Supply media for mechanical seals
Introduction

Selection of the correct sealing system requires the choice of a suitable supply medium. The question of which supply medium is the right one is therefore important, but not always easy to answer. The fact is that unsuitable supply media may significantly reduce the life time of seals and have a negative effect on the process stream.

For the operator of the production plant, it is often not easy to find the right product. This brochure will help to evaluate the effects of supply media on the life time of seals, and to choose a suitable medium taking into account the most important criteria.

On the following pages, basics, terms, and the purposes of supply media are explained. This leads to the properties of the ideal supply medium. Finally, standard supply media are discussed and selected problematic cases are described.

Generally, it is not possible to make a global statement on the basis of this brochure as to whether or not a supply medium is suitable for a mechanical seal. But the consequences and effects may be more easily evaluated, and an increase of the seal’s life time may be achieved in specific applications.
If mechanical seals are used in pumps or other machines like mixers or dryers, often a supply system with a suitable medium is necessary to cool and/or lubricate the seal or to avoid deposits. The external medium is named with the umbrella term ‘supply medium’ and performs diverse tasks dependent on the application.

Supply systems may be used in combination with single and multiple seals.

The supply system takes over the heat removal or cooling in cases of high process temperatures, or high temperatures at the seal due to the dynamic friction of the seal faces.

If the process medium itself is not suitable for lubrication of the seal because of bad lubrication properties, or other reasons, for example high solid contents, then the supply medium takes over the lubrication.

If the operating temperature is near the vapour point of the process medium, then there is an increased risk of evaporation in the sealing gap, and as a consequence dry running and destruction of the seal. The application of a supply medium can avoid this.

Supply media are also used if process media with a high solid content have to be sealed. Particles may enter the sealing gap which can lead to a destruction of the seal faces. Beyond this, solids may deposit inside the seal chamber thus blocking the o-ring’s and the spring’s movability.

Deposits at the atmospheric side of the seal occur if the process medium for example tends to crystallize or due to crack residues from oils.

In a lot of applications the process medium has to be completely separated from the environment. Possible reasons are, environmental hazards caused by the process medium, threat to safety in the workplace, or the process medium may not come into contact with oxygen.

Also heating of the seal by a supply medium may be necessary if the process medium has a high melting point. Otherwise the process medium would harden at the atmospheric side and therefore lead to damages at the seal.

### Purposes and function

<table>
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<th>Description</th>
<th>Possible purposes</th>
</tr>
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<tbody>
<tr>
<td>Quench</td>
<td>Introduction of an external medium on the atmospheric side of the mechanical seal.</td>
<td>☐ ☐ ☐</td>
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<tr>
<td>Flush</td>
<td>Introduction of the process medium itself or an external medium into the stuffing box chamber in the area of the seal faces.</td>
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</tr>
<tr>
<td>Buffer medium</td>
<td>Introduction of an external medium between two mechanical seals whereas the pressure of the buffer medium is below the pressure to be sealed.</td>
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<tr>
<td>Barrier medium</td>
<td>Introduction of an external medium between two mechanical seals whereas the pressure of the buffer (barrier) medium is above the pressure to be sealed.</td>
<td>☐ ☐ ☐ ☐</td>
</tr>
</tbody>
</table>

- ☐ Cooling of the seal
- ☐ Lubrication of the seal faces and therefore prevention of dry running
- ☐ Pressure increase in the sealing gap (increase of ΔP to the vapour curve)
- ☐ Prevention of seal face destruction e.g. by solid particles
- ☐ Prevention of deposits in the area of the seal faces
- ☐ Prevention of deposits at the atmospheric side of the seal
- ☐ Complete separation of the process medium from the environment
- ☐ Heating of the seal due to process media with high melting point

*) Standard of the American Petroleum Institute for refineries and similar applications.

The most important applications for supply media and their purposes.
Modes of operation and supply systems

Depending on the design and the arrangement of the mechanical seal, and the required functions of the supply system for the specific application, different modes of operation are possible or necessary. The plans for the auxiliary systems are based on the API 682.

**Quench**

A quench according to API Plan 51 or 62 means that mostly water or a gaseous medium like steam or nitrogen is used as supply medium at atmospheric pressure.

**Flush**

Flushing serves either to lower the temperature or to prevent deposits in the area of the seal faces. The flushing medium may be the process medium itself or an external medium. The most common API plans are 11, 21, 31 and 41. If an external medium is used then it is called API plan 32.

The flushing pressure has to be always higher than the pressure to be sealed. To restrict the flow of the flush into the process medium the flushing medium should be sealed against the impeller. This can be achieved by using a flow rate restrictor (throttle). The flow speed in the throttle gap should be between 1.0 and 2.5 m/s. Thus it is avoided that soiled product comes between the seal faces.

**Buffer and barrier medium**

If an external medium is introduced between two mechanical seals two different pressure conditions are possible:

\[ p_3 < p_1 \]: If the pressure of the supply medium \( p_3 \) is lower than the pressure to be sealed \( p_1 \), then it is named a buffer medium (equivalent to API Plan 52) or a buffer gas (equivalent to API plan 72).

\[ p_3 = p_0 \]: If the pressure of the buffer medium is atmospheric pressure then we talk about an unpressurized operation.

\[ p_3 > p_1 \]: In case of a pressurized operation according to API plan 53 or 54 the supply medium is called barrier medium or barrier gas with API plan 74.

