

Ball valves for extreme high temperature service: design and coating validation by means of bench sessions and performance tests

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Introduction

- Higher and higher performances required in the Oil&Gas field
- High temperature, thermal cycles, high pressures
- Importance of durability and effectiveness

Valve design for High Temperature

Material selection

- Piping class
- Valve data sheet
- Valve Manufacturer Experience



Valve design for High Temperature

Valve type

- Floating ball with stationary seats
- Trunnion-mounted ball with floating seats
- Evaluation of friction and torque values
- Cost impact of the assembly



Valve design for High Temperature

Body construction

- Top Entry



According to piping class and project requirements (Fugitive Emissions, connections, maintenance)

Valve design for High Temperature

Body construction

- Top Entry
- Side Entry



According to piping class and project requirements (Fugitive Emissions, connections, maintenance)

Valve design for High Temperature

Body construction

- Top Entry
- Side Entry
- Fully welded



According to piping class and project requirements (Fugitive Emissions, connections, maintenance)

Valve design for High Temperature

Stem extension

- Heat dissipation
- Preservation of stem gaskets (Fugitive Emissions)
- Preservation of operating device

- Finite Element Analyses

Valve design for High Temperature

Stem extension

- Heat dissipation
- Preservation of stem gaskets (Fugitive Emissions)
- Preservation of operating device

- Finite Element Analyses
- Test sessions

Valve design for High Temperature

Stem extension

- Heat dissipation
- Preservation of stem gaskets (Fugitive Emissions)
- Preservation of operating device

- Finite Element Analyses
- Test sessions
- Internal spreadsheet

Valve design for High Temperature

Seat to ball contact

- Metal-to-metal contact
- Optimization of seat and ball geometry
- Finite Element Analyses in different conditions



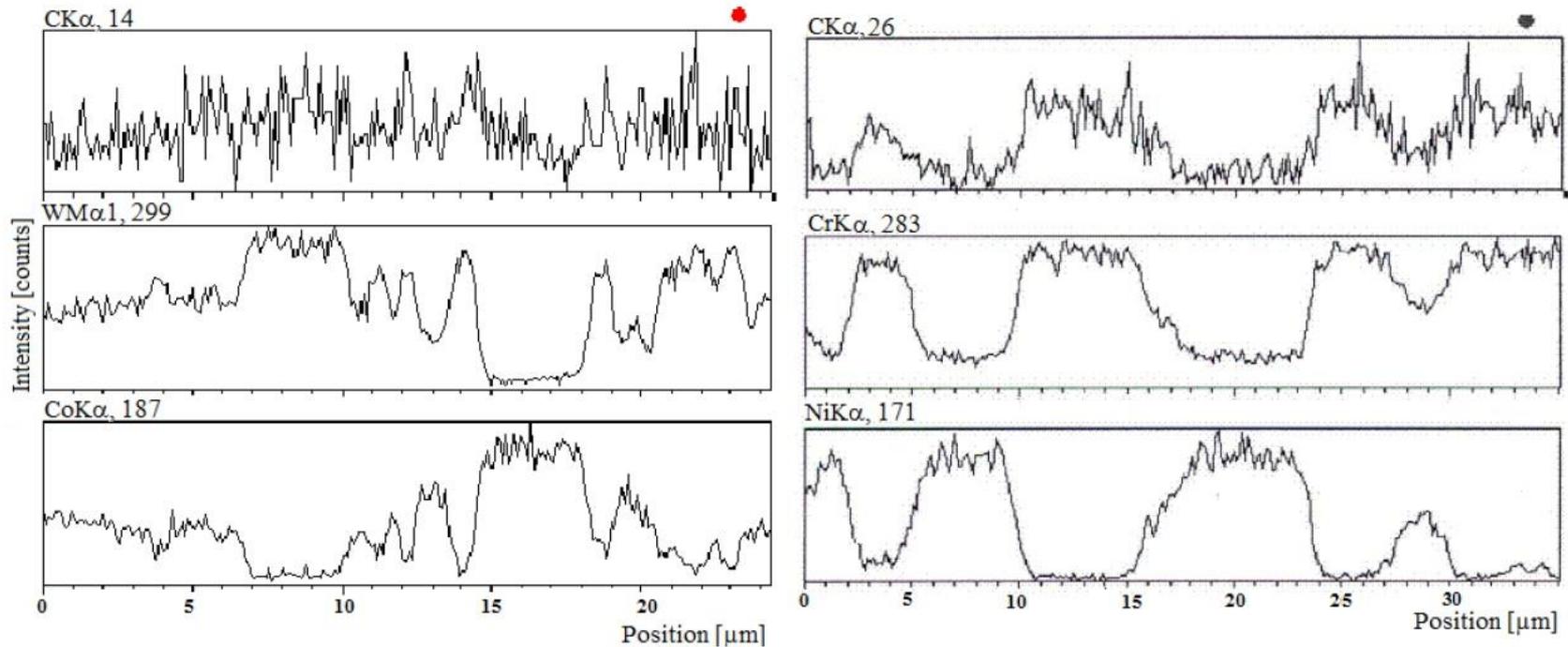
Surface Coatings

- Importance of durability in hard conditions
- Relevance of special coatings for valve metallic parts
- Avoid:
 - Galling
 - Erosion
 - Corrosion

Surface Coatings

Coating characterization: state-of-the-art

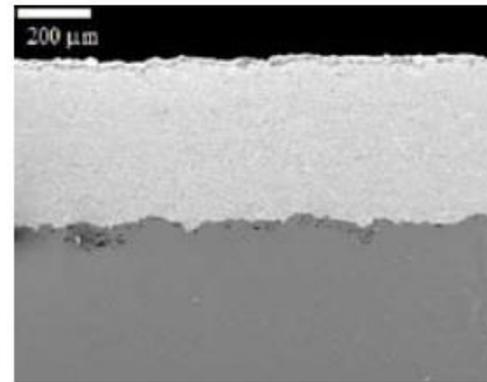
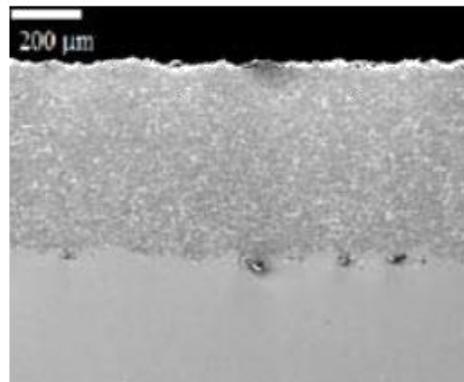
- Chemical characterization



