

Self-Diagnose the Root Causes to Your Mechanical Seal Failure



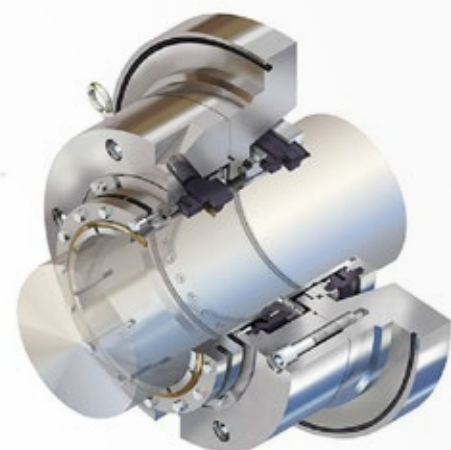
About Flowserve Corporation

Flowserve Corporation is one of the world's leading providers of fluid motion and control products and services. Operating in more than 55 countries, the company produces a wide variety of engineered and industrial pumps, seals, valves and specialty equipment. Flowserve also provides a broad range of consultative, engineering and technical support services.

Its portfolio of mechanical seals includes a very wide range of single and double, pusher and bellows designs in component and cartridge configurations. The company offers wet and dry running seals for pumps, compressor seals, steam turbine, mixer and specialty equipment seals, slurry seals and a complete selection of seal support and auxiliary systems. Flowserve seals are known for their ability to function within high-pressure, high-speed, high-temperature and highly corrosive environments.

Primary markets served by the Flowserve Corporation include oil and gas, power generation, chemical, mining and ore processing, water resources and general industries.

Flexachem are the leading distributors for Flowserve's fluid motion and control products and service within Ireland – visit our company's website to view our full product portfolio at www.flexachem.com.



Introduction

“If all the facts are known, the answer will be obvious” - Michael Huebner

Components fail for a reason; most often it is mechanical. The failed mechanism leaves clues that can be identified to help determine the cause of the failure.

Mechanical seal failure analysis is just one component of the larger equipment and systems analysis as part of Root Cause Analysis (RCA). It is estimated that 90% of the mechanical seals in a typical plant fail due to reasons other than wearing out. The seal failure analysis offers clues to other equipment, system or operational deficiencies.

This guide is designed to help the user visually review individual seal components and derive the “most likely” failure modes. As each component is reviewed, a common failure cause may become readily apparent.

To actually find the root cause of a failure, the user should take the evidence found in the seal failure analysis and determine if it points to equipment or system issues.

When reviewing each component, think about the following five key questions:

1. What is the function of the component?
2. What if it stopped performing its function?
3. What could cause it to stop performing its function?
4. How is it affected by the environment?
5. How does it interact with neighboring parts?

Collecting Data

Troubleshooting a seal application goes beyond looking at seal parts. Data gathering should start as soon as the work order is generated. Keep in mind, the opportunity to gather this data is lost once the equipment is removed from service. Make sure proper PPE, per the company's guidelines, is utilised for the job. Remember, you may come into contact with hazardous process media while disassembling the components of the mechanical seal. Ensure the proper troubleshooting tools are immediately available. These would include seal and pump outline drawings pump curve data, camera, marker, notepad, contact thermometer, measuring tools, container and funnel, watch/timer, inspection mirror, magnifying glass, picks and hex head wrenches.

While the equipment is still operating, it could be helpful to determine the following:

1. Identify source or location of leakage.
2. Quantify the leakage if possible. Use a suitable container of known volume and note the time it takes to fill completely.
3. Watch the leakage rate. Does it change over time due to variable operational conditions?
4. Is the seal squealing, spitting or sputtering?
5. Verify operating conditions.
6. If a centrifugal pump, identify where it is operating on the published curve.
7. Check the condition of any seal support systems or piping plans.
8. Note any piping movement and vibrations.
9. Take vibration readings and determine if it has changed over time or if it exceeds the maximum allowable limit.
10. Review work order history to determine the equipment's length of service.
11. Review with operations to determine whether any unit upsets, wash downs, and equipment startup or shutdown occurred prior to leakage being noted.

While the equipment is being disassembled, it may be helpful to note:

1. Does the shaft rotate freely without noise or rubbing?
2. Is the seal compression setting correct? On cartridge seals, can you properly reinstall the seal setting devices?
3. Is piping for seal support free from obstruction, including orifices?
4. Are there any rub marks from the impeller contacting wear rings, back plate or volute?
5. Is the pump suction free and clear of obstruction?
6. Is the coupling in good condition?

While disassembling the equipment, perform the typical equipment check for bearing condition.

Refer to FIS144, which includes:

1. Shaft end play
2. Radial deflection
3. Shaft run-out
4. Stuffing box face perpendicularity
5. Seal register concentricity

Refer to equipment OEM manuals for tolerances.

While disassembling the mechanical seal it is helpful to do so in a clean, well lit area. Use the seal drawing to assist in disassembly.

Take photos throughout the whole process; frequently photos will reveal issues not observed by the naked eye.

Retain the components until analysis is finalised.

Use this guide to review each component. The photos in this guide will help point toward possible failure modes. As each component is reviewed, common failure modes should reveal themselves to provide you with a road map to improvement. Each example makes suggested recommendations for improving the situation. Various bullet points are stated for consideration. In most instances, the recommendations are listed as individual options and are not cumulative.

Consult your local Mechanical Seal Specialist in Flexachem to determine the best corrective actions.

Table of Contents

■ **COMPRESSION UNIT**

Pusher Seal Chemical Attack 8

Pusher Seal Pins, Lugs and Drive Slots — Worn..... 10

Pusher Seal Pins and Lugs Bent or Broken 12

Pusher Seal Rubbing..... 14

Pusher Seal Solids Buildup..... 16

Pusher Seal Springs..... 18

Bellows Seals Chemical Attack 20

Bellows Seals Fracture 22

Bellows Seals Face Spinning or Loss of Retention 24

■ **SEAL FACES**

Normal Face Wear..... 26

Carbon Blistering..... 28

Multiple Chips on Seal Faces 30

Coking — Oxidation..... 32

Salting — Crystallization..... 34

Varnishing and Plating..... 36

Solidification Due to Freezing 38

Solids Buildup..... 40

Comet Trails 42

Delamination of Coated Faces..... 44

Erosion of Seal Face..... 46

Face Fractures..... 48

Face Chips in the Wear Track 50

Fracture at Pin Slot or Drive Mechanism 52

Heat Checking..... 54

Excessive (Heavy) Face Wear 56

I.D. Wear 58

O.D. Wear..... 60

Leaching 62

Phonographic Groove Wear..... 64

Solids Impingement Face Erosion 66

Spalling..... 68

Split Seal Face Alignment 70

Uneven Face Wear — Nose Height 72

Chipping Due to Vaporisation — Flashing 74

Wide Wear Track 76

No Face Wear 78

Non-Contacting Gas Seal — Face Damage..... 80

Contacting Dry Running Seal — Face Damage 82

■ **SLEEVE AND COLLAR**

Sleeve Issues — Dynamic Gasket Damage 84

Sleeve Bearing Fretting 86

Sleeve Damage by Set Screws 88

Sleeve — Installation Failures..... 90

Sleeve Drive Collar Failure 92

Bushing Contact With Sleeve 94

■ **ELASTOMERS AND GASKETS**

Abrasion 96

Chemical Attack 98

Compression Set 100

Cuts, Tears and Nicks..... 102

Explosive Decompression..... 104

Extrusion..... 106

Gasket — Hard, Brittle and Cracked..... 108

O-ring Nibbling Extrusion 110

Elastomers Soft or Swollen 112

Spiral or Rolling Damage 114

Polymerisation 116

Flexible Graphite Gaskets..... 118

Spiral Wound Gaskets 120

Flat Gasket Extrusion..... 122

■ **GLANDS AND HOUSINGS**

Housing Components and Misalignment..... 124

Bearings in Seal Assembly 126

Setting Device Damage 128

■ **APPENDIX A**

Corrosion and Chemical Compatibility 130

General Corrosion..... 131

Crevice Corrosion 131

Pitting Corrosion 132

Galvanic Corrosion 132

Intergranular Corrosion 133

Stress Corrosion Cracking 133

Erosion Corrosion 134

Cavitation..... 135

Methods of Preventing or Minimising Corrosion..... 135

■ **APPENDIX B**

Dynamic Gasket Hang-Up 136

■ **APPENDIX C**

Face Eccentricity 137

■ **APPENDIX D**

Face Distortion 138

■ **GLOSSARY**

..... 139



PUSHER SEAL

CHEMICAL ATTACK



PUSHER SEAL

CHEMICAL ATTACK

What:

- A reaction between the process fluids and metal components, resulting in a detrimental change to the seal.
- Metal surfaces appear matted, dull, honeycombed, flaky and may exhibit a loss of hardness, loss of material or pitting.

Why:

- Process fluids are incompatible with the materials of construction.
- High temperatures and increased concentrations accelerate corrosion.
- Oxygen-rich environments can accelerate corrosion.
- Isolated stagnant areas, such as crevices, or at a gasket can also accelerate corrosion.

Where:

- On exposed metallic surfaces.
- In crevices such as O-ring grooves, snap ring grooves or face holders.

Prevention:

- Check materials for chemical compatibility. (Reference FTA101)
- Perform chemical analysis of process stream and cleaning fluids.
- Investigate possible contamination during upset conditions.
- Increase seal chamber cooling to minimise corrosiveness.
- Isolate the process fluid from the seal chamber with a Plan 32 external flush.
- Upgrade component materials as necessary.

Reference: Corrosion Section Appendix A



PUSHER SEAL

PINS, LUGS & DRIVE SLOTS - WORN



PUSHER SEAL

PINS, LUGS & DRIVE SLOTS - WORN

What:

- The drive components have flats or indentations worn into them from the other sealing components.
- Worn components prevent proper motion of the flexible seal face.

Why:

- Poor lubrication creating excessive friction between the seal faces.
- Axial or radial movement causes wear on the drive components during operation.
- Poor equipment conditions can cause excessive movement of the drive mechanism.
- Wear can be caused by poor perpendicularity or concentricity of the shaft to the seal chamber.
- Excessive torque on sealing faces can also cause heavy loads on drive components.

Where:

- At the drive mechanisms including pins, lugs and slots in stationary or rotating elements.

Prevention:

- Review equipment process conditions to eliminate off design operation.
- Perform mechanical equipment integrity and vibration checks to ensure they are within manufacturer specifications (Reference FIS144).



PUSHER SEAL

PINS, LUGS BENT OR BROKEN



PUSHER SEAL

PINS & LUGS BENT OR BROKEN

What:

- Pins and lugs used as positive seal drives are deformed, bent, sheared or otherwise damaged.

Why:

- Excessive torque due to over-pressurisation.
- Poor lubrication creating excessive friction between the seal faces.
- The process fluid freezing or solidifying in the seal cavity, causing adhesion between the seal faces.
- Poor equipment condition causing excessive movement of the seal. overloading the drive mechanism.

Where:

- At the drive mechanisms such as pins and lugs in stationary or rotating units.

Prevention:

- Review application and seal selection to ensure capabilities for operating conditions.
- Maintain adequate vapor pressure margin.
- Review startup and shutdown procedures to ensure against upset conditions, including cold startup, dry running and cavitation.
- Perform mechanical equipment integrity and vibration checks to ensure they are within manufacturer specifications (Reference IS144).



PUSHER SEAL

RUBBING



PUSHER SEAL

RUBBING

What:

- Unintended contact between stationary and rotating components.

Why:

- Shaft misalignment or concentricity issues.
- Bent shaft or large shaft deflection.
- Non-piloted gland ring installed eccentric to the shaft.
- Throat bushing improperly retained to prevent axial movement.

Where:

- Contact between the O.D. of a rotating component and I.D. of the seal chamber or gland.
- Contact between the I.D. of a stationary component and the O.D. of the sleeve.
- Throat bushing moves axially during pressure reversal and contacts a rotating component.

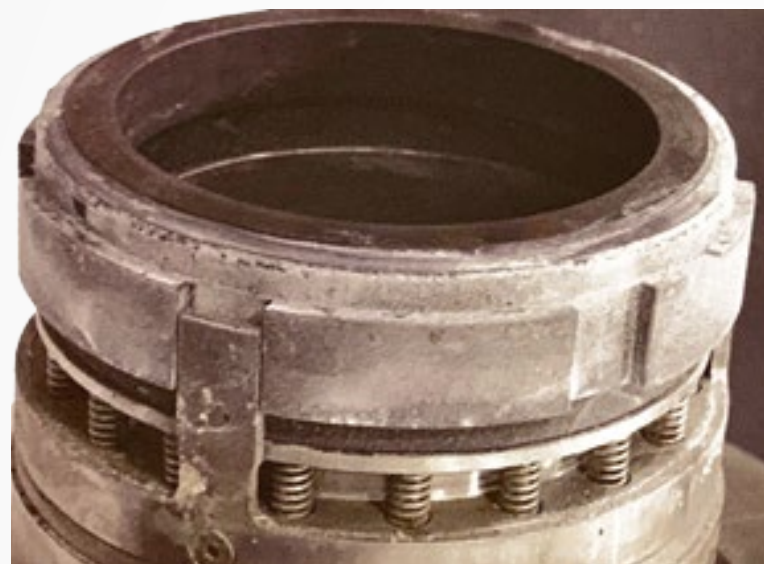
Prevention:

- Perform mechanical equipment integrity checks for radial deflection, shaft run-out and concentricity (Reference FIS144).
- Perform proper seal installation for a non-piloted gland to ensure concentricity with the shaft.
- If possible, convert to a piloted gland ring or shaft centered design.
- Mechanically retain the throat bushing.



PUSHER SEAL

SOLIDS BUILDUP



PUSHER SEAL

SOLIDS BUILDUP

What:

- Solid deposits hang up the flexible seal components.
- Debris on the seal components that prevent axial motion of the seal faces.
- Sealing integrity is compromised due to solids accumulation at the sealing surfaces.
- Accumulation of solids in the seal chamber prevents the circulation of process fluids around the seal.
- This can occur on the product side or the atmospheric side of the seal.

Why:

- In high-temperature hydrocarbon applications, coking (which is a heavy sludge-like residue that results from a reaction with oxygen or chemical breakdown) can hang up dynamic seal parts.
- In applications with dissolved solids, salting can occur on the atmospheric side of the seal due to evaporation of the process fluid.
- In thermal-sensitive fluids, weepage can solidify at lower temperatures outside of the process stream.
- In cryogenics or low-temperature applications, environmental moisture can freeze, hanging up dynamic seal parts.
- Seal components exposed to process fluids with suspended solids become packed in services such as minerals, slurries or paper stock.

Where:

- Coking and salting develops on the atmospheric side of the seal.
- Thermally sensitive fluids may solidify within the seal chamber, between the seal faces or on the atmospheric side of the seal.
- Freezing occurs in the area of the seal gland exposed to the atmosphere while the equipment is operating. After shutdown the ice may melt, eliminating clues during disassembly.
- Suspended solids may settle out in confined areas, including the seal chamber, gasket grooves and spring pockets.

Prevention:

- Change to metal bellows seal design, eliminating dynamic gaskets.
- Control temperature using jacketed seal chambers and/or seal gland. Use heating or cooling as required.
- For freezing, salting or coking, use a clean quench (steam for coking, methanol quench for freezing, API Plan 62).
- Use dual seals with pressurised barrier fluids (API Plan 53 or 54) to control fluid film and minimise seal exposure to solids.
- Add a clean external flush (API Plan 32) to single seals to minimise seal exposure to solids.



PUSHER SEAL SPRINGS



PUSHER SEAL SPRINGS

What:

- The breakage or permanent deformation of the springs.
- Corrosion of springs, causing weakening.

Why:

- Excessive stress due to seal misalignment or over-compression.
- Spring rubbing in the spring pocket due to excessive cycling or vibration.
- Metal degradation due to exposure to incompatible chemicals.

Where:

- Individual spring components.

Prevention:

- Correct equipment misalignment.
- Check seal setting and installation procedures.
- Check process chemical compatibility with spring material of construction (Reference FTA101).



BELLOW SEALS

CHEMICAL ATTACK



BELLOWS SEALS

CHEMICAL ATTACK

What:

- General loss of material, pitting, cracking or spalling on the metal components.
- Damage to the components by fluid environment.

Why:

- Incompatibility of metallic components with process fluids under operating conditions.
- Exposure to high temperatures or operating conditions, which increases corrosiveness of the environment.
- Exposure to trace chemicals such as sulfur, hydrogen sulfide or chlorides, which can cause cracking or pitting.

Where:

- On any exposed metallic components.
- In crevices between components.
- Bellows assembly may be constructed with multiple metal alloys. and corrosion may be evident on only one or more parts of the assembly.

Prevention:

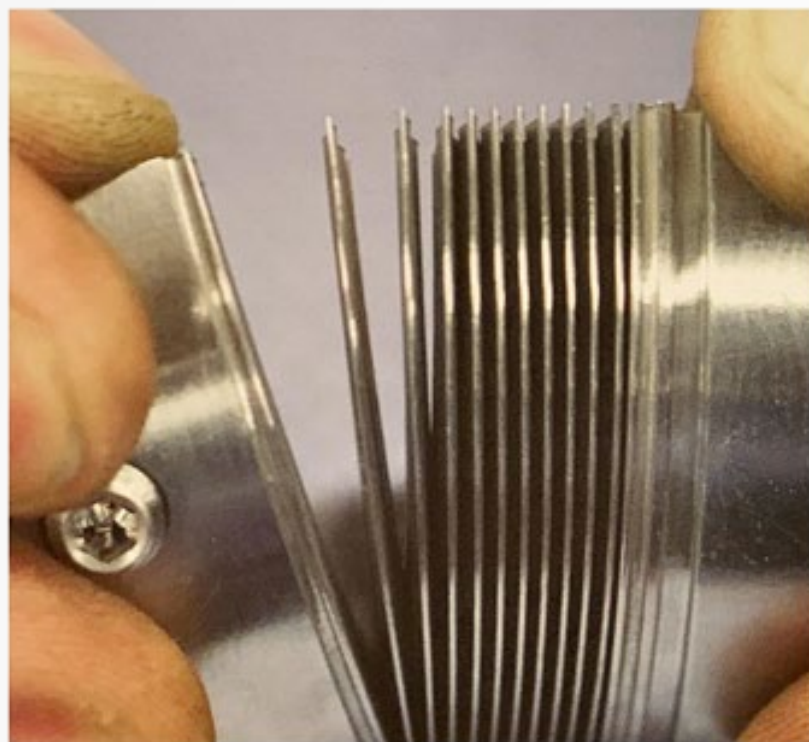
- Check chemical compatibility of metals with chemicals at operating conditions (Reference FTA101, "A" ratings required).
- Use higher alloyed, more corrosion-resistant materials for seals.
- Reduce temperature of the operating environment; if possible.
- Use an external injection of a less aggressive chemical (Plan 32), if possible.