In most cases it is recommended that the barrier pressure should be 2-3 bar higher than the highest pressure to be sealed. In cases with operating pressures \( p_1 > 20 \) bar the barrier pressure should be 10 % higher than the pressure to be sealed. Different values should be seriously challenged and matched with the relevant experts, if necessary. In case of vacuum operation higher differential pressures may be required after consulting EagleBurgmann.

If a quench or a buffer medium is used due to the pressure conditions, the quench medium is enriched with the process medium in the course of time. In case of a flush according to API plan 32, or a pressurized operation according to API plan 53 or 54, the pressure of the barrier medium is always higher than the operation pressure of the process medium to be sealed. The result is that the barrier medium is introduced into the process medium in a certain amount.

In a lot of cases a circulation of the supply medium is required. This can be provided by a natural circulation by the thermosiphon effect, or by forced circulation using an integrated pumping device inside the seal, or a circulation pump. The circulating volume is dependent on different parameters like the type of circulation, the rotational speed, or the viscosity of the used supply medium.

Further information about the API is available in the brochure “Sealing systems according to API 682” which will be sent to you on request.
Supply systems

Supply systems can be divided into pressureless and pressurized systems. Examples for such systems are displayed on this page.

During the installation some general things have to be considered:
• Assembly and operating manual of the supply system.
• The installation of the supply system should provide an easy operation, monitoring and maintenance.
• The tank should be positioned above the mechanical seal (approximately 1 ... 2 m) to allow a natural circulation of the supply medium. The distance may be shorter if the circulation is supported by a pumping device inside the seal or a circulation pump.
• The piping of the supply system loop should be made of stainless steel and the dimensions should be according to the assembly and operating manual. The pipe sections are normally connected by screwed joints.
• The arrangement of the piping should be as short and streamlined as possible. To avoid air pockets the pipes should be installed steadily rising. To change the direction, only pipe bends and for shut-offs, ball valves with full bore should be used.
• In principle the outlet pipe of the mechanical seal has to be connected with the lateral connection of the supply system tank. Please carry out the following instructions for the connection:
  • Mechanical seal OUT has to be connected with supply system IN.
  • Supply system OUT has to be connected with mechanical seal IN.
The ideal supply medium

The demands on the “ideal” supply medium are sophisticated and it is difficult to always fulfill all criteria. Therefore each decision is characterized by setting priorities and making compromises. Mainly the following criteria are important to select a suitable supply medium:

- High lubrication capacity
- High heat capacity
- Free of solids
- No tendency to deposit
- High resistance of the used materials
- High ageing resistance
- Suitable viscosity
- Good compatibility with the process medium
- No classification as hazardous substance
- High ignition temperature and high flash point
- Sufficient distance between the boiling point and the process temperature
- No tendency to foam
- Good availability and low costs

General demands

One of the primary tasks of a supply medium is the lubrication of the seal faces consequently the supply medium should have a high lubrication capacity. In most cases the lubricity of water is sufficient. Also, a high heat capacity has advantages if the supply medium is used for cooling the seal, because the heat capacity is proportional to the heat removal. The heat capacity of the supply medium has to be considered during the dimensioning of the supply system to calculate the required circulation rate for example.

The supply medium may neither contain solids nor tend to build up deposits. Deposits or smears may occur, for example, due to crack residues of oils, or due to residue building additives in oils, particularly zinc or phosphor additives or silicates. For this reason also media which tend to crystallize should not be used.

The materials of the supply system have to be resistant against the supply medium. For example if EPDM elastomers are used, no oil may be used as supply medium.

Important is also the high ageing resistance which means the supply medium should not change its properties even after time. This may happen by the influence of temperature or shear stress, by contact with air (oxidation reactions, cracking, formation of acids, polymerisation) or humidity (hydrolysis, formation of acids).

<table>
<thead>
<tr>
<th>Heat capacity</th>
<th>spec. heat capacity at 20 °C [kJ/(kg·K)]</th>
<th>Thermal conductivity at 20 °C [W/(m·K)]</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>normal</em> water</td>
<td>4.3</td>
<td>0.6</td>
</tr>
<tr>
<td>30 % propylene glycol/70 % water</td>
<td>3.95</td>
<td>0.47</td>
</tr>
<tr>
<td>oil</td>
<td>~2</td>
<td>~0.1</td>
</tr>
<tr>
<td>silicone oils</td>
<td>1.45</td>
<td>~0.15</td>
</tr>
<tr>
<td>glycerine</td>
<td>2.4</td>
<td>0.3</td>
</tr>
<tr>
<td>ethanol</td>
<td>2.4</td>
<td>0.17</td>
</tr>
<tr>
<td>air</td>
<td>1</td>
<td>0.026</td>
</tr>
<tr>
<td>nitrogen</td>
<td>1</td>
<td>0.026</td>
</tr>
</tbody>
</table>

Oil and other hydrocarbons have about half of the heat capacity of water.

