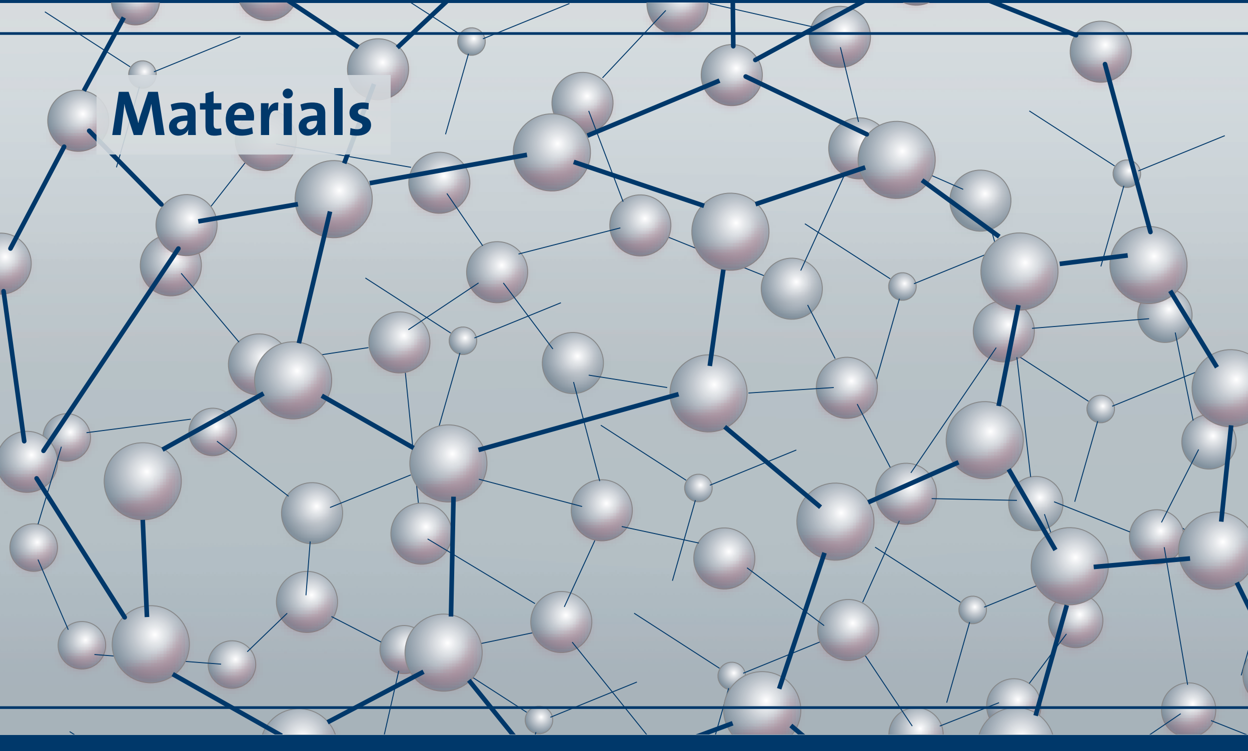
Chapter 3



Materials

The preceding chapters have explained the composition and principle of operation of mechanical shaft seals. This chapter describes commonly used materials for the various parts of the mechanical shaft seal, including a number of tests of seals with different seal face materials.

1. Seal face materials

Few materials are suitable for seal faces. To keep leakage as low as possible, the seal gap must be very small. As a result, the lubricating film is very thin. Consequently, the seal face materials must be able to withstand rubbing against each other at high load and speed.
The best seal face materials have low friction, high hardness, good corrosion resistance and high heat conductivity.

The choice of seal face materials is decisive of the function and life of the mechanical shaft seal. In the following, commonly used seal face materials will be described.

Carbon graphite

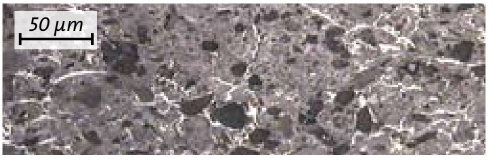


Fig. 3.1: Micrograph showing the material structure of antimony-impregnated carbon graphite

Fig. 3.2: Micrograph showing the material structure of resin-impregnated carbon graphite

Carbon graphite is a widely used seal face material thanks to its anti-friction properties.
The material is suitable as counter face material to many other types of materials.
Carbon graphite is a mixture of hard carbon and graphite.

Impregnated carbon graphite
Each carbon graphite manufacturer offers their own carbon graphite grades, depending on the source of the hard carbon, the graphite content, the grain size, mixing and baking.
After pressing and baking, the carbon graphite contains 5–20 % porosities. To obtain a leak-proof product, the carbon graphite must be impregnated, using metals or resins as impregnating agents.

The metals used for metal-impregnation are low-melting-point types such as antimony (Sb), tin (Sn), lead (Pb) or alloys of these products. See fig. 3.1.
According to EN 12756, the material code for this group is named A. See page 96.

Resin-impregnation often involves a phenolic resin. See fig. 3.2.
According to EN 12756, the material code for this group is named B.