Reference: Corrosion Section Appendix A



BELLOW SEALS

FRACTURE



BELLOWS SEALS

FRACTURE

What:

- Fracture, splitting or breakage of the bellows at the O.D. or I.D. welds.
- Failure or breakage of the bellows diaphragms.

Why:

- Cracking of bellows due to fatigue caused by cyclic axial motion or vibration.
- Operation of the seal with insufficient lubrication between the seal faces, nutation or slip-stick.
- Deformation of bellows due to excessive axial load.
- Deformation or breakage of bellows due excessive pressure differential.
- Loss of material due to mechanical contact, corrosion or erosion.

Where:

- In the O.D. or I.D. weld bead.
- Most commonly found at the first or second diaphragm on the I.D. weld from either end of the bellows assembly.

Prevention:

- Ensure all alignments and run-outs between the shaft and seal chamber are within required limits. (Reference FIS144)
- Eliminate sources of high vibrations within the pump.
- Ensure an adequate vapor pressure margin is available under operating conditions.
- Eliminate operation or upset conditions which may result in dry running or slip-stick between the seal faces.
- Ensure operating conditions are within the design specifications of the seal.



BELLOW SEALS

FACE SPINNING OR LOSS OF RETENTION



BELLOWS SEALS

FACE SPINNING OR LOSS OF RETENTION

What:

- Spinning of seal face in the bellows gland or face holder.
- Seal face cocking or pushing out of the bellows gland or face holder.

Why:

- Loss of shrink fit due to operation at higher temperature.
- High torque between seal faces due to solidification of process or adhesion of seal faces.
- High I.D. pressure differential on bellows seal.

Where:

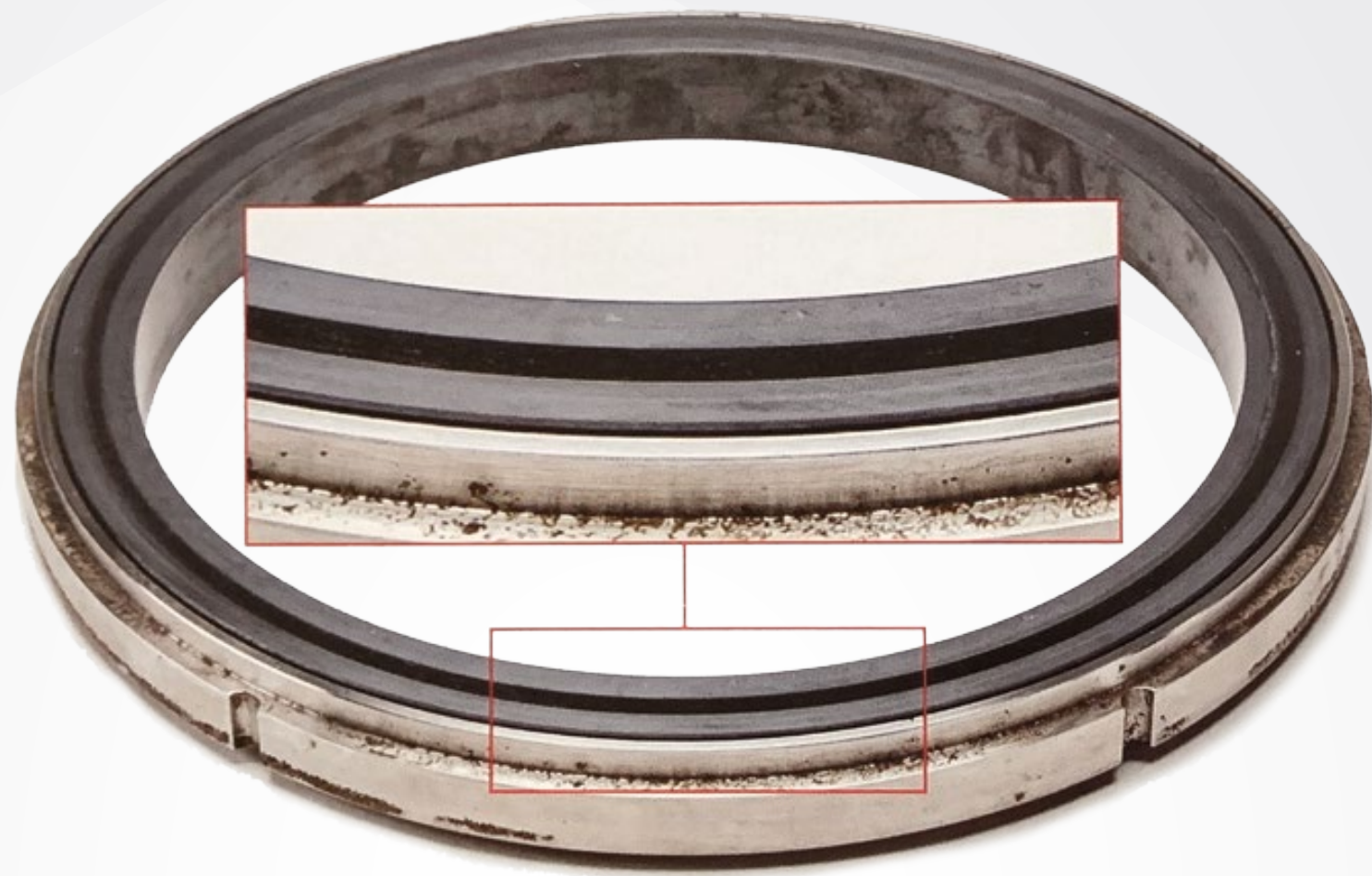
- Seal face in the bellows gland or face holder.

Prevention:

- Use seals rated for high-temperature conditions.
- Ensure process fluid does not solidify between seal faces.
- Avoid operating the seal without fluid in the seal chamber.
- Consider using an external injection if fluid conditions are unreliable.
- Change seal orientation to avoid high I.D. pressure differential.



NORMAL FACE WEAR



NORMAL FACE WEAR

What:

- Very light polishing or change in reflectivity on the wear surface of the seal faces.
- Wear surface is smooth, with no grooving or wear.

Why:

- Faces touch lightly during operation with proper contact pressures.
- Rotation of the face causes smoothing of surface finish on the wear track.
- Contact area has a slight wear-in or polishing during operation.

Where:

- Seen on the contact area of one or both seal faces.

Prevention:

- No prevention or corrective action required.



CARBON BLISTERING



CARBON BLISTERING

What:

- Craters, voids or pits of removed material found on the seal carbon face wear nose.
- Irregular sections on the carbon face, which appear as polished high spots.
- Cracks may be visible on the face.
- If a pit is present, there may be a comet trail created by debris being pulled into the sealing interface.

Why:

- Process fluid penetrates the carbon voids. When the seal face heats up, the fluid expands quickly and cannot escape the void fast enough, resulting in a blister.
- Caused by traction between the faces during startup and operating with high viscosity fluids or light hydrocarbons.

Where:

- Carbon seal faces operating in higher viscosity fluids, ISO 32 and above.
- Frequent start and stop operations will create more blisters.
- In flashing light hydrocarbon services.

Prevention:

- Ensure cooling of the seal faces. Proper cooling will make the carbon less susceptible to blistering.
- Change the carbon face to antimony impregnated carbon.
- Replace the carbon face with a hard face such as silicon carbide or tungsten carbide.
- In dual seals, use low viscosity buffer or barrier fluid.
- Reduce frequent stops and starts.



MULTIPLE CHIPS ON SEAL FACES



MULTIPLE CHIPS ON SEAL FACES

What:

- Edge chipping on the inside and/or outside of seal faces.
- Chips do not extend across the faces.

Why:

- Chipping caused by heavy edge loading.
- The narrow face wears a groove into the wider face.
Changed conditions cause the faces to move out of established wear pattern.
- Seal face coning deflection from excessive pressure and/or heat.
- Chipping on the rotating face of a bellows due to nutation (coining).
- Popping and slapping of faces due to flashing of process fluids, such as hot water or light hydrocarbons.
- Chipping caused by excessive equipment vibration.

Where:

- Seal face I.D. and/or O.D.
- Chipping caused by nutation is commonly found on the O.D. of a bellows seal face.

Prevention:

- Check the equipment mechanical integrity: replace bearings as required (Reference F1S144).
- Monitor pump vibration levels to ensure that the limits are not exceeded.
- Confirm actual operating conditions and ensure the seal is within its design limits.
- Ensure adequate face lubrication.
 - Properly vent equipment and seal chamber before operation.
 - Ensure the seal cavity has sufficient vapor pressure margin.
 - Confirm lubricating properties of sealed fluid.
 - Consider other seal face material combinations.



COKING - OXIDATION



COKING - OXIDATION

What:

- Black, hard, grainy material buildup on the atmospheric side of the seal face.
- Buildup is thermally decomposed hydrocarbon converted to a varnish, lacquer or abrasive sludge.
- Heavy coke buildup can decrease the unit loading on the seal faces and cause excessive leakage.
- Coking can cause hang-up of the dynamic seal face.

Why:

- Hydrocarbon in the presence of high temperatures causes a chemical breakdown or oxidation of the hydrocarbon.

Where:

- Found on the atmospheric side of the seal faces.
- Found on hydrocarbon services above 121°C (250°F).

Prevention:

- Reduce seal cavity temperature by running Plan 21, 23 or 32
- Remove the oxygen from the atmospheric side of the seal faces by adding a quench Plan 62:
 - Dry steam quench — removes the oxygen and will wash away residue. **WARNING:** wet steam may cause seal problems.
 - Nitrogen quench — removes the oxygen but will not wash away residue.



SALTING - CRYSTALLISATION



SALTING - CRYSTALLISATION

What:

- Granular residue buildup on the atmospheric side of the seal face.
- The buildup of crystals can cause hang-up of the dynamic seal face.

Why:

- Dissolved minerals such as salts or caustics, form after the process fluid has evaporated from leakage accross the seal faces.
- Crystals can also appear as a result of fluid temperature dropping below its freeze point.

Where:

- Found on the atmospheric side of the seal faces.

Prevention:

- Add a Plan 62 liquid quench to wash away the residue.
- Utilise a dual seal that isolates the product from the atmosphere with a barrier or buffer fluid (Plan 52, 53 or 54).



VARNISHING AND PLATING



VARNISHING AND PLATING

What:

- A thin film of residue buildup at the seal faces or on the atmospheric side of the seal.

Why:

- The residual film deposited after the base fluid evaporates from leakage across the seal faces.
- Residual film formed by thermal decomposition of the process fluid.
- This buildup can result in hang-up of the dynamic seal face, causing excessive leakage.
- If the buildup occurs at the seal faces, varnishing can impact the fluid film, causing excessive leakage.

Where:

- Found across the seal faces and the atmospheric side of the seal.

Prevention:

- Add a liquid quench to wash away the residue at the atmospheric side of the seal face (Plan 62).
- Utilise a dual seal that isolates the product from the atmosphere with a barrier or buffer fluid (Plan 52, 53 or 54).



SOLIDIFICATION DUE TO FREEZING



SOLIDIFICATION DUE TO FREEZING

What:

- Temperature-related product solidification causes the seal faces to hangup or glue together.
- Frozen condensation on the atmospheric side of the seal due to humidity accumulating on the seal and shaft.

NOTE: Frozen media may be gone upon examination of the seal due to melting.

Why:

- This condition exists when the temperature of the process fluid at the mechanical seal or atmospheric side of the seal drops below freezing point of the process fluid or atmospheric condensation.
- Freezing the seal faces together can cause high torque during startup, resulting in face fractures, drive pin damage, unseated stationary faces or broken bellows.

Where:

- Processes which freeze under ambient conditions.
- Atmospheric freezing most often occurs in cryogenic applications.

Prevention:

- Ensure equipment including seal chamber are brought up to operating temperature before startup.
- Maintain the seal support system within a safe operating temperature range above process freezing under all ambient conditions.
- Use warming jacket or heat tracing for seal and seal support system as required.
- For atmospheric freezing add a dry nitrogen or inert gas quench to keep moisture or humidity away from seal faces (Plan 62).
- Utilise a dual seal that isolates the product from the atmosphere with a barrier or buffer fluid (Plan 52, 53 or 54).



SOLIDS BUILDUP



SOLIDS BUILDUP

What:

- A residue buildup on the atmospheric side of the seal.
- A deposit of suspended solids that can cause hang-up of the dynamic seal face.

Why:

- Residual buildup of solids after the evaporation of the liquid in the process stream.
- Solids content in the process fluid may cause carbon face damage, resulting in a higher buildup of solids.

Where:

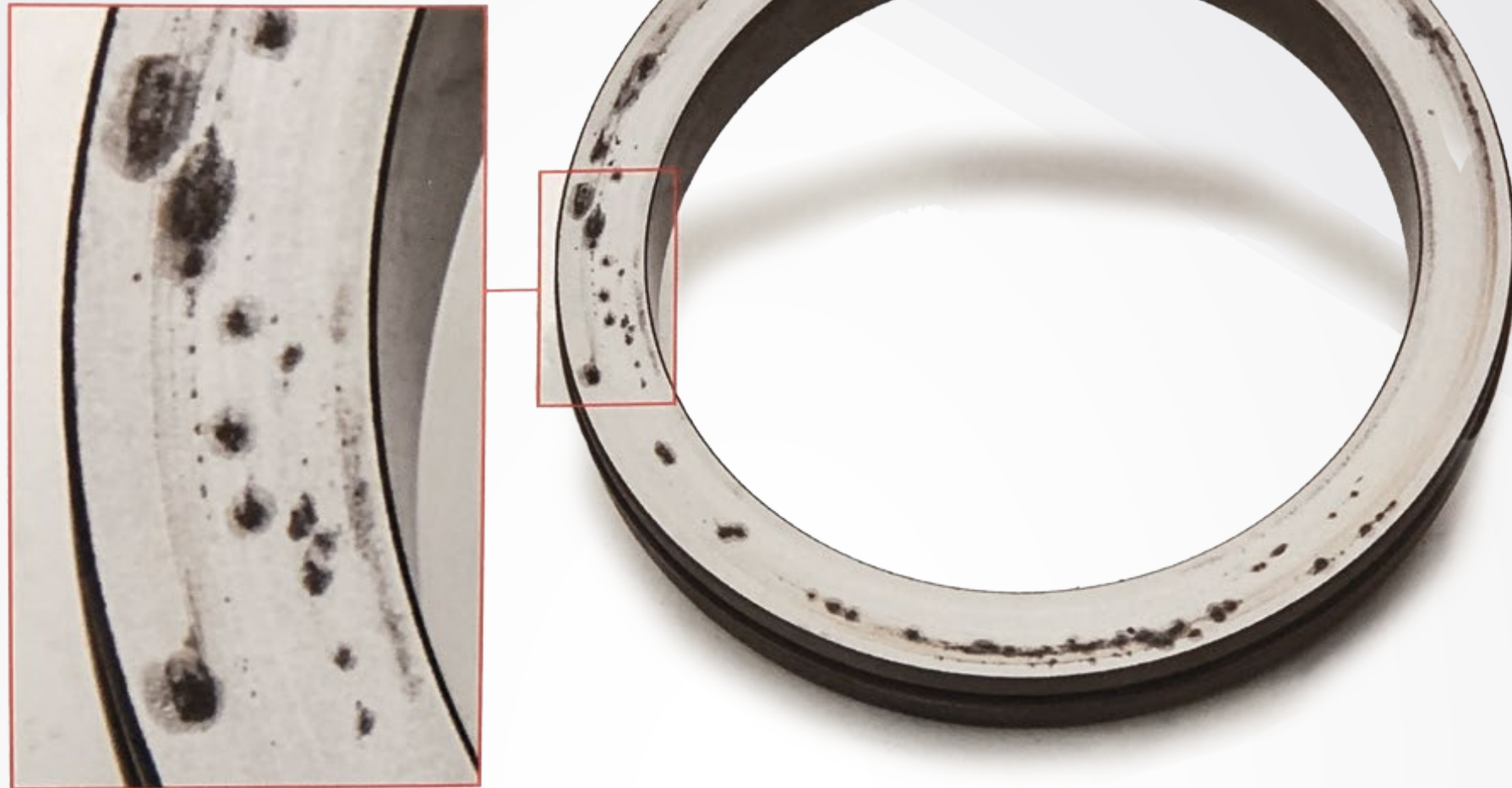
- Located on the atmospheric side of the seal.

Prevention:

- Use a hard vs. hard face combination to minimise face damage.
- Add a water or condensate quench to wash away the solids (Plan 62).
- Use a clean external flush to isolate the process from the seal chamber (Plan 32).
- Utilise a dual seal that isolates the product from the atmosphere with a barrier or buffer fluid (Plan 52, 53 or 54).



COMET TRAILS



COMET TRAILS

What:

- The seal face wear track has a streak that appears as a comet with a tail.
- It can be seen by the naked eye.

Why:

- Foreign material has migrated between the seal face and is smeared around the wear track.
- Material has pulled out of the seal face due to thermal or mechanical damage. These particles then migrate around the face.
- Break up or disintegration of blister material between the seal faces.

Where:

- In services with suspended solids.
- Loss of fluid film, causing particle generation.

Prevention:

- Ensure there are no dry running situations.
- Reference FTA160 for proper Flush Plan application.
- A Plan 32 may be required to remove solids.



DELAMINATION OF COATED FACES



DELAMINATION OF COATED FACES

What:

- Coatings are applied to base metals to create a hard sealing face.
- Coatings can separate or delaminate from the base metals.
- Coating damage can be exhibited by blisters, material pull-out or cracking.

Why:

- Corrosion to the base metal causes delamination of the coating.
- Thermal distress from dry running can cause delamination.
- Exceeding pressure, speed and temperature limits of the seal face.
- Excessive differential thermal expansion between coating and base material.

Where:

- The wear track will exhibit damage from thermal distress.
- The entire face can exhibit damage from corrosion.

Prevention:

- Ensure the seal is operating within its design parameters.
- Check the chemical compatibility of the base metals with the process. (Reference FTA101)
- Ensure the equipment and flush plan are operated properly.
- Replace with solid hard face.



EROSION OF SEAL FACE



EROSION OF SEAL FACE

What:

- Loss of material due to high-velocity impact of solids in liquid.

