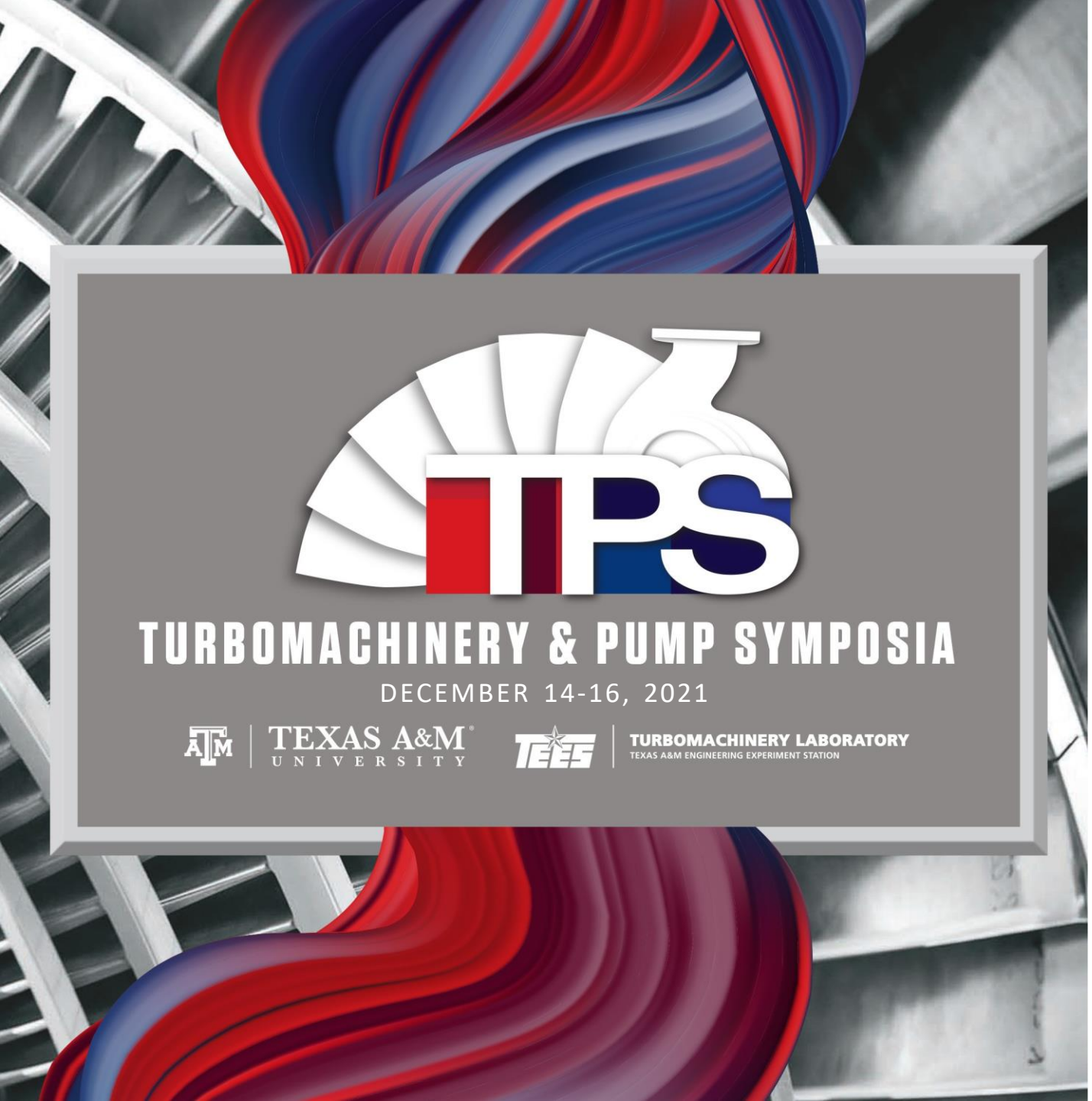

Significant MTBF improvement of a Water Injection Pump application by using diamond coated seal face material technology

EagleBurgmann

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Nikolaus Necker is a Lead Expert for Engineered Mechanical Seals at EagleBurgmann Germany GmbH & Co. KG, Wolfratshausen, Germany. He is responsible for the application engineering in all kinds of Oil and Gas services. His job includes sales and applications of sealing technology for pumps world-wide (On- and Offshore) since he started with Burgmann in 1990. He is a member of the MPUR Advisory Board since 2000. Nikolaus Necker has a Masters of Engineering (Mechanical Engineering, 1989) from the Munich University of Applied Sciences and has a Pump Engineer Diploma from the University of Graz (Austria).

TURBOMACHINERY & PUMP SYMPOSIA

Abstract

A well-known oil company in Oman is producing crude oil using “produced water injection” as their favorite Enhanced Oil Recovery (EOR) techniques.
This nasty water is reinjected into the well by high-pressure multistage centrifugal pumps, using a dual pressurized mechanical seal arrangement in combination with API682 Piping Plan 53B. The average MTBF was 12 months only. It was the seal manufacturers recommendation to upgrade the mechanical seal design and to change the seal face material to diamond coated seal face technology. This new seal was qualified successfully by intensive dynamic testing and finally installed in the field.

TURBOMACHINERY & PUMP SYMPOSIA

Oil extraction and Enhanced Oil Recovery (EOR)

Primary recovery

- The reservoir pressure is a natural mechanism. The reservoir pressure is sufficient to force the oil to the surface

Secondary recovery

- Supply of external energy, like injecting fluids, **water injection** or using Electrical Submersible Pumps to bring the oil to the surface, and incease the production of crude oil up to 45 %

Tertiary recovery (EOR)

- Heat the oil by Steam injection, to reduce viscosity using steam injection, increasing the amount of crude oil up to 60 %, or gas reinjection CO_2, N_2

TURBOMACHINERY & PUMP SYMPOSIA

Produced water injection – a different story!!

General Definition:

Produced water is trapped in permeable sedimentary rocks along with oil and gas, and through subterranean drilling processes the water is brought to the surface with the oil or gas as a by-product

When produced water arrives at the surface it must be reused or disposed of as it can contain harmful and damaging properties. The main chemical contaminants of produced water causing heightened concern, both onshore and offshore, are oil, grease, organic and inorganic compounds.