For special purposes, resin-impregnated carbon graphite can be further heat-treated to convert the resin to carbon. It might prove necessary to repeat the impregnation and heat treatment process several times to obtain a leak-proof carbon-impregnated carbon.

Resin-bonded carbon graphite
Resins containing up to 70 % carbon-graphite fillers can be injection moulded and used without baking. The material is called "resin-bonded carbon". The resin-bonded carbon has a lower wear and chemical resistance than the resin-impregnated carbon.

Properties
In vacuum, the friction of graphite is high whereas it is low under normal atmospheric conditions. In hot water applications (> 100 °C), metal-impregnated carbon graphite has a lower friction and higher wear resistance than similar types of resin-impregnated carbon graphite. The disadvantage of metal impregnation is the limited corrosion resistance.
In addition, a drinking water approval cannot be obtained with metal-impregnated carbon graphite, see Chapter 6.

The typical dry coefficient of friction value for carbon graphite against a hard seal face material is 0.1 - 0.2 under normal atmospheric conditions. The stiffness and toughness of carbon graphite is low. These properties must be taken into consideration when designing and mounting mechanical shaft seals. In cold, clean water, a mechanical shaft seal with one carbon graphite seal face has a lifetime of several years. However, if the seal is used in hot water or solids-containing water, the seal must be changed at regular intervals.

Aluminium oxide (alumina)

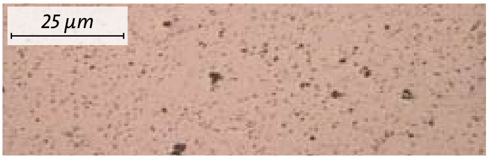


Fig. 3.3: Micrograph showing surface of alumina

Fig. 3.4: Micrograph showing etched surface of alumina

Aluminium oxide is a ceramic material, also known as "alumina". Alumina is commonly used as seal face material due to its good wear resistance and low price.
Each supplier offers his own grades of alumina with different compositions of glass phase and various grain sizes. See figures 3.3 and 3.4.
According to EN 12756, the material code for this group is named V.

Properties
The corrosion resistance in water is limited to a certain pH range, depending on the composition of the glass phase as well as on the purity. The best corrosion resistance is obtained with a 99.99 % alumina. However, the price of the material increases drastically with the purity. Alumina is only suitable for low-load applications due to its low thermal conductivity as compared to tungsten carbide and silicon carbide. Alumina is mostly used as counter face to carbon graphite. The stiffness of alumina is high, but the thermal shock resistance is limited.

Tungsten carbide (WC)

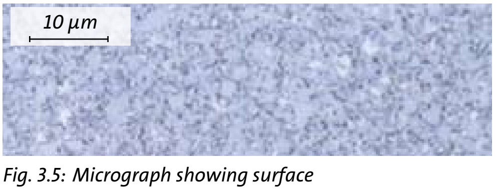


Fig. 3.5: Micrograph showing surface of tungsten carbide

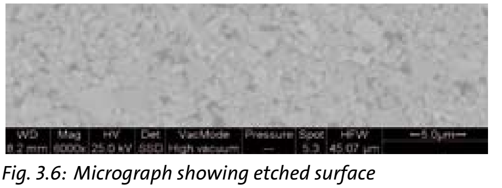


Fig. 3.6: Micrograph showing etched surface of tungsten carbide

Tungsten carbide (WC) is the designation of the type of hard metals based on a hard tungsten carbide phase and usually a softer metallic binder phase. The correct technical term of tungsten carbide is "cemented tungsten carbide". However, the abbreviated term "tungsten carbide" is often used for convenience, "cemented" being understood. See figures 3.5 and 3.6.
According to EN 12756, the material code for this group is named U.

Properties
The hardness of WC is below that of most ceramics, whereas the wear resistance of the material is superior, mainly due to its high toughness. WC is a heavy material with a density of approx. 14 g/cm^3. Cobalt-bonded (Co) WC is only corrosion-resistant in water if the pump is made of a non-inert material such as cast iron. The corrosion resistance of some chromium-nickel-molybdenum-bonded WC types is similar to stainless steel EN 1.4401 (AISI 316). WC with less than 0.5 % binder phase has the highest resistance to corrosion, although the material is not resistant in media such as water containing hypochlorite. Due to its extremely high wear resistance, WC is the preferred seal face material for applications involving abrasive particles.

Silicon carbide (SiC)

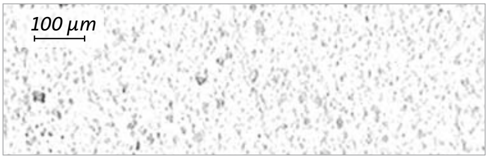


Fig. 3.7: Micrograph showing surface of dense silicon carbide

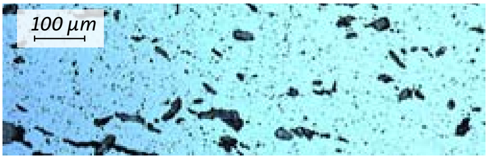


Fig. 3.8: Micrograph showing surface of graphite-loaded silicon carbide

SiC ceramics can be manufactured in many ways giving different properties.
According to EN 12756, the material code for this group is named Q. See figures 3.7 and 3.8.

