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: 62
Employees: Almost 5,600 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 950 employees
Certifications: IATF 16949, DIN ISO 14001, ISO 45001, 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 62 operating companies with almost 5,600 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 950 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.
Refrigeration oils play an important role in the area of lubricants and lubrication technology. The expected long life of refrigerant compressors largely depends on the quality of the used refrigeration oil.

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

The 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.

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 NH3 applications
- Synthetic refrigeration oils for hydrocarbon refrigerants
- Synthetic refrigeration oils for HFO refrigerants

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.

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.

*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.
DIN 51503 describes the minimum requirements which refrigeration oils have to fulfill. 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.

REQUIREMENTS AND CLASSIFICATION OF REFRIGERATION OILS

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The classification of refrigeration oils according to DIN 51503, part 1 (2011) is in line with the refrigerants used in the refrigeration system

KAA
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, napthenic 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 (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, napthenic 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 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.

* the actual revision (october 2020) of DIN 51503-1 will lead to the classification of HFO and HFO/HFC refrigerants under group KD.
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.

**PHYSICAL AND CHEMICAL DATA OF REFRIGERATION OILS**

**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**

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Typical data to characterize a refrigeration oil

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 refrigeration 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.

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 air-conditioning 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 oil film”) 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 mm²/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:

\[ \nu = \frac{\eta}{\rho} \]

\( \eta \) = kinematic viscosity
\( \nu \) = dynamic viscosity
\( \rho \) = 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 operating 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:
RENSO TRITON SE / SEZ based on polyol esters (POE)
Example: Kinematic viscosity and vapour pressure (Daniel Plot) RENISO TRITON SE 55 – R134a mixture

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>Pressure [bar]</th>
<th>90 % oil</th>
<th>80 % oil</th>
<th>70 % oil</th>
<th>60 % oil</th>
<th>50 % oil</th>
<th>40 % oil</th>
<th>30 % oil</th>
<th>20 % oil</th>
<th>10 % oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>4</td>
<td>13</td>
<td>13</td>
<td>13</td>
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<td>13</td>
</tr>
</tbody>
</table>

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 diagram)**

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>Complete miscibility, no phase separation between -60 °C and +90 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>90</td>
</tr>
<tr>
<td>10</td>
<td>80</td>
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<td>20</td>
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<tr>
<td>-80</td>
<td>20</td>
</tr>
<tr>
<td>-90</td>
<td>10</td>
</tr>
</tbody>
</table>

**RENISO K series**

Highly refined, naphthenic mineral oils, free of additives. The RENISO K series can be used in NH₃ 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 NH₃ 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.

### 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**

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>Vapour pressure [bar]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.06</td>
</tr>
<tr>
<td>10</td>
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<td>60</td>
<td>1.0</td>
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<tr>
<td>70</td>
<td>1.2</td>
</tr>
<tr>
<td>80</td>
<td>1.3</td>
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</table>

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>Kinematic viscosity [mm²/s]</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>0.07</td>
</tr>
<tr>
<td>10</td>
<td>0.08</td>
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<tr>
<td>50</td>
<td>0.2</td>
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<tr>
<td>60</td>
<td>0.3</td>
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<tr>
<td>70</td>
<td>0.4</td>
</tr>
<tr>
<td>80</td>
<td>0.5</td>
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</tbody>
</table>

All % figures represent mass of oil in the refrigerant.
Synthetic refrigeration oils

Alkyl benzenes (AB)

**RENISO S / SP series**
Chemically and thermally highly stable alkyl benzenes (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.

**Polyalphonefiins (PAO) / synthetic hydrocarbons**

**RENSIO SYNTH 68**
Thermally stable polyalphasein (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.

RENSIO SYNTH 68 can be also used as a refrigeration oil for R123 (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).

**RENSIO UltraCool 68** and RENISO UltraCool 100
RENSIO 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 estolomer properties (good compatibility with CR sealants) as they are only known from mineral oil products.

**Polyl esters (POE)**

**RENSIO TRITON SE / SEZ series**
Synthetic refrigeration oils based on thermally and chemically highly stable polyol esters (POEs), special monoo- and/or dipentaerythritol esters. Due to their good miscibility these polyol ester oils are perfectly suited for applications with HFC/C 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 R22A2 and R417A. Similarly RENISO TRITON SE/SEZ products are also recommended for use with partially-fluorinated propane and butane derivate (e.g. R245fa, R286fa, R227ea) in heat pumps and expanders (ORC systems, waste heat recovery).

RENSIO 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.

RENSIO 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.
Polyalkylene glycols (PAG)

**RENISO PG 68**
Synthetic, NH₃-miscible refrigeration oil based on special polyalkylene glycols (PAG) with an additive system designed to provide enhanced ageing stability.

The selected synthetic components display excellent viscosity-temperature behaviour and good thermal stability. RENISO PG 68 is specially developed for NH₃ systems which use the direct evaporation principle (RENISO PG 68: with ammonia miscible oil).

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

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

**RENISO PAG 46 and RENISO PAG 100**
Selected polyalkylene glycols (PAG) for automotive air conditioning systems which use R134a as refrigerant. Also recommended for the use in ammonia dry expansion (DX) systems (NH₃-miscible oils). RENISO PAG 46 and PAG 100 are also reliable lubricant solutions in systems with hydrocarbons as refrigerants (e.g. propane, propylene). (attention: phase separation / miscibility gap!)

Lubricants for CO₂ 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 CO₂ 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 CO₂ 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 CO₂ 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 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.

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**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.
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 85 E – CO₂ mixture

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)

Example:
Miscibility of RENISO C 85 E with CO₂ (miscibility gap)
Natural refrigerants have been used for refrigeration since the middle of the 19th century - mainly in food production and storage. Ammonia (NH₃) in particular has proven itself in industrial refrigeration for over 120 years. Although the so-called safety refrigerants - for example CFCs, which are banned today - were increasingly used in new systems in the 50s and 60s of the 20th century, ammonia has always been able to maintain its dominance in industrial refrigeration technology. Also due to the environmental discussion about the greenhouse effect, the market share of ammonia refrigeration technology and its components is increasing again today.