These chemicals do not occur naturally in aquatic ecosystems, and therefore pose a threat to the environment. And because of the harmful levels of contaminants, it is illegal to dispose produced water in marine or onshore environs unless it has been properly treated

The Application details – Produced water Disposal Pump

CENTRIFUGAL PUMP DATASHEET

1	Note	APPLICABLE TO:	PURCHASE	APPLICABLE NTL/INTNTL STANDARD:	API 610, 11th ed., DEP 31.29.02.30 and SP-2013 (Note-6)			Rev
2		FOR NPS	Petroleum Development of Oman	UNIT	Deep Water Disposal Pump			
3		SITE NPSHA		SERVICE	Produced Water			
4		NO. REQ	1	PUMP SIZE		TYPE	Centrifugal	No. STAGES	VTC
5		MAX Pump performance	HPcp 200-330-5st/33 (E.45301) (Note 5)	MODEL		SERIAL NO.	3812-21069	

LIQUID CHARACTERISTICS

	Units	Maximum	Minimum	Note
LIQUID TYPE OR NAME :		Produced Water		Max & min values refer only to the property listed
VAPOR PRESSURE@60degC :	bar a	0.0026		
RELATIVE DENSITY :		1.008		
SPECIFIC HEAT :	kJ/(kg-K)			
VISCOSITY :	Pa s	0.0009027		

OPERATING CONDITIONS (6.1.2)

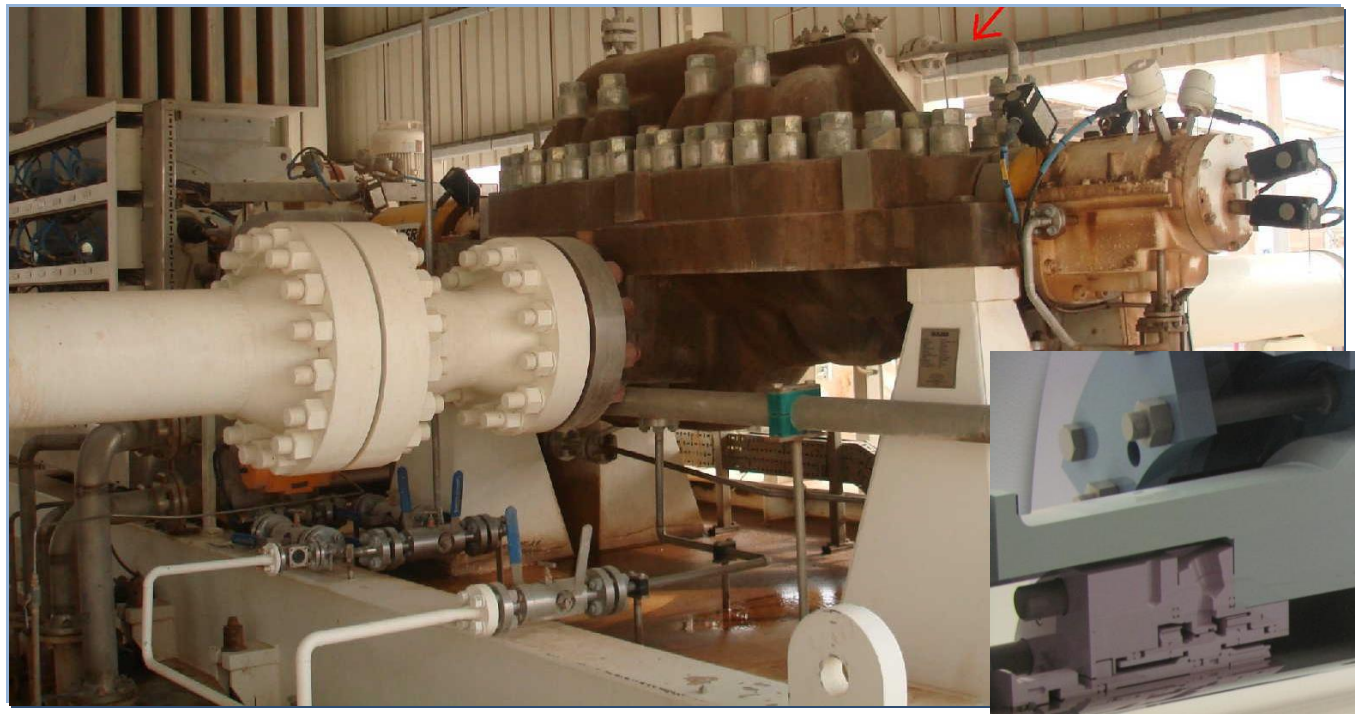
	Units	Maximum	Rated	Normal	Minimum
NPSHA Datum:		C.L. Impeller			
PUMPING TEMPERATURE :	°C	60	50	40	25
FLOW :	m³/h			833.333	
DISCHARGE PRESSURE : (6.3.2)	bar a			150.29	
SUCTION PRESSURE :	bar a			14.1	
DIFFERENTIAL PRESSURE :	bar			136.19	
DIFFERENTIAL HEAD :	m			1378.12	(Note:8,9)
NPSHA :	m	143			(Note:7)
HYDRAULIC POWER :	kW		3153		

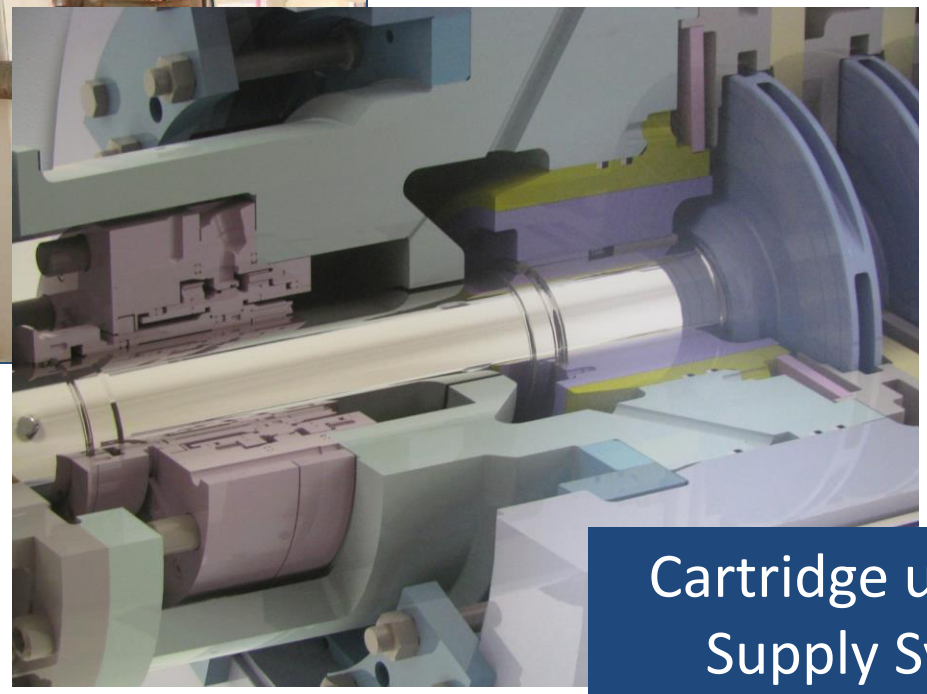
SERVICE :	CONTINUOUS
PUMPS OPERATE IN: (Note 10,13)	PARALLEL
CORROSION DUE TO : (6.12.1.9)	(Note 1-4)
EROSION DUE TO : (6.12.1.9)	(Note 1-4)
H2S CONCENTRATION (ppm) :(6.12.1.12)	(Note 1-4)
CHLORIDE CONCENTRATION (ppm) :	(Note 1-4)
PARTICULATE SIZE (DIA IN MICRONS)	(Note 1-4)
PARTICULATE CONCENTRATION (PPM)	(Note 1-4)

