB	± 15% of fresh oil value	80	0.1
	KE	± 15% of fresh oil value	80	0.1
Alkyl benzene (AB)	KAA	**	100	–
RENISO S/SP	KC	± 15% of fresh oil value	60	0.07
	KE	± 15% of fresh oil value	80	0.1
Polyalkylene glycol (PAG)	KAB	**	500	–
RENISO PAG/ACC **RENISO PG/GL**	KB	± 15% of fresh oil value	800	0.2
	KD	± 15% of fresh oil value	800	0.2
	KE	± 15% of fresh oil value	800	0.2
Ester oils (POE, complex esters)	KB	± 15% of fresh oil value	150	0.2
	KC	± 15% of fresh oil value	150	0.1
RENISO TRITON SE/SEZ	KD	± 15% of fresh oil value	200	0.2
RENISO C	KE	± 15% of fresh oil value	200	0.2

Threshold values for used refrigeration oils: Explanations (in line with DIN 51503-2, draft version)

* 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 threshold values are exceeded.

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

The advantages of FUCHS refrigeration oils.

Logistics

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 oil, alkyl benzene and PAO.

Our RENISO refrigeration oils are available in a variety of user-friendly containers ranging from 1-litre screw-top cans through to 1 m^3 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 m^3 containers and tankers being permanently pressurised (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 negligible. 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 samples of the technical documentation.

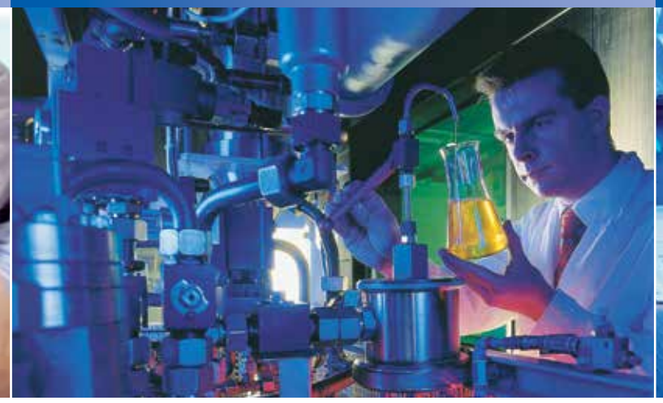
Consulting

FUCHS high-tech lubricants

We will gladly supply you with further details about the standard products, specialties and greases that make up our extensive lubricant program and our expert application engineers will be pleased to answer all of your technical questions.

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.

Your benefits



The advantages of our 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.

Our expertise

Refrigeration oils – our expertise

- R&D
  – In-house 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 is available
- Logistics / Production
  – Stainless steel components and N_2 inert gas atmosphere during manufacturing and filling
  – Special containers
- Service
  – Testing of used refrigerator oils and evaluation of results
  – Intensive consulting / Application engineering

SUSTAINABLE INNOVATION

The RENISO product portfolio.

RENISO WF SERIES – MINERAL OIL BASED REFRIGERATION OILS

Product Name	Description	Density at 15 °C [kg/m³]	Flp., Clev. [°C]	Kin. Visc. 40 °C [mm²/s]	Kin. Visc. 100 °C [mm²/s]	VI (viscosity index)	Pourpoint [°C]	Main Application Area
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	15.0	3.1	–	-51	

RENISO K SERIES – MINERAL OIL BASED REFRIGERATION OIL

Product Name	Description	Density at 15 °C [kg/m³]	Flp., Clev. [°C]	Kin. Visc. 40 °C [mm²/s]	Kin. Visc. 100 °C [mm²/s]	VI (viscosity index)	Pourpoint [°C]	Main Application Area
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 HCFC refrigerants and ammonia (NH_3). RENISO KES 100 and RENISO KW 150 are suitable for applications with high evaporation and condensation temperatures, such as air-conditioning applications, heat pumps - especially recommended 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 KW 150		917	215	150	10.9	27	-30	
RENISO TES 100	Highly refined, paraffinic mineral oil with high ageing stability, very good viscosity-temperature characteristics and excellent lubricating properties. DIN 51503 - KC.	868	236	102	12.1	110	-36	RENISO TES 100 is suitable for chlorine-containing refrigerants like R22, e.g. in turbo compressors, particularly JCI (BBC York), Carrier.

RENISO S / SP SERIES – FULLY SYNTHETIC REFRIGERATION OILS BASED ON ALKYL BENZENE

Product Name	Description	Density at 15 °C [kg/m³]	Flp., Clev. [°C]	Kin. Visc. 40 °C [mm²/s]	Kin. Visc. 100 °C [mm²/s]	VI (viscosity index)	Pourpoint [°C]	Main Application Area
RENISO SP 32	Fully synthetic refrigeration oils based on chemically and thermally stable alkyl benzene. RENISO SP 32, 46, 100 and 220 contain highly effective AW* additives (**not suitable for NH_3 applications**). Excellent solubility 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 and NH_3. DIN 51503 - KAA, KC, KE.	877	180	40	5.1	17	-39	
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.

