MECHANICAL SHAFT SEAL FAILURE ANALYSIS

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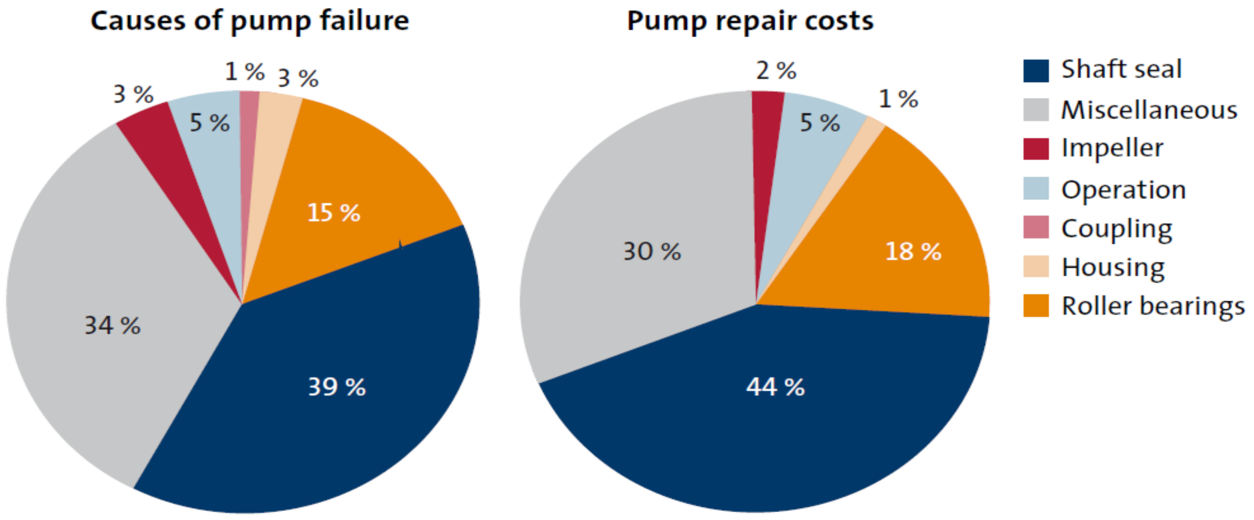
Introduction to mechanical shaft seal failures

Failure of the mechanical shaft seal is the most common cause of pump downtime. The shaft seal is exposed to widely varying operating conditions. Sometimes operating conditions change to become quite different from the specific conditions for which the seal was intended.
The diagrams below show that shaft seal failure is by far the most common cause of pump system failure. See figures 1 and 2.



Lubrication failures

Proper functioning of mechanical shaft seals with hard/hard seal face material pairings depends on lubrication by the pumped medium. Dry running and poor lubrication can produce the results described below.

1. Dry Running.

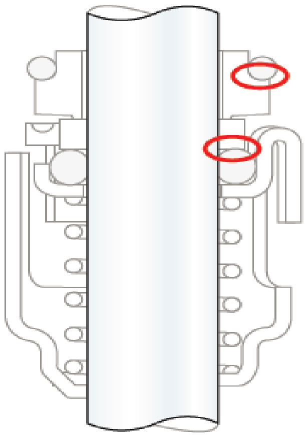


Fig. Surface damage due to high temp. on secondary seals.

Dry running occurs when there is no liquid around the seal, either due to absence of pumped medium in the pump or poor venting. Resulting in the formation of air around the seal. The absence of lubricating

The absence of lubricating film causes the friction between the seal faces to increase. Consequently, the temperature rise dramatically. As there is no pumped medium in contact with the seal rings, the heat must be transported away through the seal. Many seals with hard seal faces reach a temperature of several hundred degrees Celsius on the seal faces within few minutes. The typical damage caused by dry running is burnt elastomeric parts. The damage occurs where the O-ring is in contact with the hot seal ring**. See fig**