The main SiC types are as follows:

- Direct-sintered.
  This SiC type is the most commonly used type for seal faces.
- Reaction-bonded.
  This SiC type has limited corrosion resistance in alkaline water due to the content of free silicon.
- Liquid-phase sintered.
  This SiC type has limited corrosion resistance in alkaline water due to the content of glass phase.
- Converted carbon graphite.
  This SiC type is manufactured from carbon graphite. It can be made as a thin SiC layer on the surface of the carbon graphite.

Properties

The direct-sintered SiC is brittle and requires careful handling. The material is light weight with a density of slightly above 3 g/cm³. The resistance to wear and corrosion is superior.
The direct-sintered SiC has a typical porosity below 2 %, but also grades with pores have been developed. The pores are discrete, non-interconnected and dispersed in a controlled manner throughout the body of the material.
The spherical pores act as fluid or lubricant reservoirs, helping to promote the retention of a fluid film at the interface of sliding component surfaces. This pore-based lubrication mechanism allows porous SiC to outperform conventional reaction-bonded and sintered SiC types in hot water.

Sophisticated sintering or the addition of different fillers can imply variations in these standard SiC grades. Fillers can be added to obtain improved electric conductivity, more toughness or lower friction.

Carbon or graphite inclusions can be used as dry lubricant to reduce friction. To use graphite inclusions successfully as lubricant, it is necessary to optimise the bonding between the SiC and the graphite as well as the size and amount of the graphite inclusions.

Diamond coatings

Diamond is the best known material for wear parts. Diamond has the highest hardness and thermal conductivity of any known material. In addition, it has an excellent corrosion resistance and a low friction. These properties make diamond the ideal material for seal faces. The major drawback of diamond is the price.

Diamond coatings have been commercialised during the last decade. Coatings can be made as polycrystalline diamond and as a more amorphous carbon called diamond-like carbon (DLC). The polycrystalline diamond has the lattice structure of diamond, where each carbon atom has four neighbour carbon atoms equally spaced (Sp^3 bonds). See fig. 3.9. In DLC coatings, some of the carbon atoms are located in structures similar to the diamond lattice.
Other carbon atoms are located in a structure similar to the lattice of graphite, which is hexagonal. See fig. 3.10.

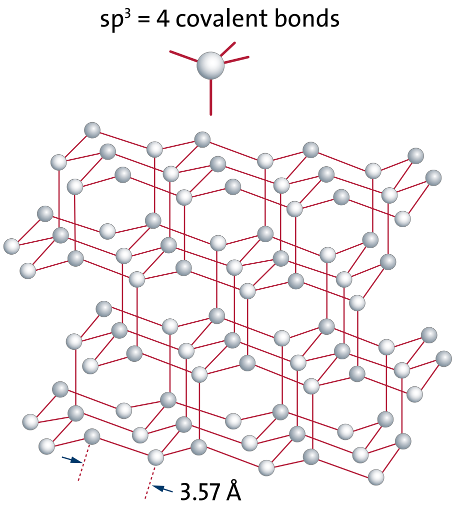


Fig. 3.9: Carbon atoms in the lattice structure of diamond (Sp^3 bonds)

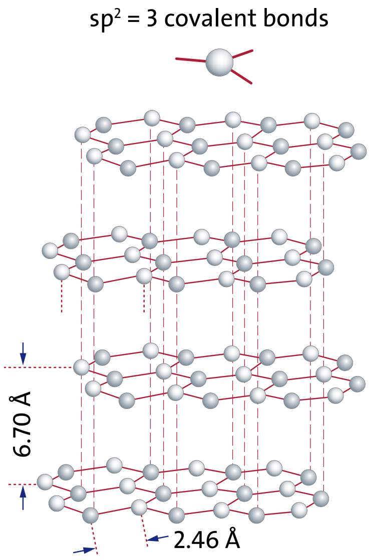


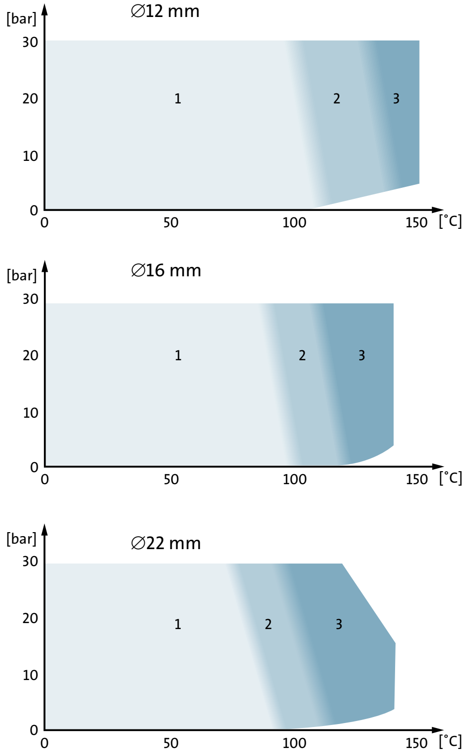
Fig. 3.10: Carbon atoms in the lattice structure of graphite (Sp^2 bonds)