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

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

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

**Lubricants for ammonia applications**

**RENISO UltraCool 68 and RENISO UltraCool 100**

Synthetic refrigeration oils based on synthetic hydrocarbons / PAG with an excellent price-performance ratio: very high thermal and aging resistance, extremely low oil evaporation loss in the compressor, good CR compatibility. Also perfectly suitable for heat pump applications (see also page 18f).

**RENISO SYNTH 68**

Synthetic premium refrigeration oil based on high-purity polyalphaolefins (PAO). For NH₃ refrigeration systems with heavily loaded compressors and low evaporation temperatures. Unsurpassed in cold fluidity and thermal and aging stability. RENISO SYNTH 68 can also be used as refrigeration oil for R723 (dimethyl ether-ammonia mixture) (see also page 18f).

**RENISO PG 68**

Synthetic, ammonia-miscible refrigeration oil based on polyalkylene glycol (PAG). For NH₃ direct evaporation systems (see also page 20). Due to the special PAG chemistry, please contact FUCHS application technology before using RENISO PG 68 – especially before refilling.

**Properties of RENISO UltraCool 68 and RENISO UltraCool 100:**
- Significantly higher aging resistance than mineral oils.
- Reduced tendency towards deposits and laking.
- Good compatibility with sealing materials, especially CR elastomers.
- RENISO UltraCool 100 – especially suitable for heat pumps.

**Properties of RENISO SYNTH 68:**
- For significantly longer oil change and service intervals.
- Extremely low evaporation losses and thus minimized oil consumption.
- Suitable for the lowest evaporation temperatures (pour point -57 °C).
- Food grade lubricant with NSF H1 registration.

**Properties of RENISO PG 68:**
- Good ammonia miscibility.
- High viscosity index (VI = 210) for reliable lubrication.
- Specially dried.
Synthetic refrigeration oils

Lubricants for ammonia applications

Refrigeration oil for ammonia: RENISO KC 68
Example: Kinematic viscosity and vapour pressure (Daniel-Plot): RENISO KC 68 and ammonia R717

Refrigeration oil for ammonia: RENISO SYNTH 68
Example: Kinematic viscosity and vapour pressure (Daniel-Plot): RENISO SYNTH 68 and ammonia R717

Example: Low temperature viscosity of RENISO KC 68 with dissolved ammonia R717

Example: Low temperature viscosity of RENISO SYNTH 68 with dissolved ammonia R717
As natural refrigerants, hydrocarbons have a number of advantages over fluorinated refrigerants. Typical representatives such as propane R290, propylene R1270, isobutane R600a have a high thermal resistance, are chemically stable, show good material compatibility and are relatively cheap. Their main advantage, however, lies in the very low GWP of 3 to 6. This means that they are not subject to any restrictions in terms of use under the F-Gas Regulation.

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

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

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

**RENISO LPG 68**

For hydrocarbon refrigerants, special refrigeration oils with reduced refrigerant dissolution have a clear advantage in terms of the lubricating film thickness. RENISO LPG 68 was developed with precisely this aim in mind. RENISO LPG 68 is based on a special synthetic polyalkylene glycol (PAG) fluid. When choosing the base liquid, the focus was on the low hydrocarbon dissolution and thus the lowest possible dilution under the influence of refrigerant. The latest additive technology ensures high aging and thermal stability, reliable wear protection and a reduced tendency to foam. In particular, the suppression of the foaming of oil when the pressure drops is an important criterion for reliable wear protection.

RENISO LPG 68 has good miscibility with hydrocarbon refrigerants. For this reason, with RENISO LPG 68 a safe oil transport and an unimpaired heat transfer in the circuit can be guaranteed.

RENISO LPG 68 is suitable as a refrigeration oil for all hydrocarbon refrigerants - including propane R290, propylene R1270 or isobutane R600a / butane R 600. Both reciprocating and screw compressors are reliably lubricated with RENISO LPG 68.

RENISO LPG 68 is used in refrigeration / air conditioning applications as well as in heat pumps. RENISO LPG 68 can also be recommended for the transport and compression of natural gas.

**Properties of RENISO LPG 68:**

- Good miscibility with hydrocarbon refrigerants such as propane.
- Reduced refrigerant dissolution and thus less dilution and lower viscosity loss.
- Favourable foaming behaviour during outgassing of the refrigerant.
- Reliable wear protection.
- High resistance to aging.
- High thermal resistance.
- Very favourable viscosity-temperature behaviour: very high viscosity index (VI = 184): for increased lubricant film thickness.

Left picture: Conventional PAG refrigeration oil: Strong foaming.

Right picture: FUCHS refrigeration oil RENISO LPG 68: Reduced foaming during outgassing of propane.
## Synthetic refrigeration oils

**Lubricants for hydrocarbon refrigerants**

**Refrigeraion oil for hydrocarbons: RENISO LPG 68 based on PAG**

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

### Kinematic viscosity and vapour pressure (Daniel-Plot):

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>Kinematic viscosity [mm²/s]</th>
<th>Vapour pressure [bar]</th>
</tr>
</thead>
<tbody>
<tr>
<td>-40</td>
<td>10,000</td>
<td>100 % oil</td>
</tr>
<tr>
<td>-30</td>
<td>10,000</td>
<td>50 % oil</td>
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<tr>
<td>-20</td>
<td>10,000</td>
<td>30 % oil</td>
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<tr>
<td>-10</td>
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<td>20 % oil</td>
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<tr>
<td>0</td>
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<tr>
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<td>10,000</td>
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</tr>
<tr>
<td>110</td>
<td>10,000</td>
<td>10 % oil</td>
</tr>
<tr>
<td>120</td>
<td>10,000</td>
<td>10 % oil</td>
</tr>
</tbody>
</table>

In addition to RENISO LPG 68, the following refrigeration oils are in use successfully for hydrocarbon refrigerants for more than 10 years:

- **RENiSO TRiTON SE/SEZ series (POE) - also for hydrocarbon refrigerants**
- Synthetic refrigeration oils based on chemically and thermally extremely stable polyol esters (POE) (see page 19).
- Their polar structure also reduces the refrigerant dissolution and thus the decrease in viscosity compared to mineral oils.