SITE AND UTILITY DATA

TURBOMACHINERY & PUMP SYMPOSIA

Several installations: Oman, Middle East, in general BB3 pumps





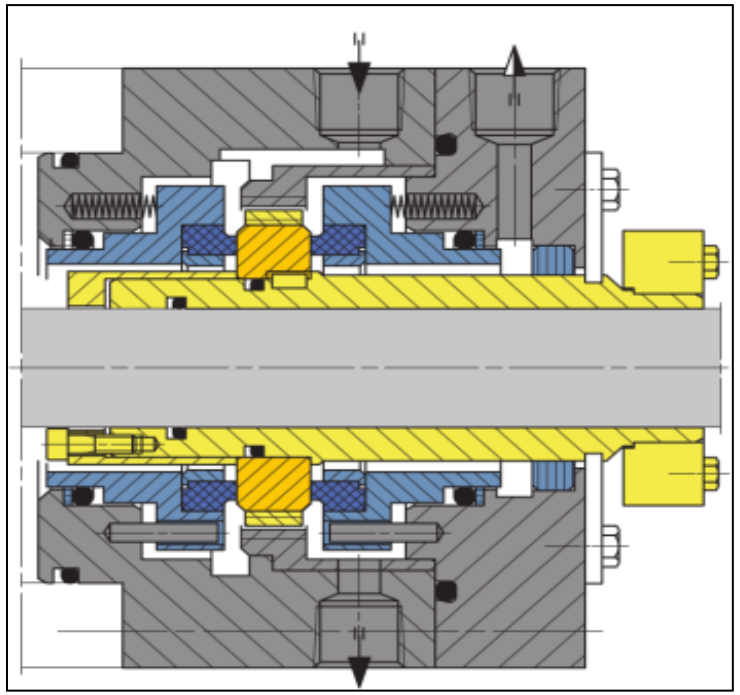
Cartridge unit with Supply System API-Plan 53B

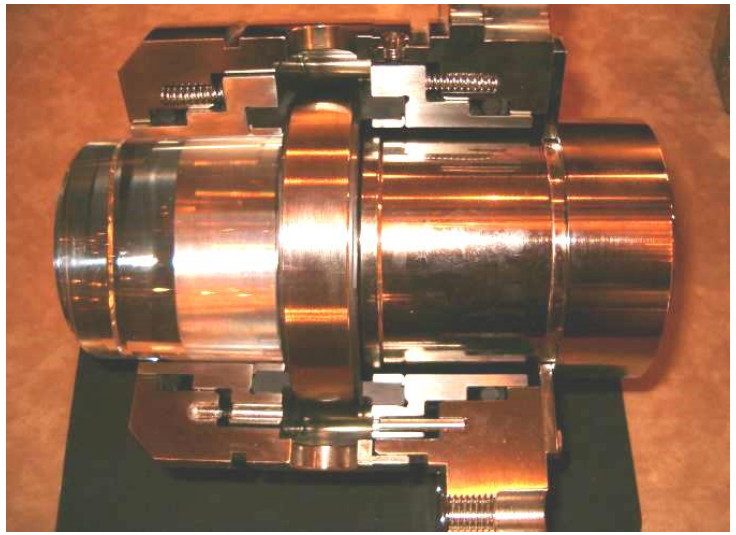
TURBOMACHINERY & PUMP SYMPOSIA

Existing Mechanical Seal: Engineered dual Seal, pressurized Plan 53B

Features:

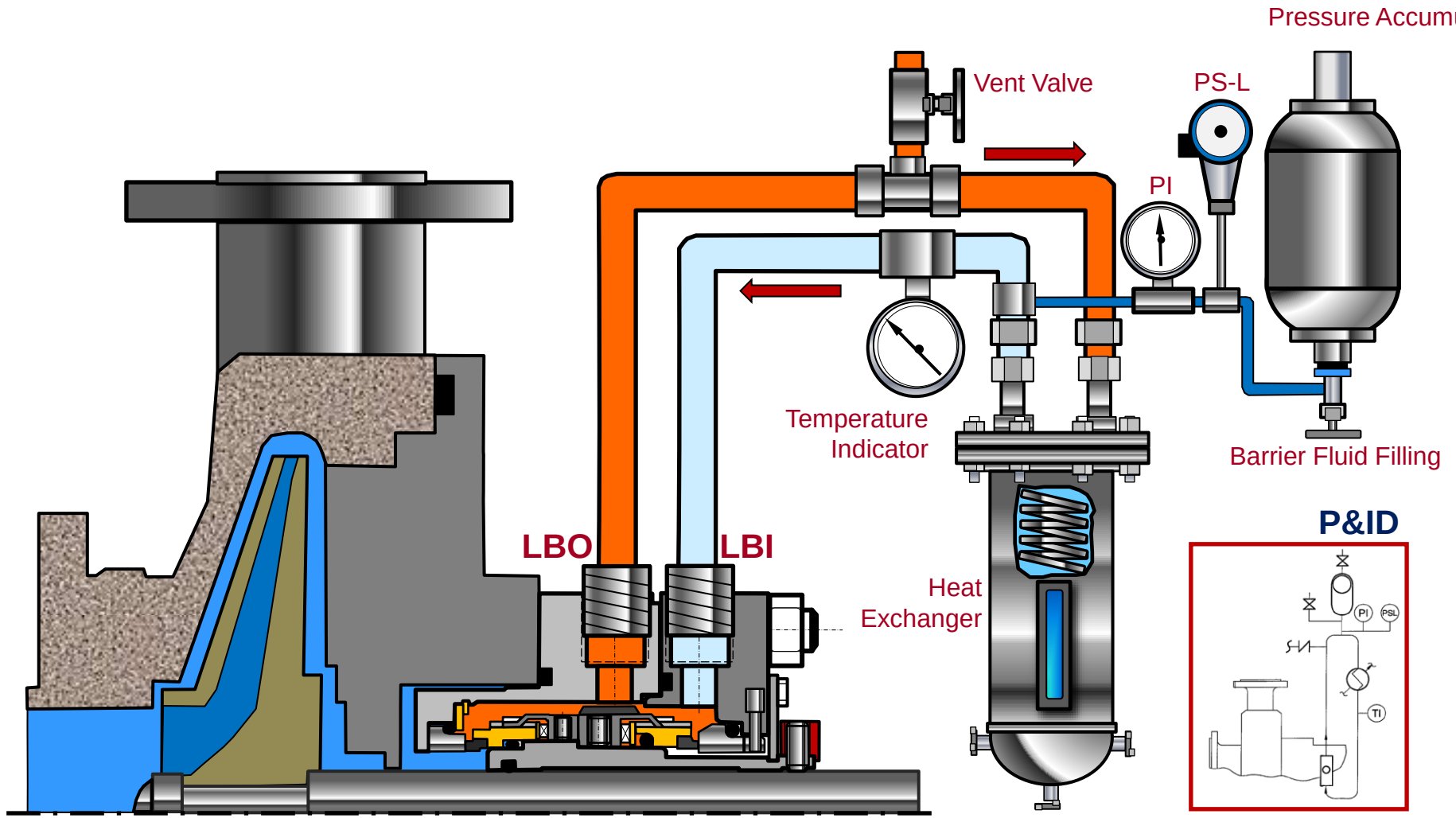
- Face-to-Face arrangement
- Stationary spring-loaded units
- Shrink-fitted, robust seal faces
- Insensitive to shaft deflections due to stationary design
- Rotating mating ring design
- Optimum heat dissipation due to integrated pumping device and optimized seat design
- Few components





TURBOMACHINERY & PUMP SYMPOSIA

Typical API 682 Piping Plan 53B



External piping provides clean barrier-fluid for the seal faces of a pressurized dual seal arrangement. Pre-pressurized bladder accumulator provides pressure to the closed loop circulation system

Seal inspection - Typical Observations

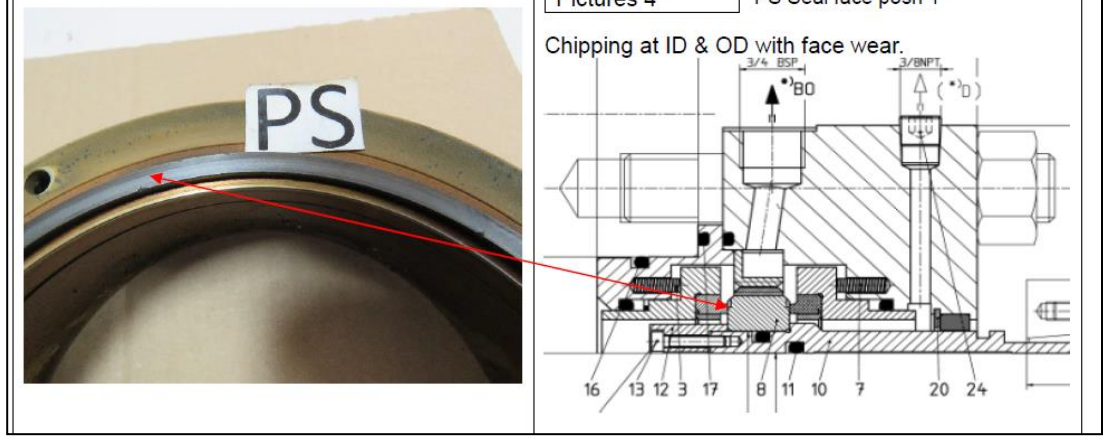
Process Side (Inboard Seal):

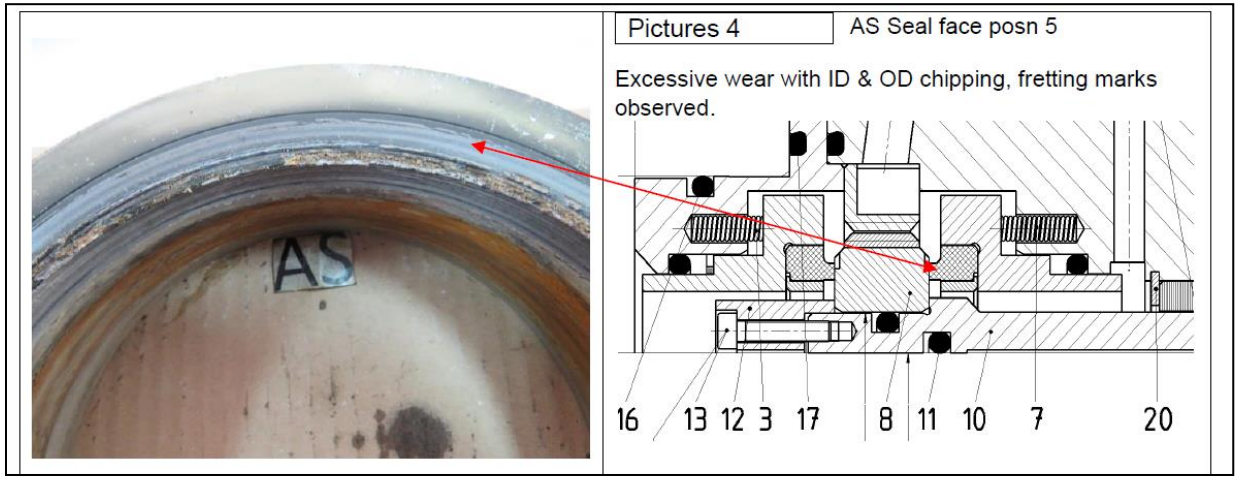
- Chipping at ID of seal face
- Chipping at OD of seal face
- Shiny / heavy contact on OD of seal face
- Blistering on carbon face
- Scale , muck deposition on ID area
- Fretting marks at O-ring area