Different variants of DLC coatings can be made, ranging in hardness from 1000 to 4000 HV.
The DLC coating thickness ranges from 0.1 to 10 μm and affects the production costs to a great extent. When the coating thickness is small, the adhesion to the substrate must be very strong to prevent delamination when the DLC coating is used on a seal face.
The best properties are obtained with thick polycrystalline diamond coatings on a hard substrate. However, if the counter face does not have a similar coating, it may suffer from wear.

2. Seal face material pairings

Carbon graphite against WC

Carbon graphite against WC is a widely used seal face material pairing.
The carbon graphite/WC pairing withstands dry running for several minutes without causing damage to the mechanical shaft seal. The corrosion resistance depends on the carbon graphite grade as well as on the alloying elements of the WC binder.
If the pumped medium contains hard particles, wear on the seal faces must be expected.
Due to the favourable lubricating properties of carbon graphite, the seal is suitable for use even under poor lubricating conditions, such as hot water. However, under such conditions, wear on the carbon graphite face reduces seal life.
The level of wear depends on factors such as pressure, temperature, pumped medium, seal diameter, carbon graphite grade and seal design. See fig. 3.11.
All materials pairrings performance diagrams in Chapter 3, refer to 3000 RPM.



Pos.	Operating hours before wear-out
1	More than 14,000
2	8,000 - 14,000
3	4,000 - 8,000

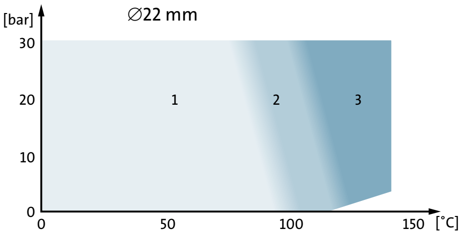
Fig. 3.11: Pressure/temperature diagrams showing operating life of Grundfos type H carbon graphite/WC shaft seals in water at three different shaft diametres

Low speeds reduce lubrication between seal faces. This could have resulted in increased wear. However, due to the shorter running distance, the level of wear is unaltred in most cases.

Carbon graphite against direct-sintered SiC

Carbon graphite against SiC is another widely used seal face material pairing.
The corrosion resistance of the carbon graphite/SiC pairing is very good.
The dry running properties are similar to those of carbon graphite/WC.
The use of the carbon graphite/SiC pairing for hot-water applications may cause heavy wear on the SiC face, depending on the grade of the carbon graphite and the water.

The use of porous or graphite-loaded SiC against carbon graphite causes far less wear than with dense SiC. See fig. 3.12.

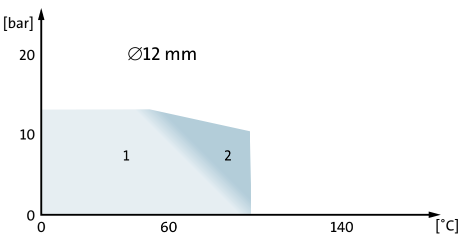


Pos.	Operating hours before wear-out
1	More than 14,000
2	8,000 - 14,000
3	4,000 - 8,000

Fig. 3.12: Pressure/temperature diagrams showing operating life of Grundfos type H carbon graphite/SiC shaft seal in water for a ∅22 shaft

Carbon graphite against alumina

Carbon graphite against alumina is a widely used seal face material pairing for mass-production low-cost seals.
The corrosion resistance is often limited in water to a range between pH 5 and pH 10, depending on the alumina grade used.
The dry-running properties are similar to those of carbon graphite/WC, but the performance in hot water is much poorer. See fig 3.13.

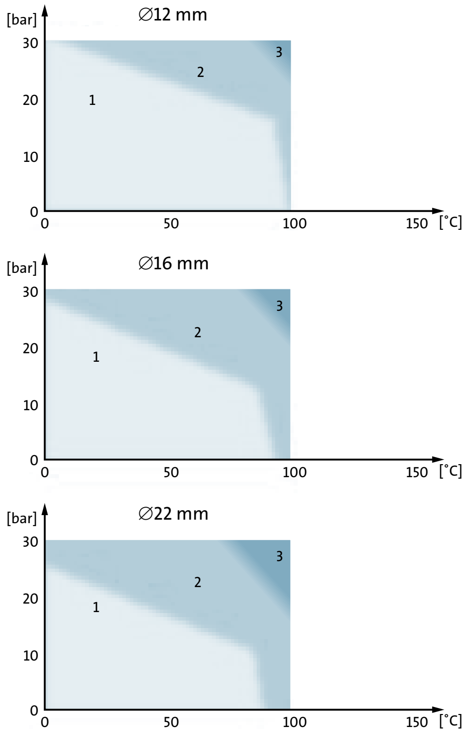


Pos.	Operating hours before wear-out
1	More than 14,000
2	8,000 - 14,000

Fig. 3.13: Pressure/temperature diagrams showing operating life of Grundfos type C carbon graphite/alumina shaft seal in water for a ∅12 shaft

WC against WC
A shaft seal with WC seal faces is extremely wear resistant. Being very robust, WC resists rough handling.
The dry friction of WC against WC is high. Consequently, the WC/WC shaft seal material pairing has poor dry-running properties. A shaft seal with WC/WC seal faces running completely dry may be damaged within less than one minute of dry running.

