

# 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
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- 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



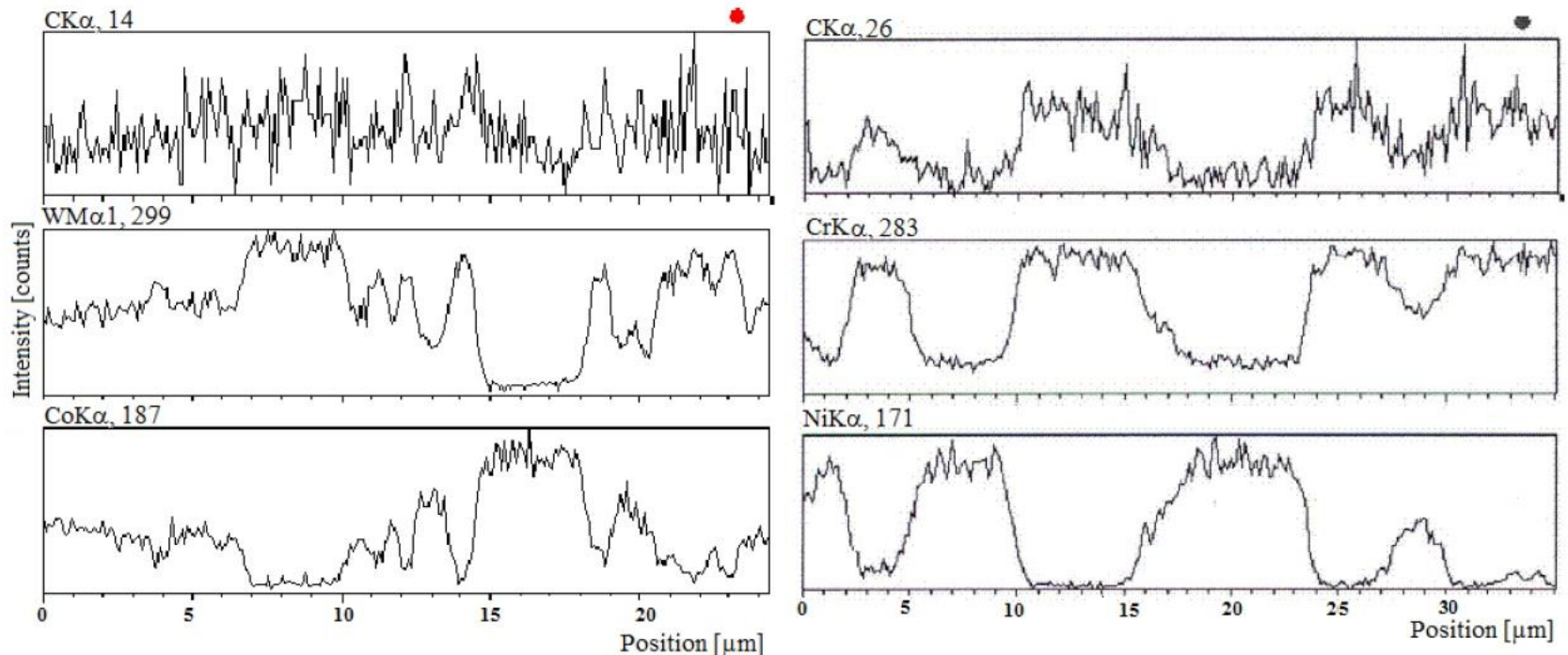
# Surface Coatings

- 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

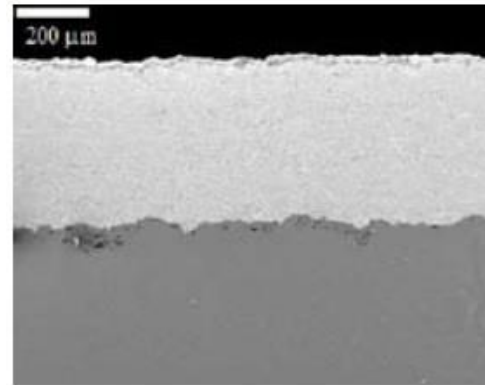
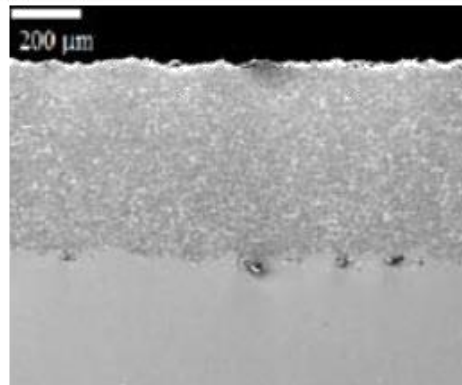
- Chemical characterization