Surface Coatings

Coating characterization: state-of-the-art

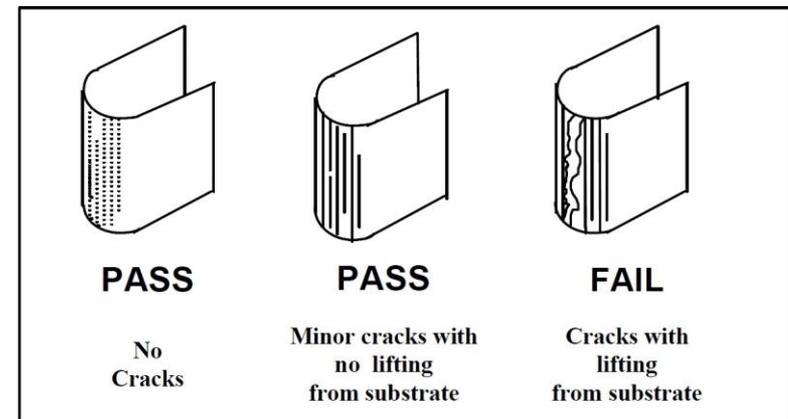
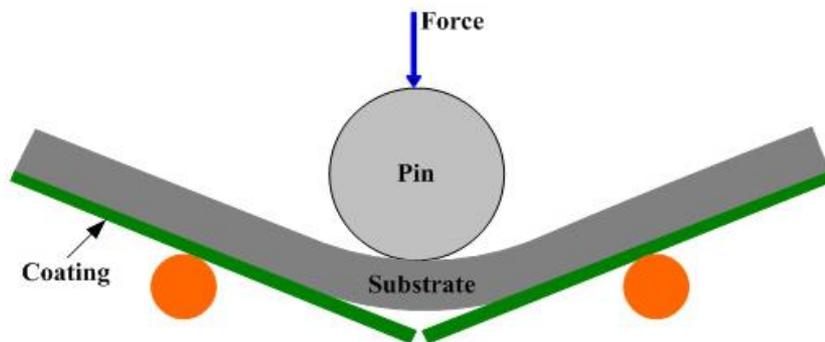
- Chemical characterization
- Metallographic characterization



Surface Coatings

Coating characterization: state-of-the-art

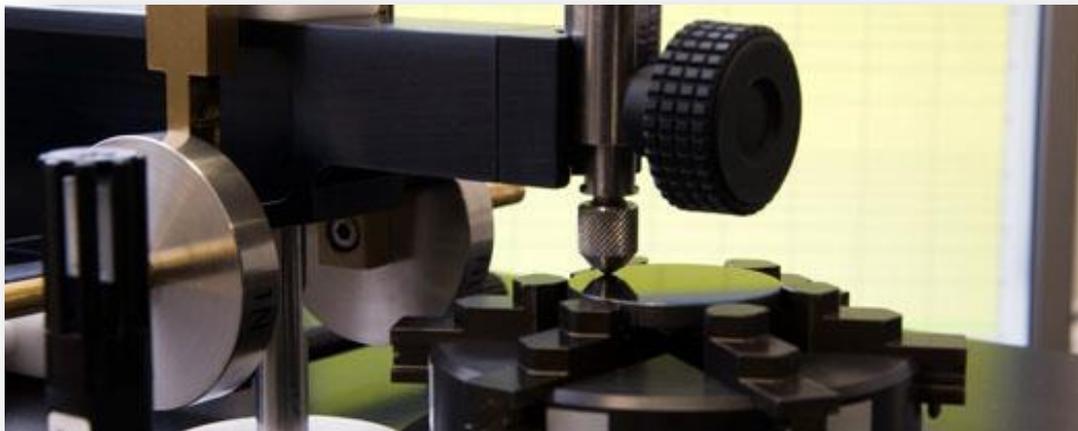
- Chemical characterization
- Metallographic characterization
- Mechanical properties



Surface Coatings

Coating characterization: state-of-the-art

- Chemical characterization
- Metallographic characterization
- Mechanical properties
- Tribological properties



Surface Coatings

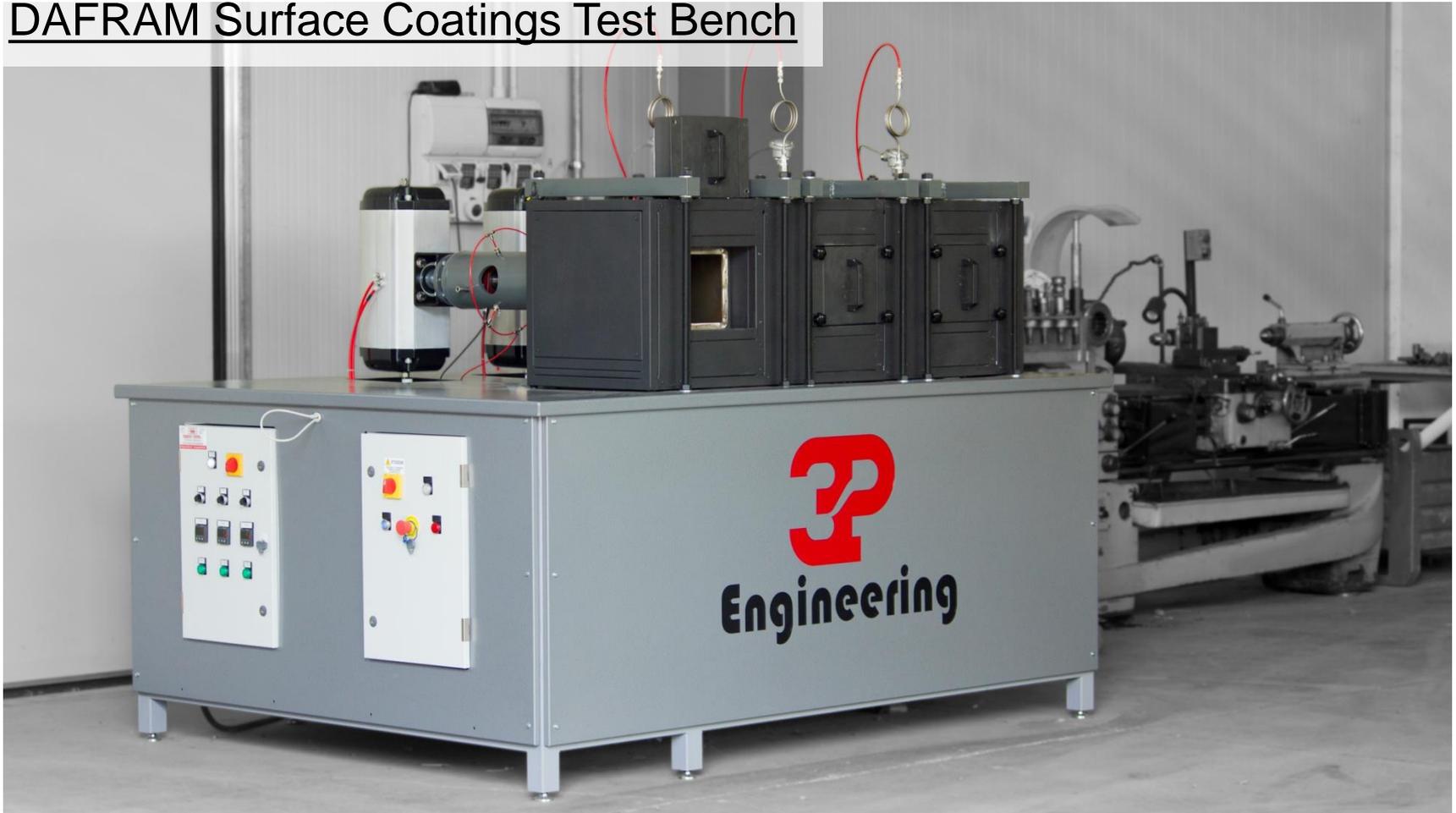
Coating characterization: state-of-the-art