Specific heat capacities and thermal conductivities of typical media.
Viscosity

Low viscosity fluids are generally more suitable to be used as supply medium than fluids with a high viscosity. The higher the operational demands on the seal regarding rotating speed and heat generation the lower the viscosity has to be. (In exceptional cases higher viscosities may be required. This has to be checked on an individual basis.

The viscosity is dependent on temperature and decreases with increasing temperature and vice versa. Therefore the viscosity index of the supply medium should be as high as possible, which means the temperature dependence of the viscosity should be as low as possible. In general synthetic oils have a higher viscosity index than mineral oils. Independent of the operation mode of the mechanical seal, the following recommendations regarding the optimal viscosity of the supply medium can be given. Preferably it should be observed within the whole operating temperature range.

- Natural circulation: 0.5 to 5 mm²/s;
- Forced circulation by a pumping device inside the mechanical seal: 0.5 ... 12 mm²/s;
- Forced circulation by an external circulation pump: 0.5 ... 15 mm²/s.

A pumping device inside a mechanical seal may be a pumping screw or a pump ring. Here the performance curve has to be considered because it is dependent on the viscosity. Seals with different pump devices like the EagleBurgmann Cartex® have to be examined separately.

If an external pump is used for the circulation its design data has to be observed. For example, if an EagleBurgmann SPU500 is used the maximum allowable viscosity is 15 mm²/s.

If a gear pump is used in an EagleBurgmann SPA, a pressurized barrier fluid system, the viscosity within the whole operating temperature range has to be 12 mm²/s minimum.

In exceptional cases, for example, with compressors or agitators, higher viscosities (up to 68 mm²/s) may be used. But this always has to be checked with the relevant experts.

Viscosity

The viscosity describes the “thickness” of liquids and melts, but also of suspensions. It is a measure of the fluid’s internal resistance to flow and is defined by the frictional resistance with which a fluid responds to deformation by compressive or shear stress. The higher the viscosity the “thicker” the fluid and the lower the capability of flow.

There are two related measures of fluid viscosity – known as dynamic and kinematic viscosity.

The dynamic viscosity is the ratio of shear stress and the velocity gradient vertical to the flow direction. It can be defined by the force F to move 2 parallel planes with the velocity v against each other. In most cases it is measured with rotation viscometers.

\[
\text{Dynamic viscosity } \eta = \frac{F}{A \cdot \Delta \frac{v}{d}}
\]

Graphical illustration of the dynamic viscosity. Source: Römpf Lexikon

The current unit of dynamic viscosity \( \eta \) is mPa•s. In earlier times the unit P (Poise) or cP (Centi poise) was used.

1 cP = 1 mPa•s. Water has a viscosity of 1 mPa•s at 20 °C.

The kinematic viscosity \( \nu \) is a measure of the internal friction in a fluid. It is measured for example with a capillary or falling sphere viscometer, or it is calculated by dividing the dynamic viscosity by the density of the liquid:

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

Today the common unit of the kinematic viscosity \( \nu \) is mm²/s. In earlier times the unit St (Stokes) or cSt (centi Stokes) was used.

1 cSt = 1 mm²/s.

Specialities regarding the viscosity are non-Newtonian fluids. In contrast to Newtonian fluids these fluids change their viscosity with the applied strain rate. As a result, non-Newtonian fluids may not have a well-defined viscosity. Examples for non-Newtonian fluids are blood, cement glues, quicksand, sand-water-mixtures, starch-water-mixtures, lubricants, polymer melts, ketchup and pudding. Depending on their properties change by the applied shear rate, non-Newtonian fluids may be divided into pseudoplastic fluids (viscosity is reduced with shear rate) and dilatants (viscosity is increased with shear rate).

Non-Newtonian fluids should not be used as supply medium for mechanical seals because their properties change when shear forces are applied. This may have negative effects on the life time of the mechanical seal.
The ideal supply medium

Compatibility with the process medium

The compatibility of the supply medium with the process medium has to be checked together with the end user in each case. The supply medium should be inert against the process medium, which means no reaction can take place between the supply medium and the process medium at the corresponding operating conditions.

Also the quality of the process medium must not be negatively influenced by the supply medium. This is of particular importance with end products such as, food, cosmetics and pharmaceuticals.

If necessary specific regulations like the german “Regulation about the use of extraction solvents and other auxiliary materials in the production of food”, the german food and commodities act „Lebensmittel- und Bedarfsgegenständegesetz (LMBG)” and specific “Codes of federal regulations” (CFR) of the food & drug administration (FDA) has to be considered. The evaluation whether a medium can be used as supply medium in the food and pharmaceutical industry has to be done by the operator of the seal.

On the strength of past experience supply media which are certified according to USDA-H1 or NSF/H1 (USDA = United States Department of Agriculture, NSF = National Sanitary Foundation) can be used. Probably media which are approved according to CFR 172: “Food additives permitted for direct addition to food for human consumption” or CFR 178: “indirect food additives: adjuvants, production aids, and sanitizers” may also be used.