Why:

- Solids in liquid impacting a surface at high velocity.
- The velocity of the rotating face makes it more susceptible to erosion.

Where:

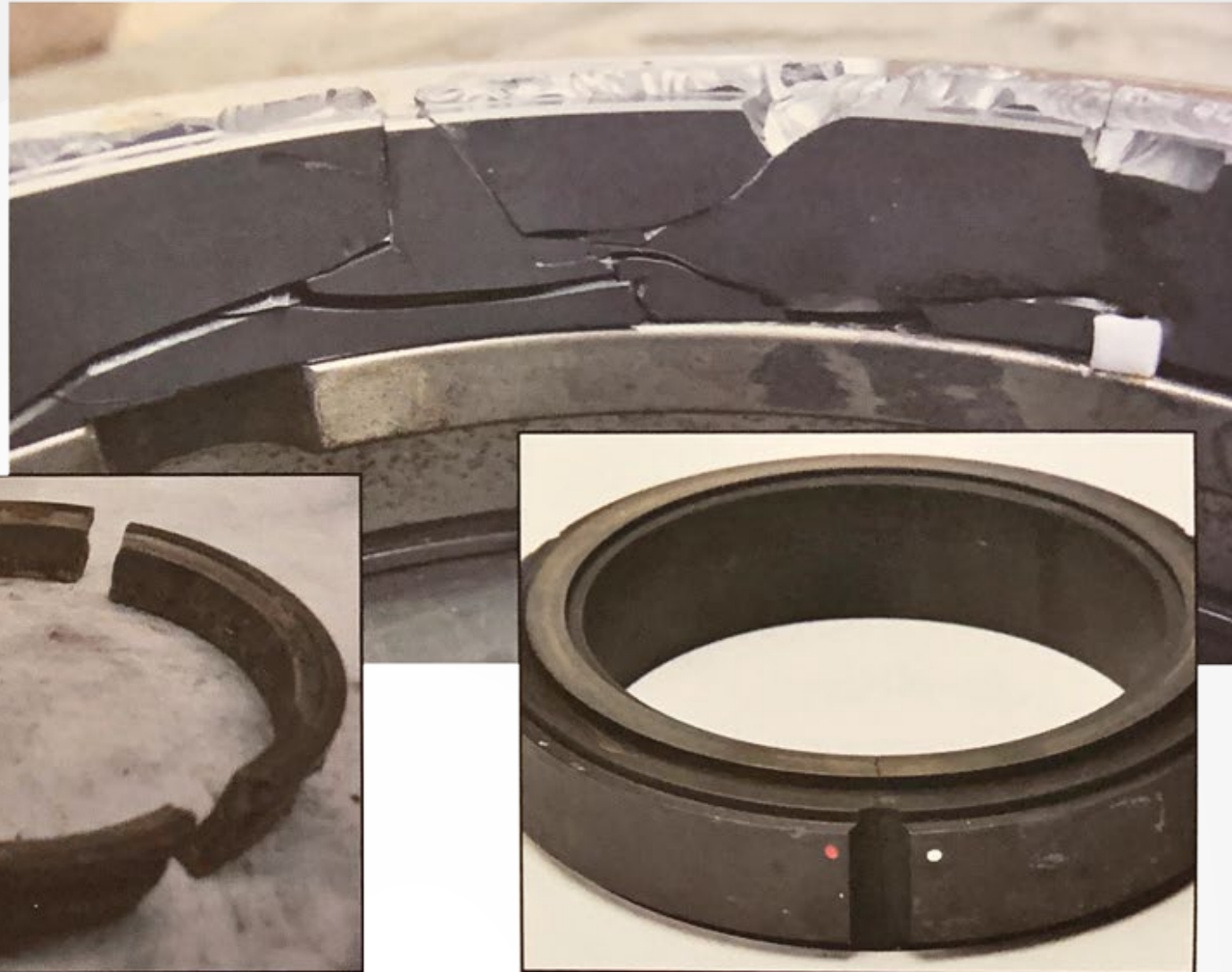
- On the process contact surface of the sealing face.
- Drive pin and slots can exhibit accelerated erosion.
- Carbon seal faces exhibit higher rates of erosion.
- Localised erosion of seal components due to high velocity seal flush.

Prevention:

- Use a harder face combination.
- Consider seals designed for use in fluids with high solid content.
- Reduce solid concentration and/or fluid velocity.
- Reduce velocity of seal flush.



FACE FRACTURES



FACE FRACTURES

What:

- Seal face fractures extending through the cross-section of the face.

Why:

- Rough handling of seal during transportation or seal installation.
- Contact between the seal face and other components, caused by differential thermal expansion.
- Shaft deflection causes shaft to impact the seal face.
- Improper assembly and disassembly by prying or hammering on the seal face.
- Buildup of solids between seal face and mating components in high-temperature applications.
- Excessive I.D. pressurisation of the seal face.

Where:

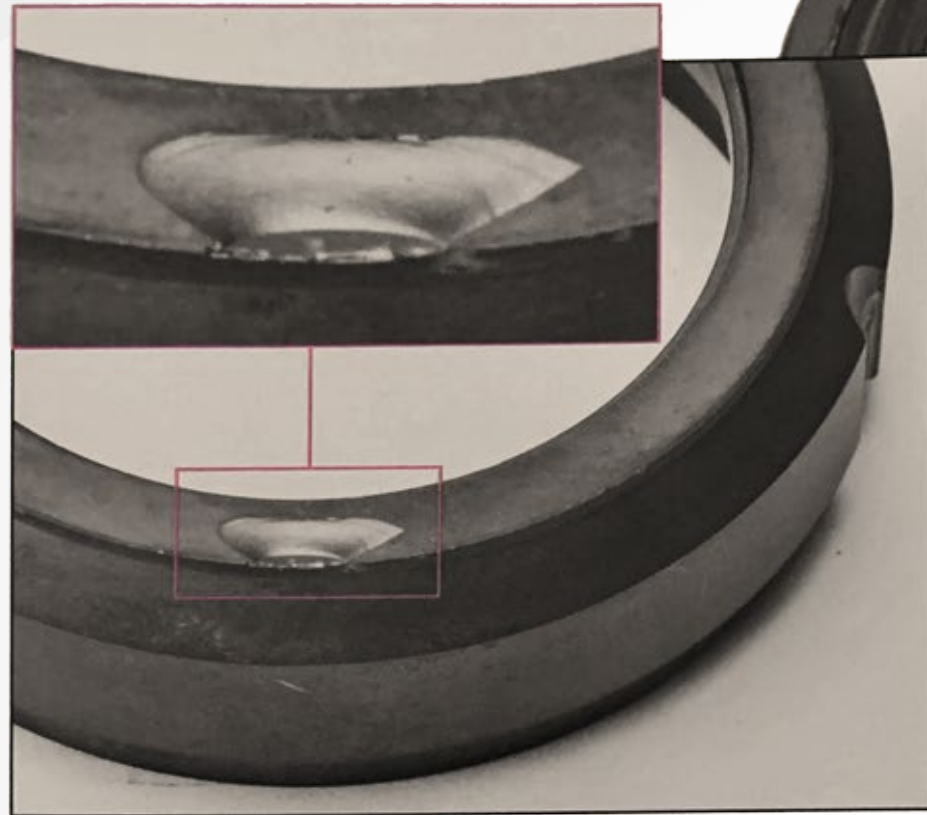
- A fracture can occur at any location on the seal face.

Prevention:

- Properly package seal for shipping.
- Inspect the seal for damage prior to installation.
- Ensure the seal is designed for actual operating conditions.
- Ensure operating conditions do not exceed equipment capabilities.
- Ensure equipment is in good condition.
- Use proper tools and procedures when assembling or disassembling the seal.



FACE CHIPS IN THE WEAR TRACK



FACE CHIPS IN THE WEAR TRACK

What:

- Triangular- or fan-shaped fracture on the inside and/or outside diameters of the face and observed on the sealing surface.
- The fracture allows product to penetrate deep into the seal faces, which increases seal leakage.

Why:

- Fracture of the face resulting from contact with another component.
- Modern ceramic materials are very hard and brittle, thus prone to chipping damage due to contact.
- This may also occur on the softer carbon face.
- Chipping may occur during non-operations such as shipping, installation or removal from equipment. Fresh chips without debris or stains are typically signs of rough handling.

Where:

- Typically, a chip initiates from the impact point and propagates into the face in a fan shape.
 - I.D. chips result from impact with the shaft or sleeve.
 - O.D. chips result from contact with the gland or housing.

Prevention:

- Ensure the seal is installed properly.
 - Be sure the stationary face is squarely seated in the gland or housing.
 - Avoid contact with other seal components during installation.
- Ensure that the equipment run-out does not exceed the capabilities of the seal.
- Always reinstall centering tabs before seal removal from equipment and before any shipping and handling.



FRACTURE AT PIN SLOT OR DRIVE MECHANISM



FRACTURE AT PIN SLOT OR DRIVE MECHANISM

What:

- Seal face has a chip, crack or fracture originating at the face pin or slot location.
- Severity can range from a simple chip to complete fracture through the seal face.
- Crack or chip caused by interactions between face and pin.

Why:

- The fracture can cause excessive seal face leakage as well as damage to the non-fractured faces during operation.
- High torque loads at the seal faces create excessive stresses at the face pin and slot location.
- Slapping due to start-stop operations, causing drive mechanism to impact face.
- Solidification of product between faces.
- Excessive vibration caused by cavitation or imminent bearing failure.
- Installation issue such as the misalignment of pins during assembly.

Where:

- Damage at the pin or slot location found on the back O.D. or I.D. away from the seal face.
- Complete fracture through the seal face originating at the pin or slot.

Prevention:

- Confirm the seal is designed properly for the application.
- Ensure the seal was installed with the drive mechanism aligning properly with the slots.
- Correctly install seal to avoid overloading seal faces.
- Properly warm up pump before startup in high viscosity or solidifying fluids.
- Perform complete equipment integrity checks. (Reference FIS144)
- Use a soft start when applicable.



HEAT CHECKING



HEAT CHECKING

What:

- Radial cracks across the rubbing surface of the seal face.
- The number of cracks can vary from tightly packed to barely visible to the naked eye.

Why:

- Rapid localised heating.
- Loss of lubrication due to overload or vaporisation.
- Off design dry running conditions.

Where:

- On the face contact rubbing surface.
- Commonly found on tungsten carbide, Stellite® or chrome oxide.

Prevention:

- Ensure the seal is sufficiently lubricated.
- Vent seal chamber to remove vapors.
- Properly set the seal.
- Use proper Flush Plan to ensure vapor pressure margin and cooling. (Reference FTA160)



EXCESSIVE (HEAVY) FACE WEAR



EXCESSIVE (HEAVY) FACE WEAR

What:

- Excessive loss of material from the mating surface of the seal faces.

Why:

- Lubrication between the mating surfaces is not adequate.
- Excessive face loading due to high pressure or mechanical conditions.
- Secondary seal hang-up of flexibly mounted face.
- Vaporisation of the product between the seal faces.
- Abrasives between the mating surfaces.
- The seal has been installed incorrectly.

Where:

- Found at the mating surfaces between the seal faces.
- Normally found on carbon seal faces. but also can be found on other face materials.

Prevention:

- Ensure the seal mating surfaces are sufficiently lubricated.
- Properly vent seal chamber and Flush Plan to prevent lack of lubrication.
- Check chemical compatibility of secondary seals (Reference FTA101).
- Make sure the seal is set properly and not overly compressed.
- Ensure there is adequate vapor pressure margin inside the seal chamber.
- For abrasive wear on carbon face, consider substituting carbon with a hard face.
- If abrasives are present, use the appropriate Flush Plan such as:
 - On a single-stage overhung pump, use a Plan 13 when the density of the solids is greater than the density of the process fluid.
 - On a between bearings pump use a Plan 31 with a cyclone separator to reduce solids from the flush fluid.
 - Use a Plan 32 with a clean external flush fluid.
 - In boiler feed water services containing iron particles use a Plan 23 with a magnetic separator.



I.D. WEAR



I.D. WEAR

What:

- Contact occurs at the inside diameter on the rubbing surface of the face.
- The contact region may display damage ranging from slight polishing to heavy wear.
- During operation the seal leaks; leakage rate decreases when equipment is shut down.

Why:

- Fluid shear heats the faces and can cause thermal coning distortion and I.D. contact. (Reference Appendix D)
- Insufficient O.D. pressure can cause coning, resulting in contact at the I.D. of the face-rubbing surfaces. (Reference Appendix D)
- I.D. pressurisation contributes to coning. (Reference Appendix D)
- Differential thermal expansion of seal components can cause coning.
- Insufficient face lubrication causes face-generated heat and thermal coning.
- Adjustment of the impeller after the setting devices are removed, causing excessive face loading.
- Improper setting of a component seal.

Where:

- Seals are not properly designed to resist coning in the application.
- High-viscosity fluids have higher seal-generated heat, resulting in excessive shear and coning.
- Flashing fluids or applications where the pump may be operating with poor lubrication of the seal.
- Improper venting of a seal chamber or starting a pump dry.
- Excessive I.D. pressurisation on the inner seal of a dual seal arrangement.

Prevention:

- Ensure the seal is operating within the operating parameters of the seal design. Review special operating parameters with Flexachem.
- Follow manufacturer's installation instructions to ensure proper seal setting.
- Ensure the Flush Plan is vented and operated properly.
- Use lower viscosity barrier or buffer fluid in dual seals.
- Ensure adequate vapor pressure margin.



O.D. WEAR



O.D. WEAR

What:

- Contact occurs at the outside diameter on the wear surfaces of the faces.
- The contact region may display damage ranging from slight polishing to heavy wear.

Why:

- Contact at the O.D. of the seal face is typically the result of excessive pressure coning deformation. (Reference Appendix D)
- O.D. coning deformation may cause excessive contact loading and high seal face torque due to the lack of lubrication across the seal faces.
- The seal may be operating outside designed pressure limits.
- The shaft rotates too slowly to generate enough heat to create a stable, fluid film. (Reference Appendix D)

Where:

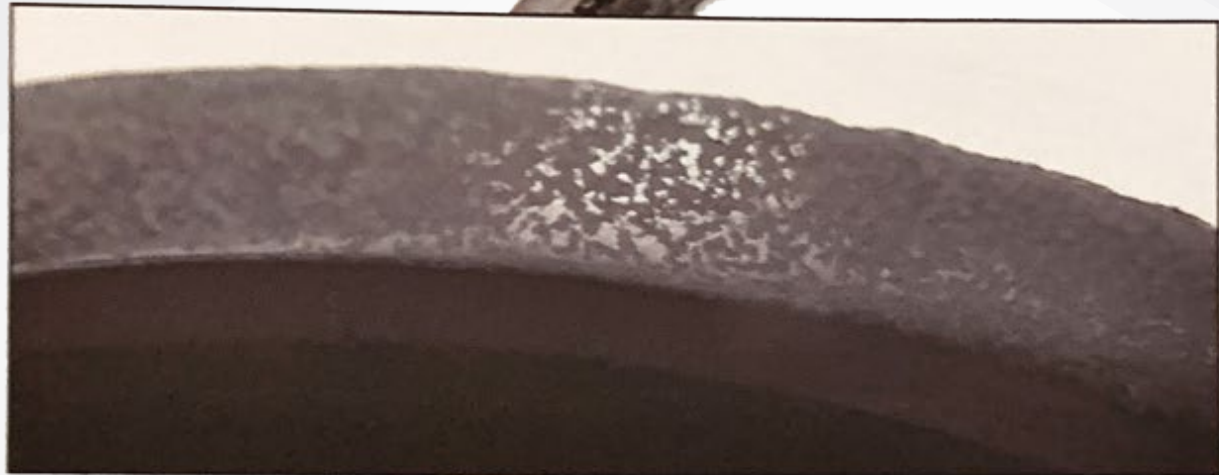
- Located at the O.D. of the wear surfaces on the faces.

Prevention:

- Ensure the seal is operating within the pressure limits of the seal design.
- Ensure the Flush Plan is operating correctly.
- Ensure the seal is designed for all operating conditions, including slow rolling the equipment.



LEACHING



LEACHING

What:

- Leaching is a chemical attack to the seal face binder or substrate material.
- A leached face is often characterised by a flat matte finish on any wetted seal face surface.
- All the surfaces may feel rough like fine sandpaper and will look porous when viewed under magnification.

Why:

- The seal face binder or substrate component is chemically attacked by the process fluid or system cleaning solutions.
- The severity of the attack can be influenced by process fluid temperature and concentration.
- The nature and severity of the damage is dependent on the type of seal face material.

Where:

- Can be found on most seal faces.
- Easiest to spot on the surfaces exposed to the process.
- There may be a difference in appearance between the wearing and non-wearing surfaces.

Prevention:

- Review process and cleaning chemicals for seal face material compatibility and upgrade materials as necessary (Reference FTA101).
- Investigate to determine if changes have been made to the process stream or cleaning solution.
- Apply suitable API Plan to reduce seal chamber temperature to minimise corrosion. (Reference FTA160)



PHONOGRAPHIC GROOVE WEAR



PHONOGRAPHIC GROOVE WEAR

What:

- A series of fine concentric grooves across the rubbing surface of the seal face.
- The grooves may be uniform around the circumference of the face or may change in depth and width.

Why:

- Grooving is caused by suspended abrasive particles in the fluid.
- Particles smaller than one micron can enter the fluid film between the faces.
- Hard faces can be worn by abrasive particles imbedded in soft mating face.

Where:

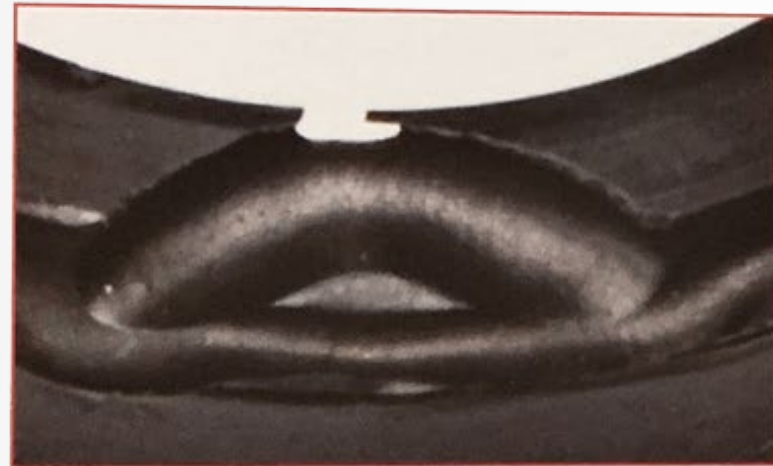
- Can be found on either or both faces.