- **RENiSO SYNTH 68 (PAO) - also for hydrocarbon refrigerants**
- Highly pure polyalphaolefins (PAO) as base oils for very good cold flow properties (see page 18) and a favorable viscosity-temperature behavior (high VI). RENISO Synth 68 has been firmly established in the field of hydrocarbon refrigerants for over 10 years and has very good practical experience.

- **RENiSO WF series (Mineral oil)**
- RENISO WF refrigeration oils based on selected hydrogenated mineral oils, so-called isodewaxed base oils, with an effective additive system for increased wear protection.
- Low-viscosity RENISO WF oils have been used by well-known manufacturers for over 20 years to increase efficiency in fully hermetic R600a refrigerator compressors (see pages 16 + 17).

### Properties of RENISO TRiTON SE/SEZ and RENISO SYNTH 68:
- Excellent miscibility properties with hydrocarbon refrigerants.
- High viscosity index (VI) for a stable lubricating film.
- High aging and high temperature resistance.
- Reliable wear protection.

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

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**Diagram:**

- Graph showing the phase separation and complete miscibility of RENISO LPG 68 with propane R290.

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**Diagram:**

- Graph showing the critical point R290 and the miscibility gap of RENISO LPG 68 with propane R290.

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**Diagram:**

- Graph showing the concentration (mass % oil in R290-oil mixture) vs. temperature (°C) for the miscibility of RENISO LPG 68 with propane R290.
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 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 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 TRITION SE/SEZ oils for stationary applications have proven to be reliable lubricants.

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

The new F-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**

<table>
<thead>
<tr>
<th>Refrigerant HFO / HFC</th>
<th>GWP*</th>
<th>Replacement for refrigerant HFC</th>
<th>GWP*</th>
<th>Composition</th>
<th>Safety group**</th>
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</thead>
<tbody>
<tr>
<td>R1233zd(E)</td>
<td>1</td>
<td>R123 / R245fa</td>
<td>858</td>
<td>Trans-1-chloro-3,3,3-Trifluoropropane</td>
<td>A1</td>
</tr>
<tr>
<td>R1234yf</td>
<td>&lt; 1</td>
<td>R134a</td>
<td>1300</td>
<td>2,3,3,3-Tetrafluoropropane</td>
<td>A2L</td>
</tr>
<tr>
<td>R1234ze(E)</td>
<td>&lt; 1</td>
<td>R134a</td>
<td>1300</td>
<td>Trans-1,3,3,3-Tetrafluoroprop-1-en</td>
<td>A2L</td>
</tr>
<tr>
<td>R1336m(z)</td>
<td>2</td>
<td>R245ta</td>
<td>858</td>
<td>1,1,1,4,4-Hexafluor-2-butene</td>
<td>A1</td>
</tr>
<tr>
<td>R44A</td>
<td>295</td>
<td>R22 / R407C</td>
<td>1760 / 1620</td>
<td>R32 / R152a / R1234zd(E)</td>
<td>A2L</td>
</tr>
<tr>
<td>R44A</td>
<td>1270</td>
<td>R404A / R507A</td>
<td>3940 / 3990</td>
<td>R32 / R125 / R134a / R1234zd(E) / R1234yf</td>
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</tr>
<tr>
<td>R44A</td>
<td>1280</td>
<td>R404A / R507A</td>
<td>3940 / 3990</td>
<td>R32 / R125 / R134a / R1234yf</td>
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</tr>
<tr>
<td>R450A</td>
<td>547</td>
<td>R134a</td>
<td>1300</td>
<td>R134a / R1234zd(E)</td>
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<tr>
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<td>1945</td>
<td>R404A / R507A</td>
<td>3940 / 3990</td>
<td>R32 / R125 / R1234yf</td>
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<tr>
<td>R452B</td>
<td>676</td>
<td>R410A</td>
<td>1920</td>
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<tr>
<td>R454A</td>
<td>238</td>
<td>R404A / R507A</td>
<td>3940 / 3990</td>
<td>R32 / R1234yf</td>
<td>A2L</td>
</tr>
<tr>
<td>R454B</td>
<td>467</td>
<td>R410A</td>
<td>1920</td>
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<td>A2L</td>
</tr>
<tr>
<td>R454C</td>
<td>146</td>
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<td>3940 / 3990</td>
<td>R1234yf / R32 / R744</td>
<td>A2L</td>
</tr>
<tr>
<td>R51A</td>
<td>573</td>
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<td>1300</td>
<td>R134a / R1234yf</td>
<td>A1</td>
</tr>
<tr>
<td>R51A</td>
<td>2</td>
<td>R123</td>
<td>79</td>
<td>R1336m(z) / R1234zd(E)</td>
<td>B1</td>
</tr>
</tbody>
</table>

* 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

- **R134a**
- **R404A / R507A**
- **R410A**

**GWP**

- **R1234yf**
- **R1234zd(E)**
- **R134a**
- **R125**
- **R152a**
- **R32**
- **R744**
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

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 R1234yf (miscibility gap)

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

RENISO TRITON SEZ 75 AC – for electrically driven R1234y A/C compressors

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

The POE-based refrigeration oil RENISO TRITON SEZ 75 AC was developed for precisely this application. Due to the high specific resistance of RENISO TRITON 75 AC, the insulation of the electrical compressor parts is ensured at all times. In addition, the use of RENISO TRITON SEZ 75 AC in R1234yf air conditioning systems guarantees reliable lubrication of the electrical compressor and perfect oil transport in the refrigeration circuit. RENISO TRITON SEZ 75 AC is also suitable for use in electric R134a compressors.