# Surface Coatings

## Coating characterization: state-of-the-art

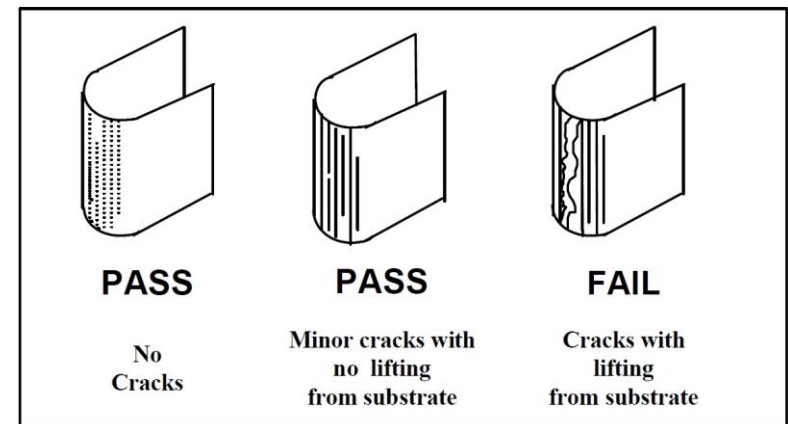
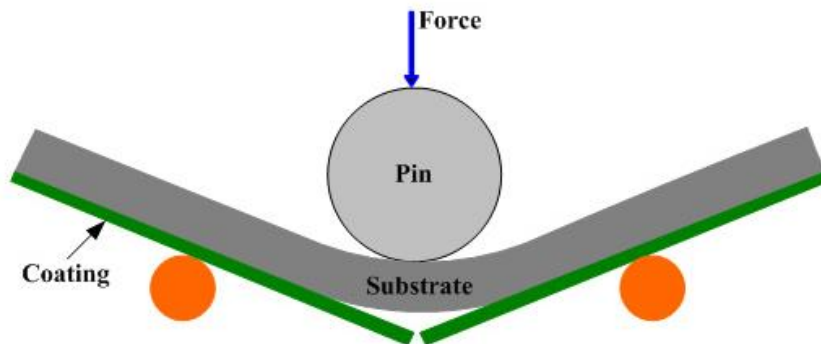
- Chemical characterization
- Metallographic characterization



# Surface Coatings

## Coating characterization: state-of-the-art

- Chemical characterization
- Metallographic characterization
- Mechanical properties