Prevention:

- On a single-stage overhung pump, use a Plan 13 when the density of the solids is greater than the density of the process fluid.
- On a between bearings pump, use a Plan 31 with a cyclone separator to reduce solids from the flush fluid.
- Use a Plan 32 with a clean external flush fluid.
- In boiler feed water services containing iron particles, use a Plan 23 with a magnetic separator.
- Change to two hard faces.
- Use a dual pressurised seal with barrier fluid (Plan 53 or 54).



SOLIDS IMPINGEMENT FACE EROSION



SOLIDS IMPINGEMENT FACE EROSION

What:

- Loss of material in a localised area on the seal faces or other components.

Why:

- High-velocity injection stream against a seal component, resulting in the loss of material in a localised area.
- Erosion or material loss is aggravated by the presence of abrasive or solid particles in the fluid stream.
- Seal face erosion can change the face loading and sealing integrity.
- Erosion of metallic components can cause material loss and adversely impact seal performance.

Where:

- Typically found in the area of the injection port of the seal gland.
- Can be found on the stationary seal face, especially on the softer face materials such as carbon.
- Metal components may demonstrate this type of localised wear, especially on thinner components such as bellows diaphragms and bellows glands.

Prevention:

- Reduce the velocity of the seal flush by decreasing the flush rate.
- Reduce the velocity by increasing the diameter of the through hole at the flush port
- Move the seal flush tap so it is not directly over the seal faces.
- Use multi-port injection to better distribute the flush.
- Change Flush Plans from Plan 11 to Plan 13 or 32.
- Remove the solids from the flush by adding a cyclone separator or filter (Plan 31).



SPALLING



SPALLING

What:

- Spalling occurs on carbon and is similar to blistering, but exists only on the non-mating surfaces.

Why:

- Thermal stress causes spalling.
- Fluid penetrates the carbon, and when rapidly heated, expands and pops out a section of the carbon.

Where:

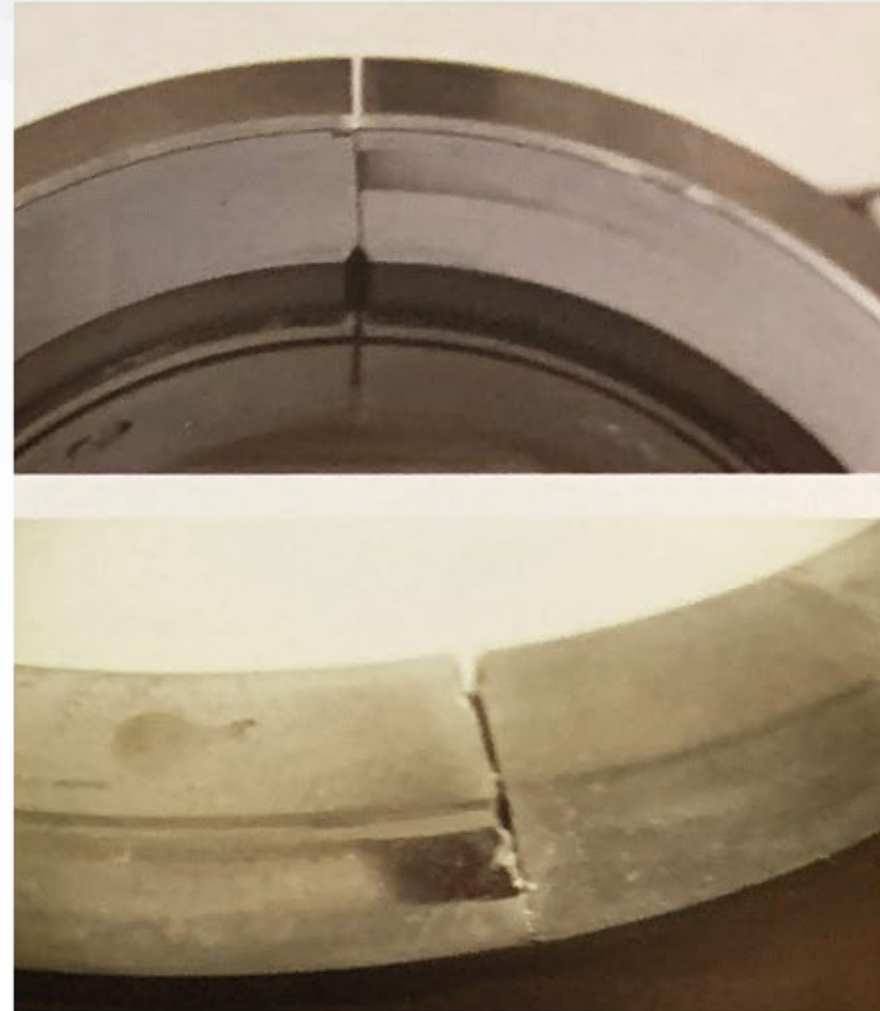
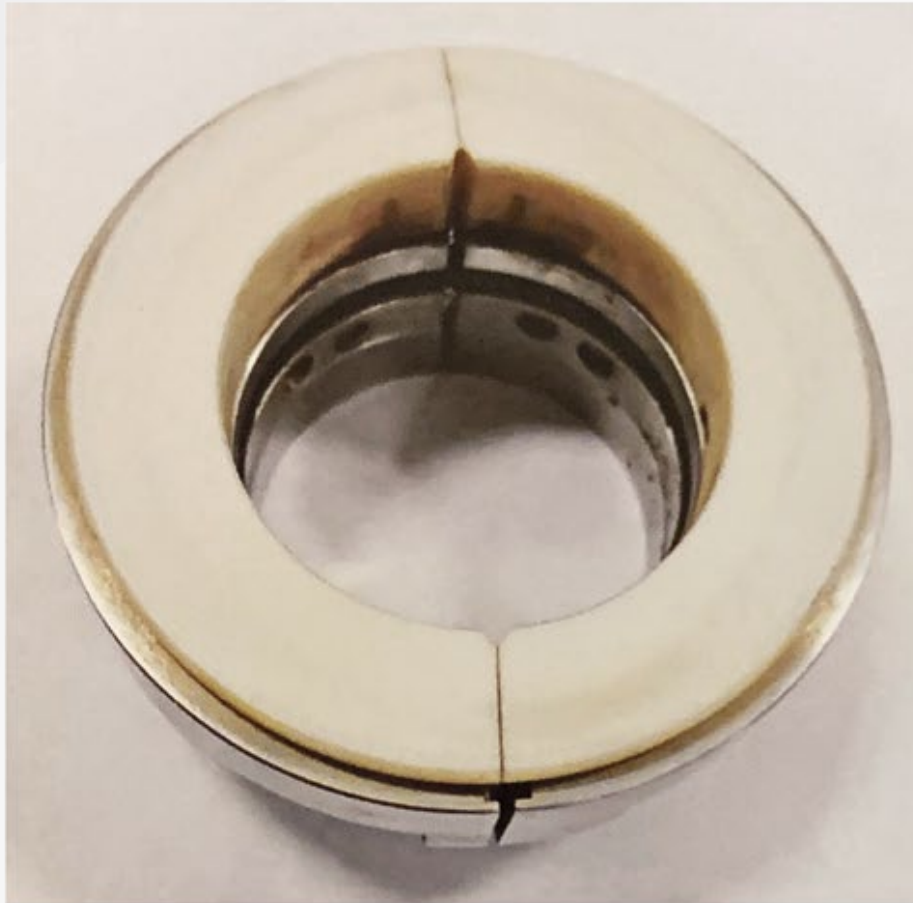
- Found on porous carbon non-sealing face surfaces.
- Occurs in rapidly increasing temperature conditions.

Prevention:

- Avoid rapidly increasing temperature conditions like dead headed pumps.
- Change the carbon face to antimony impregnated carbon.
- Change from a single to dual pressurised seal to ensure lubrication of the seal faces (Plan 53 or 54).



SPLIT SEAL FACE ALIGNMENT



SPLIT SEAL FACE ALIGNMENT

What:

- Improperly aligned split seal faces resulting in the joints not lining up, creating a sharp edge on the mating surface.

Why:

- The seal faces are manufactured whole, then split and the joints should align themselves back together, referred to as keying.
- When the split seal faces are improperly aligned, leakage will occur and the hard face may act like a cutting tool machining off the mating seal face.

Where:

- At the fracture or split line of the seal face.
- One side will be raised and show signs of heavy contact.
- The low side will show signs of limited contact close to the split line.

Prevention:

- Ensure the seal is installed properly and seal faces are keyed together.
- Because of light service duties of split seals, carbon versus ceramic (alumina oxide) tends to be a successful face combination.
- Ceramic has a courser grain structure than silicon carbide, making it easier to install.



UNEVEN FACE WEAR - NOSE HEIGHT



UNEVEN FACE WEAR - NOSE HEIGHT

What:

- Seal face wear nose is worn in a non-uniform manner.

Why:

- Seal face loading may not be equal.
- Seal face may be hung up, resulting in heavier wear on one side.
- Seal chamber face may not be perpendicular to the shaft.
- Installation causing gland to be cocked.
- Seal face unseated from anti-rotation pin, resulting in a cocked face.

Where:

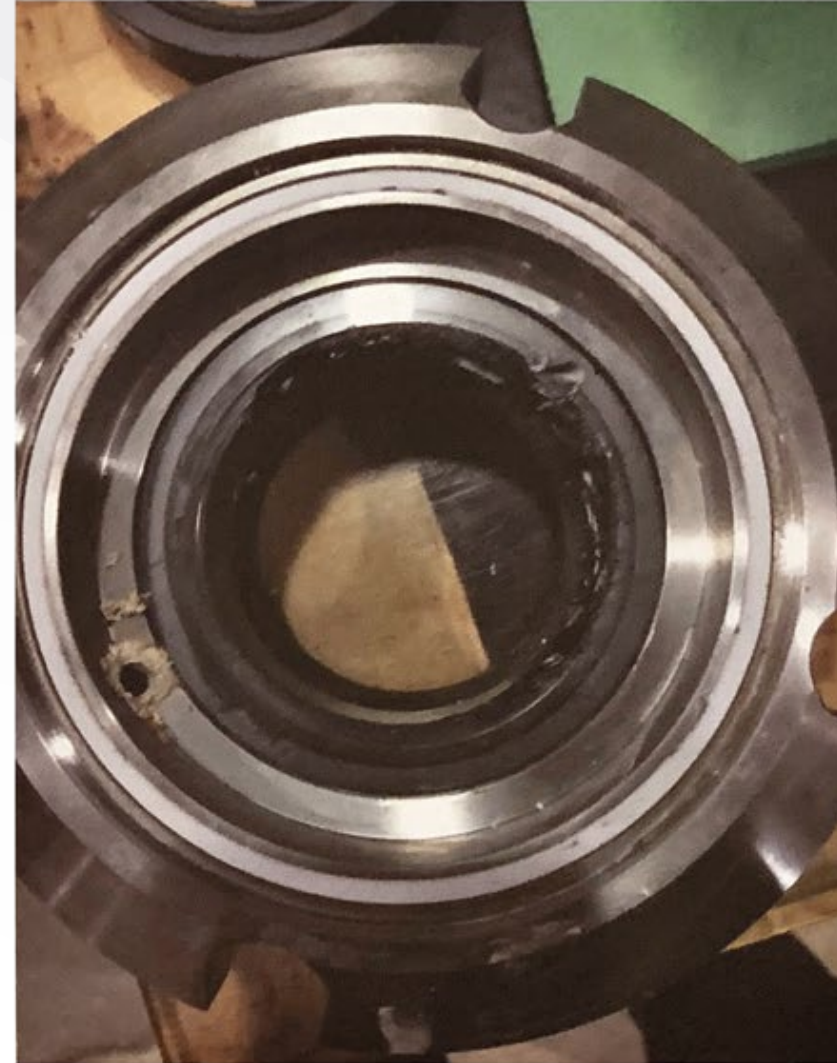
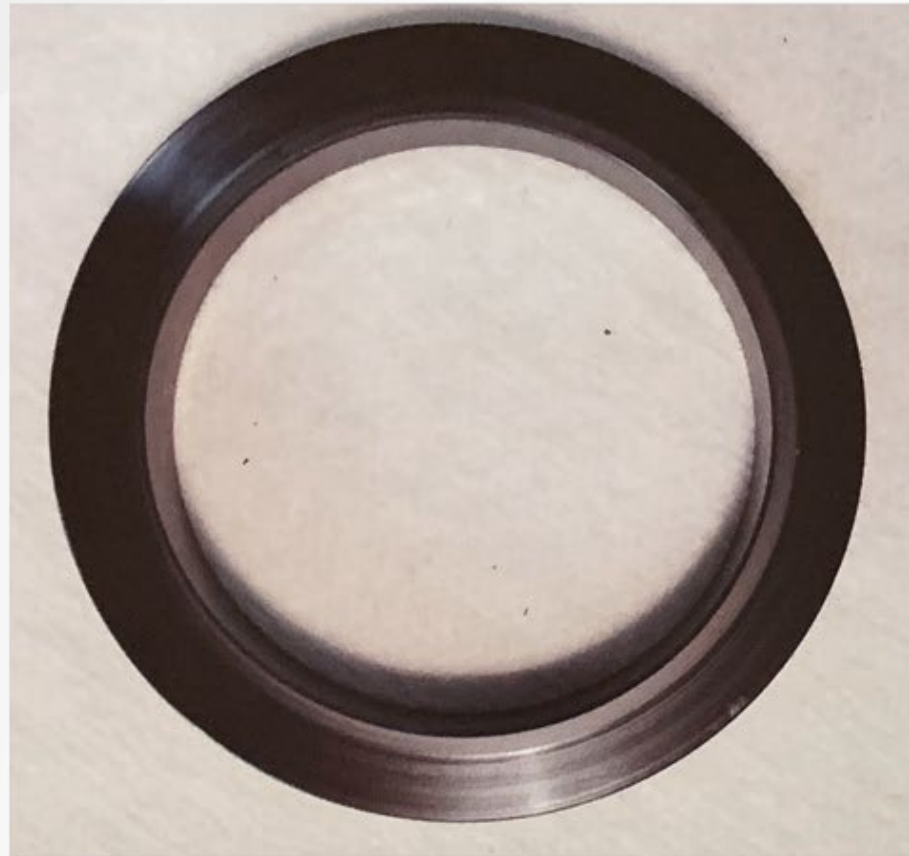
- Seal face nose-wearing surface.

Prevention:

- Ensure seal face flexibility and that the seal does not hang up during operation.
- Complete an equipment check for seal chamber face to shaft perpendicularity to ensure it is within OEM tolerances. (Reference FIS144).
- Install a flexible stator seal which isolates the seal from perpendicularity issues.
- Tighten stud bolts evenly, taking special care when flat gaskets are used.
- Ensure the seal is assembled and installed properly per the installation instructions.



CHIPPING DUE TO VAPOURISATION - FLASHING



CHIPPING DUE TO VAPORISATION - FLASHING

What:

- Chipping at the O.D. or I.D. edges of the seal face.
- Blistering may also accompany chipping at the seal faces.
- A line across the seal face may be evident part of the way down the face where the fluid is changing from liquid to gas.

Why:

- Vaporisation between the seal faces creates excessive opening forces, resulting in popping and hard contact between the faces.
- This is typically caused by not adequately removing heat or due to insufficient vapor pressure margin (VPM).

Where:

- Commonly happens with light hydrocarbons or hot water when the seal is operated too close to the fluid's vapor pressure.

Prevention:

- It is recommended the seal chamber pressure be a minimum 3.4 bar (50 psi) above the vapor pressure.
- Check all the fluids in the operation stream for proper vapor pressure allowances.
- Check changing process conditions to accommodate proper vapor pressures as changes occur.
- Improve cooling and circulation at the seal faces by adding a multi-port flush and properly sizing the orifice for the appropriate Flush Plan.
- Cool the product down with a Flush Plan 23 (or 21), which will also lower the vapor pressure.
- Utilise face technology to reduce seal generated heat.



WIDE WEAR TRACK



WIDE WEAR TRACK

What:

- The wear track or pattern on the opposing seal face is wider than the wear nose width.

Why:

- A wide wear track will cause additional leakage due to wiping product across the seal face while the equipment is operating.
- If found on the rotating face, this condition may be caused if the box bore is not concentric to the shaft.
- If found on the stationary face, the equipment has run out and the seal face is tracking with the shaft movement.

Where:

- On pumps or higher speed equipment; this is a sign of problems with equipment condition or off-design operation.
- Visually measure the seal wear track and compare it to the wear nose width.
- This is expected on agitators, mixers and specialty equipment and should be designed for when applying the seal.

Prevention:

- Ensure the equipment is operating properly within its design limits.
- Check equipment for bearing fit, concentricity between shaft and seal chamber, shaft run-out or a bent shaft. (Reference FIS144)

Reference: Appendix C - Face Eccentricity



NO FACE WEAR



NO FACE WEAR

What:

- No visible wear track on either face.

Why:

- Improper seal setting dimension.
- Set screws not tightened properly.
- Friction drive seal (elastomer driven) was installed with too much lubrication.
- Both seal faces are rotating or not rotating in unison.
- Shaft axial position set after drive collars are installed.

Where:

- Seal faces are not rotating — look for signs of wear in other areas.
- Seal faces are rotating together — look for a missing drive mechanism and faces “rung in”.

Prevention:

- Ensure seal is set properly.
- Refer to Seal Drawing and Installation Procedures.
- Utilise proper lubrication when installing friction-driven seal (non-positive drive seal).
- Drive pin may be required.



NON-CONTACTING GAS SEAL - FACE DAMAGE



NON-CONTACTING GAS SEAL - FACE DAMAGE

What:

- Grooving on either seal face.
- Carbon residue in the face pattern.
- Fractured seal faces.
- Evidence of minimal contact up to complete pattern removal.

Why:

- Faces designed as non-contacting have contacted during operation.
- Required barrier gas seal pressure is lost during operation.
- Liquid, dirt or debris infiltrates into the face pattern area.
- Contact between faces due to axial movement during operation.
- Unidirectional face rotating in the wrong direction.
- Operating the seal below the minimum operating speed.
- Excessive vibration due to off-design equipment operation and misalignment.
- Equipment not designed to accommodate non-contacting seals.

Where:

- Between seal faces designed with lift-off features.

Prevention:

- Maintain the required barrier gas pressure at all times.
- Ensure the barrier gas is clean and dry.
- Perform equipment alignment checks for seal chamber run-out and perpendicularity to ensure equipment meets OEM tolerances (Reference F1S144).
- Operate equipment above required lift-off speed.
- Use bi-directional face pattern if reverse rotation occurs.
- Operate the equipment within its specified design capabilities.