2. Poor Lubrication

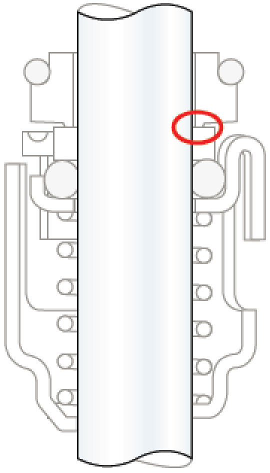


Fig. Severe thermal cracks in seal face caused by poor lubrication

Similar to dry running, the frictional heat generated on the seal faces as a result of poor lubrication may also cause problems. Poor lubrication may occur when the viscosity of the pumped medium is very low or if the temperature is well above the boiling point at atmospheric pressure. Under these conditions, the frictional heat dissipating in small areas on the seal face can be very high. The alternating local heating and cooling of the seal faces may cause small, radial, thermal cracks in the seal faces. **See fig.**

Noise - *When lubrication is poor or totally absent, shaft seals with seal rings made of hard materials tend to generate a loud noise. When noise is generated from the mechanical shaft seal, some parts of the seal vibrate. This may reduce the life of the seal.*

Contcontaination failures

The pumped medium is often a mixture of miscible liquids and a solution of solids, in addition to small suspended insoluble particles. The lubricating film in the sealing gap is subjected to large gradients in temperature, pressure and velocity.

1. Hang - up

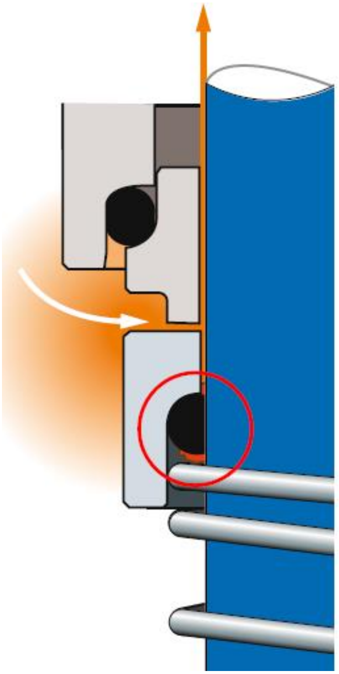


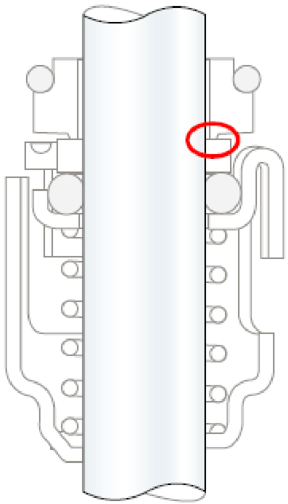
Fig. Sketch of seal hang-up due to blocking of the axial movement of the dynamic O-ring

Hang-up of a mechanical shaft seal means that the axial movement of the rotating part of the shaft seal is blocked. Hang-up mainly occurs in connection with O-ring-type.

In connection with O-ring-type shaft seals, settlements or precipitations may build up on the shaft beside the O-ring, preventing the O-ring from sliding freely. When the temperature or pressure in the system change, the dimensions of pump parts change likewise. As a result, the O-ring must be able to slide freely on the shaft or sleeve to continue to function correctly. **See fig**.

A hang-up failure is not always possible to observe during an analysis, as the seal has already been disassembled.

2. Opening of the sealing gap



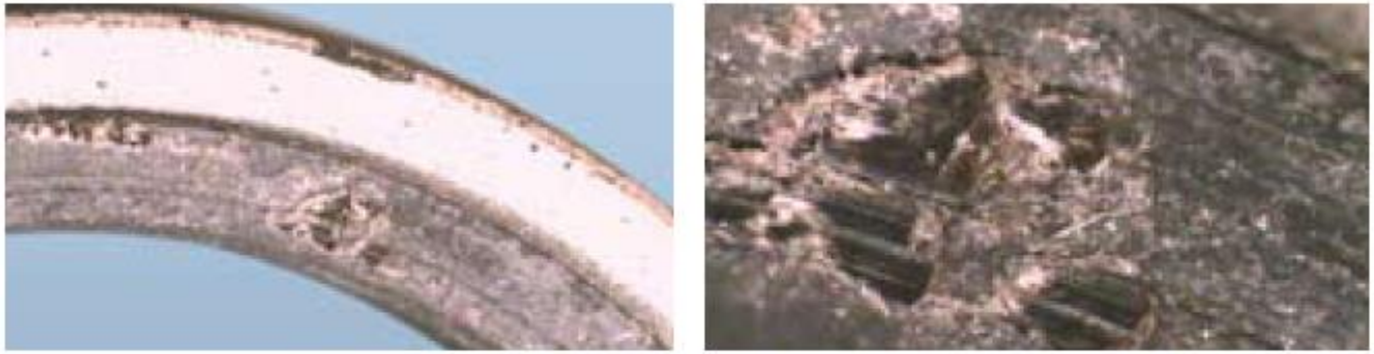


Fig. *Deposits on carbon graphite seal face*

Some suspensions and solutions tend to cause build-up of scattered deposits on the seal faces.