Security aspects

In principle the evaluation of the supply medium regarding environmental hazard, health hazard and security aspects (safety in the work place) has to be done by the operator of the seal. The used supply medium should not be classified as a hazardous substance, thus it should neither be harmful to health nor to the environment.

The ignition temperature of the supply medium should be significantly higher than the maximum operating temperature. Low flammability is a further criterion: the flash point should be significantly higher than the maximum operating temperature. The formation of explosive or ignitable mixtures with air has to be avoided in all cases.

The maximum operating temperature should be at least 40 °C lower than the boiling point of the supply medium. If the seal is only low stressed, which means low pressure, low sliding velocity and low temperature, a lower temperature difference of e.g. 20 °C may be sufficient. This has to be clarified on an individual basis.

Documents to evaluate the supply medium with regard to environmental hazard, health hazard and security aspects (safety in workplace):

- Material safety data sheet
- Technical instructions on air quality control – “TA-Luft”
- GESTIS database on hazardous substances (Information system on hazardous substances of the German Social Accident Insurance)
- List of hazardous substances of the German Institute for Occupational Safety and Health. It contains the classification and the labelling of substances according to the EC-directive 67/548/ EGV, Appendix I “List of hazardous substances”, and the TRGS 905 “Directory of carcinogenic, mutagenic or reproduction toxic substances”.
- European chemical Substances Information System (ESIS)
- Regulation (EE) No. 1272/2008

Ignition temperature and flash point

The ignition temperature is the lowest temperature of a hot surface at which substances self ignite. According to this, the ignition temperature is the lowest temperature which flammable gases, vapours, dusts or finely dispersed solids must have in the most ignitable mixture with air to initiate the combustion or the explosion. It is not a material constant but dependent on the test conditions.

The flash point is the lowest temperature, corrected to a pressure of 101,3 kPa (760 Torr), at which the vapours can be ignited by an ignition source under specified test conditions.

Source: Rinngpe Online Lexikon
Gas solubility, foaming

Increased gas content in the supply medium has a negative impact on the seal and has to be avoided. Also foaming is problematic in combination with a supply medium.

Generally the gas solubility of liquids increases with rising pressure and decreasing temperature. Dissolved salts decrease the solubility of gases. Due to the lower density and the centrifugal forces the dissolved gas (e.g. air, nitrogen) accumulates at the smallest diameter and thus can not escape. This may lead to a ring of gas in the seal gap and thus leads to dry running and destruction of the seal faces.

The degassing of the medium may be mainly a problem in pressurized operation with the usage of a thermosiphon vessel where nitrogen is used to create the pressure in the supply system: in this case nitrogen can dissolve in the barrier fluid and degasses inside the seal. Therefore it is recommended to limit the maximum barrier pressure in combination with thermosiphon systems to 20 bar.

Foaming of the supply medium may occur if air degasses in a liquid but does not collapse at the surface. This may have different reasons, e.g. high content of additives in oils, impurities or leak air.

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Henry's law

\[ c_i = \alpha_{ij} \cdot p_i \]

- \( c_i \) = concentration of gas in liquid
- \( p_i \) = partial pressure of the gas above the liquid
- \( \alpha_{ij} \) = temperature dependent solubility coefficient of the gas \( i \) in liquid \( j \)
  (= Bunsen absorption coefficient or Bunsen coefficient)

The amount of gas which is dissolved in a liquid is proportional to its partial pressure at the liquid surface (at equilibrium). At equilibrium means the liquid is saturated. Only at high pressures there will be a difference in proportionality.
In this chapter detailed information about standard supply media is provided and existing problems are described.

Supply media which are often used:
- Water
- Mixtures of water-glycol
- Alcohols
- Different oils like mineral oils, synthetic oils, white oils or vegetable oils
- Gaseous media like nitrogen or steam

Water

In a lot of cases water is a suitable supply medium. In most of the cases demineralized water or distilled water can be used. Because the lubrication characteristics of these water qualities are quite bad the suitability has to be checked with an expert from EagleBurgmann in case of hard/hard seal face combinations and high operational demands on the seal.

Make sure that the temperature at the seal outlet does not exceed 60 °C. On the one hand a sufficient distance to the boiling point has to be ensured and on the other hand the deposition of calcium carbonate should be kept on a low level.

The water should not contain any solids as they tend to deposit (calcium carbonate). The deposition of calcium carbonate is mainly problematic at the atmospheric side of the seal due to the vaporisation of the leakage. This may lead to clogging of the dynamic O-ring.

Water with the following properties is suitable as supply medium.