- Nevertheless, traditional analysis presents some limits of adherence to reality
 - Deformations of parts under pressure
 - Contact between ball and seat rings
 - Temperature effects (Process Fluid)



Surface Coatings

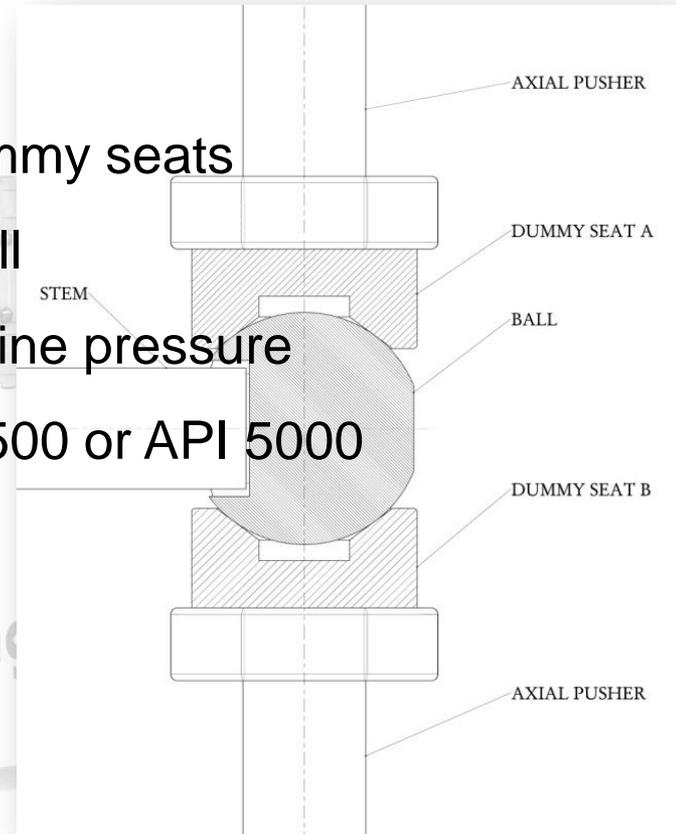
DAFRAM Surface Coatings Test Bench



Surface Coatings

DAFRAM Surface Coatings Test Bench

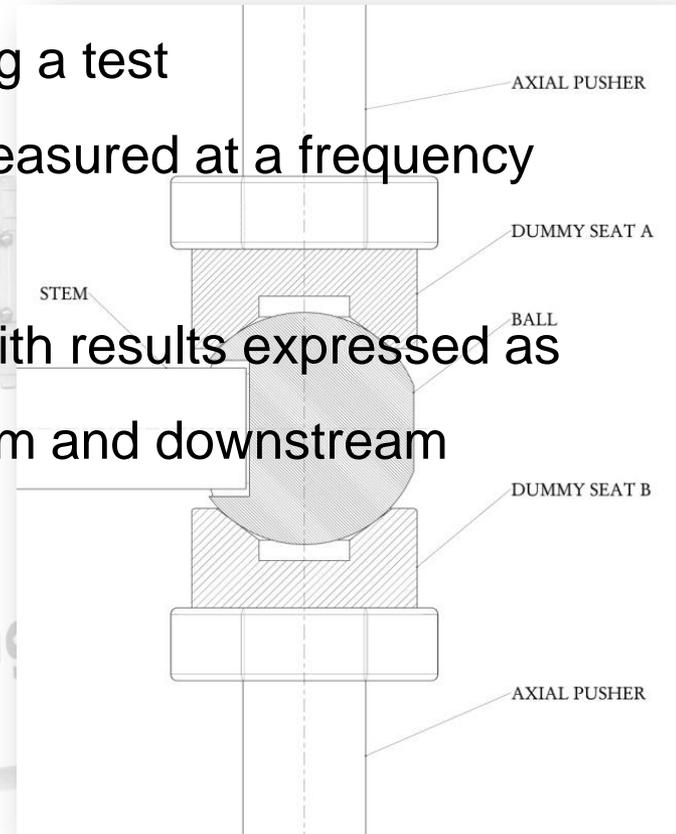
- 3 thermal chambers
- Specimen composed by a ball and two dummy seats
- Standard ball valve actuator moving the ball
- Pneumatic pistons simulating the effect of line pressure
- Equivalent pressure from LP to ANSI CL 2500 or API 5000
- Test temperature up to 650°C
- 9 kW Incoloy-made electrical resistances
- Tests under abrasive media