CONTACT DRY RUNNING SEAL - FACE DAMAGE



CONTACTING DRY RUNNING SEAL - FACE DAMAGE

What:

- Substantial carbon residue around the seal faces.
- High and uneven wear on the seal faces.
- Hard face grooving in the contact area.
- Chipping on I.D. or O.D. of soft face.

Why:

- Contamination on the seal face with product or foreign substance.
- Speed, pressure or temperature limits are exceeded.
- Excessive radial movement or run-out.

Where:

- Slow speed mixer seals.
- Pump containment seals.

Prevention:

- Review the operating conditions for suitability of the seal for the application.
- Ensure no foreign materials such as product or lubricants contact the seal faces.
- Perform equipment alignment checks for seal chamber run-out and perpendicularity to ensure equipment meets OEM tolerances (Reference FIS144).



SLEEVE ISSUES - DYNAMIC GASKET DAMAGE



SLEEVE ISSUES - DYNAMIC GASKET DAMAGE

What:

- The most common sources of seal sleeve failure are from corrosion and abrasion at the dynamic gasket location.

Why:

- Excessive perpendicular run out between shaft and the seal chamber face.
- Coatings that bubble and separate from the base metal.
- Broken seal components tumble in the seal chamber and cut and gouge the sleeve surface.
- Corrosion.
- The sleeve surface roughness exceeds capabilities of dynamic gaskets to slide and/or seal against the sleeve surface.
- Scrubbing or “fretting” of sleeve under dynamic gaskets.
- The sleeve exhibits dimensional instability due to corrosive material removal.
- Dings or scratches from handling or tumbling broken debris.

Where:

- On the sleeve underneath the dynamic gasket.

Prevention:

- Ensure that the sleeve base metal is appropriate to stand up to corrosion from both the barrier fluid and process fluid, and combinations of both. (Reference FTA101)
- If fretting is present, select a non-fretting metal or apply a coating under the dynamic gasket.
- Square up the equipment to reduce vibration and relative motion between the component and the sleeve.
- Don't reuse sleeves that exhibit signs of corrosion, especially in the areas where gaskets are expected to seal.
- Sleeves with coatings that bubble and separate will leak. Inspect carefully and determine whether or not the base metal is being chemically attacked.



SLEEVE BEARING FRETTING



SLEEVE BEARING FRETTING

What:

- A wear process that occurs with repeated cyclic rubbing between two surfaces.

Why:

- Axial vibration, rotation and misalignment creates relative motion among the sleeve, shaft and bearing.
- Higher loads result in more severe fretting wear.

Where:

- Where the bearing contacts the sleeve.
- Between the sleeve and shaft, directly under the bearing.

Prevention:

- Confirm dimensions and tolerances are within bearing, shaft and sleeve specifications.
- Perform equipment alignment checks for seal chamber run-out and perpendicularity to ensure equipment meets OEM tolerances. (Reference FIS144)
- Ensure equipment vibrations are within OEM specifications.



SLEEVE DAMAGE BY SET SCREWS



SLEEVE DAMAGE BY SET SCREWS

What:

- Excessive set screw cup point indents and burrs.
- Out-of-Round sleeve.
- Cup on set screw is supposed to be sharp and hard to cut into sleeve material which insures proper holding power and resistance to loosening. Small indents from the set screw cup point are normal and expected.

Why:

- When set screw is over tightened it causes:
 - the sleeve to become oval shaped.
 - a dent on the inside of the sleeve.
 - it to cut too far into the sleeve material raising burrs around the cup.

Where:

- When cup point set screws are used to attach seal components to the sleeve.

Prevention:

- Follow set screw tightening instruction and do not exceed torque standards.
- Always use new set screws as specified.



SLEEVE - INSTALLATION FAILURES



SLEEVE - INSTALLATION FAILURES

What:

- Sleeve will not slide over the shaft for installation.

Why:

- Shaft over-sized.
- Sleeve inside diameter undersized.
- Shaft bent.
- Shaft or sleeve burrs.
- Seal sleeve not round.
- Debris between shaft and sleeve.

Where:

- Between sleeve and shaft.

Prevention:

- Check shaft O.D. to ensure it is within OEM specifications.
- Perform equipment alignment checks for a bent shaft (Reference FIS144).
- Inspect and eliminate burrs and dings from shaft or sleeve.
- Ensure shaft is free from dirt or other contamination.
- Carefully lubricate shaft with the proper amount and type of grease.



SLEEVE DRIVE COLLAR FAILURE



SLEEVE DRIVE COLLAR FAILURE

What:

- Hard rub on the drive collar perpendicular surface to the shaft.
- Damage on the I.D. of the drive collar.
- Drive collar loose or spinning freely before disassembly.
- Drive collar is out of round or egg shaped.
- Set screws missing from collar.
- Set screw cup points are rounded or no cup point indents on the shaft.
- Galling of the collar against the stationary components.

Why:

- Improper set screw torque during installation.
- Shaft material is harder than the set screw material.
- Hydraulic thrust exceeds set screw holding power.
- Shaft moves axially to load collar against the seal housing.
- Improper impeller adjustment sequence drives seal collar against stationary part.
- Vibration causes set screws to back out.

Where:

- Drive collar on atmospheric end of seal sleeve.

Prevention:

- Refer to seal installation instructions for proper setting procedures.
- Ensure that the set screw material is harder than the shaft.
- Properly sequence the disengagement of the setting devices.



BUSHING CONTACT WITH SLEEVE



BUSHING CONTACT WITH SLEEVE

What:

- Sleeve and bushing damage from excess rubbing contact.

Why:

- Improper clearance between seal chamber and gland pilot.
- Improper seal installation for shaft centered seal design.
- Radial shaft motion causes sleeve to contact bushing at one point due to a bent shaft, excessive side forces on the impeller, operating the equipment off BEP or failed bearings.
- 360-degree contact on the sleeve or shaft occurs when the shaft is not concentric with throat bushing or the seal gland.

Where:

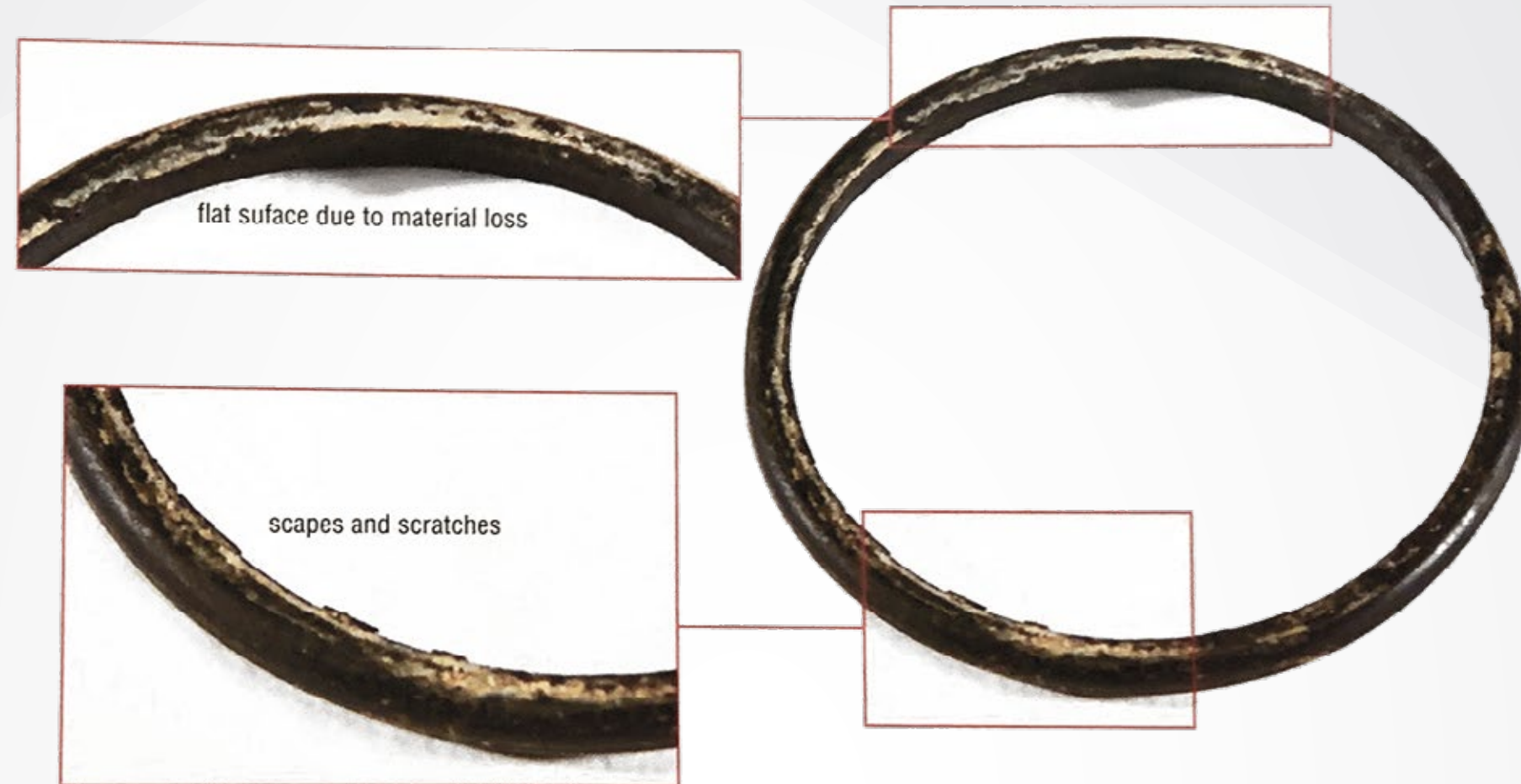
- On the O.D. of the sleeve under the bushing and on the I.D. of the bushing.

Prevention:

- Confirm pilot dimensions on pump with seal assembly drawing supplied with seal.
- Review installation instructions for proper seal installation.
- Perform run-out checks and determine equipment condition and correct if necessary (Reference FIS144).
- Operate the pump at the Best Efficiency Point (BEP) per published OEM pump curves.
- Install a different bushing design that is more tolerant of equipment dimensional inaccuracies (consider a floating bushing).
- Apply a hard coating on the sleeve under the bushing.



ABRASION



ABRASION

What:

- Material loss creating a flat surface on a dynamic O-ring indicates abrasion.
- Scrapes and scratches may be exhibited on the abraded elastomer surface.
- Abrasion may also be exhibited on surfaces contacting the elastomer.

Why:

- Abrasion is a result of relative motion between the elastomer and sealing surface.
- Process fluid contaminated with abrasive particles may accelerate the wear of an elastomer.
- Improper lubrication may cause excessive friction and wear.
- A rough surface against the dynamic O-ring may abrade the elastomer.

Where:

- Found on and around the elastomer of the flexible seal face in pusher seals.

Prevention:

- Ensure the pump shaft perpendicularity to the seal mounting gland is to specifications. (Reference FIS144)
- Consider a flexible stator seal design to minimise the effects of equipment perpendicularity issues.
- Minimise oscillating axial shaft movement.
- Protect the seal with the appropriate Flush Plan. (Reference FTA160)
- Ensure the contacting surface at the dynamic O-ring is 32 RMS (micro-inches).
- Consider changing to a bellows seal.

Note: Other dynamic secondary seal configurations and materials may be susceptible to abrasion.



CHEMICAL ATTACK



CHEMICAL ATTACK

What:

- Elastomers include O-rings, U cups, V cups, square rings, flat gaskets, or any other component containing polymers.
- Chemicals that are incompatible with the elastomer material can soften, harden, leach, blister, crack, discolor and/or swell the elastomer.
- In some cases, the degradation is observable only by measuring properties of the elastomer.

Why:

- The elastomer is incompatible with process or cleaning fluids.
- Elevated temperatures increase the chemical corrosiveness.
- Incompatible lubricant used during assembly or installation.

Where:

- Process and cleaning fluids are the primary cause of chemical attack.

Prevention:

- Confirm process conditions have not changed, including: — Temperature. — Product. — Wash down, Clean-In-Place (CIP) or Steam-In-Place (SIP).
- Review elastomer compatibility with all process conditions (reference FTA101 or other chemical compatibility guide).
- Review installation procedures, i.e., use caution when applying lubricants during installation of seals and gaskets.



COMPRESSION SET



COMPRESSION SET

What:

- The failure of a compressed elastomer to return to its original shape.

Why:

- Elastomer compound is incompatible with chemicals, causing volume swelling overfills in the cavity.
- Clean-In-Place (CIP) and Steam-In-Place (SIP) incompatible with elastomer material.
- Excessive high temperature.
- Excessive squeeze.
- Some elastomers have poor memory characteristics.

Where:

- Found in both dynamic and static seal locations.
- High-temperature applications.
- High-pressure applications.
- All elastomers can take a compression set, but perfluoroelastomers are more susceptible.

Prevention:

- Confirm elastomer material is appropriate for all process fluids and conditions, including CIP and SIP. (Reference FTA101)
- Consider elastomer components with better compression set capabilities.
- Increase cooling to the seal.



CUTS, TEARS AND NICKS



CUTS, TEARS AND NICKS

What:

- Elastomer exhibiting physical damage such as cuts, tears or nicks.

Why:

- Installation damage over shafts containing key slots, threads or insufficient lead chamfers.
- Twisted or pinched during installation.
- Burrs and sharp edges on mating component can damage the elastomer during installation.
- Inadequate lubrication on equipment shaft.
- General mishandling of the elastomer.

Where:

- Found in both dynamic and static elastomers.

Prevention:

- Review installation procedures.
- Remove all burrs, sharp corners and edges before installation.
- Add lead chamfers where necessary on shafts.
- Cover threads and keyways with PTFE tape during installation.



EXPLOSIVE DECOMPRESSION



EXPLOSIVE DECOMPRESSION

What:

- O-rings that exhibit random short splits or ruptures deep into the cross-section.
- When first removed from service, the O-ring surface may also exhibit multiple small blisters.

Why:

- Absorbed gases rapidly expand, causing blisters or splits when the O-ring is depressurised.

Where:

- Damage may occur on any O-ring surface exposed to the process fluid.
- Most commonly found in high-pressure applications with flashing fluids such as light hydrocarbons or carbon dioxide (CO₂).

Prevention:

- Use an elastomeric material less sensitive to explosive decomposition such as a harder higher durometer O-ring.
- With careful consideration, utilise spring-energised gaskets or "J" rings.



EXTRUSION



EXTRUSION

What:

- Elastomer forced through a small gap by pressure or thermal expansion of the gasket.
- It is recognised by its relatively smooth appearance on the thin extruded surface.

Why:

- Excessively high pressure on elastomer.
- Durometer of the elastomer is too low for the application.
- Oversized gap between mating parts.
- Improperly designed O-ring groove for the application.
- Excessive elastomer swell due to chemical attack or thermal expansion.
- Softening of the elastomer by high temperature or chemical attack.

Where:

- Both dynamic and static seal locations.

Prevention:

- Confirm elastomer selection and seal design against all operating conditions.
- Consider higher durometer elastomers for high-pressure applications.
- Complete a chemical analysis of process fluid and confirm proper material selection. (Reference FTA101)



GASKET - HARD, BRITTLE AND CRACKED



GASKET - HARD, BRITTLE AND CRACKED

What:

- Elastomer becomes hard.
- Elastomer loses elasticity and flexibility.
- Formation of cracks or crevices on the elastomer.
- Compression set.

Why:

- Temperature exceeds the elastomer capabilities.
- Chemical attack.

Where:

- Occurs on elastomer in direct contact with the product.
- Elastomers in contact with high-temperature processes or seal components.

Prevention:

- Install the correct elastomeric material. (Reference FTA101)
- Ensure operating conditions are acceptable for the seal.
- Increase cooling to the seal area for high-temperature conditions.
- Redesign the seal to utilise flexible graphite gaskets.



O-RING NIBBLING EXTRUSION



O-RING NIBBLING EXTRUSION

What:

- Extrusion is an elastomer forced through a small gap by pressure or thermal expansion of the gasket.
- O-ring nibbling extrusion is a special case of extrusion accelerated by oscillating axial movement.
- It is recognised by its ribbed appearance on the thin extruded surface of the O-ring.

Why:

- Oscillation due to excessive axial shaft motion.
- Out of perpendicular condition exists within the seal or equipment.
- The above oscillation must be accompanied by one of the following extrusion conditions:
 - Excessively high pressure on elastomer.
 - Durometer of the elastomer is too low for the application.
 - Oversized gap between mating parts.
 - Improperly designed O-ring groove for the application.
 - Excessive elastomer swell due to chemical attack or thermal expansion.
 - Softening of the elastomer by high temperature or chemical attack.

Where:

- Found only on the dynamic O-ring.

Prevention:

- Confirm the equipment condition is within manufacturer's specifications. (Reference FIS144)
- Confirm elastomer selection and design against all operating conditions. (Reference FTA101)
- Consider higher durometer elastomers for high-pressure applications.
- Complete a chemical analysis of process fluid and confirm proper material selection.



ELASTOMERS SOFT OR SWOLLEN

normal elastomer



swollen elastomer



ELASTOMERS SOFT OR SWOLLEN

What:

- Cross-section of the elastomer is enlarged.
- Reduction in elastomer hardness.
- May be accompanied by compression set (Refer to Elastomer Compression Set).

Why:

- Elastomer compound is incompatible with chemicals in the application.
- Clean-In-Place (CIP) and Steam-In-Place (SIP) incompatible with elastomer material.
- Higher temperatures accelerate chemical degradation.

Where:

- Any elastomer.

Prevention:

- Ensure the proper lubricant is used during seal installation.
- Confirm elastomer material is appropriate for all process fluids and conditions, including CIP and SIP. (Reference FTA101)



SPIRAL OR ROLLING DAMAGE



SPIRAL OR ROLLING DAMAGE

What:

- Elastomer damage or leakage that occurs when an O-ring is twisted during installation or operation of the seal.

Why:

- Improper seal installation.
- Reciprocating motion during operation.
- Uneven O-ring loading.