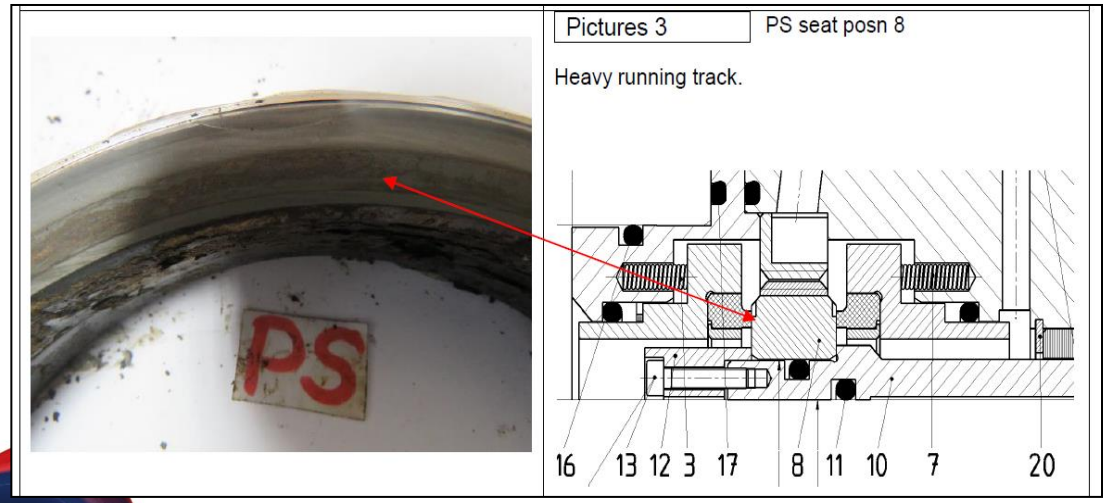
Atmospheric Side (Outboard Seal):

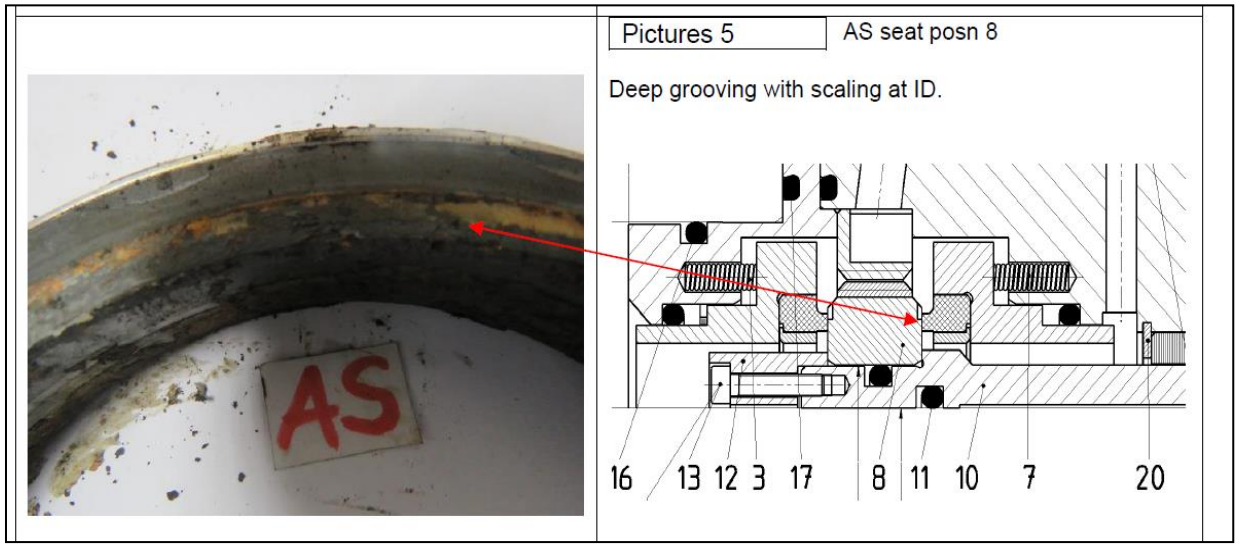
- Heavy wear track, grooving
- Chipping at ID and OD
- Fretting at O-ring area
- Muck and scales deposits on all over seal ring area in contact with barrier fluid