Surface Coatings

DAFRAM Surface Coatings Test Bench

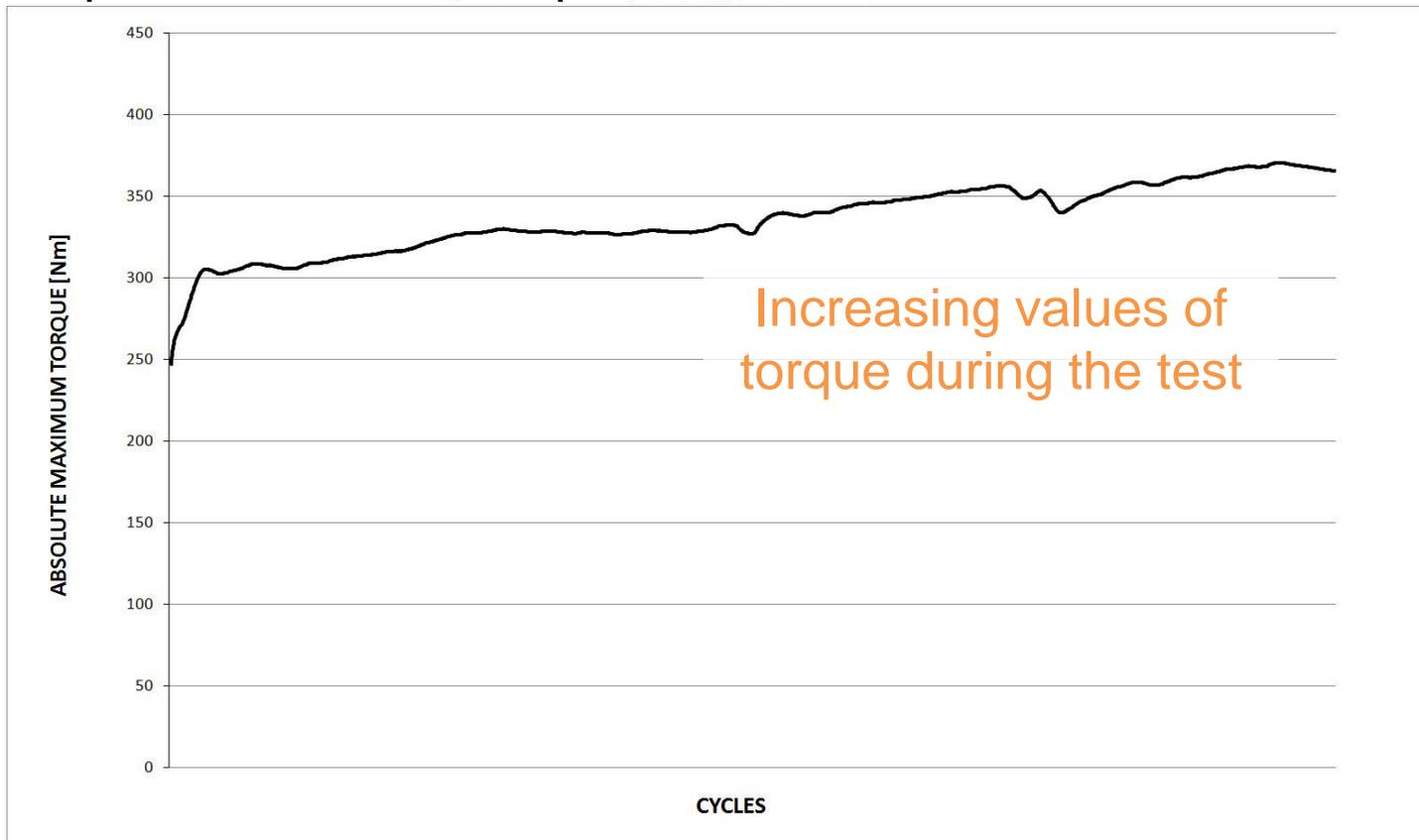
- Thousands of openings and closures during a test
- Actual values of torque, angle and force measured at a frequency of 2500 Hz
- Leak tests conducted at regular intervals with results expressed as Percentage of Pressure Drop from upstream and downstream
- Customized Post Processor



