THE MECHANICAL SEAL, THE PLANT'S FUSE - **THE MATERIALS USED TO MANUFACTURE A MECHANICAL SEAL**

In the first, introductory edition of this bulletin, we listed the main causes of malfunction and the subsequent failure of mechanical seals.

www.fluiten.it

In this second edition, we introduce the reasoning behind the choice of materials used to manufacture them, and the parameters you have to consider in order to make a correct choice.

A mechanical seal consists of:

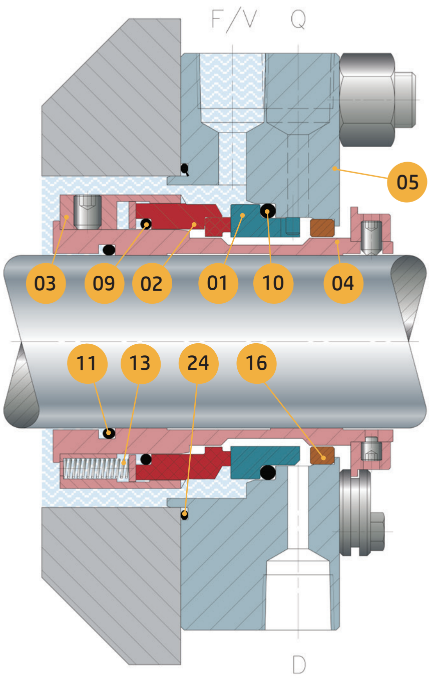
• Sealing (or sliding) surfaces, i.e. the stationary and rotating rings

• Secondary gaskets

• Metal spring(s) or bellows

• Other metal parts: seal body/collar, spring pushing ring and locking grub screws

• Cartridge seals are also fitted with a flange, shaft sleeve and other components.



01. Stationary ring, **02**. Rotating ring, **03**. Seal body, **04**. Sleeve, **05**. Flange, **09**. Rotating ring gasket, **10**. Stationary ring gasket, **11**. Sleeve gasket, **13**. Springs, **16**. Bush, **24**. Flange gasket

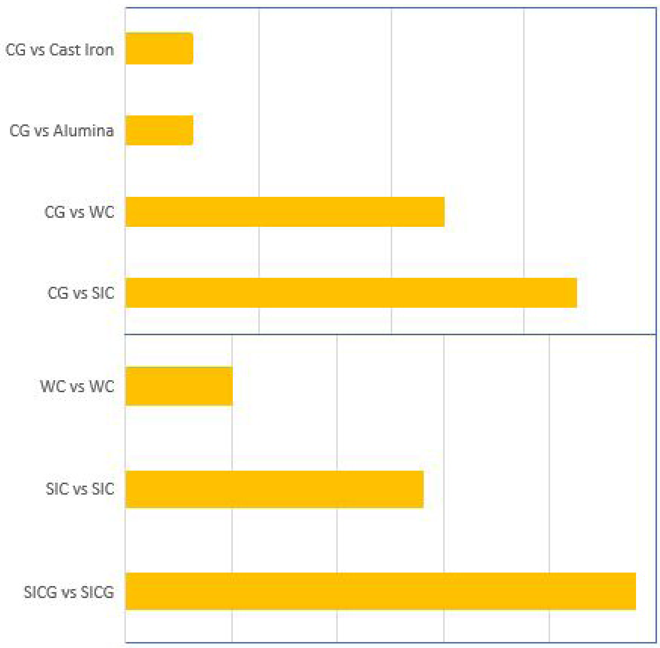
How to choose the materials for the various mechanical components:

When choosing the sealing surfaces, we have to consider the various factors that affect the viscous friction created between the two seal rings. This friction leads to a temperature increase, which should not cause the liquid film to evaporate since this will provoke premature ring wear.

The factors that affect friction are the load (the axial thrust between the two seal rings), the sliding speed, the surface roughness, and the state of lubrication considering the temperature and viscosity of the fluid sealed.

The recommended rotating and stationary ring materials should be chosen according to the nature of the fluid sealed and the PxV factor (operating pressure x peripheral velocity).

Maximum PV allowed for sealing face combinations



CG: Graphite **WC**: Tungsten carbide **SIC**: Silicon carbide **SICG**: Silicified graphite

Operating conditions permitting, it is best to pair up materials of different hardness with one of the two rings able to adapt to the opposite face.

Graphite's properties include excellent resistance to chemical aggression, a low coefficient of friction when in contact with a very hard surface, and low surface roughness. Silicon carbide has high hardness, excellent resistance to chemical aggression, and outstanding thermal conductivity, which is an important feature in order to dissipate the heat generated by friction between two contact surfaces. These two materials are very able to adapt to each other, which is an ideal condition for the formation of the liquid film needed to cool and lubricate the seal rings.

In some uses with fluids containing abrasive particles or in processes where the release of graphite powder cannot be tolerated, it is necessary to resort to two hard materials like silicon carbide or tungsten carbide.

Different kinds of graphite and silicon carbide may be used for mechanical seals, and each has its own peculiarities.