- $6.5 \leq \text{pH-value} \leq 7.5$
- $25 \mu S/cm \leq \text{conductivity} \leq 250 \mu S/cm$
- $\text{Total dissolved solids (TDS)} \leq 500 \text{mg/l}$
- $\text{Hardness of water} \leq 100 \text{ppm CaCO}_3 (= 5.6 \text{°dH})$
- $60 \text{mg/l CaCO}_3 (\leq \text{Alkalinity} \leq 150 \text{mg/l CaCO}_3) \text{ (ideal is between 80 and 120 mg/l CaCO}_3)$
- no solids
- $\text{Turbidity} < 5 \text{NTU}$
- $\text{Chloride content} < 250 \text{ppm}$
- $0 \leq \text{LSI (Langelier saturation index)} \leq 0.5$
- $\text{Free of gas, which means} \leq 0.2 \text{Ncm}^3 \text{dissolved gas per cm}^3 \text{of water}$

In general distilled or demineralized water fulfill these criteria.
The Langelier saturation index can be calculated on the basis of a water analysis, e.g. with the LSI-calculator from EagleBurgmann.

\[
LSI = pH - pHs
\]

\[
pHs = f (\text{TDS}, T, c(CaCO}_3, A)
\]

- \(\text{TDS}\) = Total dissolved solids in mg/l
- \(T\) = Temperature in °C
- \(c(CaCO}_3\) = Concentration of calcium carbonate (CaCO\(_3\)) in mg/l
- \(A\) = Alkalinity (measured as CaCO\(_3\) in mg/l)
- \(pH\) = pH-value of the water

The decision tree below can be used to evaluate the quality parameters of water which should be used as supply medium. The surrounding conditions, mainly the temperature play a decisive role.

Some of the parameters interact in their effects thus if only one parameter is given the evaluation of the water quality is not possible. Therefore the saturation index (also Langelier saturation index, LSI) was established which describes the tendency of water regarding calcium carbonate deposition.

The alkalinity describes the capacity of water to neutralize acids. It is measured in mg calcium carbonate per liter of water (mg/l CaCO\(_3\)). If the alkalinity is not known the following assumption may be made (However this is only an approximation and therefore imprecise):

\[
\text{Alkalinity (mg/l CaCO}_3\) = \text{Carbonate hardness (mg/l or ppm) \times 0.7}
\]

Typically calcification occurs under the following conditions:

- Hardness > 100 ppm CaCO\(_3\) ≈ 5.6 °dH ≈ 1 mmol/l
- TDS > 1000 ppm and pH > 7.5

However the temperature of the water plays a decisive role and has to be considered. The tendency of calcium carbonate deposition increases with increasing temperature. Indeed there are possible measures to influence the calcification:

- Demineralization by reverse osmosis, distillation or de-ionization. With the aid of these water treatment methods the dissolved minerals are removed from the water and thus the total dissolved solids (TDS-value) will be reduced.
- Water softening by using additives or ion exchangers. Thereby the calcium and magnesium concentration in the water will be reduced.
- Acidification of the water by using e.g. citric acid. The pH-value should not fall below 6.
- Avoidance of high temperatures

<table>
<thead>
<tr>
<th>Comparative table for hardness values</th>
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If the total hardness is known but not the calcium hardness it can be assumed that the measured hardness comes from calcium carbonate ("worst case"). Then calcium hardness = total hardness.

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.2</td>
<td>0.4</td>
<td>1.3</td>
<td>1.8</td>
<td>17.8</td>
</tr>
<tr>
<td>3</td>
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<td>1.1</td>
<td>3.8</td>
<td>5.3</td>
<td>53.4</td>
</tr>
<tr>
<td>5</td>
<td>0.9</td>
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<td>6.5</td>
<td>8.9</td>
<td>89.0</td>
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<tr>
<td>8</td>
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<td>1.8</td>
<td>3.6</td>
<td>12.5</td>
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<td>178.0</td>
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<tr>
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<td>4.6</td>
<td>16.3</td>
<td>23.1</td>
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<td>18</td>
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<td>5.4</td>
<td>10.7</td>
<td>37.5</td>
<td>53.4</td>
<td>534.0</td>
</tr>
</tbody>
</table>

1 German degree of hardness [°d] is equal to 10 mg CaCO\(_3\) per 1 l of water.
**Water-glycol mixtures**

are mixtures of water and ethylene or propylene glycol. Further additives should not be used. Water with cooling agents like antifreeze or corrosion inhibitors, heat transfer media and cooling brines are not suitable.

Propylene glycol should be preferred because ethylene glycol has a health hazard potential and is subject to the classification according to the EC-directive of hazardous substances.

Typically, mixtures of about 30 % glycol and 70 % water are used as supply medium. Mixtures with a glycol content of more than 50 % should not be used because the viscosity significantly increases with increasing glycol content. The advantage of mixtures of water-glycol over water is the considerably lower freezing point.
Dynamic viscosity of water-propylene glycol mixtures
Source: Internet, Pekasol L Data sheet, pro Kühlsole GmbH

Dynamic viscosity of water-ethylene glycol mixtures
Source: Internet, Glykosol N Data sheet, pro Kühlsole GmbH

Dynamic viscosity of water-glycerol mixtures
Source: Ullmann's Encyclopedia of Industrial Chemistry, paper Glycerol
Glycerol (propanetriol) is another alcohol which is used in mixtures with water as supply medium preferred for food and pharmaceutical applications. At room temperature glycerol is a colourless, odourless, viscous and hygroscopic liquid which is well miscible with water. The melting point is quite high at about 18 °C, the viscosity at room temperature (20 °C) is 1,500 mPa·s.