Surface Coatings

DAFRAM Surface Coatings Test Bench

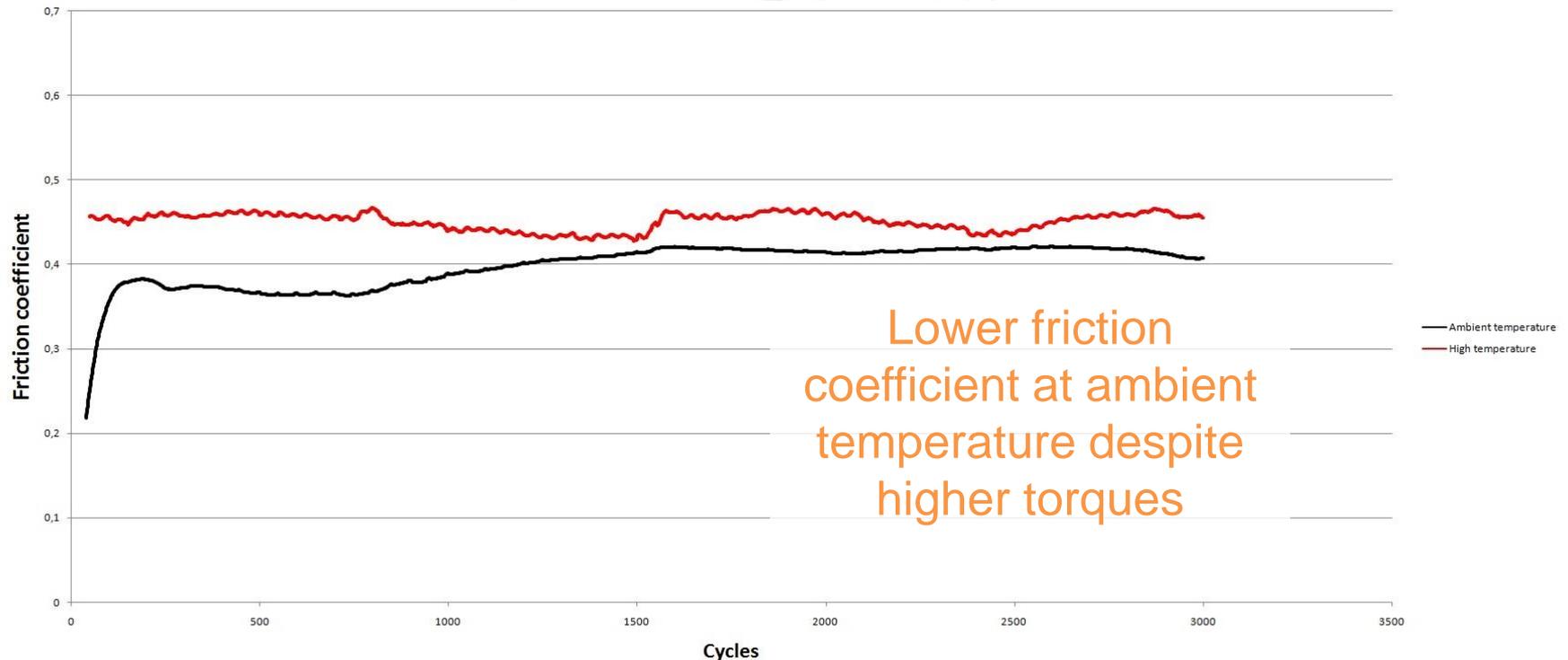
- Example of maximum torque trend



Surface Coatings

DAFRAM Surface Coatings Test Bench

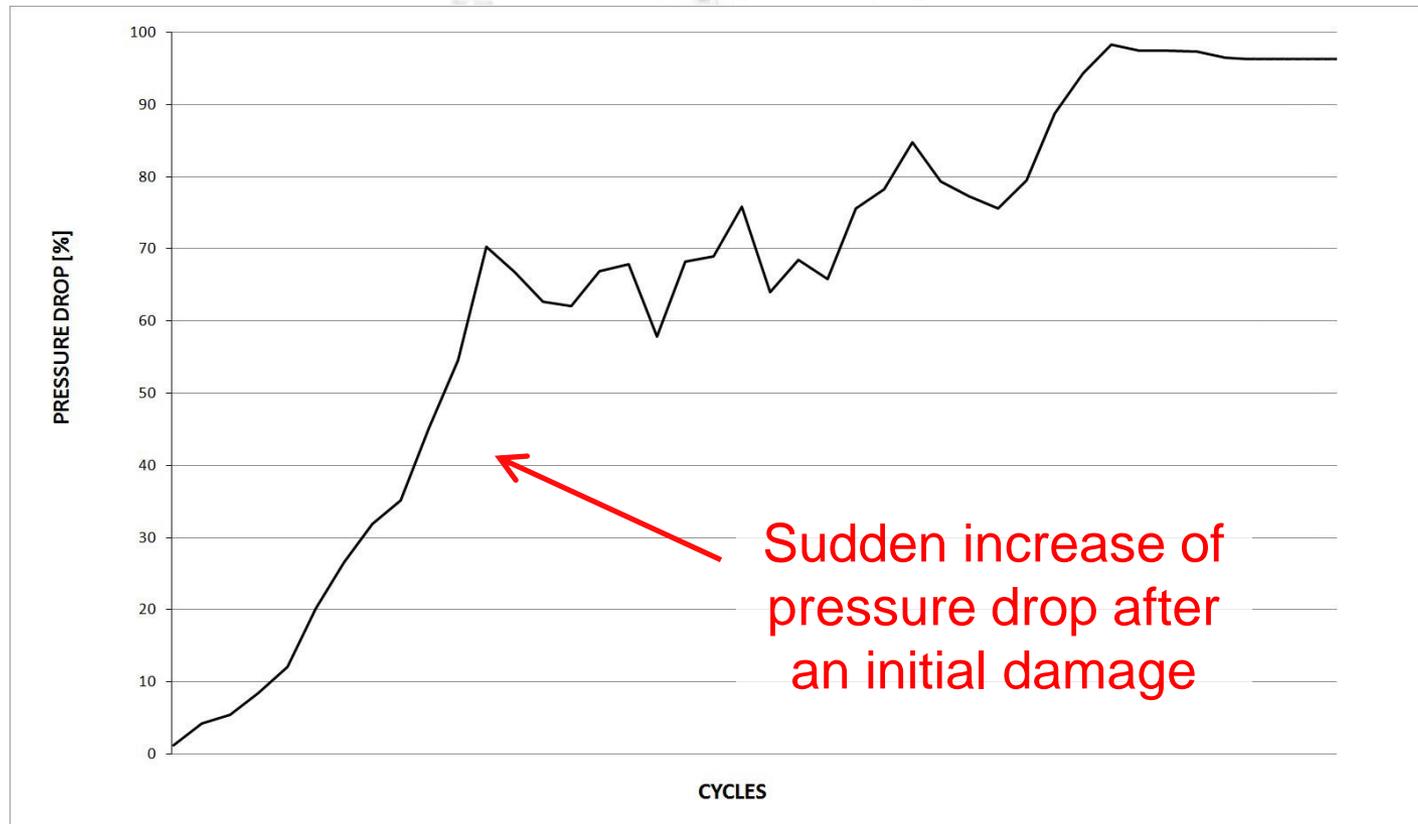
- Example of friction coefficients trend



Surface Coatings

DAFRAM Surface Coatings Test Bench

- Example of leakage trend



Case Study

- Innovative refining process, heavy residues
- ANSI Class 2500, 704 °C maximum temperature
- Body material: ASTM A182 F317
- Trim material: Inconel 718

Objective of Investigation:

- Design validation
- Coating selection (3 alternatives)