Specific electrical resistance of PAG oils mixed with R1234yf

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

Specific electrical resistance of RENISO TRITON SEZ 75 AC mixed with R1234yf: electrical resistivity stays higher compared to PAG oils – better insulation protection against short circuits.
The FUCHS service program

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**
- **RENISO K**
  - Mineral oils
- **RENISO SYNTH**
  - Refrigeration oils (miscible: e.g. polyalkylene glycols)
- **RENISO S/IP**
  - Alkyl benzenes (AB)
- **RENISO PAG/ACC**
  - Polyalkylene glycols (PAG)
- **RENISO TRITON SE/SEZ**
  - Ester oils (POE, complex esters)

### Deviation in kinematic viscosity at +40 °C [mm²/s]*

<table>
<thead>
<tr>
<th>Brand name</th>
<th>Group</th>
<th>Deviation in kinematic viscosity at +40 °C [mm²/s]*</th>
</tr>
</thead>
<tbody>
<tr>
<td>RENISO K</td>
<td>KE</td>
<td>± 15% of fresh oil value</td>
</tr>
<tr>
<td>RENISO SYNTH</td>
<td>KB</td>
<td>± 15% of fresh oil value</td>
</tr>
<tr>
<td>RENISO S/IP</td>
<td>KE</td>
<td>± 15% of fresh oil value</td>
</tr>
<tr>
<td>RENISO PAG/ACC</td>
<td>KD</td>
<td>± 15% of fresh oil value</td>
</tr>
<tr>
<td>RENISO TRITON SE/SEZ</td>
<td>KD</td>
<td>± 15% of fresh oil value</td>
</tr>
</tbody>
</table>

### Max. water content [mg H₂O/kg oil]

<table>
<thead>
<tr>
<th>Brand name</th>
<th>Group</th>
<th>Max. water content [mg H₂O/kg oil]</th>
</tr>
</thead>
<tbody>
<tr>
<td>RENISO K</td>
<td>KE</td>
<td>60</td>
</tr>
<tr>
<td>RENISO SYNTH</td>
<td>KB</td>
<td>80</td>
</tr>
<tr>
<td>RENISO S/IP</td>
<td>KE</td>
<td>80</td>
</tr>
<tr>
<td>RENISO PAG/ACC</td>
<td>KD</td>
<td>800</td>
</tr>
<tr>
<td>RENISO TRITON SE/SEZ</td>
<td>KD</td>
<td>200</td>
</tr>
</tbody>
</table>

### Neutralization number [mg KOH/g]

<table>
<thead>
<tr>
<th>Brand name</th>
<th>Group</th>
<th>Neutralization number [mg KOH/g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>RENISO K</td>
<td>KE</td>
<td>0,07</td>
</tr>
<tr>
<td>RENISO SYNTH</td>
<td>KB</td>
<td>0,1</td>
</tr>
<tr>
<td>RENISO S/IP</td>
<td>KE</td>
<td>0,07</td>
</tr>
<tr>
<td>RENISO PAG/ACC</td>
<td>KD</td>
<td>0,2</td>
</tr>
<tr>
<td>RENISO TRITON SE/SEZ</td>
<td>KD</td>
<td>0,2</td>
</tr>
</tbody>
</table>

### 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 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** – HFC/HC refrigeration oils (e.g. polyol esters, polyalkylene glycols)

**KE** – Hydrocarbon refrigeration oils (e.g. mineral oils, alkyl benzenes, complex and polyol esters)

**KD** – CO₂/refrigeration oils (e.g. polyol esters, polyalkylene glycols)

**KC** – Ester oils (e.g. mineral oils, alkyl benzenes, polyalphaolefins, polyalkylene glycols, polyol esters)

Determining water content according to Karl Fisher

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

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

### Determining viscosity according to DIN EN ISO 3104 and DIN 51777-1

<table>
<thead>
<tr>
<th>Brand name</th>
<th>Group</th>
<th>DIN EN ISO 3104</th>
<th>DIN 51777-1</th>
<th>DIN 51777-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>RENISO K</td>
<td>KAA</td>
<td>**</td>
<td>100</td>
<td>60</td>
</tr>
<tr>
<td>RENISO SYNTH</td>
<td>KB</td>
<td>**</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>RENISO S/IP</td>
<td>KE</td>
<td>**</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>RENISO PAG/ACC</td>
<td>KD</td>
<td>**</td>
<td>500</td>
<td>800</td>
</tr>
<tr>
<td>RENISO TRITON SE/SEZ</td>
<td>KD</td>
<td>**</td>
<td>150</td>
<td>150</td>
</tr>
</tbody>
</table>

### Determining water content according to DIN 51777-2

<table>
<thead>
<tr>
<th>Brand name</th>
<th>Group</th>
<th>DIN EN ISO 3104</th>
<th>DIN 51777-2</th>
<th>DIN 51558-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>RENISO K</td>
<td>KE</td>
<td>**</td>
<td>0,07</td>
<td>0,07</td>
</tr>
<tr>
<td>RENISO SYNTH</td>
<td>KB</td>
<td>**</td>
<td>0,1</td>
<td>0,1</td>
</tr>
<tr>
<td>RENISO S/IP</td>
<td>KE</td>
<td>**</td>
<td>0,07</td>
<td>0,1</td>
</tr>
<tr>
<td>RENISO PAG/ACC</td>
<td>KD</td>
<td>**</td>
<td>0,2</td>
<td>0,2</td>
</tr>
<tr>
<td>RENISO TRITON SE/SEZ</td>
<td>KD</td>
<td>**</td>
<td>0,2</td>
<td>0,2</td>
</tr>
</tbody>
</table>