If certain pressure and temperature limits are exceeded, the seal may generate noise. The noise is an indication of poor lubrication, causing wear of the seal in the long term. The limits of use depend on seal diameter and design.
The pressure/temperature diagrams of the various seals show areas where noise may occur. See fig. 3.14.



Pos.	Range
1	Good performance
2	Risk of periodical noise in connection with start-up and variations in pressure and temperature
3	Periodical noise

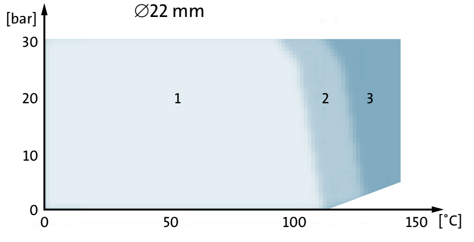
Fig. 3.14: Pressure/temperature diagrams of Grundfos type H WC/WC shaft seals in water showing performance range for three different shaft diameters

Note: The running-in wear period with noise of a WC/WC seal face material pairing is up to four weeks. However, typically, no noise occurs during the initial operating days due to higher leakage

SiC against SiC

Being an alternative to WC/WC, the SiC/SiC material pairing is used where higher corrosion resistance is required. This material pairing has good resistance against abrasive particles due to the high hardness. The friction is high, but for some SiC grades containing solid lubricants, the friction is only half, giving some improvement of the dry-running properties. Seals incorporating these SiC grades may be capable of running several minutes without being lubricated by the pumped medium.

The performances in hot water of seals incorporating porous SiC grades or SiC grades contaning solid lubricants can be seen in fig. 3.15.



Pos.	Range
1	Good performance
2	Risk of periodical noise in connection with start-up and variations in pressure and temperature
3	Periodical noise

Fig. 3.15: Pressure/temperature diagram of Grundfos type H SiC/SiC shaft seal in water showing performance range for a ∅22 shaft

3. Testing of shaft seals

Various types of simple testing configurations, such as ring-on-ring or even pin-on-disc, can be used to evaluate whether a material is suitable for a machanical shaft seal. Such tests give information about the tribological performance of materials and may even reveal wear processes in the tribological system. To get an accurate picture of the performance of a shaft seal, the tests must be made under conditions resembling the application for which the seal is intended.

Seal performance in hot water

The lubrication of the seal faces in hot water is limited. This is due to the low viscosity of water at high temperatures as well as to the evaporation in the seal gap. The temperature and pressure limits for shaft seals can be obtained by means of extensive testing.

Above these limits, noise from the seals may be expected and fatigue wear may occur.

The pressure-temperature diagram, fig. 3.16, shows how the limits of good performance change with the velocity. At lower velocities, the limits shift towards lower temperatures.

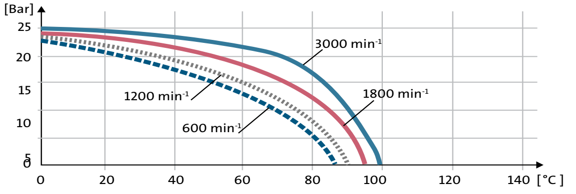


Fig. 3.16: Example of limits of stable friction of a shaft seal at different velocities

The hot-water tests are performed in tap water. At pressures and temperatures below the relevant curve with stable friction, the seal faces are exposed to a minimum of wear. Some wear may be expected above the relevant curve. See fig. 3.16.

Another way of showing temperature limits is to plot the wear rate as a function of the temperature at a fixed pressure. See fig. 3.17.

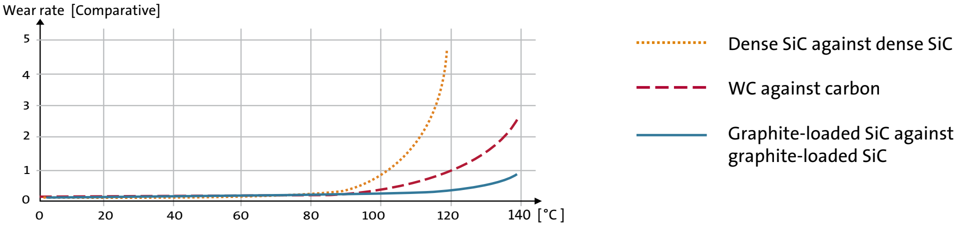


Fig. 3.17: Comparative wear rate of seal faces with three different material pairings

Dry running

Dry running may cause serious damage to the seal.
As it may be difficult to avoid dry running altogether in some applications, it is important to test the dry running performance of the seal. This can be done in a very simple way by running the shaft seal completely dry with a thermocouple attached to the seat or with thermographic equiment. The results obtained are slightly affected by the relative humidity of the air in the test room.
Fig. 3.18 shows the temperatures measured on the seat of various dry-running seals.