Where:

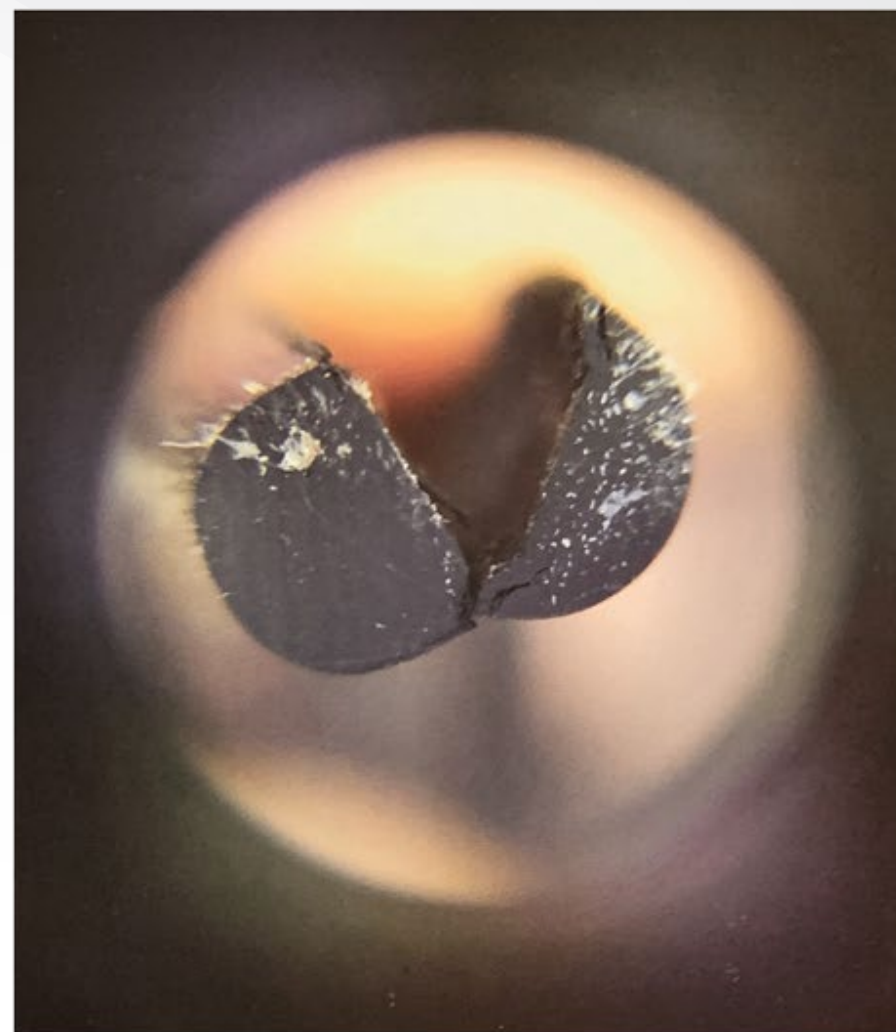
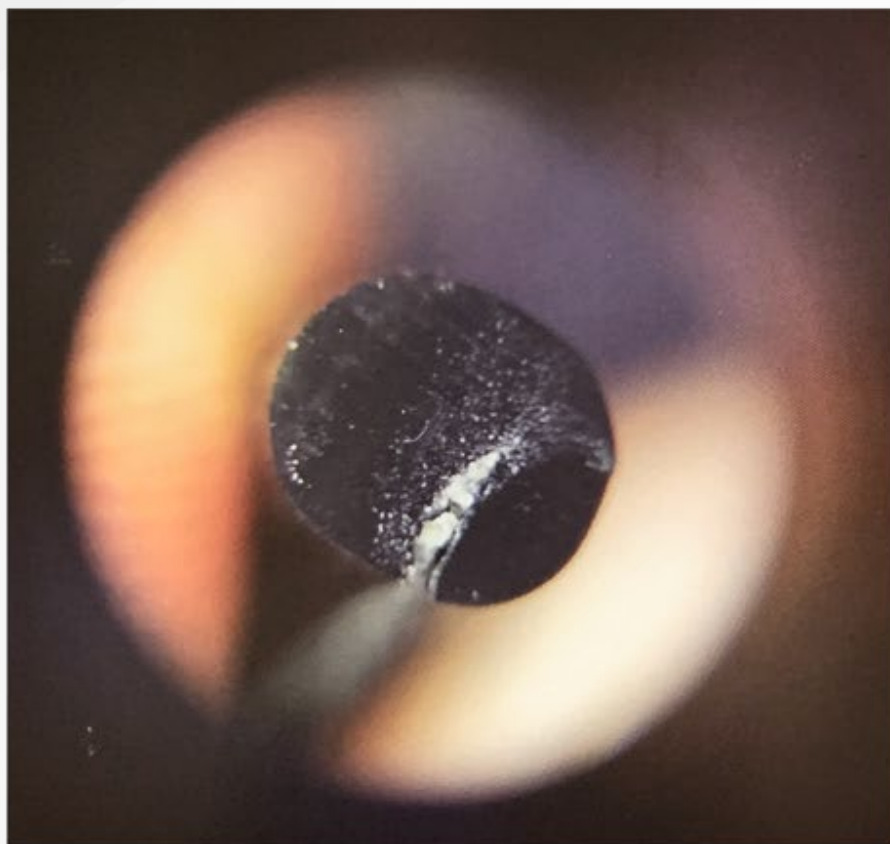
- Any O-ring location.

Prevention:

- Lubricate O-ring per installation instructions.
- Inspect hardware components for out-of round condition.
- Improve hardware surface finish.
- Use harder durometer O-ring.
- Limit reciprocating motion by performing proper condition checks (Reference FIS144).
- Confirm the equipment condition is within manufacturer's specification (Reference FIS144).



POLYMERISATION



POLYMERISATION

What:

- Foreign particles are found within the elastomer.
- The elastomer is torn, swollen or split, containing foreign material.
- Often accompanied by compression set and hardened surfaces.

Why:

- Product permeates the gasket and reacts with compounds within the elastomer, causing new polymer chains to form.

Where:

- Occurs more frequently in elastomers with low durometer hardness.
- Found with process fluids which polymerise easily, such as: acrylic acid, butadiene, isobutylene, polyethylene, polyvinyl chloride and styrene monomers.

Prevention:

- Ensure chemical compatibility of elastomer (Reference FTA101).
- Use a high durometer elastomer.
- Ensure there is no unexpected mixing or contamination of products within the process.



FLEXIBLE GRAPHITE GASKETS



FLEXIBLE GRAPHITE GASKETS

What:

- Leakage past flexible graphite gaskets.

Why:

- Gaskets damaged during installation.
- Gasket sealing surfaces damaged, scratched, or corroded.
- Gaskets improperly compressed during assembly or installation.
- Gaskets exposed to water or a wet steam quench in high temperature application.

Where:

- Internal seal component interfaces between bellows capsule and sleeve or stationary face and gland.
- Sleeve gaskets in drive collars in high temperature seal design.

Prevention:

- Inspect seal surfaces to ensure they are clean and free from damage.
- Handle flexible graphite gaskets with extreme care to prevent damage.
- Ensure assembly surfaces have appropriate chamfers and are free from burrs and sharp edges.
- Torque assembly screws to values shown in assembly or installation instructions.
- Prevent exposure of gaskets to a wet steam quench by using dry steam and appropriate steam traps in high temperature services.



SPIRAL WOUND GASKETS



SPIRAL WOUND GASKETS

What:

- Leakage past spiral wound gasket.

Why:

- Gland bolts not properly tightened preventing proper compression of the gasket.
- Scratches, contamination, or other damage to gasket sealing surfaces.
- Improper split-line alignment or gap in the casing gasket at the seal chamber face on horizontal split case pumps.
- Corrosion or chemical attack of metal or filler material in the spiral wound gasket.

Where:

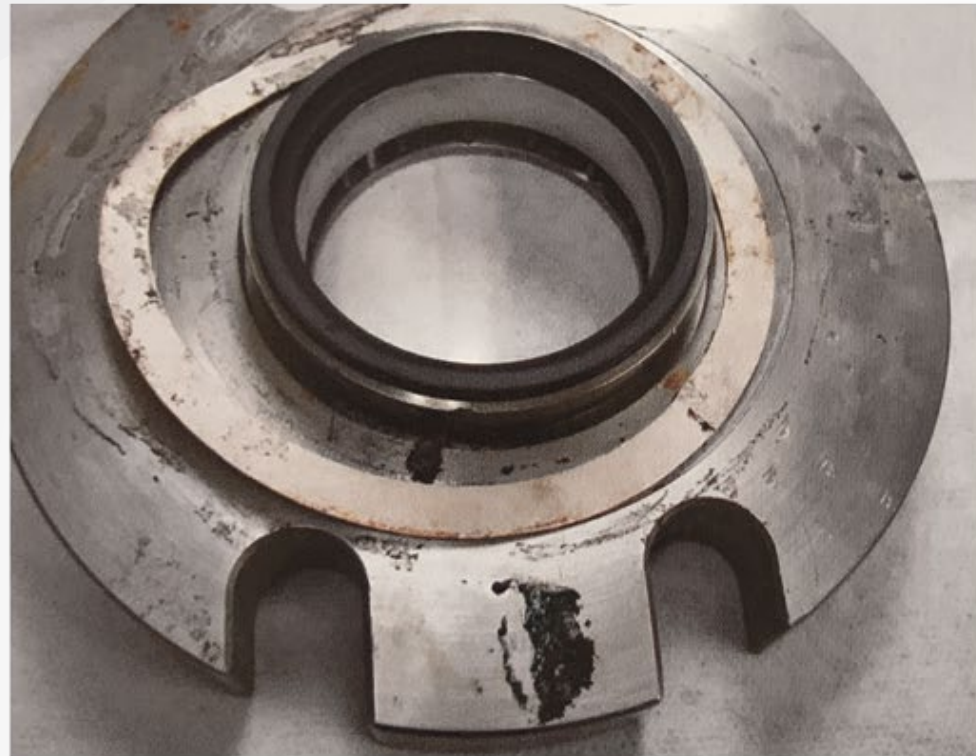
- On gland gasket between the seal chamber face and the pump.
- Between seal glands on the seal assembly with multi-piece glands.

Prevention:

- Ensure seal surfaces are flat and do not have misalignment around split lines.
- Ensure gasket surfaces are clean and free from scratches, pits, or other damages.
- Properly tighten gland bolts to ensure a metal-to-metal contact between the gland and the seal chamber face.
- Use a radially wider gasket to give greater contact area.
- Change materials of construction to be more corrosion resistant under application conditions.
- Always use a new gasket.



FLAT GASKET EXTRUSION



FLAT GASKET EXTRUSION

What:

- Gasket material extrudes out of contact area between gland and seal chamber face.
- Gasket material extends radially inward towards seal.

Why:

- Gasket is over compressed.
- Thermal expansion of gasket material initiates extrusion.
- Selected gasket materials are prone to creep. (e.g. virgin PTFE)
- Gasket material is too thick, displacing excessive amounts of material into the seal area.

Where:

- Any gland design that uses flat gaskets that does not have metal-to-metal contact with seal chamber face.

Prevention:

- Evenly tighten gland bolts to properly seat gasket.
- Change gasket material to material which resists extrusion such as glass filled PTFE or a fiber filled gasket.
- Change gland to have metal-to-metal contact between seal chamber and gland after tightening.
- Change to O-ring sealed gland gasket.



HOUSING COMPONENTS AND MISALIGNMENT



HOUSING COMPONENTS AND MISALIGNMENT

What:

- Internal contact of rotating parts on stationary housing components.
- Wear marks within housing bolt holes and associated bolts.

Why:

- Equipment that normally operates with erratic shaft side loading.
- Housing parts are cocked and off center.
- Mounting bolts not properly tightened, causing the housing to move.
- Movement causes bolting fatigue, bearing failure, wallowed holes and compressed metal around bolt heads.

Where:

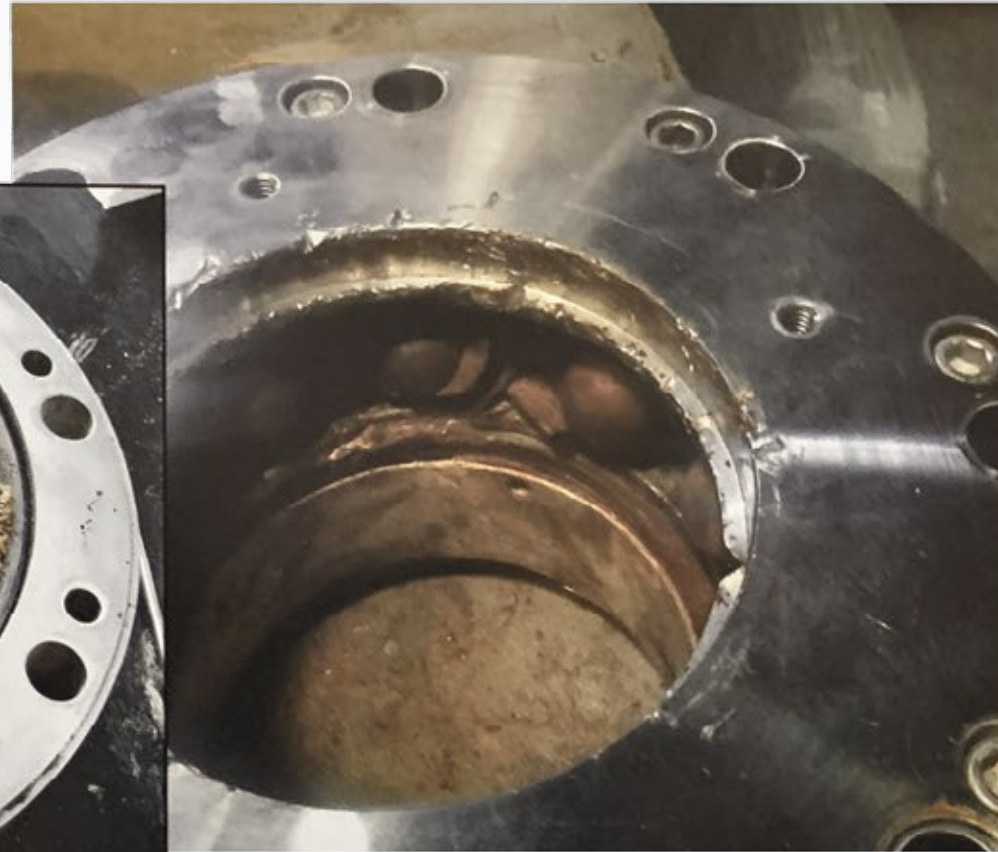
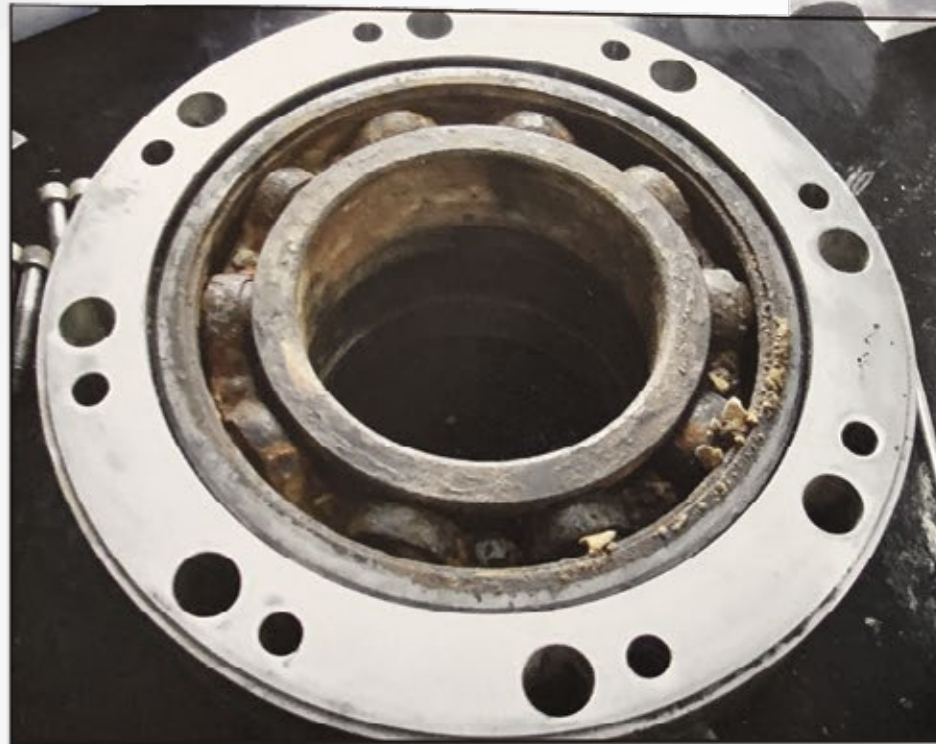
- Contact on the I.D. of the housing.
- Contact on the housing through holes.
- Wear and degraded threads and heads on the bolts.
- Wear marks in the bearing seat.

Prevention:

- Properly torque housing bolts.
- Perform equipment checks per FIS144.



BEARINGS IN SEAL ASSEMBLY



BEARINGS IN SEAL ASSEMBLY

What:

- Bearing seizes, causing equipment failure and/or seal failure.
- Bearing produces high equipment drive torque and noise.
- Bearing wears and causes excessive dynamic movement.

Why:

- Bearing lubricating interval not maintained.
- Water from wash down or the atmosphere contaminates the bearing lubricant, compromising lubricating capabilities.
- Seal bearing as the third bearing in a three-bearing system and adversely interacts with the equipment bearings.
- Incompatible lubricants are mixed, causing loss of lubricating properties.