Seal face inspection – Chipping on OD and ID



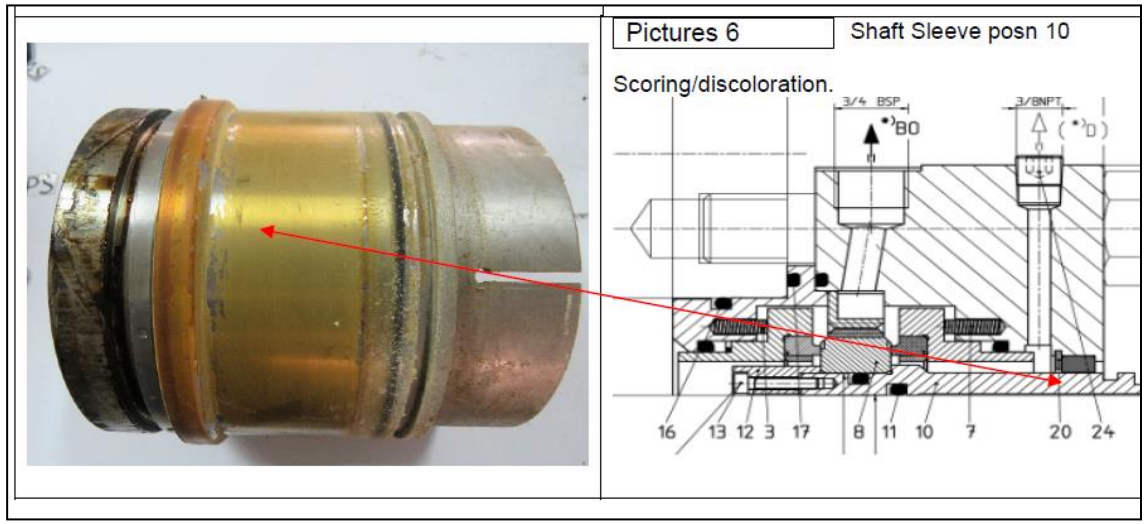


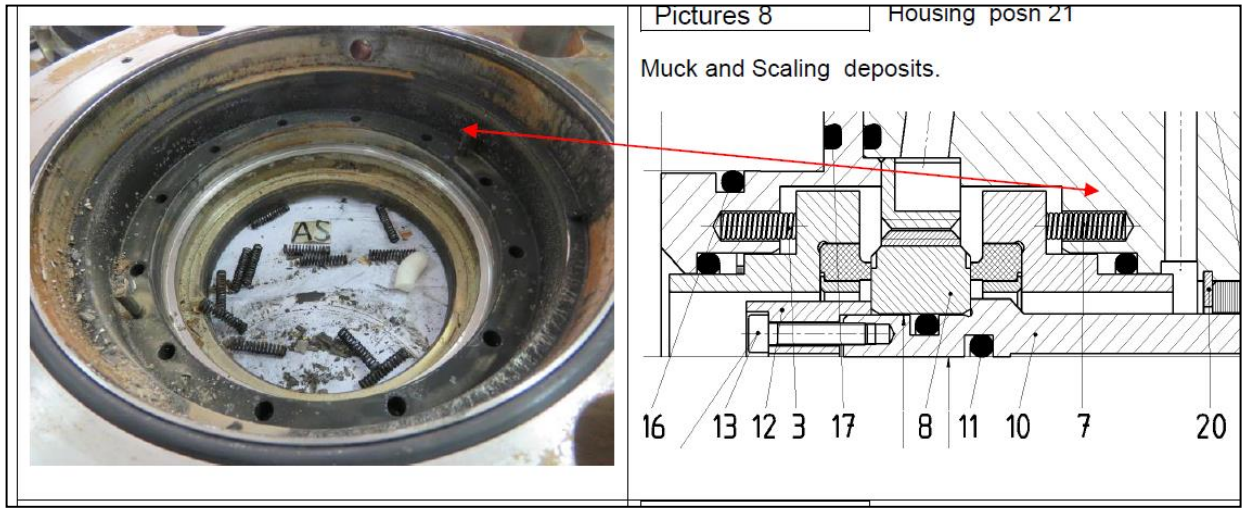


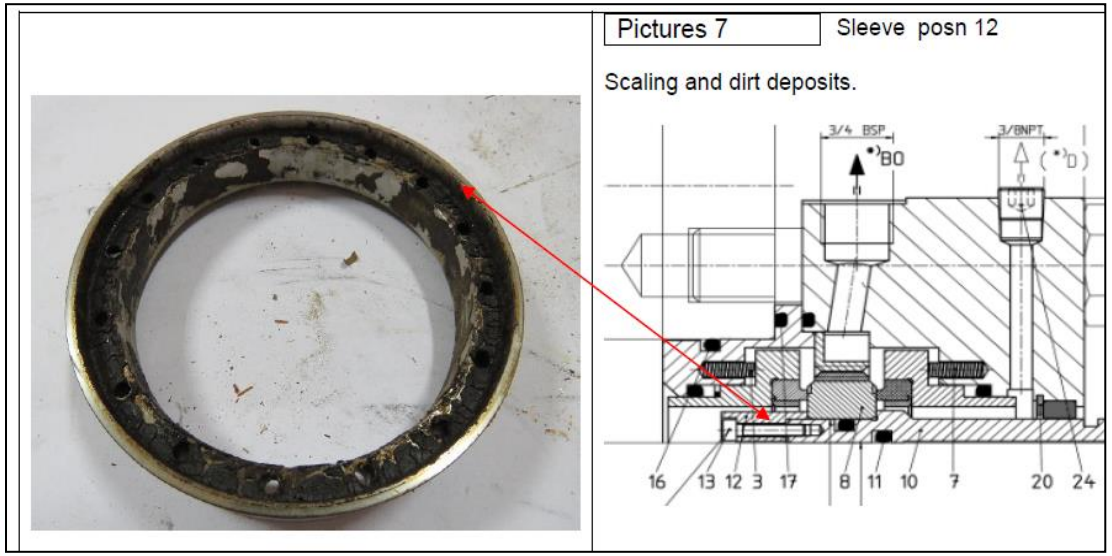


TURBOMACHINERY & PUMP SYMPOSIA

Scale & Muck Deposition







Plan 53M (Modified) Seal System Reservoir – thick layer of sand and muck observed in the tank

Probable Root Causes of the intensive seal leakage

- For Process side seal face, chipping at ID is due to process media characteristics, which is causing deposition of scales at ID area and chipping
- The chipping on OD, scoring marks on seal face is indicating improper quality of the barrier fluid. Barrier fluid appears to be heavy contaminated
- The deposition of muck and scales on seal interior parts is an evidence
- The improper quality of barrier fluid is also affecting the seal faces - shiny and heavy wear track, blistering, grooving are showing poor lubricating properties of barrier fluid
- Fretting at dynamic O-ring area indicates that shaft has axial movement

Conclusion

Based on the observations of the seal components, seal faces and site findings/observations, it was concluded that the seal failures are mainly due to:

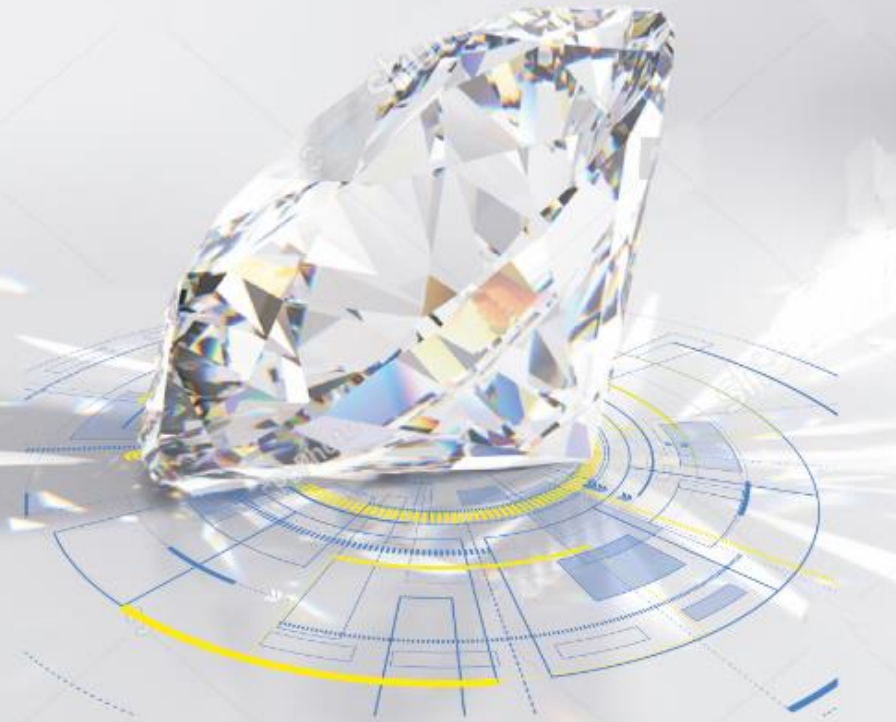
- Pumped fluid properties
- Improper surrounding
- Equipment condition
- Operational issues
- Assembly & installation issues