As the deposits only cover part of the seal faces, the sealing gap opens correspondingly. The result is a leaking shaft seal. The leakage is small at the beginning, accelerating as more liquid passes the sealing gap. The settlement accelerates, because the temperature is higher on the surface of the already anchored deposits. **See fig.**

3. Clogging

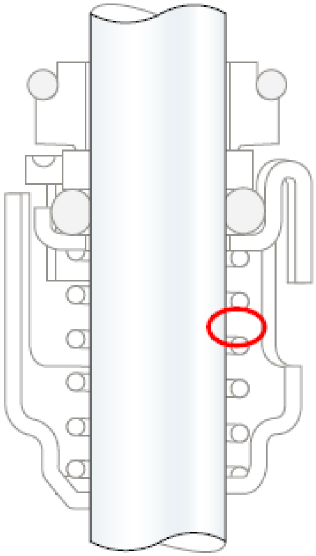
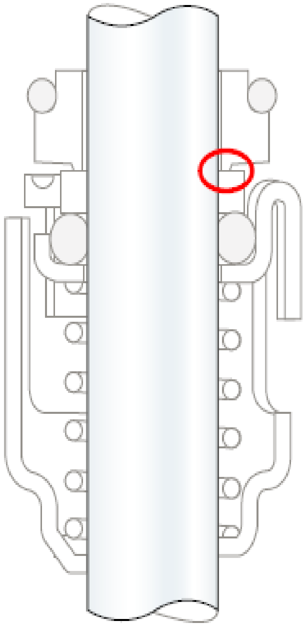


Fig. *Metal bellows seal clogged by lime scale build-up*

When the pumped medium has a high content of suspended particles and fibers, the seal can fail due to precipitation or consolidation of the particles and fibers on or at springs, bellows, seal-drivers or O-rings. The sedimentation rate is affected by the pumped medium and the flow conditions around the seal. In extreme cases, the sedimentation on metal bellows shaft seals may prevent the axial spring action of the bellows. Subsequently, the seal can open when the operating conditions are changed. **See fig.**

Note- If a change in operating conditions an axial compression of a bellows clogged by sediments, the closing force of the seal can be extremely high. This may result in excessive mechanical stress on the seal components or failure due to poor lubrication.



4. Particles and deposits

Small amounts of hard particles on the seal faces result in increased wear, especially when using hard/soft seal face material pairings. In such cases, small, hard particles might be squeezed into the soft seal ring from where they act as a grinding tool on the hard seal ring. Impurities between seal faces result in a high leakage rate, permanently or until the impurity has been grinded and flushed away.

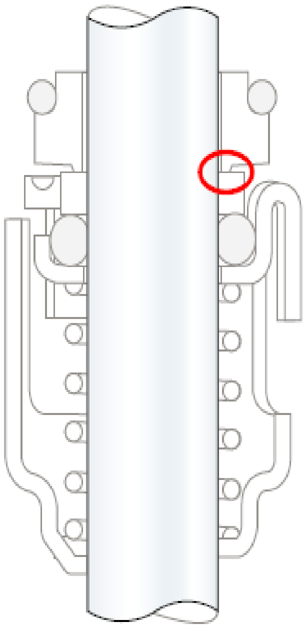
5. Sticking

Sticking occurs when the two seal rings are locked or partially welded together. The locked state results in a failure if the interconnection is higher than the starting torque of the motor. It may also result in mechanical damage of seal parts. Sticking can have different causes. Mainly hard/hard seal face pairings have a tendency to sticking. The main causes of sticking are precipitation of sticky materials from the pumped medium on the seal faces or corrosion of the seal faces. Sticking is only possible on shaft seals of pumps with start/stop operation. The period it takes for the seal rings to stick together ranging from a few hours and up, depending on the pumped medium.