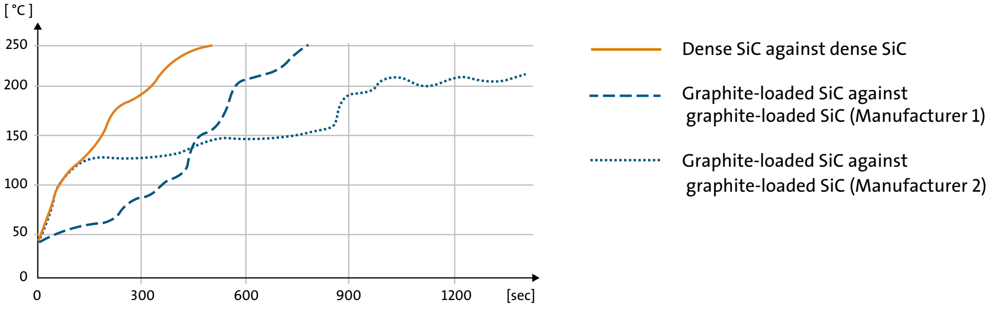


Fig. 3.18: Temperature on seat at dry running of seals with different SiC grades

As will be seen from fig. 3.18, dense SiC against dense SiC and graphite-loaded SiC aginst ifself (manufacturer 1) show poor dry-running performance, similar to WC against WC. The graphite-loaded SiC against itself (manufacturer 2) shows better dry-running performance.
Dry-running tests show large variations, even within the same grade of SiC.

Seal performance in water containing abrasive particles

If both seal faces are made of hard materials such as ceramics, wear on the seal faces caused by abrasives are rarely observed. The seal gap in a mechanical shaft seal is typically below 0.3 micron. Theoretically, this means that only particles below 0.3 micron can enter the seal gap. In practice, the edge of a seal face is not completely sharp. Consequently, particles measuring a few microns are able to enter the seal gap. Normally, such small particles only cause a polishing wear on a hard/hard seal face material pairing.

When one of the faces is a carbon ring, the edge of the seal face will wear and permit larger particles to enter the seal face.
Such larger particles can be trapped in the carbon seal face and cause wear on the hard counter face.

Seal performance in water containing glycol

Water containing glycol may cause problems with leaking seals. The problems often arise due to additives such as inhibitors, antioxidants, alkalines, etc. Some additives such as silicates and phosphates may crystallize in the seal gab as hard particles. These hard crystallites cause wear on seals with one carbon face. See fig. 1.24a, page 20.

Organic film binders, so-called inhibitors, adhere to all surfaces in contact with the liquid, including a major part of the seal face. Many inhibitors may build up sticky layers in the seal gap, resulting in leakage. Seals with WC/WC or SiC/SiC seal faces have better self-cleaning properties than seals with a carbon/SiC seal face material pairing. A high closing force and a narrow width of the seal face reduces the risk of build-up of deposits. See type G, page 28, and type R, page 29.
Fig. 3.19 shows the results of tests made with various seal face material pairings in water containing glycol with a high content of additives.

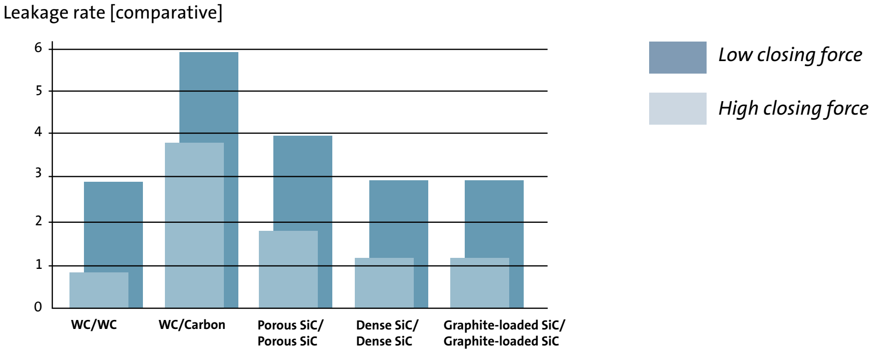


Fig. 3.19: Leakage of seals with different material pairings running in water-based anti-freeze liquid

To prevent a large seal gap with excessive leakage, a smooth surface finish is preferred. On the other hand, if the surface finish is too smooth, seizure of the seal faces may occur. Consequently, a compromise is often made with a different surface roughness of the two seal faces.
The leakage rate of hard/hard material pairings is elevated until the seal faces have become smooth as a result of the running-in.
Seals with one carbon seal face often have a lower, accumulated leakage during the running-in period because this period is shorter as compared to a seal with hard/hard material pairings.
Seals with a high closing force have a shorter running-in period because the lubricating film is thinner.