Case Study

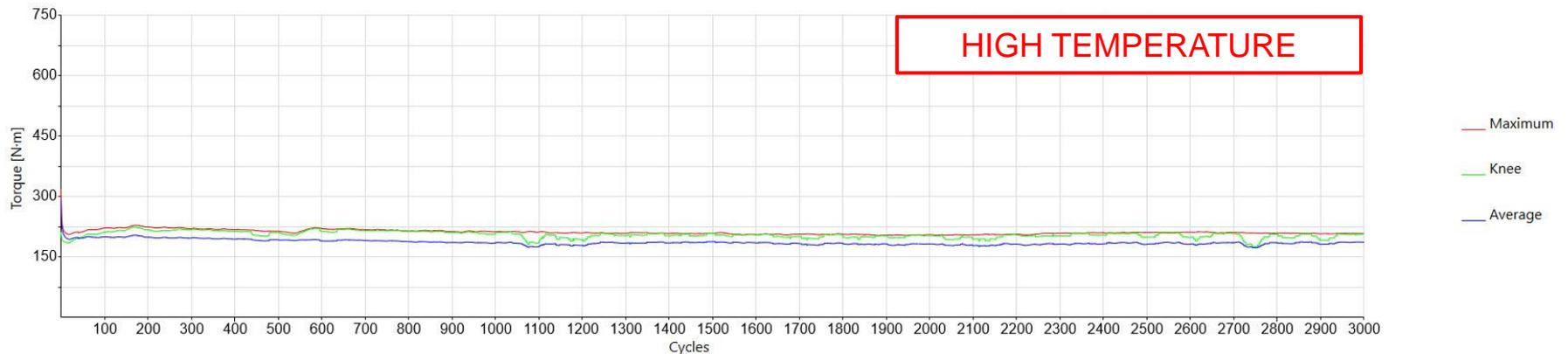
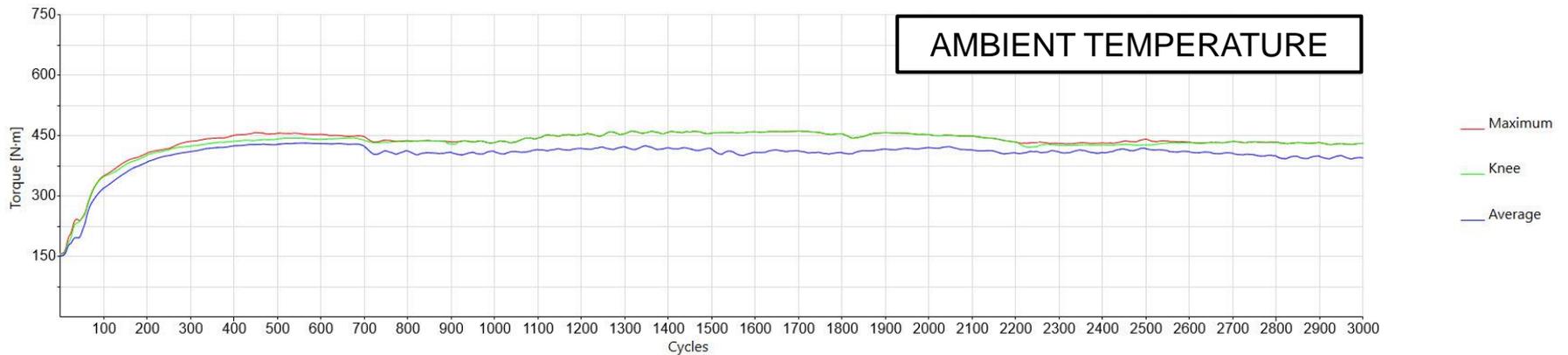
Design validation

- Heat transfer during valve operation
- Thermal analysis of valve components
- Deformations and tightness capability of pressure controlling parts

Case Study

Coating selection

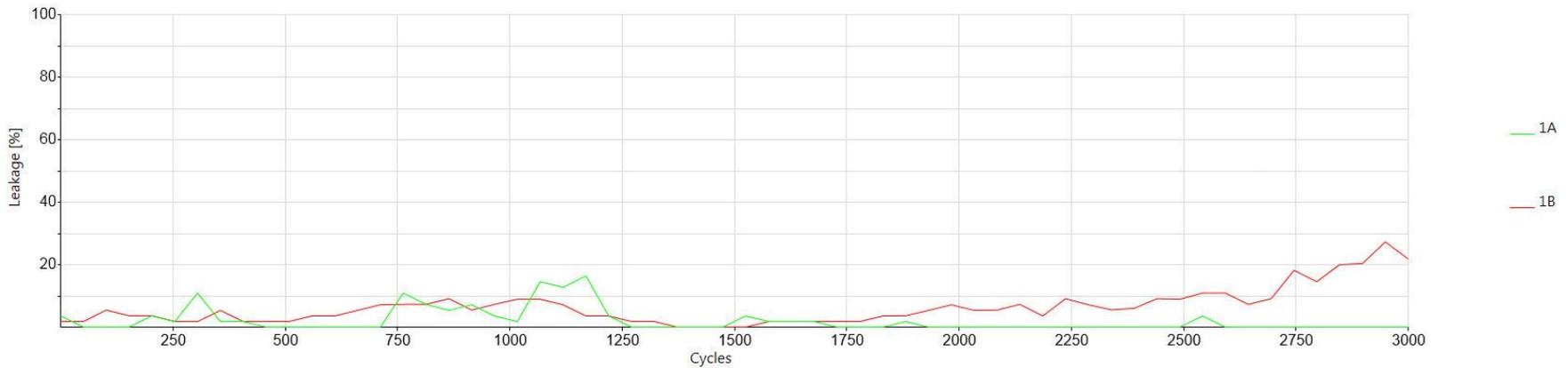
- Coating A: ambient and high temperature (650 °C) torque trends