Oils

If oils are used as supply medium the following things have to be considered: If they are exposed to higher temperatures for any length of time their properties may negatively change. A lot of oils, mainly mineral oils, build up residues similar to lacquer or glue up to tar, at higher thermal stress. This happens due to a partial decomposition of the base oil therefore they are not very much thermostable. A maximum temperature of 60 °C at the outlet of the seal is recommended.

In general oils may only be used within the specified service temperature range for oxygen atmosphere according to the manufacturer.

If oils are used as supply medium their hygroscopicity may be a problem. The water content may be up to 1,500 ppm whereas the lubrication capacity drastically decreases at water contents ≥ 750 ppm.

Mineral oils often contain additives, e.g. to improve the corrosion protection or the ageing stability. These additives may thermally decompose and form deposits on the seal faces, which may lead to a destruction of the seal faces.

This problem is known for example with the additive ZnDTP (Zinc dithiophosphate) because ZnDTP decomposes at about 120 °C.

Please also make sure that no ash is used as additive.

Alcohols

Preferred supply media, including for food and pharmaceutical applications, are the alcohols ethanol or propanol. Also mixtures with water are possible. Most of the alcohols, mainly the alcohols with lower molecular mass are volatile substances, which means that they evaporate fast at atmospheric conditions. From this some disadvantages result. On the one hand the supply medium often has to be refilled, mainly if used as unpressurized buffer medium and on the other hand ignitable mixtures with air may form more easily.

An advantage of most alcohols is the low melting point of significantly below 0 °C. Therefore alcohols are preferred in low temperature applications. Ethanol has a melting point of -114.5 °C and a boiling point of 78.3 °C the melting point of propanol is -126 °C and the boiling point 97 °C. Due to their high vapour pressure, in Germany the TA-Luft has to be considered. Possible alternative alcohols may be 1-butanol or 2-methyl-1-propanol, but they are classified as harmful.
Standard supply media

Mineral oils

Often so called lubricating oils are used as supply media. They are composed of the high boiling fractions of the raw oil and are separated by vacuum distillation, de-paraffinized and de-aromatized. At the end high quality products are treated with hydrogen under pressure to eliminate impurities. Thus the base oils are produced. The properties of the end product (motor oil, gear oil, electrical insulating oil, metal working oil, hydraulic oil etc.) are adjusted by mixing of base oils with different properties and by selecting suitable additives.

Lubricating oils are classified in viscosity classes according to the ISO-VG (International organisation for standardization – Viscosity Grade). The labeling shows the viscosity at 40 °C. Example: ISO VG 5 → ~5 mm²/s at 40 °C

In many cases also hydraulic oils are used as supply medium. These are operating liquids used for hydrostatic and hydrodynamic transmission of power. The labelling shows which additives were added.

Compressor oils are an additional group of mineral oils which are often used as supply medium. They are highly raffinated mineral oils and therefore of higher thermal stability than “standard” mineral oils. They are used to lubricate fast running bearings and gears installed in turbo compressors and steam turbines. Oils for this use are specified in the DIN 51515. However, compressor oils are not suitable for high sliding velocities (> 100 m/s), because they form deposits or smears on the sliding faces.

Good experiences exist with the oils „Shell Morlina 5 and 10“ and “Aral Vitam AC“, which have proven themselves as barrier fluids used on several test rigs.

A further recommendation is “Klüber Paraliq 12“, a paraffin type mineral oil:
- Certified according to NSF-H1, which means that it may be used in food and pharmaceutical applications
- Operating temperature range: -10 °C ... 60 °C
- Kinematic viscosity: 17 mm²/s at 40 °C and 3.7 mm²/s at 100 °C

Synthetic oils

There are different types of base oils produced by chemical synthesis. The most important group are the synthetic hydrocarbons with the polyalphaolefines (PAO) and the alkylated aromatics. They are mainly used for the lubrication of refrigerating machines. Polyalphaolefines are saturated aliphatic hydrocarbons. They have a high oxidation resistance which is comparable with that of mineral oils and they have a very good chemical stability.

The polyglycols are an additional group of synthetic oils with their most important representatives polyethylene glycols and polypropylene glycols. They have a high viscosity index, limited oxidation resistance and very good lubrication properties.

Carboxylic acid esters were originally developed for aircraft engines. Polyoil esters and diesters belong to this group. Polyol esters are mainly used for the lubrication of refrigerating machines. Both the polyol esters and the diesters have very good thermal and oxidation resistance and a high viscosity index, usually between 160 and 180. But both groups are susceptible to hydrolysis if they get in contact with water.

The phosphoric acid esters or phosphate esters are tertiary esters of phosphoric acid. They have a low viscosity index, a good oxidation resistance but only in neutral environment; a limited thermal stability and they are susceptible to hydrolysis if they get in contact with water. Fluorinated elastomers should be preferred as secondary sealing elements.

If the oils should be fast and completely biodegradable, then either vegetable oils, polyethylene glycols or carboxylic acid esters (diester or polyol esters) should be considered.