Seal performance in pure water

Pure water can be aggressive to many ceramics. As far as direct sintered SiC is concerned, the grain boundaries containing sinter additives may be attacked in pure water.
Damage is only observed on seal faces where high shear stresses may be achieved in asperity contacts.
By controlling the sintering process, it is possible to achieve SiC grades that are more resistant in pure water.

Fig. 3.20 shows the result of tests with dense SiC grades in 40°C demineralised water with a conductivity of 2 µS/cm. Special corrosion-resistant SiC grades show no failure during 11,000 hours of testing under these conditions.

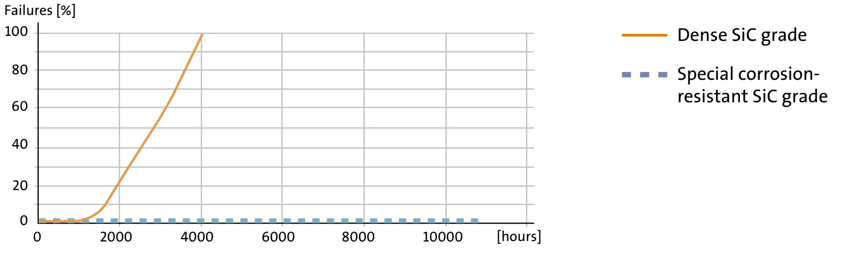


Fig. 3.20: Failure of SiC seals in demineralised water with a conductivity of 2 µS/cm

Sticking of seal faces

Very smooth and flat seal faces easily adhere to each other. In extreme cases, the adhesion is so strong that it prevents the motor from starting. Alternatively, it might cause the stationary seat to rotate in the secondary seal.

Various mechanisms act on the adhesion between the seal faces.

Physical adhesion

Vacuum may occur when two flat and smooth surfaces are pressed tightly together. Consequently, a large axial force is required to separate the two surfaces, while a lower shear force is required to rotate the surfaces. The size of the shear force at start-up is equal to the force required for a very low rotational speed. See fig. 3.21.

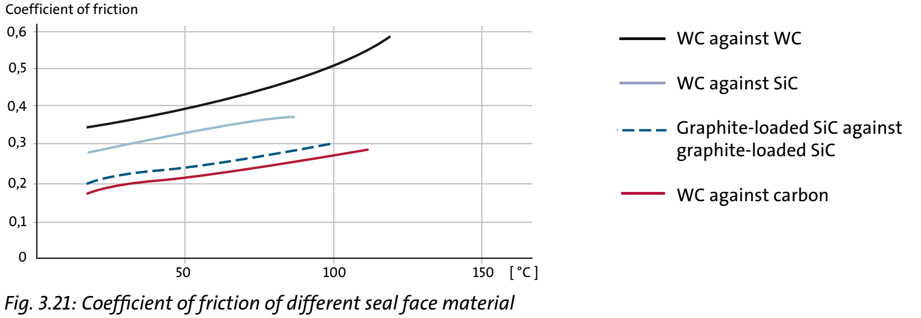


Fig. 3.21: Coefficient of friction of different seal face material pairings in water, at low rotational speed

Chemical adhesion of surfaces
All surfaces subjected to the atmosphere have an oxide layer. See fig. 4.12, page 72.
The equilibrium of the oxide layer may change when the surface gets into close contact with another surface or when it is exposed to the pumped medium. This change in equilibrium may involve chemical bindings to oxides from other surfaces. The more inert the oxide layer is to the surroundings, the weaker are the bindings to the counter surface.
If the medium is aggressive to the seal face material, the corrosion products from the seal faces may form chemical bonds, resulting in high adhesion forces.
To prevent such adhesion mechanisms, highly inert seal face material types such as SiC are preferred.

Chemical adhesion involving adhesive agents
If the pumped liquid contains ions that may precipitate on the seal face, the precipitations may act as glue between the seal faces.
This adhesion mechanism may occur in hard water and liquids containing fugitive elements and can be reduced by using a carbon/SiC seal face material pairing.
Solid lubricant-loaded SiC materials also reduce adhesion because the solid lubricant is smeared in a thin layer on the seal faces, providing low shear forces.

4. Secondary seals

As mentioned, it is important to choose the most suitable seal face material pairing to obtain the longest seal face life. Likewise, the secondary seals such as O-rings and bellows made of elastomer are essential for the right functioning and overall life of the mechanical shaft seal.
Elastomers refer to polymers with a high degree of elasticity. The material is also known under the term “rubber”.
Elastomers are the preferred choice of material for secondary seals due to their elastic properties. All these materials remain flexible within the operating range of temperature for the chosen mechanical shaft seal. The choice of elastomer is mainly based on the chemical composition and the temperature of the pumped medium. Besides, product approvals should be considered, see page 97.
For an overview of temperature and chemical resistance of elastomeric materials, see fig. 3.22.