Where:

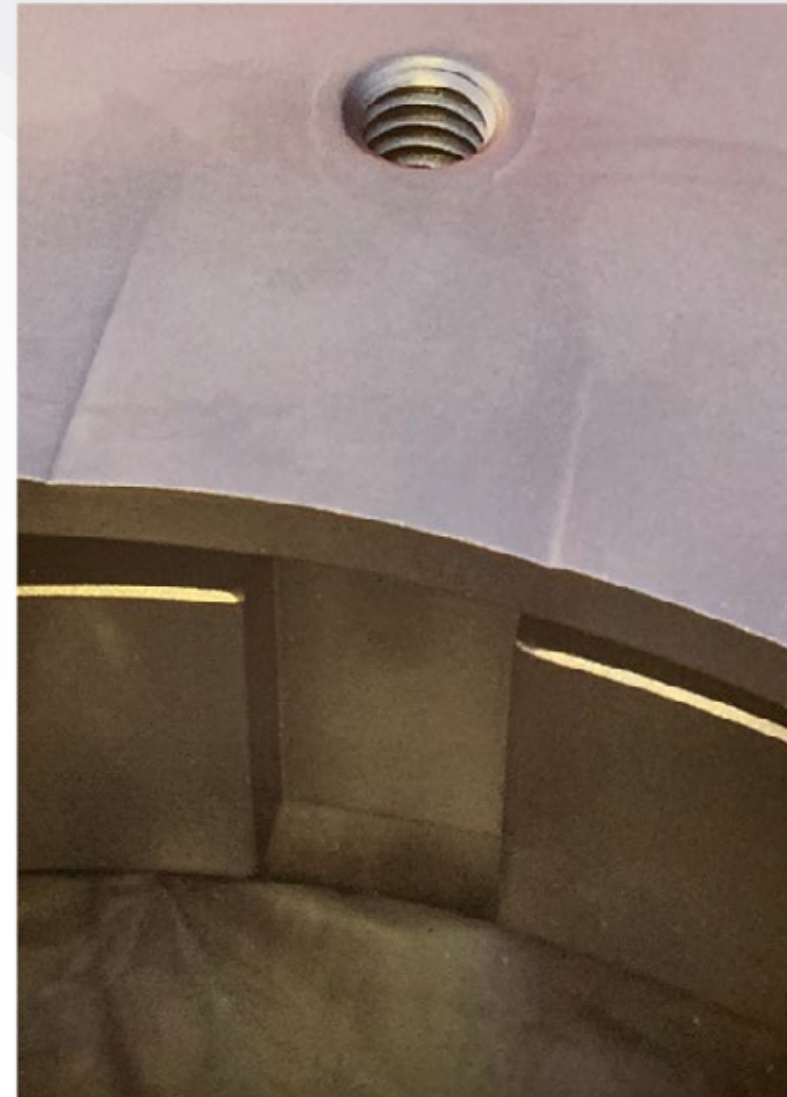
- Bearing is not properly protected from contaminants.
- Bearing is overloaded.

Prevention:

- Confirm proper lubrication prior to startup of equipment.
- Confirm proper lubricant is used.
- Confirm proper lubricating intervals are followed.
- Have lubricant analysed at regular intervals to determine condition of bearing.
- Ensure that contamination cannot enter the bearing cavity.
- Complete proper equipment checks to confirm straightness, concentricity and perpendicularity are within OEM specifications.



SETTING DEVICE DAMAGE



SETTING DEVICE DAMAGE

What:

- Setting devices on cartridge seals are bent, broken or abraded.

Why:

- Setting devices are not cleared from rotating element before equipment is operated.
- Setting devices are bent due to excessive axial load during seal installation or removal.
- Setting devices are bent when shaft is adjusted after the seal has been attached to the shaft.
- Devices are bent due to dropping or mishandling the seal during shipping or storage.

Where:

- On cartridge seals where setting devices are used.
- Damage on the setting device.
- Damage may also be found on the matting components to the setting device (i.e., sleeve or drive collar).

Prevention:

- Follow installation instructions, with special attention to setting sequence and removal of the setting device.
- Avoid rough handling of seals during shipping and handling.

Appendix A

CORROSION AND CHEMICAL COMPATIBILITY

Corrosion is a chemical interaction between a material and its environment which results in a degradation to the material. Corrosion generally occurs over a long period of time. The term corrosion is generally applied to metals, but the same basic principles of chemical compatibility also apply to elastomers and other classes of materials.

While the actual technical definition of corrosion is complex, its effect on components is not. The degradation of materials can prevent a component from functioning properly by reducing its strength, removing material, changing the component's dimensions, or causing fracturing or breaking of the material. Corrosion is also not a single mechanism and can take many forms and have different appearances. Some forms are easily seen with the naked eye, but others require a microscope and careful sample preparation to be detected. Each corrosion type is caused by the combination of specific conditions and materials. Some of the more common modes of corrosion are detailed below.

Please refer to FTA101 for the Flowserve Seal Corrosion Guide for Mechanical Seals as a general guide to corrosion rates found for many chemicals in the most common seal materials, which include most metals, elastomers and seal face materials. This document is based on years of experience and data collected from field trials and has been compared to corrosion and compatibility data from material OEMs and other published sources. Information from FTA101 or any other material compatibility reference must be compared against material performance under the actual application conditions.

Note that some materials with a generic name (e.g., 316 SS) may actually represent a family of materials. These may be manufactured by different methods (e.g., wrought, cast, etc.), provided in different forms (e.g., bar, sheet, wire, etc.), and be supplied in different material conditions (e.g., annealed, cold-worked). There may be a difference in corrosion rates between these variations of the “same alloy” due to the chemistry, microstructure or hardness of the materials.

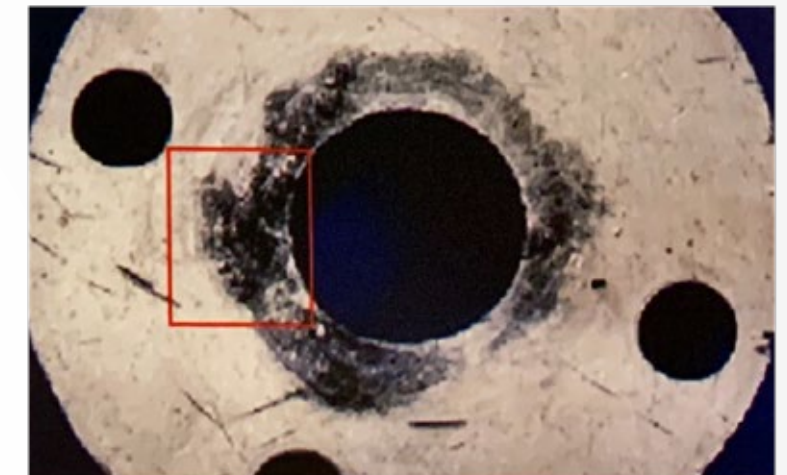
General Corrosion

General corrosion occurs uniformly on all surfaces of the metal exposed to the corrosive environment. This type of corrosion generally results in a loss of material which will affect dimensions, the surface finish and features on the component. This is the most commonly seen type of corrosion in industry. Most chemical compatibility charts which reference corrosion rates (e.g., mm/yr or mils/yr) refer to general corrosion. Since this type of corrosion occurs at a predictable rate, components can be designed with a corrosion allowance.



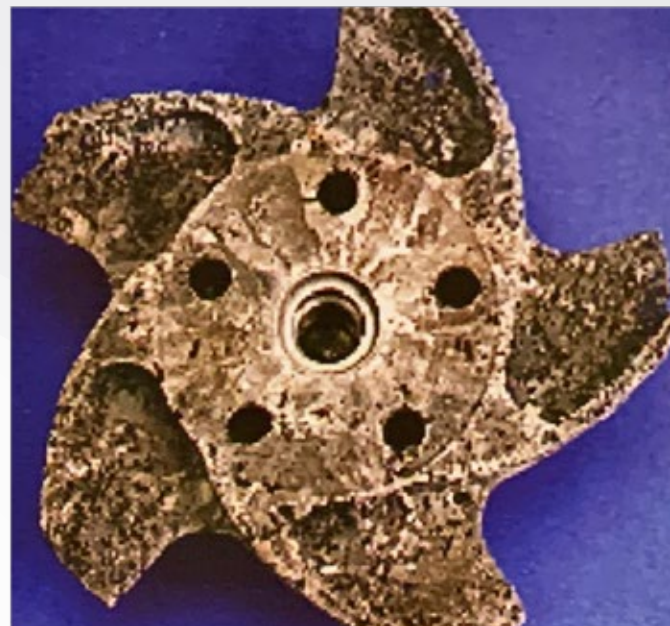
Crevice Corrosion

Crevice corrosion is an aggressive corrosion which forms in confined areas where the process fluid is stagnant and isolated from the process environment. Examples of crevices are small clearances between components, under flat gaskets, in O-ring grooves, or under buildup of scale or deposits. Crevice corrosion works by creating a local environment that attacks the protective oxide on the metal surface. It may not become evident until the mechanical seal is completely disassembled and cleaned. Since crevice corrosion is a function of the design of the exposed area of the seal, typical corrosion tables may not be useful in predicting when it will occur.



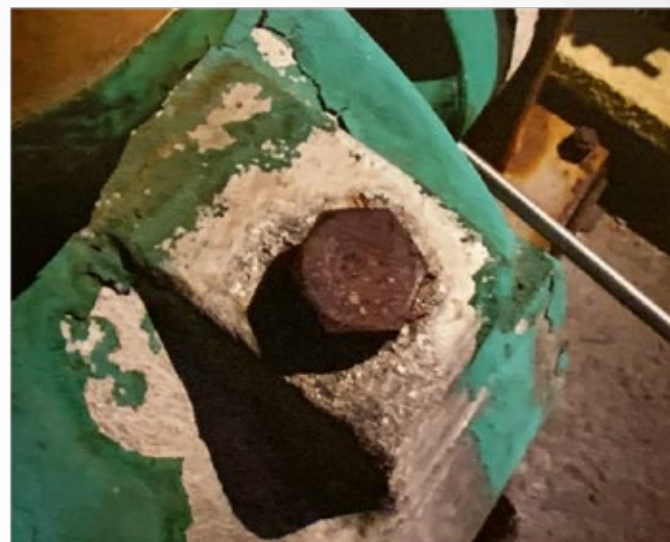
Pitting Corrosion

Pitting corrosion is a specialised case of crevice corrosion where small pits form on the surface of a metal and progress into it. Often the visible pit on the surface is very small compared to the amount of material which is attacked under the surface. This damage can penetrate through the component or create a localised weakness which allows the component to fail. Since the major portion of the damage is under the surface, it is impossible to assess the severity of the attack by only looking at the surface. One common example of pitting corrosion is chloride pitting on austenitic stainless steels (e.g., 316).



Galvanic Corrosion

Galvanic corrosion is initiated between two contacting metal components when they are exposed to a corrosive environment or conducting solution and where there is a significant difference between the electronegativity of the metals. This difference in electrical potential sets up a flow of electrons which impacts the corrosion rate of both materials. The metal with the higher corrosion resistance becomes a cathode and the corrosion rate decreases. The material with the lower corrosion resistance becomes an anode and the corrosion rate increases. The greater the difference between the electrical potential of the two metals, the more dramatic the effect on the corrosion rates.



Interganular Corrosion

When a molten metal solidifies, it will form a network of grains throughout the material. Although the basic material is chemically homogenous, the grain boundaries have slightly different properties which make them more susceptible to some corrosive environments. In these cases, the grain boundaries can be severely attacked while the majority of the metal is unaffected. This local attack will lead to different surface characteristics (e.g., roughness), create local stress risers and penetrate the metal.



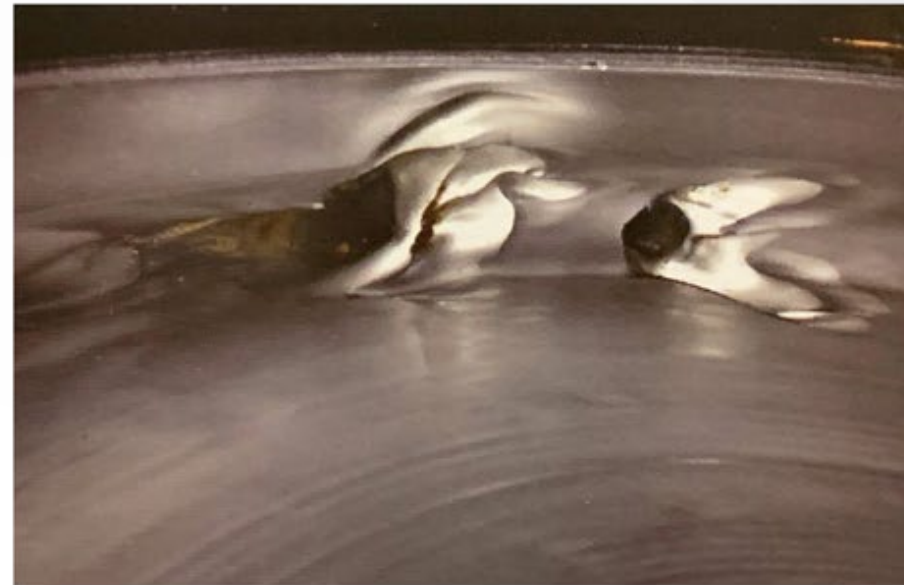
Stress Corrosion Cracking

Stress corrosion cracking (SCC) is a crack or network of cracks which start initially at the surface of a metal exposed to a corrosive environment and extend into the material. These cracks greatly reduce the strength of the material and can lead to rapid and catastrophic failure. One of the greatest challenges with SCC is there is generally no loss of material and the small crack initiation points are difficult to visibly detect on the surface of the metal. SCC is affected by the hardness of the material, the concentration of the corrosive agent (e.g., sulfur, chlorides, etc.), the temperature, and the presence of tensile stress.



Erosion Corrosion

Erosion corrosion is acceleration in the rate of attack due to the impact of solids carried by a corrosive fluid. The solids mechanically remove the protective surface film, resulting in a corrosion rate increase. Velocity of a fluid moving over a surface will affect the rate of damage. The rate is also affected by the solid's size, shape and hardness. The surface may exhibit shallow pits, horseshoes, or other local phenomena related to the flow direction.



Cavitation

Cavitation is caused by the formation and collapse of vapor bubbles in contact with a metal surface. Violent implosion of gas bubbles produces a shockwave that removes material from the surface. The implosions cause noise and significant vibration (it sounds as if it is pumping rocks). Damage often appears as a collection of closely spaced, sharp-edged pits or craters on the surface. Pump impellers often show signs of cavitation before seal components.



Methods of Preventing or Minimising Corrosion

In a general sense, corrosion can be addressed by changing the environment in the seal chamber, design features on the seal, or the materials of construction. The most effective strategy for eliminating corrosion will depend upon the specific application. In most cases, a change to the materials of construction for the mechanical seal is the easiest remedy. In some cases, this may compromise the performance of the seal or be cost prohibitive. Changing the seal design may eliminate components which are prone to corrosion or eliminate features which can initiate corrosion (e.g., crevices). Changing the environment of the seal may involve cooling the seal chamber to reduce corrosion rates or providing an external flush to isolate the seal from aggressive chemicals in the process fluid. Each of these potential solutions requires careful examination of not only the seal, but also the potential impact of the solution on the seal support system, the pump and operation of the equipment. Flowserve can work closely with end users to determine the most appropriate solution to combat corrosion problems.

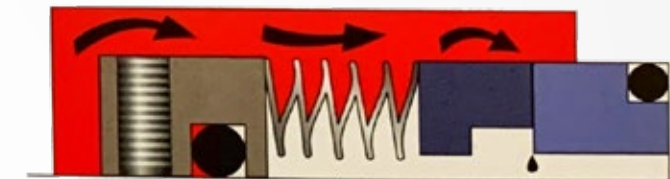
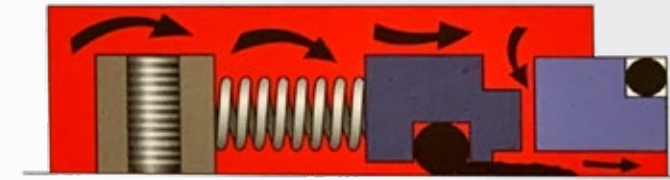
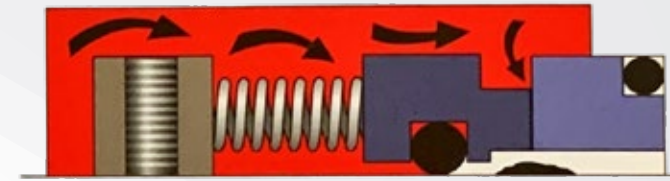
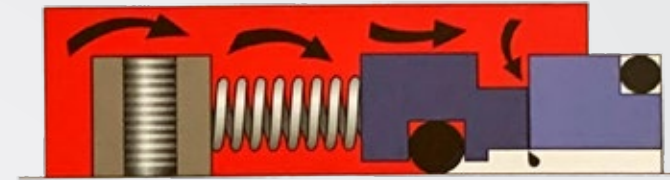
Appendix B

DYNAMIC GASKET HANG-UP

All Pusher style seals (spring loaded) have a “dynamic gasket” that is typically an O-ring type design. The gasket is called dynamic because it is required to move axially to compensate for face wear or seal movement. The dynamic gasket is under compression, so it will stop the process fluid from leaking around the seal face.

Since all seals are designed to weep or leak fluid across the face for lubrication purposes, this weepage can build up over time and create a residue that will not allow the dynamic gasket to move axially. This can be compounded by the collection of solids or contamination in the same area. When this occurs, the gasket is said to “hang up”. Then the seal will begin to leak erratically and be considered a seal failure.

A bellows style seal does not require a dynamic gasket. The bellows not only create the spring load to energise the seal faces, they also compensate for any face wear or seal movement that occurs. If dynamic gasket hang-up is an issue, the bellows seal should be considered.



Appendix C

FACE ECCENTRICITY

Rotating Face Eccentric Wear Track:

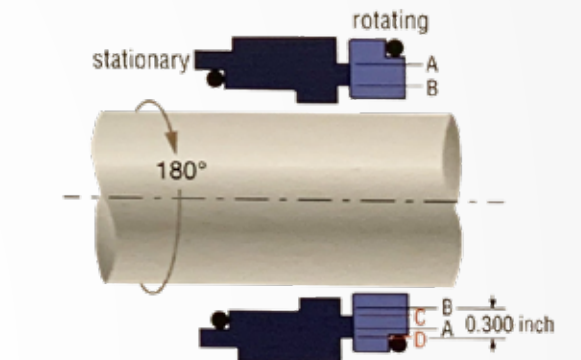
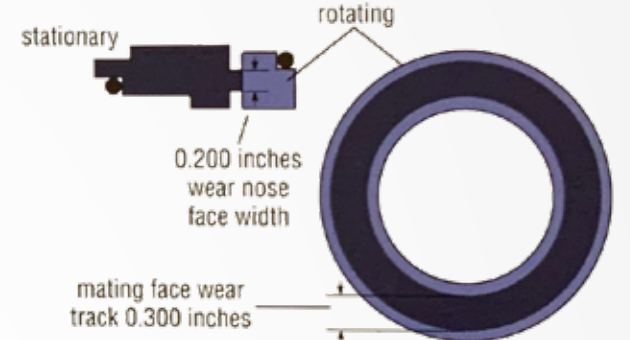
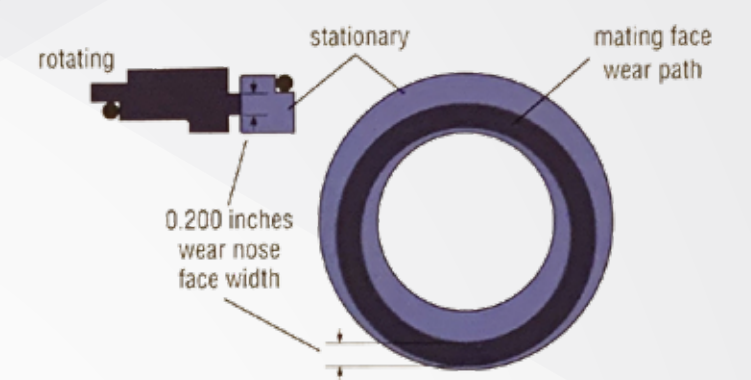
Seal wear nose is rotating with the shaft. The wear pattern is the same width as the face nose, but shifted off center or eccentric.