Proposed Upgradations of the Mechanical Seal

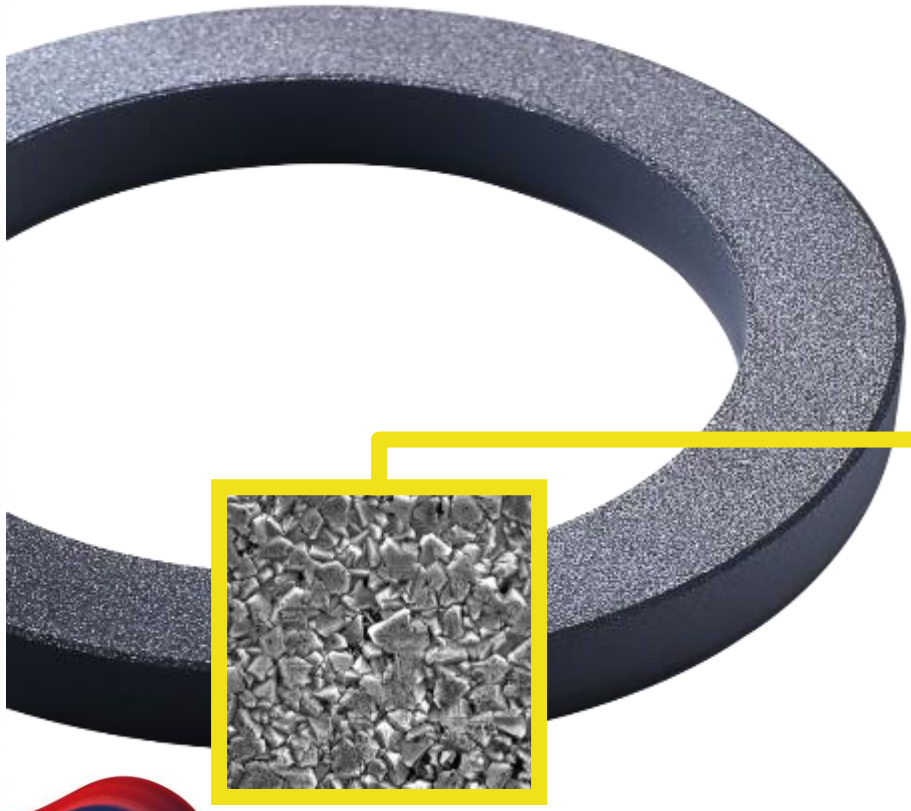
- Upgrading Seal Face MOC to **diamond seal face materials**
- Hard-coating to be provided at dynamic O-ring area to avoid fretting
- Addition of an expeller on rotating seal sleeve under PS seal area
- Changing barrier fluid to “Water + Glycol mixture” optional

Diamonds – a unique material for seal faces – the properties:

- Extreme hardness
- Excellent wear resistance
- Maximum chemical resistance
- Excellent heat conductivity
- Minimum friction



Diamond material technology improves seal performance significantly



Maximum operational performance

- **Minimal wear**
- **Extension of maintenance intervals**

→ Optimization of the entire system

Reduced total-life-cycle costs

→ Significant improvement in life-cycle costs

Minimal friction

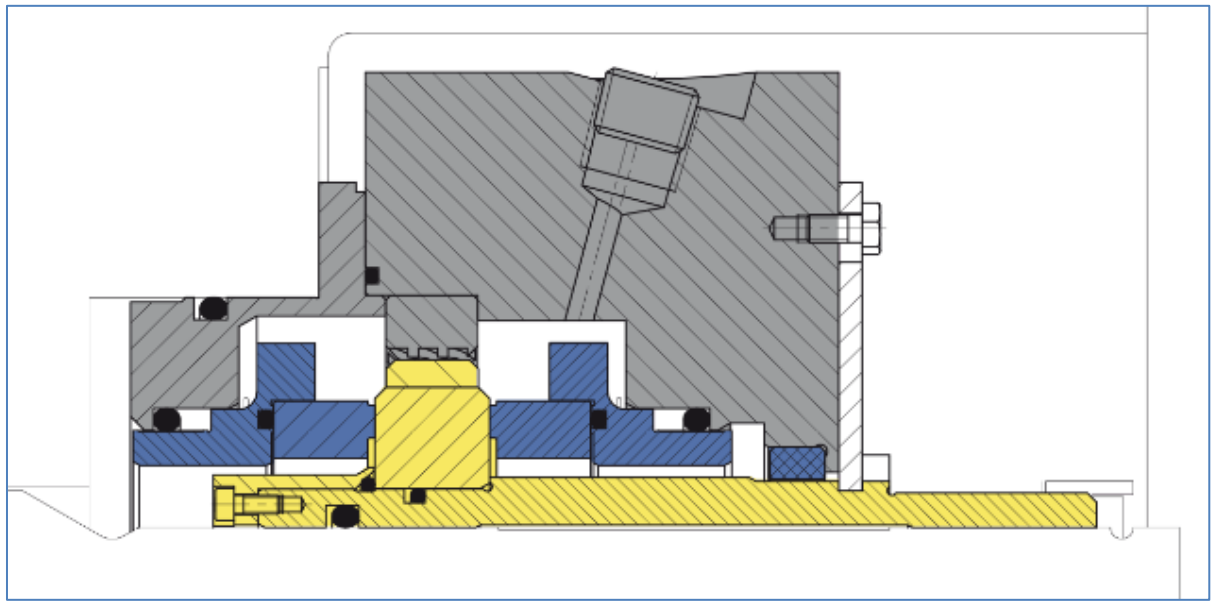
- **Minimized friction losses**
- **Reduced heat build-up**