### Determining neutralization number according to DIN 51558-1

<table>
<thead>
<tr>
<th>Brand name</th>
<th>Group</th>
<th>DIN EN ISO 3104</th>
<th>DIN 51777-2</th>
<th>DIN 51558-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>RENISO K</td>
<td>KE</td>
<td>**</td>
<td>0,07</td>
<td>0,07</td>
</tr>
<tr>
<td>RENISO SYNTH</td>
<td>KB</td>
<td>**</td>
<td>0,1</td>
<td>0,1</td>
</tr>
<tr>
<td>RENISO S/IP</td>
<td>KE</td>
<td>**</td>
<td>0,07</td>
<td>0,1</td>
</tr>
<tr>
<td>RENISO PAG/ACC</td>
<td>KD</td>
<td>**</td>
<td>0,2</td>
<td>0,2</td>
</tr>
<tr>
<td>RENISO TRITON SE/SEZ</td>
<td>KD</td>
<td>**</td>
<td>0,2</td>
<td>0,2</td>
</tr>
</tbody>
</table>
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.

The FUCHS service program

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

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.

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**

<table>
<thead>
<tr>
<th>Brand name</th>
<th>Description</th>
<th>Density at 15 °C [kg/m³]</th>
<th>Flashp. at 40 °C [°C]</th>
<th>Kin. Visc. at 100 °C [mm²/s]</th>
<th>Kin. Visc. at 40 °C [mm²/s]</th>
<th>VI (Viscosity index)</th>
<th>Pour- point [°C]</th>
<th>Main application area</th>
</tr>
</thead>
<tbody>
<tr>
<td>RENISO WF – Mineral oil based refrigeration oils</td>
<td>Special refrigeration oils for use with the refrigerant iso-butane (R600a) – highly refined, low flashpoint with R604a, containing additives to improve wear protection and ageing stability. DIN S1503 - KC, KE.</td>
<td>827</td>
<td>134</td>
<td>5.0</td>
<td>1.7</td>
<td>95</td>
<td>-45</td>
<td>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 R604a and also with all other hydrocarbon refrigerants like R22.</td>
</tr>
<tr>
<td>RENISO WF 7 A</td>
<td></td>
<td>832</td>
<td>158</td>
<td>7.2</td>
<td>2.2</td>
<td>97</td>
<td>-42</td>
<td></td>
</tr>
<tr>
<td>RENISO WF 10 A</td>
<td></td>
<td>835</td>
<td>172</td>
<td>9.6</td>
<td>2.6</td>
<td>97</td>
<td>-42</td>
<td></td>
</tr>
<tr>
<td>RENISO WF 15 A</td>
<td></td>
<td>883</td>
<td>164</td>
<td>15</td>
<td>3.1</td>
<td>9</td>
<td>-51</td>
<td></td>
</tr>
<tr>
<td>RENISO – Mineral oil based refrigeration oils</td>
<td>Highly refined, naphthenic mineral oils with high ageing stability, low pourpoint, excellent low-temperature behaviour and particularly good compatibility with the following refrigerants: ammonia (NH₃), HCFCs (e.g. R22), hydrocarbons (e.g. propane R290, propylene R1270). DIN S1503 - KAA, KKC, KE.</td>
<td>881</td>
<td>202</td>
<td>32</td>
<td>4.9</td>
<td>63</td>
<td>-45</td>
<td>For all refrigeration systems, using ammonia (NH₃) 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.</td>
</tr>
<tr>
<td>RENISO KM 32</td>
<td></td>
<td>894</td>
<td>204</td>
<td>46</td>
<td>5.8</td>
<td>47</td>
<td>-42</td>
<td></td>
</tr>
<tr>
<td>RENISO KS 46</td>
<td></td>
<td>894</td>
<td>223</td>
<td>68</td>
<td>7.4</td>
<td>58</td>
<td>-39</td>
<td></td>
</tr>
<tr>
<td>RENISO KC 68</td>
<td></td>
<td>912</td>
<td>218</td>
<td>100</td>
<td>8.4</td>
<td>20</td>
<td>-33</td>
<td></td>
</tr>
<tr>
<td>RENISO KES 100</td>
<td></td>
<td>881</td>
<td>172</td>
<td>32</td>
<td>4.6</td>
<td>31</td>
<td>-39</td>
<td>Particularly good miscibility with HCFC refrigerants, such as R22. Suitable for very low evaporation temperatures down to -40 °C. RENISO SP products are also recommended for use with Drop-in components (R404A, R407C, etc.). Due to their excellent stability RENISO SP 220 is especially designed for the lubrication of screw compressors.</td>
</tr>
<tr>
<td>RENISO S/SP – Fully synthetic refrigeration oils based on alkyl benzenes</td>
<td>Fully synthetic refrigeration oils based on chemically and thermally stable alkyl benzenes. RENISO SP 32, 46, 100 and 220 contain highly effective Anti-Wear* additives (not suitable for NSF, applications). Excellent elastomer compatibility with HFO/HFC refrigerants (e.g. R22). DIN S1503 - KC, KE.</td>
<td>875</td>
<td>199</td>
<td>46</td>
<td>5.6</td>
<td>26</td>
<td>-42</td>
<td></td>
</tr>
<tr>
<td>RENISO SP 32</td>
<td></td>
<td>871</td>
<td>190</td>
<td>100</td>
<td>7.9</td>
<td>11</td>
<td>-24</td>
<td></td>
</tr>
<tr>
<td>RENISO SP 46</td>
<td></td>
<td>872</td>
<td>192</td>
<td>220</td>
<td>13.2</td>
<td>13</td>
<td>-27</td>
<td></td>
</tr>
<tr>
<td>RENISO SP 100</td>
<td></td>
<td>877</td>
<td>180</td>
<td>40</td>
<td>5.1</td>
<td>17</td>
<td>-39</td>
<td>RENISO S 32 and RENISO S 68 do not contain Anti-Wear* additives and are suitable for use with HFO/HFC refrigerants, hydrocarbons and NH₃. DIN S1503 - KAA, KKC, KE.</td>
</tr>
<tr>
<td>RENISO SP 220</td>
<td></td>
<td>869</td>
<td>188</td>
<td>68</td>
<td>6.2</td>
<td>-30</td>
<td>-33</td>
<td></td>
</tr>
</tbody>
</table>

* Anti-Wear additives: additions to enhance the wear protection of the refrigeration of under severe friction conditions.

