Latest Advancements in Mechanical Seal Technology Using Laser Machined SiC Faces to Withstand Electro Kinetic Driven Corrosion

25th Pump User Symposium

Presented by:

Gerard van Loenhout
Flowserve Pump Division
The Netherlands

Co-Authors:

Jan Traets
Flowserve Flow Solutions Division
The Netherlands

Rainer Schmerberg and Klaus Enders
Vattenfall Europe Generation AG & Co. KG
Germany

Content :

- Background Information
- Conclusions Drawn (Field and Research)
- The Sealing Solution Applied
- Field Experience
- Way Forward
- Questions

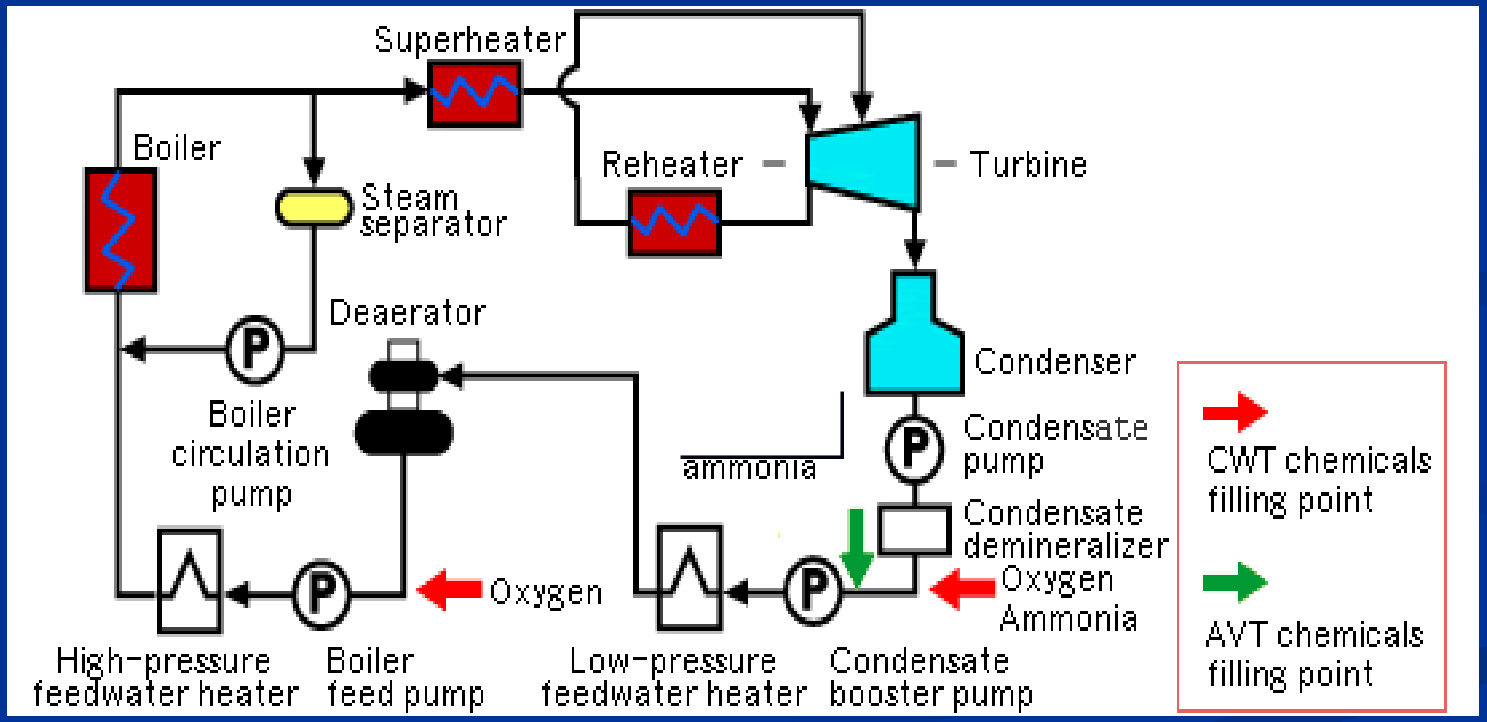
Background Information

Some facts on power plant Jänschwalde, Vattenfall Europe Generation AG & Co. KG:

- Lignite fueled 3000 MW power plant; 6 units of 500 MW, built between 1976 and 1988, fully modernized between 1991 and 1996
- During normal operation 12 multi stage turbo feed pumps in use, all equipped with mechanical seals
- Boiler feed water treatment: Combined Water Treatment (CWT)
- Frequent starts / stops of individual blocks, with pumps on slow roll operation (300 RPM), during wind energy feed into the grid
- Huge amount of seal repairs due to electro corrosion
- Technical forum held in 2003, revealed these sealing problems, customer already conducted 10 year study into this problem
- Sister stations at Boxberg, Lippendorf and Schwarze Pumpe, also Vattenfall Europe Generation AG & Co. KG, facing similar problems, but are more critical due to type of pump operation
- Sealing pressure: 2.5 MPa
- Feed water temperature: 172 – 175 °C
- Pump speed: 300 RPM slow roll, normal speed 5200 – 5400 RPM

Background Information

Typical Combined Water Treatment (CWT) Flow Sheet



Background Information

Typical CWT + AVT feed water composition comparison:

PARAMETER	SYMBOL	UNIT	CWT NORMAL	CWT LIMITS	AVT NORMAL	AVT LIMITS
ELECTRICAL CONDUCTIVITY	k	µS/cm	2	1,5 – 2,5	6	6 - 9
OXYGEN	O2	µg/l	30 - 150	250	0 - 20	< 100
TOTAL IRON COMPOSITION	Fe	µg/l	3	< 20	3	< 20
TOTAL COPPER COMPOSITION	Cu	µg/l	< 1	1	< 1	1
SILICON OXIDE	SiO2	µg/l	5 - 10	< 20	5 - 10	< 20
SODIUM	Na	µg/l	< 5	< 10	< 5	< 10