Case Study

Coating selection

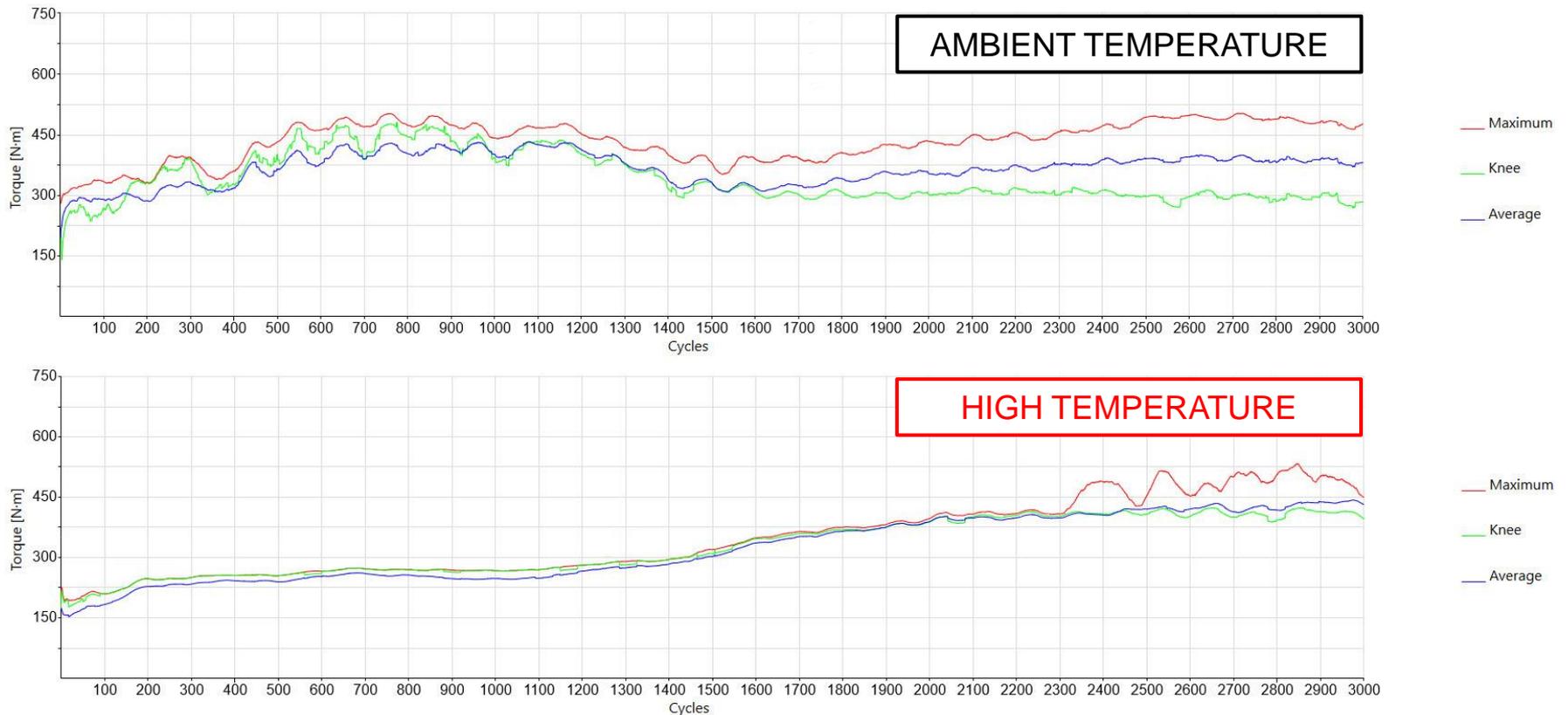
- Coating A: high temperature leakage trend (ball 1, seats A and B)



Case Study

Coating selection

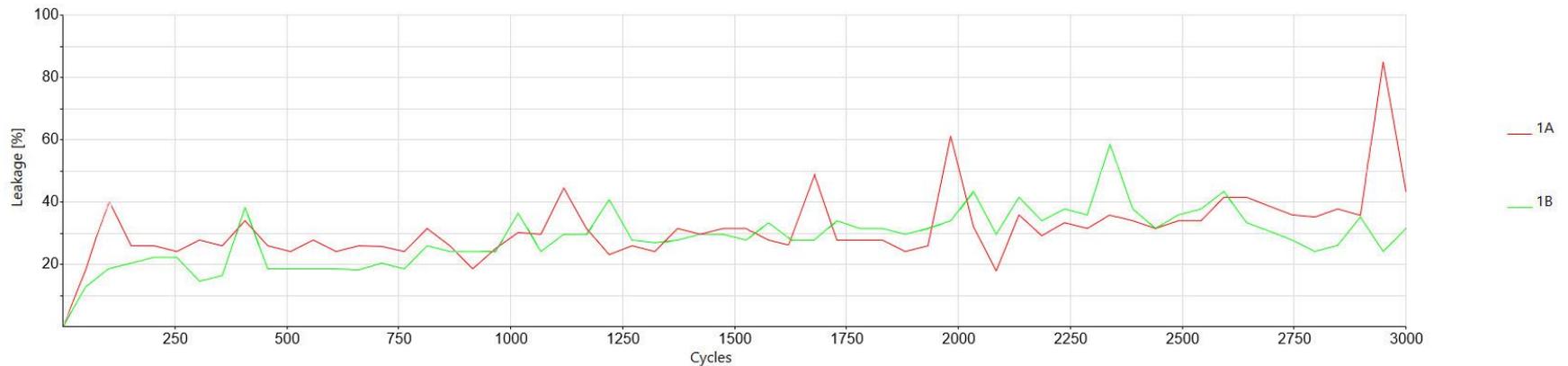
- Coating B: ambient and high temperature (650 °C) torque trends



Case Study

Coating selection

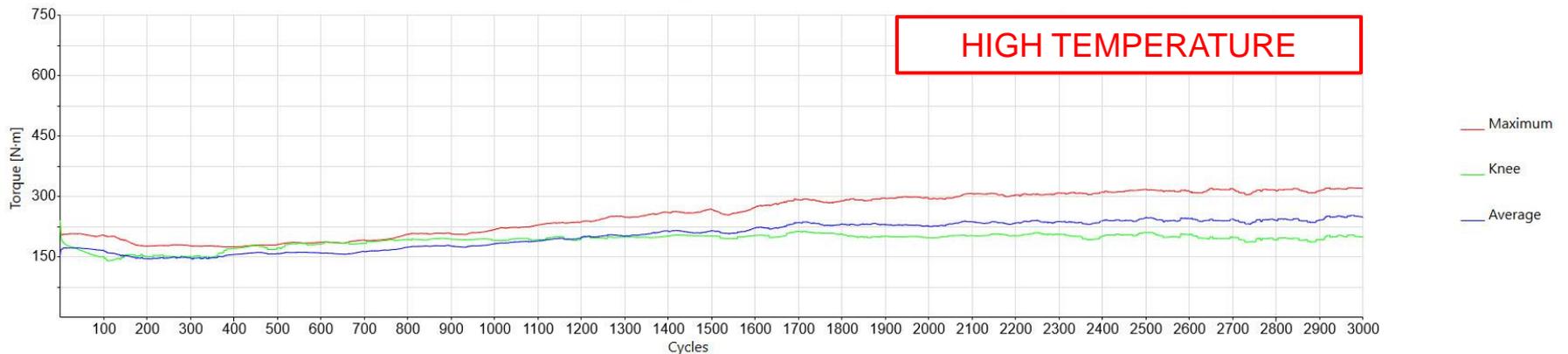
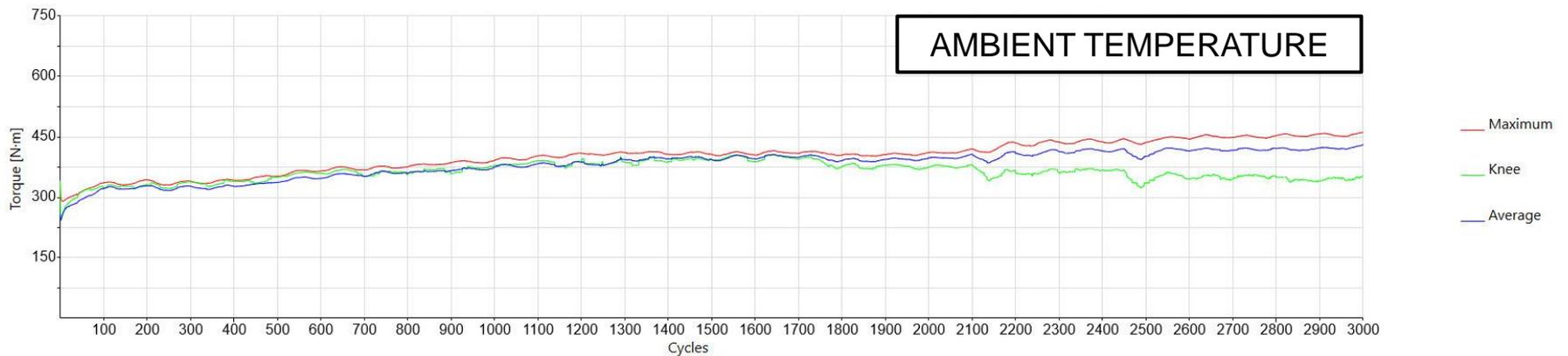
- Coating B: high temperature leakage trend (ball 1, seats A and B)