### Table: Classification of the hydraulic oils based on mineral oils

<table>
<thead>
<tr>
<th>Product group</th>
<th>Code according to DIN 51502</th>
<th>Code according to ISO 6743, part 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic oils without additives</td>
<td>H</td>
<td>HH</td>
</tr>
<tr>
<td>Hydraulic oils with oxidation inhibitors and corrosion inhibitors</td>
<td>HL</td>
<td>HL</td>
</tr>
<tr>
<td>Hydraulic oils HL with additional wear protection additives</td>
<td>HLP</td>
<td>HM</td>
</tr>
<tr>
<td>Hydraulic oils HLP/HM with additional viscosity index improvers</td>
<td>HVLP</td>
<td>HV</td>
</tr>
</tbody>
</table>

Source: ABC der Schmierung, Castrol
### Standard supply media

### Properties

<table>
<thead>
<tr>
<th>Properties</th>
<th>Mineral oils (PAO)</th>
<th>Synthetic hydrocarbons</th>
<th>Synthetic hydrocarbons</th>
<th>Synthetic hydrocarbons</th>
<th>Synthetic hydrocarbons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rheological behaviour at low temp.</td>
<td>0</td>
<td>++++</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Viscosity at high temp.</td>
<td>+</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Oxidation resistance (with additives)</td>
<td>+</td>
<td>+++</td>
<td>+</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Resistance to hydrolysis</td>
<td>++++</td>
<td>++++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Biodegradability</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Toxicity</td>
<td>low</td>
<td>low</td>
<td>low</td>
<td>low</td>
<td>low</td>
</tr>
</tbody>
</table>

**PAO**: Polyalkylated aromatics

**Polyglycols**: Polyglycols

**Diesters**: Diesters

**Polyol esters**: Polyol esters

+ +++ + good, + + + + very good, + + + excellent, 0 moderate, – poor

### Comparison between the properties of mineral and synthetic oils

Source: Industrie Report – Synthetische Schmierstoffe, Mobil Schmierstoff GmbH, 1999

### Usage of synthetic base oils in lubricants

Source: Industrie Report – Synthetische Schmierstoffe, Mobil Schmierstoff GmbH, 1999

### Synthetic oils which are suitable as supply medium

(Recommendations by Klüber Lubrication)

**General information**

- **PAO & esters**: Klüber Summit HySyn FG 15, Klüberoil 4 UH1-15 AF
- **Diesters**: Klüber Summit DSL 32
- **Polyglycols**: Klüber Summit PGS 10 A

**Approval regarding food / pharmaceutical applications**

- USDA-H1 and FDA CFR 178
- USDA-H1 / NSF H1 and FDA CFR 178
- –

**Operating temperature range [°C]**

-45 to 135
-45 to 110
–

**Kinematic viscosity at 40 °C / 100 °C [mm²/s]**

- 15 / 3.6
- 15 / 3.5
- 31 / 4.9
- 10 / 2.5

**Perfluorinated polyethers** are a further group of synthetic oils. They are special lubricants which are very stable and as a consequence they are essentially inert against chemical and corrosive attacks. Beyond this they are non-flammable, non-combustible and harmless for health and environment.

Typical applications are in processes with strong oxidants like oxygen (O₂), ozone (O₃), nitrogen oxides (NOₓ), sulfur oxides (SOₓ), halogens (e.g. F₂,Cl₂), hydrogen halides (e.g. HF,HCl,HBr) and uranium hexafluoride (UF₆).
If dry air is used it has to be considered that no reaction takes place between the process medium and air and that no explosive mixtures may form. In case of gaseous supply medium it has to be considered that the lower the dew point the dryer the gas and the worse the lubrication capacity. In case of dew point is < -70 °C the wear of the carbon seal faces will be increased. Another common gaseous supply medium is steam. It is mainly used as steam quench to heat the atmospheric side of the mechanical seal in case of process media with a high melting point. Thus solidification of the leakage is avoided. A steam quench may also be used to avoid the contact of leakage with the atmosphere if an undesired reaction occurs between the medium and the air. Steam is also used in food applications.

If a steam quench is used, it has to be considered that the steam temperature is high enough to avoid condensation of the steam within the mechanical seal. If condensation could not be avoided the condensate has to be systematically discharged to avoid disadvantages at the mechanical seal.

### White oils

Are a group of oils which are often used as supply medium. They are high-value lubricants which are synthesized out of paraffinic oils. You can differentiate between technical and extra high-quality medical white oils.

Technical white oils are very stable regarding environmental influences and gum formation and they do not get rancid. Medical white oils are used in pharmaceutical, food and cosmetic applications and have to fulfill high quality standards regarding purity and compatibility. Therefore these medical white oils are colourless, odourless and tasteless and they are aromatic and sulphur free.

Due to their limited temperature stability the maximum outlet temperature of the supply medium is recommended not to exceed 60 °C.

### Vegetable oils

The advantage of vegetable oils as supply medium is their good biodegradability. Beyond this they are easy available and may be used in the food industry. However vegetable oils have a relatively low resistance against hydrolysis and a low oxidation resistance caused by the polyunsaturated fatty acids. Therefore vegetable oils should only be used for process temperatures up to 60 °C.