RENISO TRITON SE / SEZ SERIES – FULLY SYNTHETIC REFRIGERATION OILS BASED ON POLYOL ESTER (POE)

Product Name	Description	Density at 15 °C [kg/m³]	Flp., Clev. [°C]	Kin. Visc. 40 °C [mm²/s]	Kin. Visc. 100 °C [mm²/s]	VI (viscosity index)	Pourpoint [°C]	Main Application Area
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. RENISO TRITON SE/SEZ is also suitable for the use with HFO refrigerants such as HFO-1234yf resp. HFO-1234ze.	1,001	228	20	4.4	134	-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 initial practical experiences with HFO refrigerants (e.g. HFO-1234yf, HFO-1234ze) already exist.
RENISO TRITON SEZ 32		1,004	250	32	6.1	140	-57	
RENISO TRITON SE 55		1,009	286	55	8.8	137	-48	
RENISO TRITON SEZ 68		970	258	68	8.8	125	-39	
RENISO TRITON SEZ 80		992	251	82	10.4	115	-39	
RENISO TRITON SEZ 100		970	266	100	11.4	100	-30	
RENISO TRITON SE 170		972	260	173	17.6	111	-27	
RENISO TRITON SE 220		976	285	220	20.0	105	-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	149	-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	140	-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 68 – FULLY SYNTHETIC REFRIGERATION OILS BASED ON SYNTHETIC HYDROCARBONS (PAO)

Product Name	Description	Density at 15 °C [kg/m³]	Flp., Clev. [°C]	Kin. Visc. 40 °C [mm²/s]	Kin. Visc. 100 °C [mm²/s]	VI (viscosity index)	Pourpoint [°C]	Main Application Area
RENISO SYNTH 68	Synthetic refrigeration oil based on polyalphaolefin (PAO). For NH_3 applications and hydrocarbon refrigerants. Also suitable with 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 oil based on synthetic hydrocarbons. Particularly developed for ammonia applications. DIN 51503-KAA.	854	250	62	9.1	124	-48	RENISO UltraCool 68 combines 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).

The RENISO product portfolio.

RENISO GL 68, PG 68 – FULLY SYNTHETIC REFRIGERATION OILS BASED ON POLYALKYLENE GLYCOL (PAG) FOR NH_3 APPLICATIONS

Product Name	Description	Density at 15 °C [kg/m³]	Flp., Clev. [°C]	Kin. Visc. 40 °C [mm²/s]	Kin. Visc. 100 °C [mm²/s]	VI (viscosity index)	Pour-point [°C]	Main Application Area
RENISO GL 68	Fully synthetic refrigeration oil based on polyalkylene glycol (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 solubility with NH_3. Suitable for screw and reciprocating piston compressors.
RENISO PG 68	Fully synthetic refrigeration oil based on polyalkylene glycol (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. Warning: PAG oils are hygroscopic. Avoid any contamination with water. Attention: Please contact our FUCHS application engineers.

RENISO PAG SERIES – FULLY SYNTHETIC REFRIGERATION OILS BASED ON POLYALKYLENE GLYCOL (PAG)

Product Name	Description	Density at 15 °C [kg/m³]	Flp., Clev. [°C]	Kin. Visc. 40 °C [mm²/s]	Kin. Visc. 100 °C [mm²/s]	VI (viscosity index)	Pour-point [°C]	Main Application Area
RENISO PAG 46	Synthetic refrigeration oils based on special polyalkylene glycol (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 glycol 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 com-pressors.
RENISO PAG 100		996	240	120	21.0	202	-45	
RENISO PAG 1234	Synthetic refrigeration oil on the basis of double-end-capped polyalkylene glycols (PAG). For vehicle A/C-systems with HFO-1234yf. DIN 51503-KD.	993	224	44	9.8	218	-45	RENISO PAG 1234 has been newly developed for car air-conditioning systems with HFO-1234yf. 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.
RENISO PAG 220 C	Synthetic refrigeration oil based on special polyalkylene glycol (PAG) containing a special additive system. For stationary HFC/FC systems, also suitable for hydrocarbon and CO_2 applications. DIN 51503 - KB, KD, (KE).	1,077	250	226	39.1	226	-39	Refrigeration oil based on polyalkylene glycol for HFC refrigerants such as R134a, R245fa. Especially suited for screw compressors in heat pump applications in the industrial and commercial sectors. Also suitable for CO_2 applications (oil which is not miscible with CO_2).