Background Information

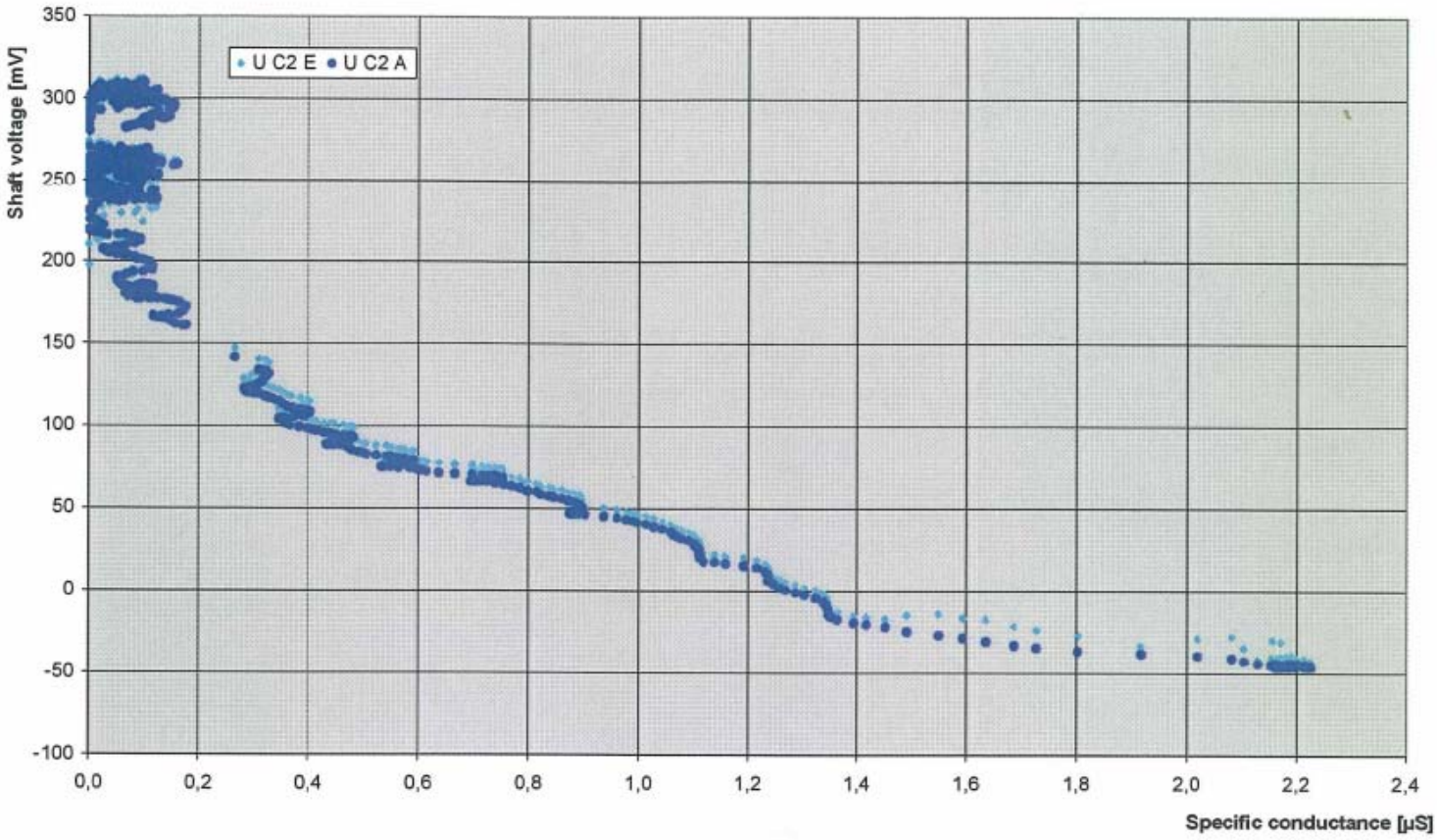


Fig. 5: Interdependence of shaft voltage and specific conductance

Background Information

Subject Boiler Feed Pump:

Indicated as the plant's worst bad actor pump

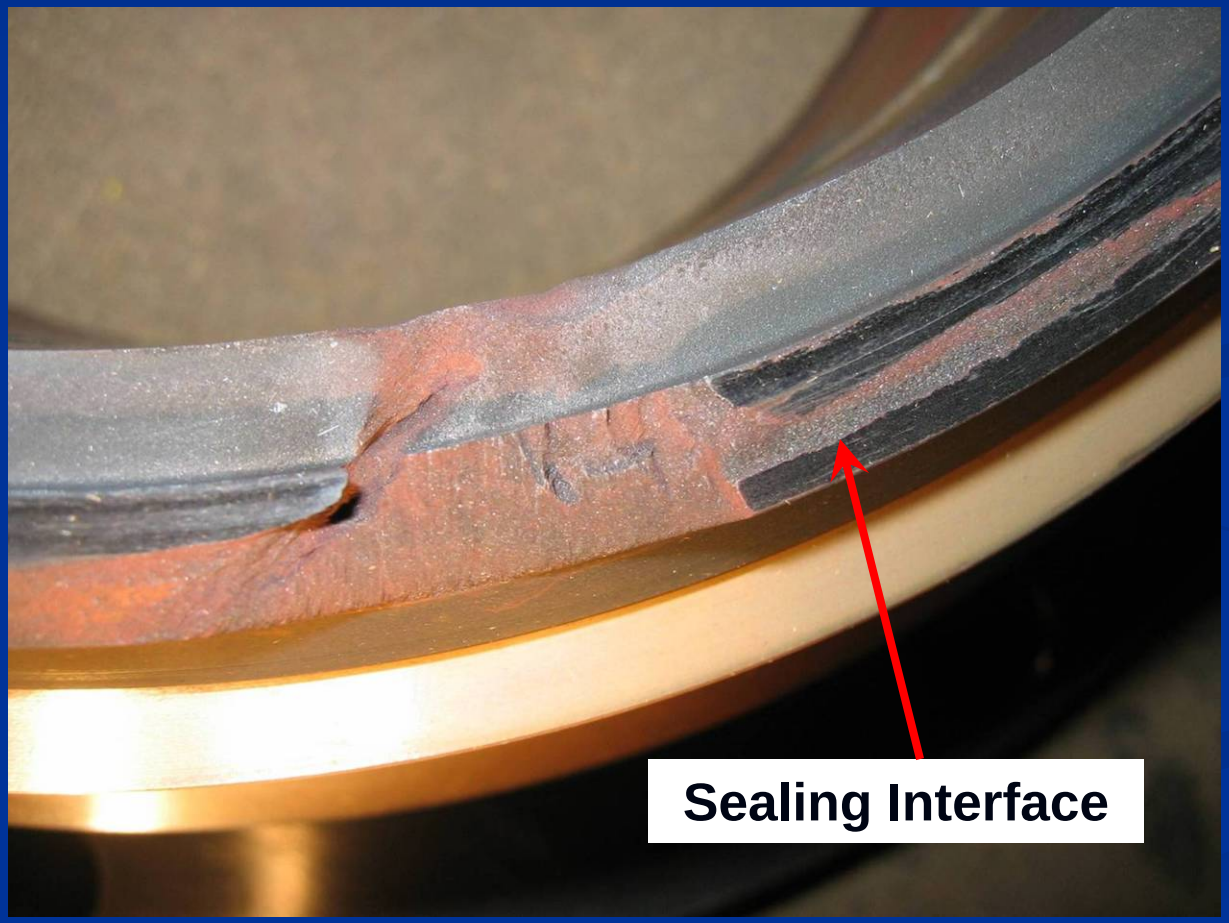
After 3,000 hours, very unpredictable performance, varying per pump. In some cases, seal MTBM was cut in half after each repair!