**RENISO SYNTH 68 / RENISO UltraCool – Fully synthetic refrigeration oils based on synthetic hydrocarbons (PAO)**

<table>
<thead>
<tr>
<th>Brand name</th>
<th>Description</th>
<th>Density at 15 °C [kg/m³]</th>
<th>Flashp. at 40 °C [°C]</th>
<th>Kin. Visc. at 100 °C [mm²/s]</th>
<th>Kin. Visc. at 40 °C [mm²/s]</th>
<th>VI (Viscosity index)</th>
<th>Pour- point [°C]</th>
<th>Main application area</th>
</tr>
</thead>
<tbody>
<tr>
<td>RENISO UltraCool 68</td>
<td>Synthetic refrigeration oil based on polyalkylidenenes (PAO). For NH₃, applications and hydrocarbon refrigerants. Also suitable for CO₂ (not miscible with NH₃). DIN S1503 - KAA, KB, KE. NSF-H1 approved acceptable as a lubricant with incidental food contact. Suitable for use in and around food processing areas.</td>
<td>835</td>
<td>260</td>
<td>68</td>
<td>10.5</td>
<td>142</td>
<td>-57</td>
<td>RENISO SYNTH 68 has been developed especially for the lubrication of highly stressed NH₃ compressors. Excellent stability with NH₃. 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 CO₂ applications (not miscible with CO₂).</td>
</tr>
<tr>
<td>RENISO UltraCool 100</td>
<td>Refrigeration oils based on synthetic hydrocarbons. Particularly developed for ammonia applications. DIN S1503-KAA.</td>
<td>854</td>
<td>250</td>
<td>62</td>
<td>9.1</td>
<td>124</td>
<td>-48</td>
<td>RENISO UltraCool 68 and UltraCool 100 combine high thermal stability (no varnish, no skidup and low evaporation rate (low oil carry-over/ low oil loss) with good elastomer compatibility (CR, NBR, HNBR).</td>
</tr>
</tbody>
</table>
### RENISO Overview of products

<table>
<thead>
<tr>
<th>Brand name</th>
<th>Description</th>
<th>Density at 15 °C [kg/m³]</th>
<th>Flashp., Clev. at 40 °C [°C]</th>
<th>Kin. Visc. at 100 °C [mm²/s]</th>
<th>VI (Viscosity Index)</th>
<th>Pour-point °C</th>
<th>Main application area</th>
</tr>
</thead>
<tbody>
<tr>
<td>RENISO GL 68, RENISO PG 68 – Fully synthetic refrigeration oil based on polyalkylene glycols (PAG) for NH₃ applications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RENISO PG 68</td>
<td>Fully synthetic refrigeration oil based on polyalkylene glycols (PAG), miscibility gap 10% oil / 90% NH₃, –30°C</td>
<td>1,044</td>
<td>250</td>
<td>70</td>
<td>14.0</td>
<td>210</td>
<td>–52</td>
</tr>
<tr>
<td>RENISO PAG 46</td>
<td>Synthetic refrigeration oils based on special polyalkylene glycols (PAG) for automotive air conditioning units with R134a. NH₃ – partly miscible refrigeration oils. Also suitable for hydrocarbon applications. DIN 51503 – KAB, KE.</td>
<td>996</td>
<td>240</td>
<td>55</td>
<td>10,6</td>
<td>187</td>
<td>–45</td>
</tr>
<tr>
<td>RENISO PAG 100</td>
<td>Synthetic refrigeration oil on the basis of double-end-capped polyalkylene glycols (PAG). For vehicle AC systems with R1234yf. Also suitable for R134a. DIN 51503 - KD, KE</td>
<td>993</td>
<td>224</td>
<td>44</td>
<td>9,8</td>
<td>218</td>
<td>–45</td>
</tr>
<tr>
<td>RENISO PAG 1234</td>
<td>Synthetic refrigeration oil based on polyalkylene glycol (PAG) for hydrocarbon applications</td>
<td>993</td>
<td>270</td>
<td>68</td>
<td>12,4</td>
<td>186</td>
<td>–45</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RENISO PAG 68</td>
<td>Synthetic refrigeration machine oil based on polyalkylene glycol (PAG). Especially for hydrocarbon refrigerants such as e.g. propane R290, propylene R1270 or isobutane R600a developed. For reduced foam formation during outgassing of refrigerant. DIN 51503 - KE</td>
<td>993</td>
<td>270</td>
<td>68</td>
<td>12,4</td>
<td>186</td>
<td>–45</td>
</tr>
<tr>
<td>RENISO TRITON SEZ 75 AC</td>
<td>Synthetic refrigeration oil for electrically driven, hermetic compressors in R1234yf car AC systems. Also suitable for R134a. DIN 51503-KD.</td>
<td>978</td>
<td>282</td>
<td>76</td>
<td>9,9</td>
<td>111</td>
<td>–42</td>
</tr>
<tr>
<td>NEW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RENISO TRITON SEZ 75 AC</td>
<td>Synthetic refrigeration oil for electrically driven, hermetic compressors in R1234yf car AC systems. Also suitable for R134a. DIN 51503-KD.</td>
<td>978</td>
<td>282</td>
<td>76</td>
<td>9,9</td>
<td>111</td>
<td>–42</td>
</tr>
</tbody>
</table>