Corrosion and wear

All parts of the mechanical shaft seal must have adequate resistance to the chemical and physical environment to operate properly during the expected working life.

1. Corrosion



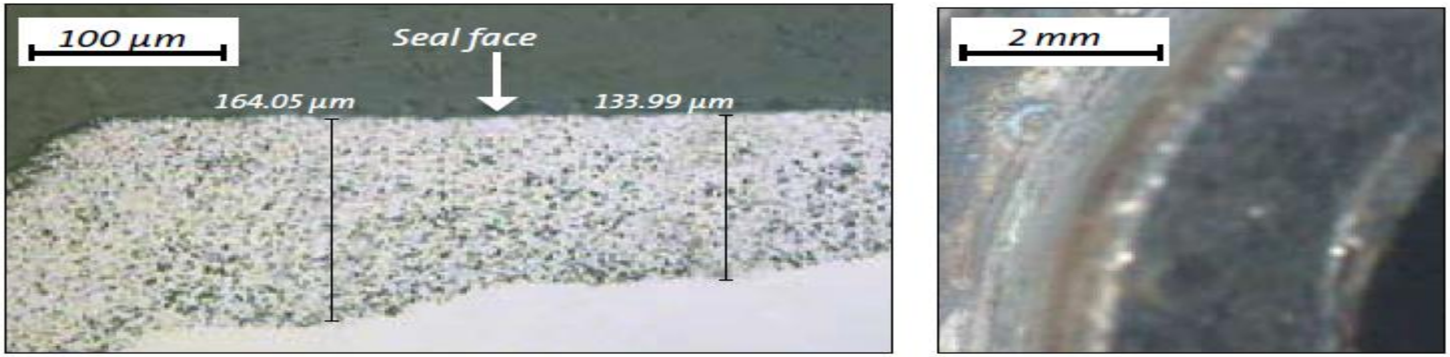


Fig. *Selective corrosion in cemented tungsten carbide.*

Most seal rings materials are made of composite materials. In order to prevent selective corrosion, all phases of the seal ring material must be resistant to the pumped medium. Corrosion in cemented tungsten carbide is typically seen as an attack on the metallic binder phase. The result of this attack is loss of the mechanical properties, including decrease in wear resistance. The selective corrosion of the binder phase may induce stresses, leading to cracks in the seal rings. **See fig.**

Fig. *Selective corrosion in cemented tungsten carbide.*

On other surfaces of the seal rings, heavy erosion can occur where the binder phase is corroded. **See fig.** In stainless steel pumps and pipe systems, tungsten carbide with cobalt binder corrodes in tap water.
In ceramic materials such as aluminum oxide, the process of a corrosion attack often dissolves or oxidizes the glass phase, resulting in a decrease in wear resistance. When the glass phase has disappeared from the surface of the seal ring. This affects the mechanical strength of the seal ring.

1. Wear

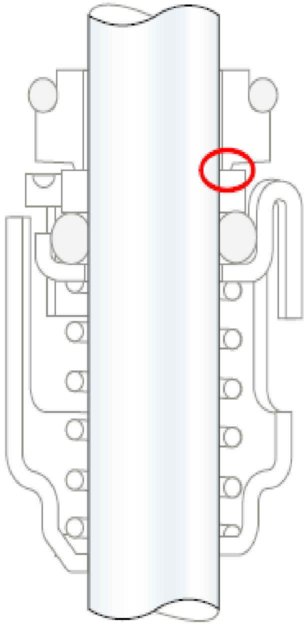


Fig. *Normal wear on surface of tungsten carbide seal ring.*

Because the thickness of the lubricating film is of the same order of magnitude as the surface roughness, the seal faces will wear to some extent. This normal wear on well-performing seals will be so small that the seal will be able to survive for many years. **See fig.** In special cases, wear can cause problems, but often seals work perfectly with severe wear.

Fig. 1 *Deep seal face grooves close to the pumped medium side.*

Fig. 2 *Grooves on seal faces at the evaporation zone*

Deep seal face grooves close to the pumped medium side indicate that hard particles from the pumped medium have entered the sealing gap. **See fig. 1**

Deep grooves close to the atmospheric side indicate that hard precipitates from the pumped medium have been created where the lubricating film evaporates. **See fig. 2**

Installation failures

Some mechanical seal failures come from wrong mounting and handling. Examples can be shaft misalignment, seats not mounted perpendicular to the shaft, axially moving shaft and wrong assembly length, etc.