RENISO ACC 68 – FULLY SYNTHETIC REFRIGERATION OILS BASED ON POLYALKYLENE GLYCOL (PAG) FOR CO_2 APPLICATIONS

Product Name	Description	Density at 15 °C [kg/m³]	Flp., Clev. [°C]	Kin. Visc. 40 °C [mm²/s]	Kin. Visc. 100 °C [mm²/s]	VI (viscosity index)	Pour-point [°C]	Main Application Area
RENISO ACC 68	Synthetic refrigeration oil based on special, double-end capped PAGs for for transcritical CO_2 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 46	Refrigeration oil for the use in vehicle A/C systems with CO_2 as refrigerant. Base oil: double end-capped PAG. DIN 51503 - KB.	995	220	43	9.7	220	-45	RENISO ACC 46 and RENISO ACC HV were developed in close collaboration with leading compressor manufacturers and OEMs specific for CO_2 air conditioning systems in vehicles. The products are based on chemical and thermal extremely stable double end-copped PAG fluids with efficient additivation – especially with regard to wear protection.
RENISO ACC HV		991	229	65	13.5	229	-45	

RENISO C SERIES – FULLY SYNTHETIC REFRIGERATION OILS BASED ON POLYOL ESTER (POE) FOR CO_2 APPLICATIONS

Product Name	Description	Density at 15 °C [kg/m³]	Flp., Clev. [°C]	Kin. Visc. 40 °C [mm²/s]	Kin. Visc. 100 °C [mm²/s]	VI (viscosity index)	Pour-point [°C]	Main Application Area
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, e.g. large-scale cooling plants and aggregate cooling systems. RENISO C 55 E for subcritical applications. RENISO C 85 E, C 120 E C 170 E for sub-and transcritical CO_2 applications.
RENISO C 85 E		993	246	80	10.6	118	-42	
RENISO C 170 E		976	286	178	18.5	116	-33	

RENOLIN LPG SERIES – FULLY SYNTHETIC GAS COMPRESSOR OILS BASED ON POLYALKYLENE GLYCOL (PAG)

Product Name	Description	Density at 15 °C [kg/m³]	Flp., Clev. [°C]	Kin. Visc. 40 °C [mm²/s]	Kin. Visc. 100 °C [mm²/s]	VI (viscosity index)	Pour-point [°C]	Main Application Area
RENOLIN LPG 100	Synthetic gas compressor oils based on polyalkylene glycol (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.**	1,002	270	100	16.2	175	-39	RENOLIN LGP 100 and LPG 185 are characterised 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 minimised. 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		1,008	286	185	27.3	186	-33	

RENISO

Refrigeration lubricant selection guide for industrial systems.

Refrigerant		Evaporator temperature		Compressor type								
ASHRAE name	Type	From (°C)	To (°C)	Piston (viscosity grade)			Screw (viscosity grade)			Centrifugal (viscosity grade)		
R12	CFC	-40	+40	32 / 46						100		
R502	CFC	-50	-20	32 / 46	32 / 46 **P**		68 / 100	68 / 100 **P**				
R22	HCFC	-25	+10	32 / 46	32 / 46 **P**		68	68 / 100 **P**		68	68	
R22	HCFC	-30	+10		32 / 46 **P**			68 / 100		68	68	
R22	HCFC	-40	+10		32 / 46			68 / 100		68		
R22	HCFC	-50	+10		32 / 46			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					
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 (ammonia)	-30	+10	68	68 **P**	68	68	68 **P**	68	68		
R717	NH_3 (ammonia)	-40	+10		68 **P**	68		68 **P**	68	68		
R717	NH_3 (ammonia)	-50	+10		68 **P**			68 **P**		68		
R717	NH_3 - dry expansion	-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							
R23	HFC	-100	-40	22 / 32								
R134a	HFC	-20	+10	32 / 55			170 / 220			68		
R134a	HFC	-30	+10	22 / 32			100			68		
R404A	HFC	-40	-30	32 / 55			170 / 220			68		
R404A	HFC	-50	-30	22 / 32			100			68		
R407C	HFC	0	+10	55 / 68			170 / 220					
R410A	HFC	-45	+10	22 / 32			100			68		
R410A	HFC	-25	+10	32 / 55			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			100			68		
R422A	HFC	-25	-5	32 / 55			170 / 220			68		
R422D	HFC	-45	+10	22 / 32			100			68		
R422D	HFC	-25	+10	32 / 55			170 / 220			68		
R427A	HFC	-40	+10	22 / 32			100			68		
R427A	HFC	-20	+10	55			170 / 220			68		
R507	HFC	-40	0	22 / 32			100			68		
R507	HFC	-20	0	55			170 / 220			68		