### Fully synthetic refrigeration oil based on POE for car AC systems in electric and hybrid cars

- **RENISO TRITON SEZ 75 AC**
  - Synthetic refrigeration oil for electrically driven, hermetic compressors in R1234yf car AC systems. Due to its high electrical resistivity, RENISO TRITON SEZ 75 AC is the ideal lubricant to secure the insulation of the electrical compressor parts at any time. Beyond that RENISO TRITON SEZ 75 AC guarantees reliable lubrication, excellent wear protection and safe oil transport in the refrigeration circuit.
RENISO Overview of products

<table>
<thead>
<tr>
<th>Brand name</th>
<th>Description</th>
<th>Density at 15 °C [kg/m³]</th>
<th>Flashp., Cloz. [°C]</th>
<th>Kin. Visc. at 40 °C [mm²/s]</th>
<th>Kin. Visc. at 100 °C [mm²/s]</th>
<th>VI (Viscosity Indекс)</th>
<th>Pour-point [°C]</th>
<th>Main application area</th>
</tr>
</thead>
<tbody>
<tr>
<td>RENISO ACC 68</td>
<td>Synthetic refrigeration oil based on special, double-end-capped PAGs for transcritical CO₂ applications. DIN 51503-K8.</td>
<td>1,007</td>
<td>286</td>
<td>55</td>
<td>8.8</td>
<td>137</td>
<td>–48</td>
<td>Specific fields of industrial and commercial refrigeration.</td>
</tr>
<tr>
<td>RENISO ACC HV NEW</td>
<td>Refrigeration oils for the use in mobile A/C systems with CO₂ as refrigerant. Base oil: double-end-capped PAG. DIN 51503-K8.</td>
<td>999</td>
<td>&gt; 220</td>
<td>68</td>
<td>14.1</td>
<td>215</td>
<td>–42</td>
<td>Refrigeration oil based on specially developed additive for use in applications with the refrigerant CO₂. Application fields: supermarket refrigeration equipment (subcritical and transcritical applications), ship cooling, as well as nearly all fields of industrial and commercial refrigeration.</td>
</tr>
<tr>
<td>RENISO C 55 E</td>
<td>Synthetic refrigeration oils based on polyol esters (POE) for CO₂ applications.</td>
<td>1,009</td>
<td>286</td>
<td>55</td>
<td>8.8</td>
<td>137</td>
<td>–48</td>
<td>Refrigeration oil based on specially developed additive for use in applications with the refrigerant CO₂. Application fields: supermarket refrigeration equipment (subcritical and transcritical applications), ship cooling, as well as nearly all fields of industrial and commercial refrigeration.</td>
</tr>
<tr>
<td>RENISO C 85 E</td>
<td>Refrigeration oils for the use in mobile A/C systems with CO₂ as refrigerant. Base oil: double-end-capped PAG. DIN 51503-K8.</td>
<td>999</td>
<td>246</td>
<td>80</td>
<td>10.6</td>
<td>118</td>
<td>–42</td>
<td>Refrigeration oil based on specially developed additive for use in applications with the refrigerant CO₂. Application fields: supermarket refrigeration equipment (subcritical and transcritical applications), ship cooling, as well as nearly all fields of industrial and commercial refrigeration.</td>
</tr>
<tr>
<td>RENISO C 170 E</td>
<td>Refrigeration oils based on polyol esters (POE) for CO₂ applications.</td>
<td>976</td>
<td>286</td>
<td>178</td>
<td>18.5</td>
<td>116</td>
<td>–33</td>
<td>Refrigeration oil based on specially developed additive for use in applications with the refrigerant CO₂. Application fields: supermarket refrigeration equipment (subcritical and transcritical applications), ship cooling, as well as nearly all fields of industrial and commercial refrigeration.</td>
</tr>
<tr>
<td>RENOLIN LPG</td>
<td>Synthetic gas compressor oils based on polyol esters (POE) for CO₂ applications.</td>
<td>1,007</td>
<td>225</td>
<td>100</td>
<td>17.2</td>
<td>190</td>
<td>–37</td>
<td>Refrigeration oil based on specially developed additive for use in applications with the refrigerant CO₂. Application fields: supermarket refrigeration equipment (subcritical and transcritical applications), ship cooling, as well as nearly all fields of industrial and commercial refrigeration.</td>
</tr>
<tr>
<td>RENOLIN LPG 100</td>
<td>Synthetic gas compressor oil based on polyol esters (POE) for CO₂ applications. Suitable for process gases, refinery gases (petroleum gases) and other hydrogen-carbon-based gases (propane, propylene, butane, etc.) and their blends.</td>
<td>1,002</td>
<td>229</td>
<td>185</td>
<td>30.1</td>
<td>205</td>
<td>–45</td>
<td>Refrigeration oil based on specially developed additive for use in applications with the refrigerant CO₂. Application fields: supermarket refrigeration equipment (subcritical and transcritical applications), ship cooling, as well as nearly all fields of industrial and commercial refrigeration.</td>
</tr>
</tbody>
</table>

Refrigeration oil selection guide for industrial and commercial refrigeration systems

### HFC refrigerant applications

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Evaporation temperature</th>
<th>Compressor type</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASHRAE name</td>
<td>Type</td>
<td>From (°C)</td>
</tr>
<tr>
<td>R22</td>
<td>HFC</td>
<td>–50</td>
</tr>
<tr>
<td>R401A</td>
<td>HFC</td>
<td>–20</td>
</tr>
<tr>
<td>R402A</td>
<td>HFC</td>
<td>–50</td>
</tr>
<tr>
<td>R408A</td>
<td>HFC</td>
<td>–50</td>
</tr>
<tr>
<td>R409A</td>
<td>HFC</td>
<td>–20</td>
</tr>
</tbody>
</table>