MATERIAL	GRAPHITE	CERAMIC	TUNGSTEN CARBIDE	SILICON CARBIDE (SiC)	SILICON CARBIDE (SiSiC)	NOTES
Lubricating properties	Good	Poor	-	-	-	
Chemical resistance	Good (1)	Very Good (2)	Limited	Very Good	Good (2)	1) Some fluids may cause unpredictable chemical reactions 2) Not suitable for basic (caustic) environments
Resistance to high temperatures	Good (1)	Good, if costant (3)	Good	Very Good	Very Good	1) Up to 180°C Resin impregnated Up to 350°C Metal impregnated Up to 450°C Electrographite 2) Fragile with thermal shock
Wear resistance (suitable for working with abrasive or crystallizing fluids)	Poor	Good	Very Good	Very Good	Very Good	
Deforamation at high pressure	YES	NO	NO	NO	NO	
Suitable for food and pharmaceutical use	NO (1)	YES		YES	YES	
Thermal conductivity	Poor	Poor	High	High	High	

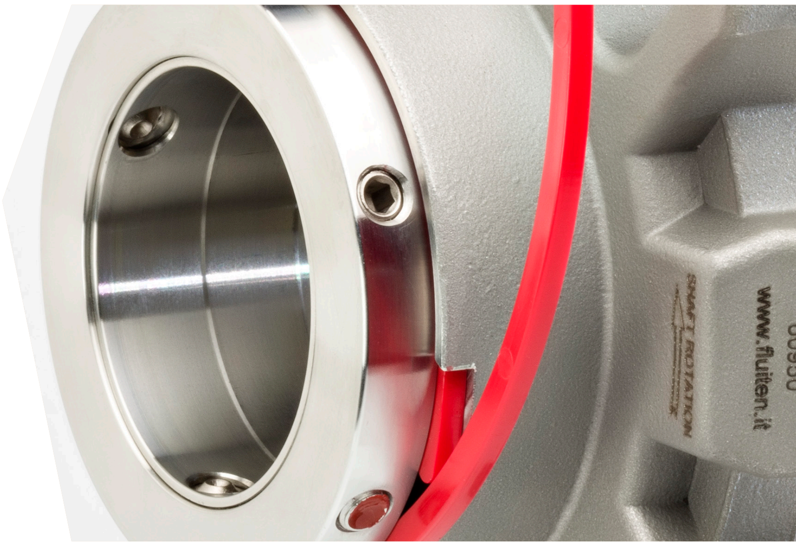
Secondary gaskets:

To prevent leakage between the rotating ring and the machine shaft (or shaft sleeve) and between the stationary ring and the flange in which it is housed, secondary gaskets are needed. These should have the following properties:

- •Chemical compatibility with the fluid sealed
- •Prevent leakage of the fluid sealed
- •Be easy to install on the machine
- •Tolerate small shaft, shaft sleeve and stationary ring flange machining errors

Last but not least, the gasket installed on the flexibile part of the seal should tolerate any small angular or axial movements the machine may make. Gaskets should preserve their characteristics throughout their life. Therefore, they have to be compatible with the fluid sealed.

Due to their shape and elastic characteristics, O-ring type gaskets lend themselves most to use on mechanical seals. If they are not properly chosen and installed, they can cause unwanted leakage.



Oring Material	elastomer	Temperature Limits	note
Nitrile Rubber	x	-40 +120 °C	Limited chemical compatibility - Low price - Because of their limited performance characteristics, they are not used as standard
Fluoroelastomer – FKM (viton)	x	-7 +176 °C Water based service: 7 +121 °C	Good chemical compatibility - Low price - Excellent resistance to acids and bases, water and hydrocarbons
Ethylene propilene (EPDM)	x	-55 + 150°C	Limited chemical compatibility - Low price. Good resistance to water, steam, weak acids and phosphoric esters. EPDM is incompatible with vegetable or mineral oils, hydrocarbons and fats - Contact with these fluids should be avoided.
Aflas	x	-10 +200 °C	Great with hot water
Perfluoroelastomers (FFKM)	x	0 + 290 °C (*1) -7 +260 °C (B)	High price compared with other elastomers. Excellent resistance to acids and bases, water and hydrocarbons. B: greater chemical compatibility
Flexible graphite	no	-240 + 480 °C	Non-elastic, brittle - suitable for static uses
PTFE	No (*2)	-180 + 250 °C	Non-elastic, suitable for static uses

Metal parts of a seal

In most cases, AISI316, equivalent to X5CrNiMo17-12-2 or DIN 1.4401, is used. It is an austenitic stainless-steel alloy consisting of 16 to 18% chromium, 11 to 14% nickel, and 2 to 3% molybdenum. It boasts excellent chemical compatibility and can be machined by chip removal with reasonable ease. For some uses, we have to use stainless ferrous alloys with a mixed austenitic and ferritic structure, known as duplex stainless steels. They have greater chemical compatibility than AISI316 and are chosen, for instance, for uses where there is high salinity, H2S or acid solutions. There are some uses where the metal parts have to be manufactured using superalloys, like Hastelloy B or Hastelloy C, which provide high corrosion resistance. Monel is an alloy of nickel and copper which is used, for example, where hydrofluoric acid is found. Titanium is also used when there are very aggressive fluids. These alloys are particularly expensive and less machinable than stainless steel.

The springs are the thinnest parts and can be more easily attacked than the other components that make up mechanical seals. Hastelloy springs can be used as an alternative to AISI316 spiral springs. Wave springs or metal bellows should be made of materials with a high modulus of elasticity (a characteristic austenitic steels do not have) and good corrosion resistance, such as duplex stainless steels, Hastelloy or Inconel 718. The latter is recommended by API682 as a material for metal bellows for use at high temperatures. The grub screws that lock the seal onto the machine shaft are normally made of AISI316. They too may be subject to tensile corrosion, so they may also be made of duplex stainless steels or super alloys.

FLUITEN provides a manual to help choose your seal and the materials it is made from. It describes various chemical-physical characteristics and suggests material choices for each fluid.
Contact us for a digital copy, or visit our website: **www.fluiten.it**

In the next bulletin we will discuss how to make sure a mechanical seal is lubricated and cooled properly. Please let us know if you are interested in receiving the next technical bulletin or send us the address of people who are interested in the subject.