Background Information

Signs of electrical currents discharging at seal metal parts (sleeve bore) as well as at the seal faces

Material research indicates that electro corrosion initiates material fatigue by extracting binder material from the carbon graphite, leading to subsequent failure

Background Information



Carbon graphite seal ring loosing mechanical integrity.

Building of a so-called ‘flow channel’ at one specific location on the ring’s circumference.

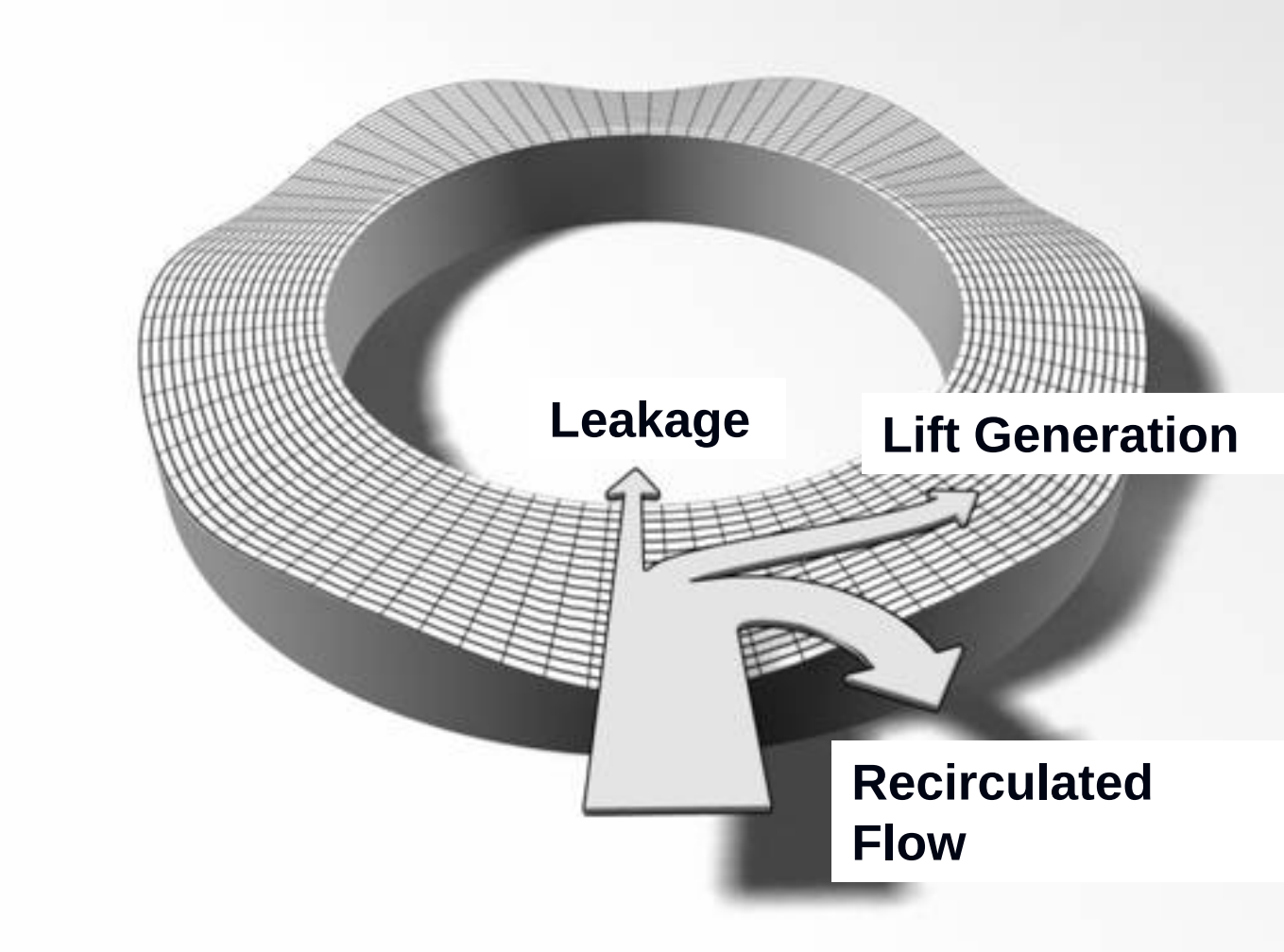
Resulting in increasing seal leakage and temperature rise of the seal loop