PAO / synth. HC — **RENISO SYNTH 68 / RENISO UltraCool 68**
based on PAO / synthetic hydrocarbon

MO — **RENISO K-Reihe / RENISO TES 100**
based on mineral oils

AB — **RENISO S- / SP series**
based on alkyl benzenes

POE — **RENISO TRITON SE- / SEZ series**
based on polyol esters

PAG — **RENISO PG / GL / PAG**
based on polyalkylene glycols

POE-C — **RENISO C series**
based on special polyol ester for CO_2

PAG-C — **RENISO ACC 68**
based on polyalkylene glycols for CO_2

Additional explanations:

P = Preferred recommendation

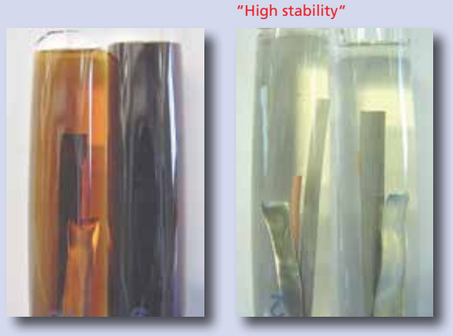
* Selection of viscosity grade acc. to recommendation of compressor manufacturer

4 good reasons for using RENISO Refrigeration Oils.

Performance comparison RENISO TRITON SEZ 80 versus standard-POE-refrigeration oils.

1 High thermo-chemical stability:

e.g. in Sealed Glass Tube Test (ASHRAE 97-2007)

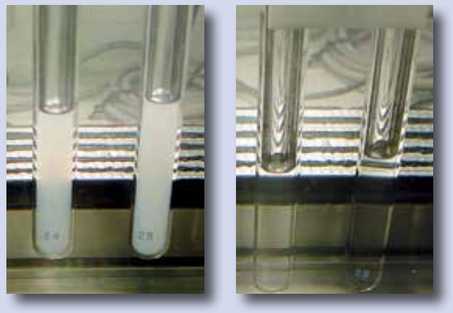


Standard POE refrigeration oils

RENISO TRITON SEZ 80 based on polyol ester (POE)

2 Very good miscibility

with HFKW/FKW: e.g. in small miscibility gap (DIN 51514)



Standard POE refrigeration oils

RENISO TRITON SEZ 80 based on polyol ester (POE)

3 Low varnish / low sludge formation

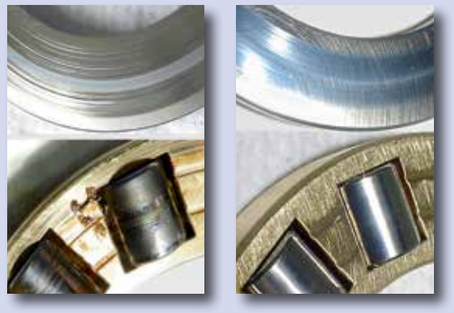
e.g. in FUCHS In-house test (oil deposuits in beaker with bearing roller after 168h/135°C)

Standard POE refrigeration oils

RENISO TRITON SEZ 80 based on polyol ester (POE)

4 Reliable wear protection

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



Standard POE refrigeration oils

RENISO TRITON SEZ 80 based on polyol ester (POE)

The RENISO product portfolio.

	Product name
Mineral oils (MO) for NH_3 and R22	**RENISO KM 32**
	RENISO KS 46
	RENISO KC 68
	RENISO KES 100
	RENISO KW 150
for HFCKW (turbo compressors)	**RENISO TES 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 hydrocarbon for NH_3	**RENISO UltraCool 68**
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
Alkyl benzenes (AB) for R22, hydrocarbons and NH_3	**RENISO S 3246**
	RENISO S 68
Polyol esters (POE) for HFC/FC, e.g. R134a, R404A, R507 for HFO and HFO/HFC blends	**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 (transcritical and subcritical)	**RENISO C 55 E**
	RENISO C 85 E
	RENISO C 170 E
Special polyalkylene glycol (PAG) for CO_2 transcritical systems (heat pumps, a/c systems)	**RENISO ACC 46**
	RENISO ACC HV
	RENISO ACC 68
Polyalkylene glycol (PAG) for CO_2 and HFC/FC (screw compressors, e.g. in heat pumps)	**RENISO PAG 220 C**
Polyalkylene glycols (PAG) for R134a in vehicle a/c systems and for NH_3 (miscible with NH_3)	**RENISO PAG 46**
	RENISO PAG 100
Special polyalkylene glycols (PAG) for HFO-1234yf and R134a vehicle a/c systems	**RENISO PAG 1234**