Case Study

Coating selection

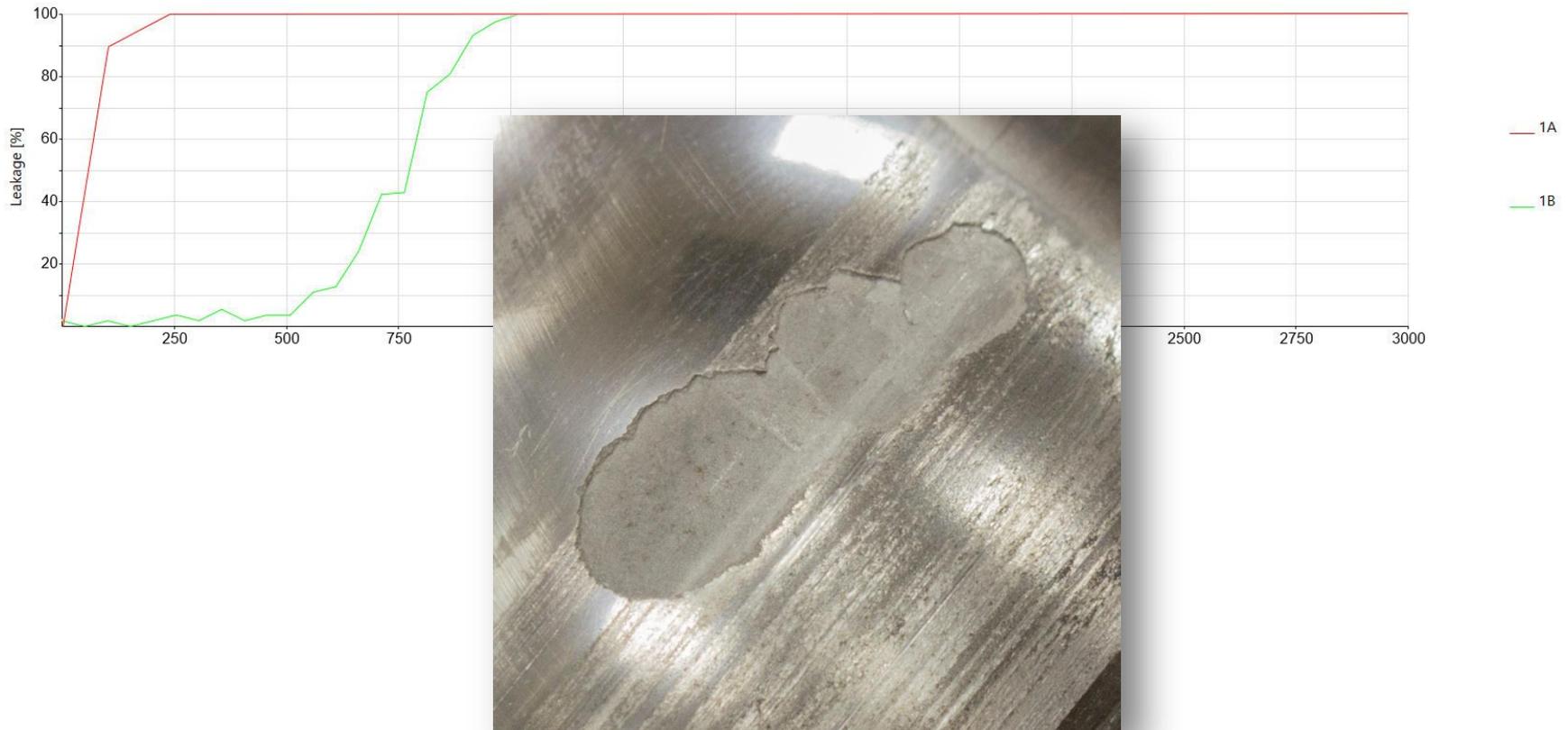
- Coating C: ambient and high temperature (650 °C) torque trends



Case Study

Coating selection

- Coating C: high temperature leakage trend (ball 1, seats A and B)



Case Study

Coating selection

- Coating A: moderate and stable leakage, stable torque. **This coating was selected.**
- Coating B: significant increase of torque value at high temperature.
- Coating C: loss of tightness capability at the very beginning of the test, serious damage of the specimen.

Case Study

Valve Type Test

- Ambient temperature ANSI Class 2500 (414 bar)
- High temperature (704 °C) ANSI Class 2500 (69 bar)
- Temperature distribution monitoring
- Functional and pressure testing:
operation and tightness

Final Conclusions

- High temperature applications: more demanding and frequent
- Valve Manufacturer experience is a starting point
- New approach is required: mix of new tools for design and testing
- Coatings and materials selection is critical for a reliable and effective outcome

Thank you for your attention

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