**P** = Preferred recommendation

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

### Natural refrigerant applications

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>Evaporation temperature</th>
<th>Compressor type</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASHRAE name</td>
<td>Type</td>
<td>From (°C)</td>
</tr>
<tr>
<td>R290</td>
<td>Propane</td>
<td>–30</td>
</tr>
<tr>
<td>R1270</td>
<td>Propylene</td>
<td>–30</td>
</tr>
<tr>
<td>R600</td>
<td>Butane</td>
<td>–30</td>
</tr>
<tr>
<td>R600a</td>
<td>Isobutane</td>
<td>–30</td>
</tr>
<tr>
<td>R717</td>
<td>NH₃</td>
<td>–50</td>
</tr>
<tr>
<td>R717</td>
<td>NH₃</td>
<td>–50</td>
</tr>
<tr>
<td>R744</td>
<td>CO₂</td>
<td>–50</td>
</tr>
<tr>
<td>R744</td>
<td>CO₂</td>
<td>–50</td>
</tr>
</tbody>
</table>

**P** = Preferred recommendation

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

HFC = Hydrochlorofluorocarbon
HFO = Hydrofluoro-Olefins

### Refrigerants

- **R22**: HFC-134a
- **R401A**: HFC-152a
- **R404A**: HFC-245fa
- **R407C**: HFC-123/134a/365mfd
- **R410A**: HFC-32/125a
- **R409A**: HFC-123/134a/365mfd
- **R417A**: HFC-32/125a/134a
- **R422A**: HFC-123/134a/365mfd
- **R429A**: HFC-123/134a/365mfd
- **R430A**: HFC-123/134a/365mfd
- **R439A**: HFC-123/134a/365mfd
- **R449A**: HFC-123/134a/365mfd
- **R459A**: HFC-123/134a/365mfd

**ASHRAE**

- **R409A**: HFC-123/134a/365mfd
- **R410A**: HFC-32/125a
- **R417A**: HFC-32/125a/134a
- **R422A**: HFC-123/134a/365mfd
- **R429A**: HFC-123/134a/365mfd
- **R430A**: HFC-123/134a/365mfd
- **R439A**: HFC-123/134a/365mfd
- **R449A**: HFC-123/134a/365mfd
- **R459A**: HFC-123/134a/365mfd

**Flashpoint**

- **40 °C**
- **23 °C**

**Kinematic viscosity**

- **100 °C**
- **40 °C**
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)

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

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)

4. Reliable wear protection
   e.g. in bearing wear testing (DIN 51819-3)
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### The RENISO product portfolio

<table>
<thead>
<tr>
<th>Product group</th>
<th>Refrigerant</th>
<th>Refrigeration oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral oils (MO)</td>
<td>for NH₃ and R22</td>
<td>RENISO KM 32, RENISO KS 46, RENISO KC 68, RENISO KES 100</td>
</tr>
<tr>
<td>for hydrocarbons (e.g. R600a - hermetic compressors)</td>
<td>RENISO VVF 5 A, RENISO VVF 7 A, RENISO VVF 10 A, RENISO VVF 15 A</td>
<td></td>
</tr>
<tr>
<td>Synthetic hydrocarbons</td>
<td>for NH₃</td>
<td>RENISO LithiaCool 68, RENISO LithiaCool 100</td>
</tr>
<tr>
<td>for hydrocarbons</td>
<td>RENISO LPG 68</td>
<td></td>
</tr>
<tr>
<td>Poryalkylene glycols (PAG)</td>
<td>for NH₃, CO₂ (not miscible) and hydrocarbons</td>
<td>RENISO Synthetic 68</td>
</tr>
<tr>
<td>for hydrocarbons, e.g. propane R290, propylene R1270, isobutane R600a</td>
<td>RENISO LPG 68</td>
<td></td>
</tr>
<tr>
<td>Allyl benzenes (AB)</td>
<td>for R22 and hydrocarbons</td>
<td>RENISO SP 32, RENISO SP 46, RENISO SP 100, RENISO SP 220</td>
</tr>
<tr>
<td>for R22, hydrocarbons and NH₃</td>
<td>RENISO S 3246, RENISO S 68</td>
<td></td>
</tr>
<tr>
<td>Polyol esters (POE)</td>
<td>for HFC/HC, e.g. R134a, R404A, R507 NEW: for HFO and HFO/HFC refrigerants</td>
<td>RENISO TRITON SEZ 22, RENISO TRITON SEZ 32, RENISO TRITON SEZ 35 SC, RENISO TRITON SE 55, RENISO TRITON SEZ 68, RENISO TRITON SE 80, RENISO TRITON SE 100, RENISO TRITON SE 170, RENISO TRITON SE 220, RENISO TRITON SE 320</td>
</tr>
<tr>
<td>for CO₂ (subcritical and transcritical)</td>
<td>RENISO C 55 E, RENISO C 85 E, RENISO C 170 E</td>
<td></td>
</tr>
<tr>
<td>Special polyol esters (POE)</td>
<td>for CO₂, transcritical systems in stationary application (heat pumps, a/c systems): Industrial and commercial applications</td>
<td>RENISO ACC 68</td>
</tr>
<tr>
<td>Special polyalkylene glycol (PAG)</td>
<td>for CO₂, transcritical systems in stationary application (heat pumps, a/c systems): Industrial and commercial applications</td>
<td>RENISO ACC 68</td>
</tr>
<tr>
<td>for R134a in mobile a/c systems, for hydrocarbons and for NH₃, miscible with NH₃, industrial application</td>
<td>RENISO PAG 46, RENISO PAG 100</td>
<td></td>
</tr>
<tr>
<td>for R1234yf and R134a mobile a/c systems</td>
<td>RENISO PAG 1234</td>
<td></td>
</tr>
<tr>
<td>for R1234yf and R134a mobile a/c systems with electric compressor</td>
<td>RENISO TRITON SEZ 75 AC</td>
<td></td>
</tr>
</tbody>
</table>

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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.