### Purity requirements on gaseous supply media

<table>
<thead>
<tr>
<th>Class</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>quantity and size of particles</td>
<td>≤ 2</td>
</tr>
<tr>
<td>humidity class</td>
<td>3</td>
</tr>
<tr>
<td>oil content</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
Diesel

Low flammable fuel mixtures for diesel engines which mainly consist of paraffines with different contents of olefines, cycloalkanes and aromatic hydrocarbons. Their composition may differ and is mainly dependent on the production process. Normally they have a boiling point between 170 °C … 360 °C and a flash point between 70 °C … 100 °C.

Diesel should not be used as supply medium because it is subject to the classification according to the EC-directive of hazardous substances (R40: Limited evidence of a carcinogenic effect).

Highly purified water


Highly purified water in different qualities is mainly used as supply medium in food and pharmaceutical applications and if aseptic operating conditions are required. The quality of “highly purified water (HPW)” and “water for injection (WFI)” is the same, whereas WFI may only be produced by distillation processes and HPW may also be produced by using membrane processes.

The problem with highly purified water with conductivities of < 5 μS/cm is the bad lubrication capacity and the high corrosiveness. If highly purified water is used it has to be considered that suitable materials are used. Stainless steels with low ferrite content are resistant whereas 1.4404 and 1.4435 have proved for higher requirements. Beyond this the surface quality has to be on a high level.

For the face materials SiC against SiC is used as standard where specific qualities have particularly proven. Because of the bad lubrication properties HS-grooves should be used. PTFE or EPDM may be used as elastomer materials.

<table>
<thead>
<tr>
<th>PW (Purified Water, gereinigtes Wasser)</th>
<th>HPW (Highly Purified Water, hochreines Wasser)</th>
<th>WFI (Water For Injection, Wasser für Injektionszwecke)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Distillation, ion exchange, or other suitable processes</td>
<td>E.g. reverse osmosis combined with ultrafiltration and ion exchange</td>
</tr>
<tr>
<td>Conductivity</td>
<td>&lt; 4.3 μS/cm at 20 °C</td>
<td>&lt; 1.1 μS/cm at 20 °C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 1.1 μS/cm at 20 °C</td>
</tr>
</tbody>
</table>

Water qualities according to Pharm. Eur.
Critical process media and the usage of supply media are for example highly concentrated acids and bases. If in this case water is used as the buffer medium (the sealed process pressure is lower than the pressure of the buffer medium) the supply system is enriched very fast with the acid or base process which may lead to an increased corrosion. Therefore the flow-through operation mode or a flush with an external medium should be used in this case.

If pressurized operation (pressure of the barrier medium is higher than the sealed process pressure) in combination with water as barrier medium is used, it may produce a spontaneous and large heat development. Beyond this a chemical potential equalization occurs despite the higher barrier pressure and therefore an equalization of the pH-value between the process and the barrier medium takes place quite fast.

A concrete example is the sealing of concentrated sulfuric acid. For this application positive experiences are available with isododecane as supply medium at operating temperatures up to 50 °C and the supply medium Galden® (perfluorinated polyether). Generally speaking perfluorinated polyethers seem to be suitable for the application with concentrated sulfuric acid because of their high chemical inertness. Paraffin and silicon oils have been found unsuitable several times because they were decomposed by the sulfuric acid.

The trend is that concentrated sulfuric acid will be either hermetically sealed by using a magnetic coupling or sealed by using gas lubricated mechanical seals.

The supply medium should be changed regularly. It is recommended to change the supply medium after each repair, each shut down or if the concentration of the process medium in the supply system is too high, but at least every 12 months. The most economic change interval has to be determined by the operator of the production plant himself dependent on his experience.

In case of acid or alkaline process media the pH-value in the supply system may be taken as indicator when to change the supply medium. When the pH-value differs more than 2 units from the original value then the supply medium should be changed. Beyond this a chloride concentration of 250 ppm should not be exceeded in a closed loop thermosiphon system because an increasing corrosion rate can be the consequence.

If the pump is installed outside then the risk of freezing has to be considered. The supply medium must not be frozen and also the change in viscosity has to be taken into account (viscosity increases with decreasing temperature). In critical cases heating for the seal should be provided.

Because of the variety of applications all technical statements can only be seen as guidance. A warranty in particular cases is only possible if the exact operating conditions are known by Engelsburgmann and if this is confirmed in a specific agreement. In case of extremely critical operating conditions we recommend requesting expert advice from our application engineers. Subject to modifications.
EagleBurgmann is one of the leading international companies for industrial sealing technology. Our products are used everywhere that safety and reliability are important: In the oil and gas industries, petroleum refining, pharmacy, chemicals, energy, food, paper, water, marine applications, aerospace and mining. Every day, more than 5,270 employees contribute their ideas, solutions and commitment to ensuring that customers all over the world can rely on our seals. Our modular seal service, TotalSealCare™, underlines our commitment to customer orientation and our provision of tailor-made services for every application.