→ Increase of energy efficiency

Much less energy required

→ e.g. compared to SiC/SiC material combinations

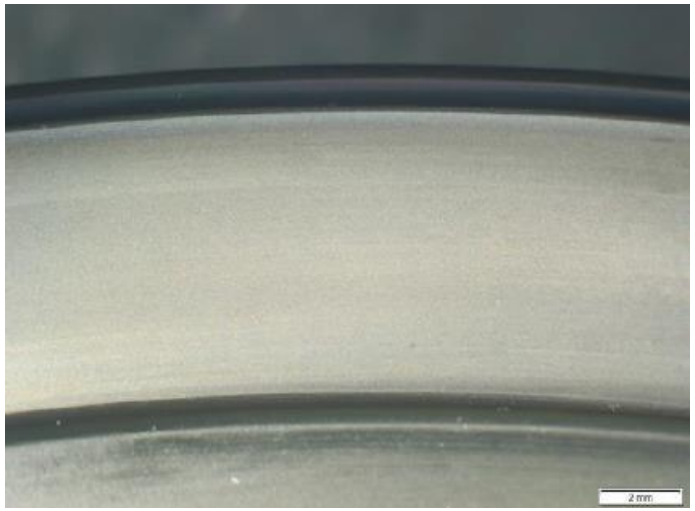
Full static & dynamic testing of the upgraded seal:



Product fluid:	Water
Barrier fluid:	Potable water
Barrier fluid pressures:	5 / 20 / 27 barg
Speed:	4.700 rpm
Temperature:	25…60 °C

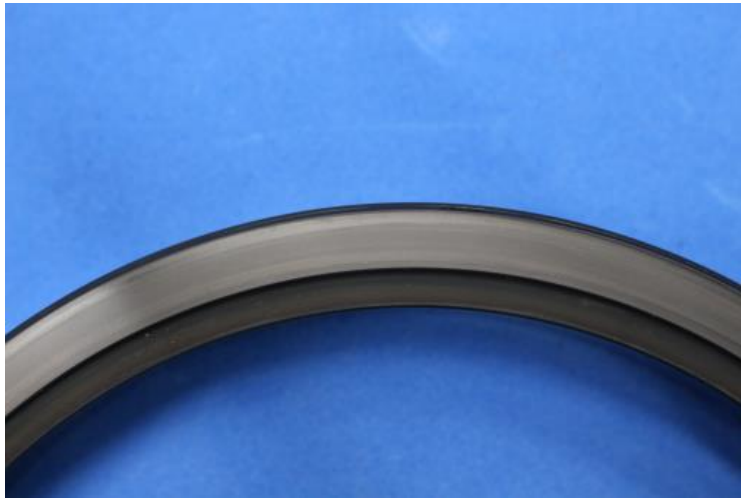
TURBOMACHINERY & PUMP SYMPOSIA

Test results – Seal face conditions Inboard / Outboard after 200h



General View

Detail View

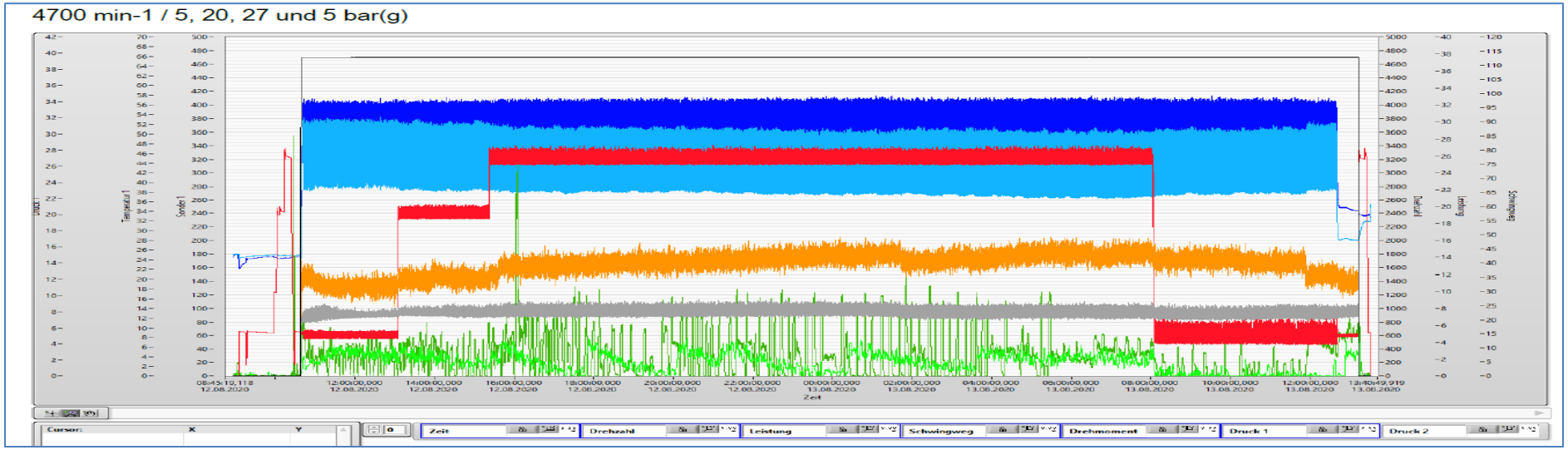


General View

Detail View

Test results

- 2 Mechanical Seals (DE and NDE) were fully tested for approx. 200 h
- Different seal face topography was tested
- In total 5 different test-runs were conducted
- Power consumption was measured with 3 KW at full speed and max. pressure
- Leakage was measured with approx. 90 ml/h @ 5 barg
  approx. 120 ml/h @ 27 barg
- Seal faces were fully inspected and considered in „as new“ condition
- O-rings do not show any deformation or wear
- The seals were fully approved for the planned field installation



Conclusion

- Diamond seal face material can enlarge seal life significantly
- Dynamic testing is a reasonable action to verify seal performance calculations
- Additional design features show benefits
- Diamond seal face material can reduce power consumption and auxiliary equipment costs
- A close cooperation between end-user and equipment manufacturer is the key for continuous improvement and success
- The revised seals will be installed in September and field performance data will be presented at the Symposium

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