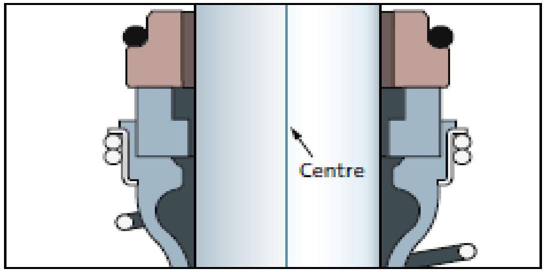


Fig. 1 *Well-aligned shaft seal*

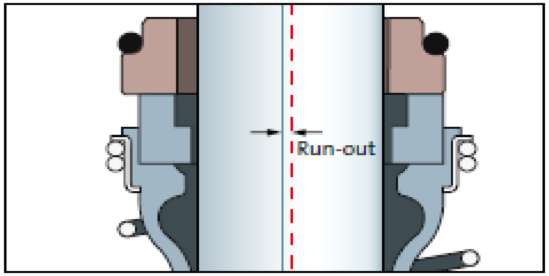


Fig. 2 *Shaft seal with radial run-out*

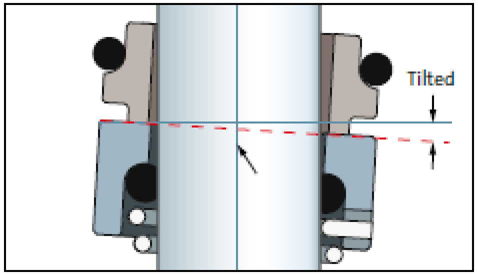


Fig. 3 *Uneven depth of wear track on the seat caused by tilted/crooked mounting*

The position and width of wear tracks on the seat indicate various problem areas. If the width of a wear track on the seat is the mirror of the sliding face of the opposite seal ring, the shaft seal seems to be well aligned with no run-out of the shaft. **See fig. 1.**
If the sliding face of the seat is broader than the rotating sliding face, a wider track on the seat all way around indicates a high run-out of the shaft. **See fig. 2.**
This can also be seen if, for some reason, there is an unbalance of the rotating mass. An uneven depth of the wear track around the seat indicates a tilted/crooked mounting of the seat. **See fig. 3.**

Summary

The main causes of failures on mechanical shaft seals used in pumps are described. It is difficult to state causes of shaft seal failures exactly, even with knowledge of the pump system.
A detailed failure analysis is needed to reduce future failures on shaft seals.

SH and SCR Series-

AS OUR PUMP IS DESIGNED FOR POSITIVE HEAD SO DO NOT START MOTOR BEFORE PRIMING OTHER WISE MECHANICAL SEAL OF THE PUMP WILL COLLAPSE OR BURN.

MAKE SURE THAT THE PUMP WILL NOT RUN UNDER DRY RUN CONDITION.

Sensor-(LiqTec)-In the event of dry running, the Shakti LiqTec immediately shuts dowmn the pump before any damage is done.
Drain Plug- When the humidity level reaches upto 85% then we have to open the Drive-end-flange

Coolant Pressure in Motor

Motor	Gauge Size	Min-Max
•Motor 4”-		
1.MCIP 100	12mm±2mm	10mm-14mm
1.MCIP 101	12mm±2mm	10mm-14mm
1.Premium 100	12mm±2mm	10mm-14mm
1.Premium 100.5	12mm±2mm	10mm-14mm
1.Premium 101	12mm±2mm	10mm-14mm
•Motor 6”-		
1.MATASF 150	44mm±2mm	42mm-46mm
1.SML150	59mm±2mm	57mm-61mm
1.SML 150 SS 304	98mm±2mm	96mm-100mm
•Motor 8”-		
1.MATASF 200	44mm±2mm	42mm-46mm
1.SML200	44mm±2mm	42mm-46mm
•Motor 10”-	64mm±2mm	62mm-66mm

- Injection
- Gauge
- PRV- Inlet (Green) and Outlet (White)
- We have to use injection for filling water inside the motor.
- To fill water inside the motor by using Green PRV port and in case of excise pressure the water will come out from White PRV port.
- Procedure- (Refer the Pressure Chart)

Thank You