The below-mentioned elastomers are used in mechanical shaft seals:

NBR
Acrylonitrile-butadiene rubber (NBR) belongs to the family of unsaturated copolymers.
Varying the composition with more acrylonitrile increases the resistance against oil, but reduces the flexibility. Compared to natural rubber, NBR is more resistant to oil and acids.
According to EN 12756, the material code for this group is named P. See page 96.

HNBR
Hydrogenerated acrylonitrile-butadiene rubber (HNBR) has the same good oil resistance as NBR and also good resistance to ozone, alkalis and amines. HNBR has a higher temperature limit in water than NBR.

MVQ
Silicone rubber covers a large group of materials in which methyl vinyl silicone (MVQ) is the main material. Silicone elastomers as a group have relatively poor tensile strength and poor wear and tear resistance. However, they have many special properties. Silicone in general has good heat resistance up to +230 °C and good cold flexibility down to –60 °C and good weather resistance. According to EN 12756, the material code for this group is named S.

EPDM
Ethylene-propylene diene monomer (EPDM) can be compounded to give many specific properties by varying the content of dicyclopentadiene, etylidene and vinyl norbornene. Compared to NBR, the material has very poor resistance to mineral oil, but excellent resistance to hot water. EPDM has a good resistance to polare liquids and poor resistance to apolare liquids. According to EN 12756, the material code for this group is named E.

FKM
Fluoro-carbon monomer (FKM) belongs to a family of rubbers designed for very high temperatures in many different liquids, due to the degree of fluorination. The material has poor resistance to hot water, but excellent resistance to oils and chemicals. FKM has poor resistance to polare liquids and good resistance to apolare liquids.
According to EN 12756, the material code for this group is named V.

FXM
Flourinated copolymer (FXM) has a good chemical resistance and withstands a wide temperature range in hot water applications.

FFKM
Perflouroelastomer (FFKM) has the best chemical resistance of any known elastomeric material. The chemical resistance of FFKM resembles that of polytetraflouretylene (PTFE), and the elastic properties resemble those of rubber. The material solves many difficult sealing problems. FFKM is very expensive and can only be made in relatively simple geometries.
According to EN 12756, the material code for this group is named K.

Pumped medium	**Elastomer**						
	NBR	HNBR	MVQ	EPDM	FKM	FXM	FFKM
Water, max. temp. [°C]	80	100	120	140	90	275	230
Mineral oils, max. temp. [°C]	100	150	120	-	200	275	230
Acids	+/-	+	+/-	+/-	+/-	+/-	+
Alkalis	+	+	+/-	+	-	+	+
Glycols	+	+	+	+	-	+	+
Oils, fuel	+/-	+/-	+/-	-	+	+/-	+
Solvents	-	-	-	-	+/-	-	+
Abrasive particles	+/-	+	-	+	+/-	+/-	-

Legend: + = excellent; +/- = good under certain conditions; - = poor; - = disastrous

Fig. 3.22: Overview of temperature and chemical resistance of elastomeric materials

5. Materials of other shaft seal parts

Besides seal rings and elastomeric parts, the other parts of the mechanical shaft seal must also be selected according to the application. The number of parts of the mechanical shaft seal depends on the complexity of the seal design.

Torque transmission parts
Metal or polymer parts can be used to transfer the torque from the seal faces to the shaft and pump housing. This is of particular importance in case of hard/hard material pairings producing a large friction torque. Metal parts are often made of stainless steel with a corrosion resistance similar to or above the level of the other pump parts. Polymers or formed sheet metal is often used for mass-produced mechanical shaft seals. Powder-metal parts can be used for minor series and machined parts for small quantities.

The mechanical shaft seal can be fastened to the shaft in different ways, but the most common is by means of small screws made of stainless steel or compression fitting.

Springs and bellows
Metal springs are used to press together the seal faces of O-ring shaft seals and rubber-bellows seals. Alloys of various levels of corrosion resistance are available.
The bellows of the bellows seals can be used to provide the force that presses the seal faces together. This is very common for metal bellows, but also applies to polymer bellows and rubber bellows. Metal bellows are made of very thin sheet material. They are often cold-worked to obtain high yield strength. The material grain size must be small compared to the thickness of the bellows.
The corrosion resistance grade of materials used for the bellows of above types must exceed that of other pump parts.

Guiding elements
High-pressure mechanical shaft seals may incorporate polymer or metal discs to minimise the gap between the rotating seal face and the shaft/sleeve. This reduces the risk of extrusion of the O-ring. See fig. 5.19, page 86.
Bellows seals may incorporate polymer or metal guiding elements to centre the rotating seal ring on the shaft.

Tubes, plugs and holders
Tubes and plugs for cartridge seals can be made of metal or rigid polymers. This also applies to holders for O-rings and clamping rings for rubber parts. The material chosen depends on the corrosion resistance, strength and dimension stability required as well as the number of identical seals to be made.

Summary
Materials for mechanical shaft seals must be chosen according to the applications.
Chemical resistance, temperature range and approvals must be considered.
For seal face materials, the friction and wear properties are very important.