Conclusions Drawn (Field and Research)

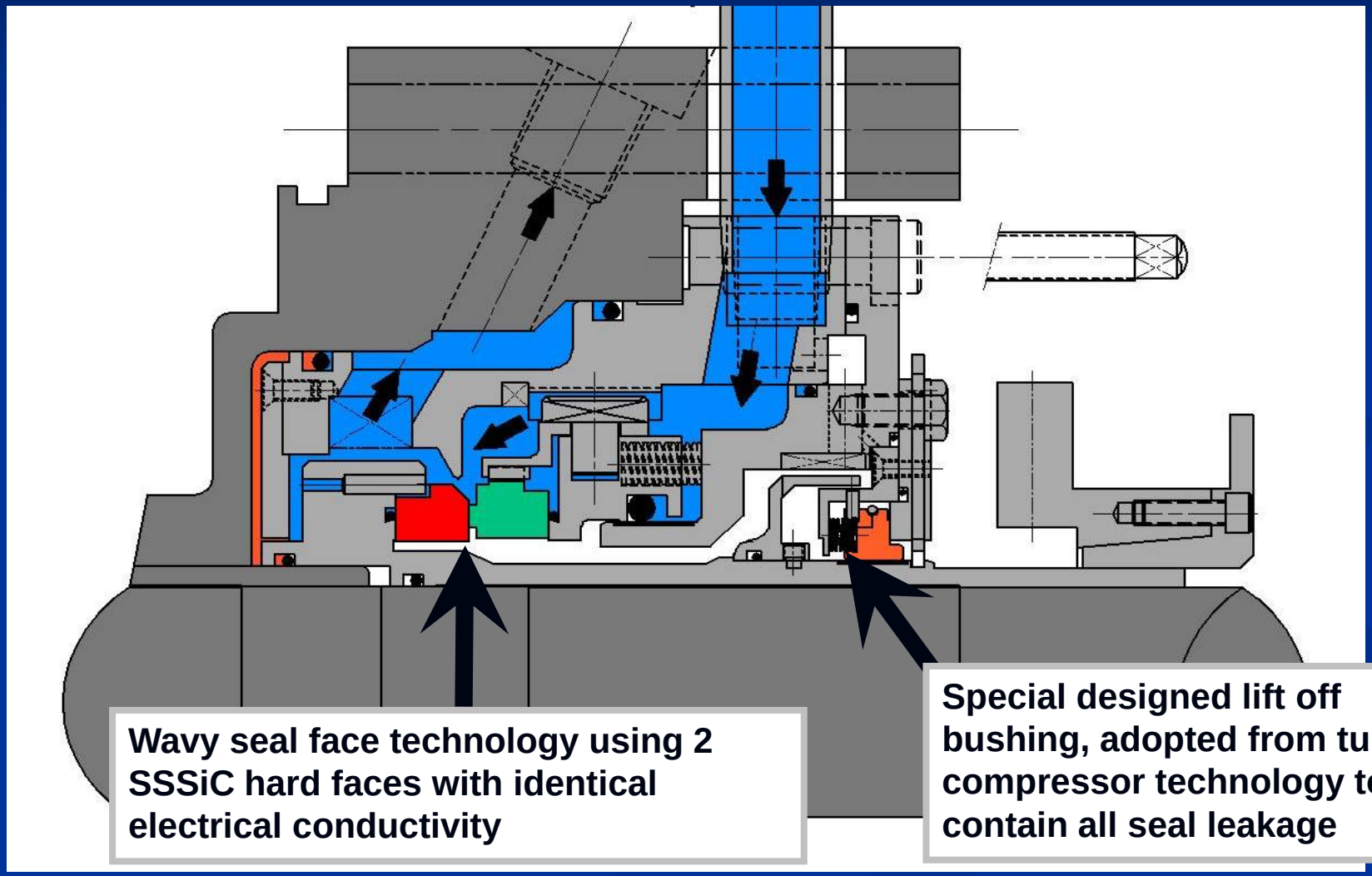
- Key to the solution to avoid electro-corrosion in mechanical seals, is to minimize / eliminate the existence of difference in electrical potential of the 2 seal face materials applied
- Keeping the sealing water temperature as cold as possible, provides a more stable fluid film for the seal faces and also reduces the electro corrosion phenomenon
- Practical experiences have proven that positively grounding the pump rotor, diminishes the electro-corrosion phenomenon.
- Reduction of pump speed also alleviates the problem, but is not regarded as a true practical solution, since it directly influence plant operation/output
- Increasing feed water conductivity by ammonia dosing can increase seal MTBM, but was not allowed by Vattenfall Europe Generation AG & Kg Co. during this specific field trial