Stationary Nose Eccentric Wear Track (Wide):

Seal wear nose is stationary. The wear pattern is much wider than the wear nose. This wider wear track will cause the product to be pulled or wiped across the mating face and may cause excessive weepage.

Example:

If the shaft is setting 0.050 inch eccentric from the box bore, using a 0.200 inch wide stationary wear nose, and low at the 6 o'clock position. At the 12 o'clock location, the stator face will contact at point A and B — 0.050 inch low. Rotating 180 degrees, the stator face will contact at point C and D, 0.050 inch high. This will make the track on the rotor mating face equal to the 0.200 inch wide nose plus 0.050 inch high and 0.050 inch low, with a total wear track width of 0.300 inch wide from B-D.



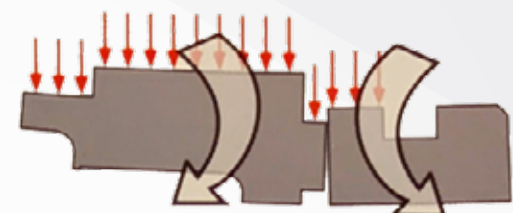
Appendix D

FACE DISTORTION

Mechanical seals operate most effectively with flat faces and a parallel fluid film. In normal operation, however, conditions will distort the seal faces. Friction and fluid shear between the faces will generate heat which will increase the temperature near the contacting area of the faces. This thermal distortion will result in a convex coning on the sealing surfaces. Mechanical seals also operate with a differential pressure across the seal faces. As the pressure acts on the seal faces, the faces will also distort. This pressure distortion will normally result in concave coning on the sealing surfaces.



Thermal Deformation Only

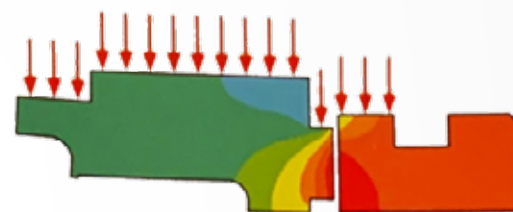


Pressure Deformation Only

To optimise seal performance, seal engineers will design the faces so that the thermal distortion and pressure distortion counteract each other, resulting in a parallel fluid film. This requires a careful analysis on how the distortions behave over a wide range of operating conditions. This is, in fact, one of the most important considerations on establishing the operating window for a specific seal. It is also an important clue when examining the seal faces and interpreting the wear pattern.

If the seal faces have a very light, uniform contact from the OD to the ID of the seal face, the thermal and pressure distortions are effectively counteracted and the fluid film is parallel. This is an ideal operating condition for the seal. If the seal faces show high contact at the ID of the face and little or no contact near the OD, the thermal distortion is greater than the pressure distortion. This can be caused by conditions such as dry running, loss of fluid film, or operation at high speeds. If the seal faces show high contact at the OD of the face and little or no contact near the ID, the pressure distortion is greater than the thermal distortion. This can be caused by conditions such as excessive pressure on the seal or operation at lower speeds.

Properly identifying face wear patterns and understanding the potential causes for wear can provide valuable insights into improving seal performance.



Combined Thermal and Pressure Deformation

Seal Failure Analysis Glossary

316 STAINLESS: A common stainless steel used extensively in mechanical seals because of its generally superior corrosion resistance.

ALIGNMENT CHECKS: Actions using specialised tools to determine concentricity, perpendicularity, axial looseness, and longitudinal straightness between rotating and stationary components of a piece of equipment. Commonly used to check the position of a shaft to a seal housing, straightness of two shafts connected by a coupling, or straightness of a shaft that may be bent.

ALLOY 20 STAINLESS: Common stainless steel with elevated amounts of nickel/chromium/molybdenum. Used for small cross-section parts because it is generally more corrosion resistant than 300 Series stainless steels.

ALLOY 276: A high-nickel alloy with strong resistance to oxidising agents such as chlorine fluids and to acids (also known as Hastelloy C-2761m).

ANSI: American National Standards Institute is the voice of the U.S. standards and conformity assessment system. ANSI is the umbrella organisation containing other organisations such as API and ASME.

ANTIMONY CARBON: A carbon graphite material impregnated with antimony metal to improve hardness, stiffness and thermal conductivity.

APGS (ADVANCED PATTERN GAS SEAL): This refers to a wide seal face onto which a spiral configuration is etched. The unidirectional spiral pattern is designed to dynamically build up pressure between seal faces, causing them to separate during operation.

API: The American Petroleum Institute is a national trade association that represents all aspects of America's oil and natural gas industry. API drives consensus standards such as API 610 and API 682 for pumps and seals used in industry.

ASME: The American Society of Mechanical Engineers aims to be the essential resource for mechanical engineers and other technical professionals throughout the world for solutions that benefit humankind.

ATMOSPHERIC SIDE OF SEAL: The non-wetted surfaces of the mechanical seal that are in contact with atmospheric gases and pressure.

AUSTENITIC METALS: A specific microstructure of a metal alloy that demonstrates excellent corrosion resistance (e.g., 316 stainless steel).

AXIAL MOTION: Longitudinal motion of any magnitude and period.

BARRIER FLUID: Externally supplied fluid at a pressure above the seal chamber pressure, introduced into a dual pressurised seal to isolate the process fluid and the environment. The barrier fluid also provides proper operating conditions for the inner and outer seals.

BASEPLATE: A plate on which a piece of equipment is mounted. It is usually used to hold the equipment level and in proper alignment and to dampen equipment vibration and prevent distortion.

BEARING SEIZE: Occurs when one or more of the rolling elements cease to roll and begin to slide. The rolling elements and races weld together, ultimately resulting in catastrophic failure.

BELLOWS (METAL): A seal assembly consisting of a series of leaflets welded together and attached to two end pieces; one that contains the seal face and one that contains the drive hardware. The bellows itself is a seal through which no fluid can pass, and the bellow also provides the spring load to the seal face.

BEP (BEST EFFICIENCY POINT): The best efficiency point is a function of the pump itself and it is the point of lowest internal friction inside the pump during pumping. This is the optimum pump operating condition and is best for the pump and seal longevity.

BETWEEN BEARINGS PUMP: The impeller(s) of this pump is mounted on the shaft with bearings at both ends of the shaft. The impeller(s)

is mounted -between bearings”.

BLISTERING: When traction between two rubbing surfaces exceeds the strength of one of the surfaces. causing a shallow ‘scoop’ shaped fracture in the surface. The fractured segment is the blister and rises out of the surface to increase the distance between the two sliding seal face surfaces.

BUFFER FLUID: Externally supplied fluid at or below the seal chamber pressure, introduced into a dual unpressurised seal to isolate the environment from the process fluid. The buffer fluid also provides proper operating conditions for the outer seal.

CARBON: Shortened version of the words resin impregnated carbon graphite, often referred to as the soft face.

CARTRIDGE SEAL: A pre-assembled mechanical seal that requires minimal effort and skill to install.

CENTERING DEVICE (SETTING TAB, CENTERING TABS): An integral component of a cartridge seal used to properly position the seal on the equipment and is removed following setting of the seal. Also stabilises the seal components during shipping and handling.

CENTRIFUGAL PUMP: A pump that adds energy to the fluid by spinning it with an impeller, then directing the flow into a discharge nozzle.

CERAMIC: A general classification of metal oxides and carbides formed into a useful shape. Common ceramics in mechanical seals are aluminum oxide, chrome oxide, silicon carbide and tungsten carbide.

CHEMICAL COMPATIBILITY: A material is said to be compatible with a chemical if the chemical does not dissolve, penetrate, soften, or otherwise modify the mechanical characteristics of the material.

CLEAN-IN-PLACE (CIP): A method of removing undesirable residue from equipment without disassembly of the equipment.

COKING: A chemical process that occurs in hydrocarbons at high temperatures where carbon and oxygen combine to create a dark, grainy hard solid.

COMPONENT: A piece of an assembly with a specific function that contributes to the assembly as a whole.

COMPONENT SEAL: A seal consisting of a rotor and a stator, a non-cartridge mechanical seal.

COMPRESSION SET: When an elastomer loses its ability to spring back to its original shape after being compressed. Caused by heat, pressure and chemical compatibility.

CONCENTRIC: When two cylinders or circles share the same centerline or center point. Usually referenced with shaft OD to the seal chamber bore.

CONTACT AREA: The area of the mechanical seal where the sliding faces mate.

CORROSION: The detrimental effect of a chemical or an environment on a material.

CRYOGENICS: Pertaining to materials at very low temperatures.

CUP POINT SET SCREW: A screw with a sharp circular tip that is designed to imbed into the surface to which it is tightened, used to lock two components together.

CYCLING: A repeating event, such as turning a piece of equipment on and off, not necessarily with fixed regularity.

CYCLONE SEPARATOR: A device which separates solids from liquids through the use of centrifugal force.

DELAMINATE: The separation of a layer from its substrate.

DISCHARGE PRESSURE: The pressure of a liquid after energy has been added by the pump; the highest pressure at the exit of the pump.

DOG POINT SET SCREW: A screw with an extension which engages a hole or slot in the mating component, used to lock two components together.

DRAIN PORTS (D): A low point of a seal gland plate where liquids can most effectively be drained using the force of gravity.

DRIVE FLAT: A flat spot on a round surface that engages a mating flat on another close-fitting round surface. A method of transmitting torque from one component to another.

DRIVE LUG: An extension from one component that engages a corresponding slot in a mating component. A method of transmitting torque from one component to another.

DRIVE PIN: A pin from one component that engages a corresponding hole in a mating component. A method of transmitting torque from one component to another.

DRY RUNNING: Indicates that a gas or vapor exists in the contact area of the seal faces, whether accidental or by design.

DUAL PRESSURISED SEAL: A seal with two sets of faces where the cavity between the seals has a barrier fluid maintained at a

pressure higher than the process fluid. Also known as API 682 Arrangement 3.

DUAL UNPRESSURISED SEAL: A seal with two sets of faces where the cavity between the seals has a buffer fluid maintained at a pressure lower than the process fluid. Also known as API 682 Arrangement 2.

DUPLEX STAINLESS: A multi-phase stainless steel with enhanced corrosion resistance.

DURCHROME: A thin coating of aluminum oxide ceramic to a metal-based material that produces a low-friction, abrasion-resistant and wear-resistant surface.

DYNAMIC SECONDARY SEAL: An O-ring or other similar type gasket that is designed to slide or move, allowing axial movement of internal seal components.

ENVIRONMENT: In the context of a mechanical seal, it is the fluid, pressure, temperature and dynamic condition in which a seal is expected to operate.

ENVIRONMENTAL CONTROLS: Piping plans, pump designs and seal designs that improve seal performance by providing optimum operating conditions.

EROSION: The gradual loss of material due to the action of fluids and/or solids acting on a surface.

FACE CONING (DEFLECTION): Distortion of the seal face due to pressure or heat, resulting in either OD or ID contact.

FIM (FULL INDICATOR MOVEMENT): The total variation between the highest and lowest gauge point of a dial or indicator when applied to a surface feature while measuring surface variations (also known as TIR)

FLANGE: A device to which another device is attached, specifically designed to act as a component in a system intended to contain fluid. A seal housing (gland) attaches to the equipment flange.

FLASHING: The physical act of a fluid changing state from liquid to gas. Occurs with the addition of heat and/or the lowering of pressure.

FLEXIBLE ROTOR: The seal face that rotates and is energised with springs or bellows.

FLEXIBLE SEAL FACE: The seal face that can move axially to compensate for wear, misalignment or movement within the equipment.

FLEXIBLE STATOR: The seal face that does not rotate and is energised with springs or bellows.

FLUOROELASTOMER (FKM): A family of rubber-like polymers with a wide range of chemical compatibility, available from a number of suppliers, e.g., DuPont’s Viton™

FLUSH PLAN: See Piping Plan.

FLUSH PORTS (F): A liquid connection (such as a threaded hole) in the gland through which liquids are injected to control the operating environment of the seal.

FRETTING: A mechanical process by which fine oscillating motion of one surface against another causes wear. Two-body fretting is commonly associated when one body is an austenitic metal and the other is a rigid polymer, e.g., PTFE.

GALLING: When one surface deforms another due to contact load and motion. Often occurs between two common metals in highly

loaded areas. Different metals have different resistance to galling.

GAS BARRIER SEAL: A seal designed to operate on a thin gas film between the faces instead of a liquid film.

GLAND: A seal housing used to attach the seal assembly to the equipment.

HANG-UP: When flexible components lose the ability to move axially.

HARD COATING: A material applied as a thin layer to a surface to reduce fretting, corrosion or traction.

HARD FACE: The seal face that is not the carbon face, such as tungsten carbide, silicon carbide or aluminum oxide ceramic.

HELIUM LIGHT BAND: A unit of measure for face flatness equaling 280 nm (11.6 pin).

HIGH ALLOY: A metal known to have enhanced chemical corrosion resistance or improved mechanical properties. Often associated with metals that contain high levels of alloying elements such as nickel, chromium and molybdenum.

IMPELLER: The component that spins in a pump volute to add energy to a liquid.

INSTALLATION PROCEDURES: A group of actions that when properly executed creates a complete and correctly assembled system.

LEAKAGE: Undesirable amount of liquid passing through surfaces that are designed to slow or stop liquid flow.

LUBRICATION: The process of reducing friction by adding a material between two opposing surfaces in motion.

KEYING: The ability of a fractured material to align back to it's original position.

MAGNETIC SEPARATOR: A component used in a seal piping plan to remove magnetic particles from the process fluid. Most commonly used with Plan 23.

MATTE FINISH: Controlled surface finish to encourage boundary lubrication to penetrate the face contact area and ensure proper lubrication.

METAL DEGRADATION: Changes that adversely affect properties of metals, which may be caused by corrosion, heat or fatigue.

NUTATION (COINING): An unstable condition of the seal that causes a 'wobbling' of the components, damaging the outer edge of the seal faces.

OEM (OE): Original Equipment Manufacturer; an organisation that designs, manufactures and assembles new equipment.

OPERATING CONDITIONS: The environment of the process within the rotating equipment. This includes minimum, maximum, commissioning, startup, stand-by, upset and cleaning conditions to which the equipment may be exposed.

OPERATING CURVE: A graph representing the relationship between head and flow of a pump.

ORIFICE: A restriction device in a pipe or tube which results in a flow reduction and pressure drop.

OUT-OF-SQUARE: The difference between two objects being away from a perfect 90° angle. Usually described in the form of perpendicularity measured as TIR.

OVER-COMPRESSION: The condition of providing more force on an object than intended by design.

PERAMIC (CERAMIC): A trade name for 99.5% pure aluminum oxide ceramic used for mechanical seal faces.

PERFLUOROELASTOMER (FFKM): A family of rubber-like materials molded from fully fluorinated polymers. They are normally selected for superior corrosion resistance and high-temperature stability, e.g., Chemraz¹ and Kalrez².

PIPING PLANS: Standardised industry-specified support systems used to control the operating environment of a mechanical seal (Reference: FTA160).

PROCESS FLUID: Any fluid used in production of the final product in contact with the working components of the equipment.

PROCESS STREAM: The sequence of events transforming raw materials into an end product.

PUSHER SEAL: A mechanical seal design with a dynamic secondary seal that slides as the faces wear.

QUENCH PORTS (0): A port designed to allow a fluid to wash over, clean and/or protect the atmospheric side of the mechanical seal.

RADIAL DEFLECTION: Movement of a shaft perpendicular to its centerline of rotation, causing the centerline to no longer be in its original position.

ROOT CAUSE ANALYSIS (RCA): A method used to discover the source of failure.

SALTING: The precipitation of dissolved solids as the fluid component evaporates or flashes off.

1 Registered trademark of Green Tweed and Company

2 Kalrez is a trademark of E. I. du Pont de Nemours and Company

SEAL CHAMBER: The part of the equipment designed to accommodate the mechanical seal.

SEAL REGISTER CONCENTRICITY: A description of how well centered the equipment’s seal chamber is when compared to the operating position of the rotating shaft on which the seal is mounted.

SEAL SUPPORT SYSTEM: A group of components assembled in the piping plan to provide an environment in which a mechanical seal will operate (Reference FTA160).

SEALING INTERFACE: The seal face contact area where sliding, friction, lubrication and wear occur.

SETTING DEVICE: An integral component of a cartridge seal used to properly position the seal on the equipment and is removed following installation of the seal. Also, it stabilises the seal during shipping and handling.

SHAFT DEFLECTION: Movement of a shaft perpendicular to its centerline of rotation, causing the centerline to no longer be in its original position.

SHAFT END PLAY: Shaft movement axially along its centerline.

SHAFT RUN-OUT: Movement of a shaft perpendicular to its centerline of rotation, causing the centerline to no longer be in its original position.

SHRINK FIT: Using temperature differentials to create clearances between two parts that at the same temperature have an interference fit.

SILICON CARBIDE: A ceramic material commonly used as a mechanical seal face.

SLEEVE: A long metallic cylinder used to adapt the rotating mechanical seal components to the equipment shaft.

SLIP-STICK: A phenomenon found with inconsistent fluid film lubrication. A rotational vibration where a sliding face overshoots its drive mechanism, stops and waits for the drive mechanism to catch up. Once the drive mechanism catches up, it forces the face to break free of static friction, again springing forward to overshoot the drive mechanism.

SOFT FACE: Normally one of a variety carbon seal faces. Always used against a harder face.

SPALLING: The process by which flakes of a material are broken off a larger solid body.

STATIONARY SEAL FACE: The seal face that is not rotating with the shaft during operation.

STEAM-IN-PLACE (SIP): Using steam to sanitise or sterilise equipment that remains assembled. Also known as Sterilise-in-Place.

STUFFING BOX: The part of a piece of equipment where compression packing is used as a sealing device.

SUBSTRATE MATERIAL: The base material onto which a hard surface or coating is applied.

SUCTION PRESSURE: The pressure of the pumped fluid as it enters the pump.



Self-Diagnose the Root Causes to Your Mechanical Seal Failure