The Sealing Solution Applied

Contamination Resistance Circulation Effects Of Waves:



The Sealing Solution Applied



The Sealing Solution Applied

What was done in 2005:

- **Test program included**:
  - Seal performance test with seal faces SSSiC versus SSSiC
  - Bushing test

- **Conditions:**
  - Pressure: 25 bar
  - Temperature: 65°C max.
  - Speed: 300 and 5400 rpm

- **Acceptance criteria:**
  - Leakage rate: 1500 cc/hr max.
  - No deterioration of sealing surfaces

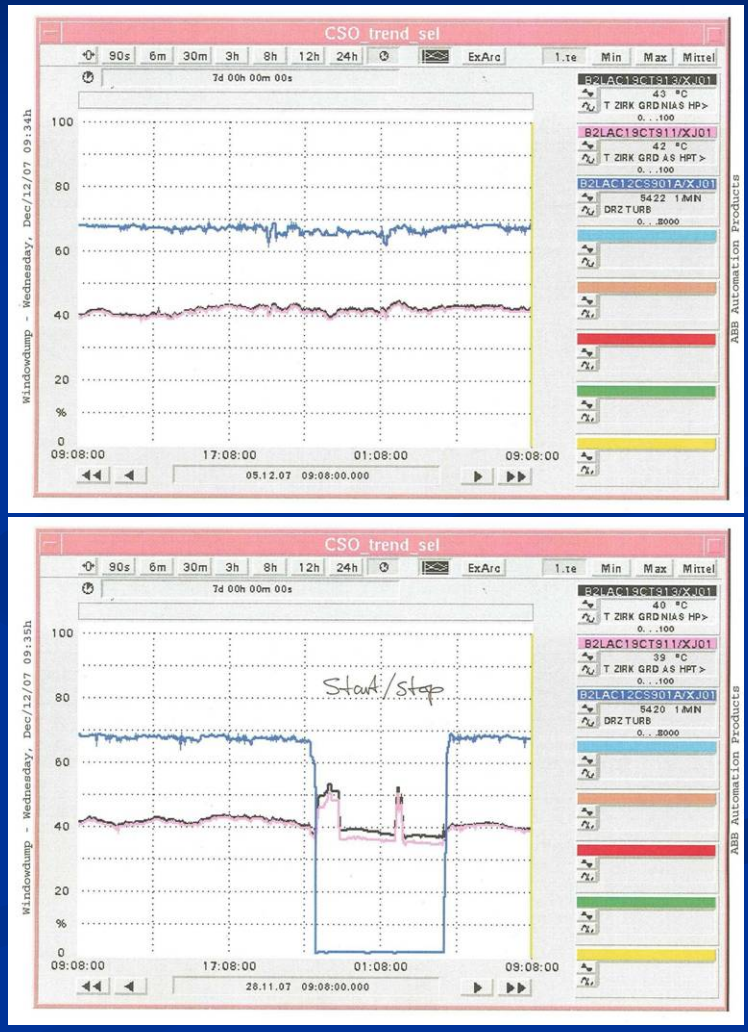
The Sealing Solution Applied

Three differently lasered faces combinations were tested

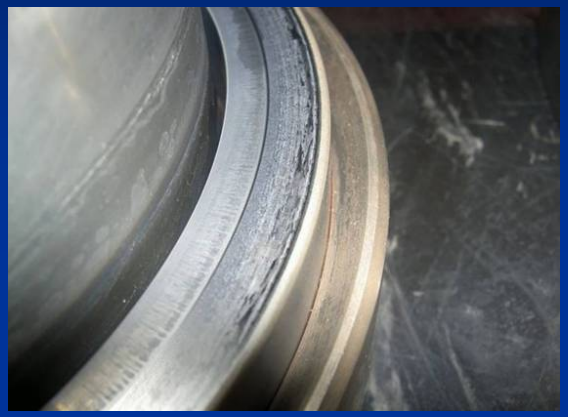
- Seal faces with leakage rates below 500 cc/hr showed wear tracks
- Face with highest leakage rate (1400 cc/hr at 5400 rpm) passed all tests at both 300 and 5400 rpm. These faces looked also excellent after slow roll testing
- Only mechanical seals were exchanged, pump and seal cooling system were not altered in any way

Field Experience

- Seals were running for 15,623 hours, when they were removed on request (used to be only 3,000 hrs. for this particular pump!)
- Initial start up March 2006.
- Reported leakage between 1,000 and 1,500 cc/hr
- Seal loop temperatures very stable, between 40 – 45 °C
- More than 20 starts / stops (local wind turbine feed into grid)
- After 400 hours no signs of electro corrosion found on seal faces!
- No visible leakage is passing the lift off bushing towards bearings

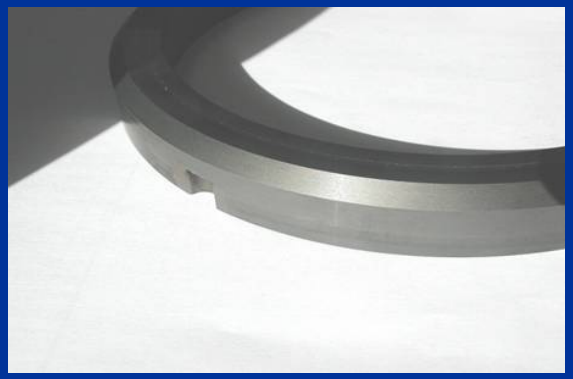


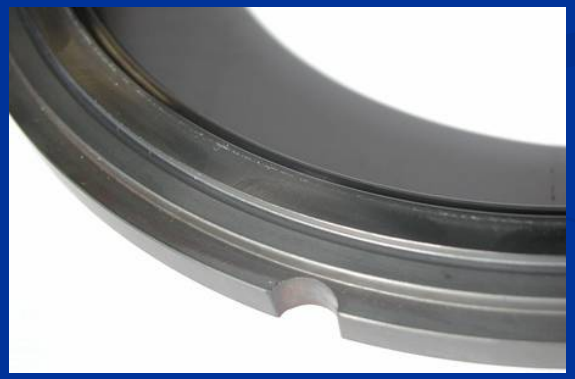
Field Experience



Original seals:

3,000 hrs and failed





Wavy Face seals:

15,623 hrs, no failure

Applied solution eliminates 95% of the electro-corrosion problem, sealing areas faces are almost EC free, no evidence of heavy damages.

Result : Increased Availability & Reliability

Way Forward

SSSiC vs. SSSiC

- Waves on stationary face
- Non-contacting
- Leakages ≈ 1500 cc/hr.
- Special bushing required
- For both conventional and nuclear BFW applications

SSSiC vs. Carbon

- Waves on rotating face
- Minor contacting
- Leakages ≈ 500 cc/hr.
- Normal bushing sufficient
- Special for nuclear (BWR) feed water applications

Questions?

Thank you for your attention!