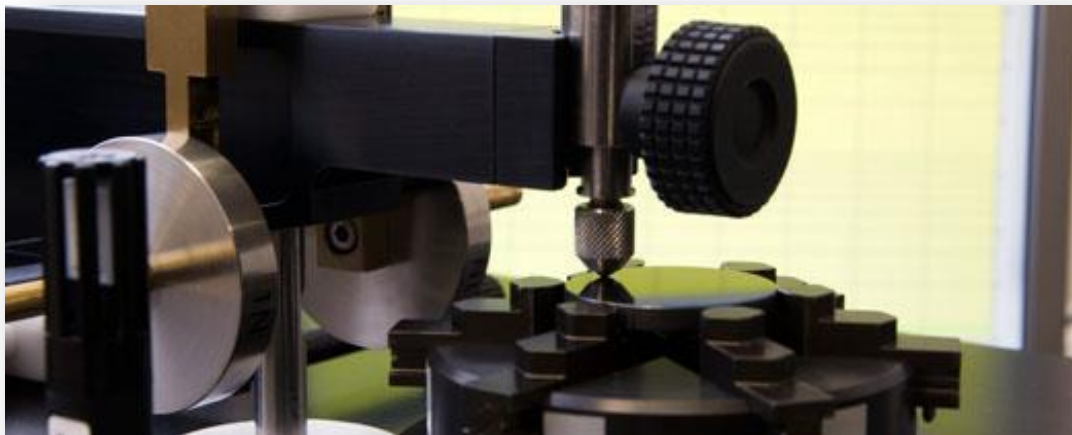




# Surface Coatings

## 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

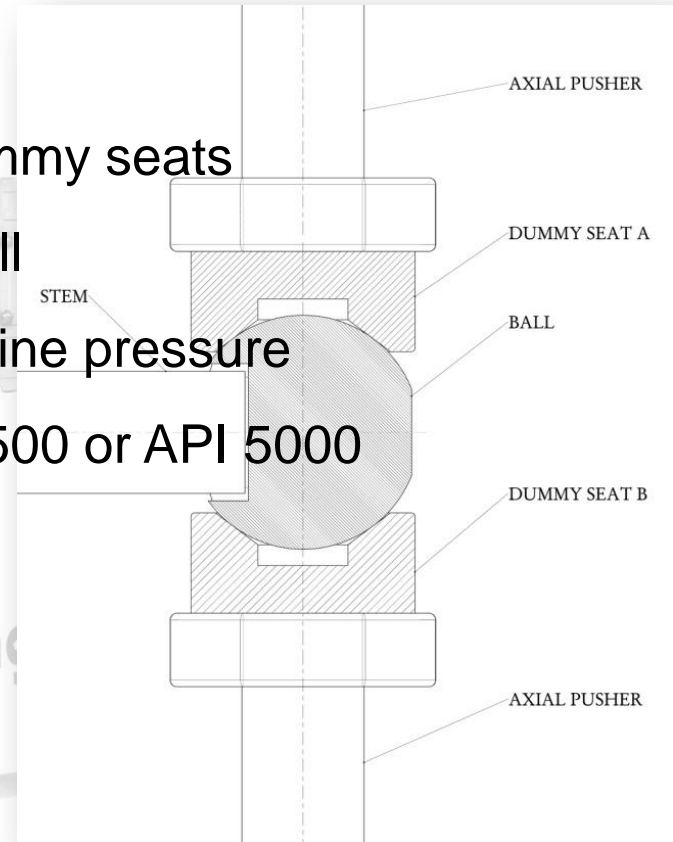
## DAFRAM Surface Coatings Test Bench



# Surface Coatings

## DAFRAM Surface Coatings Test Bench

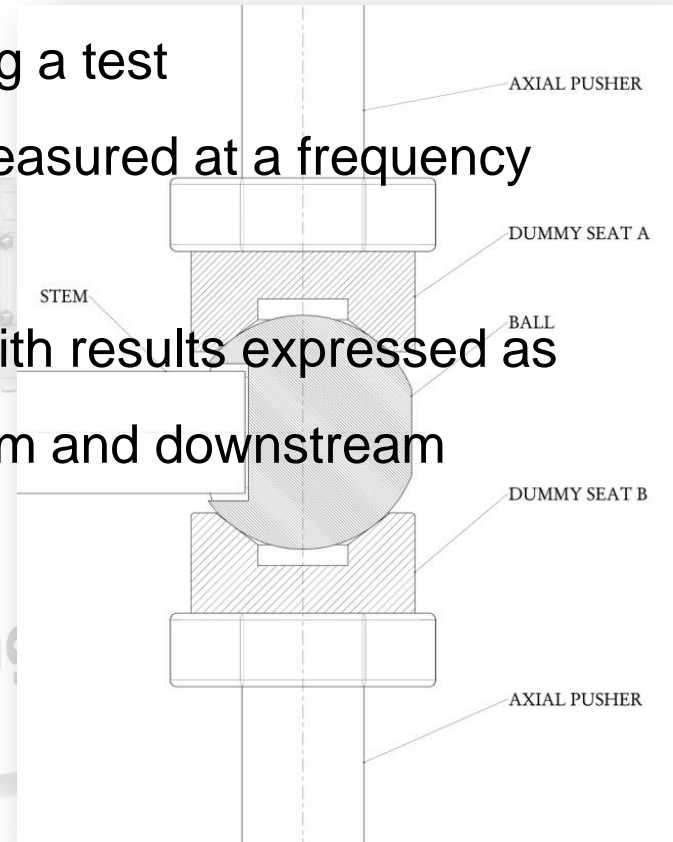
- 3 thermal chambers
- Specimen composed by a ball and two dummy seats
- Standard ball valve actuator moving the ball
- Pneumatic pistons simulating the effect of line pressure
- Equivalent pressure from LP to ANSI CL 2500 or API 5000
- Test temperature up to 650°C
- 9 kW Incoloy-made electrical resistances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



# Surface Coatings

## DAFRAM Surface Coatings Test Bench

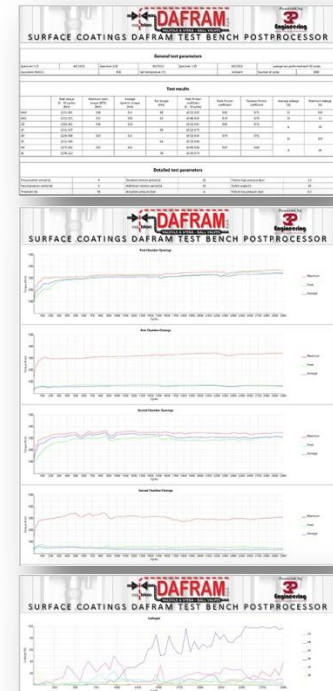
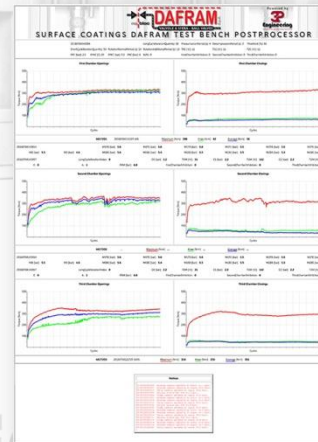
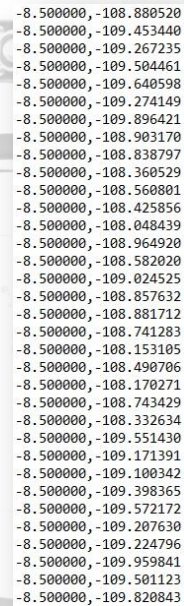
- Thousands of openings and closures during a test
- Actual values of torque, angle and force measured at a frequency of 2500 Hz
- Leak tests conducted at regular intervals with results expressed as Percentage of Pressure Drop from upstream and downstream
- Customized Post Processor





## Results

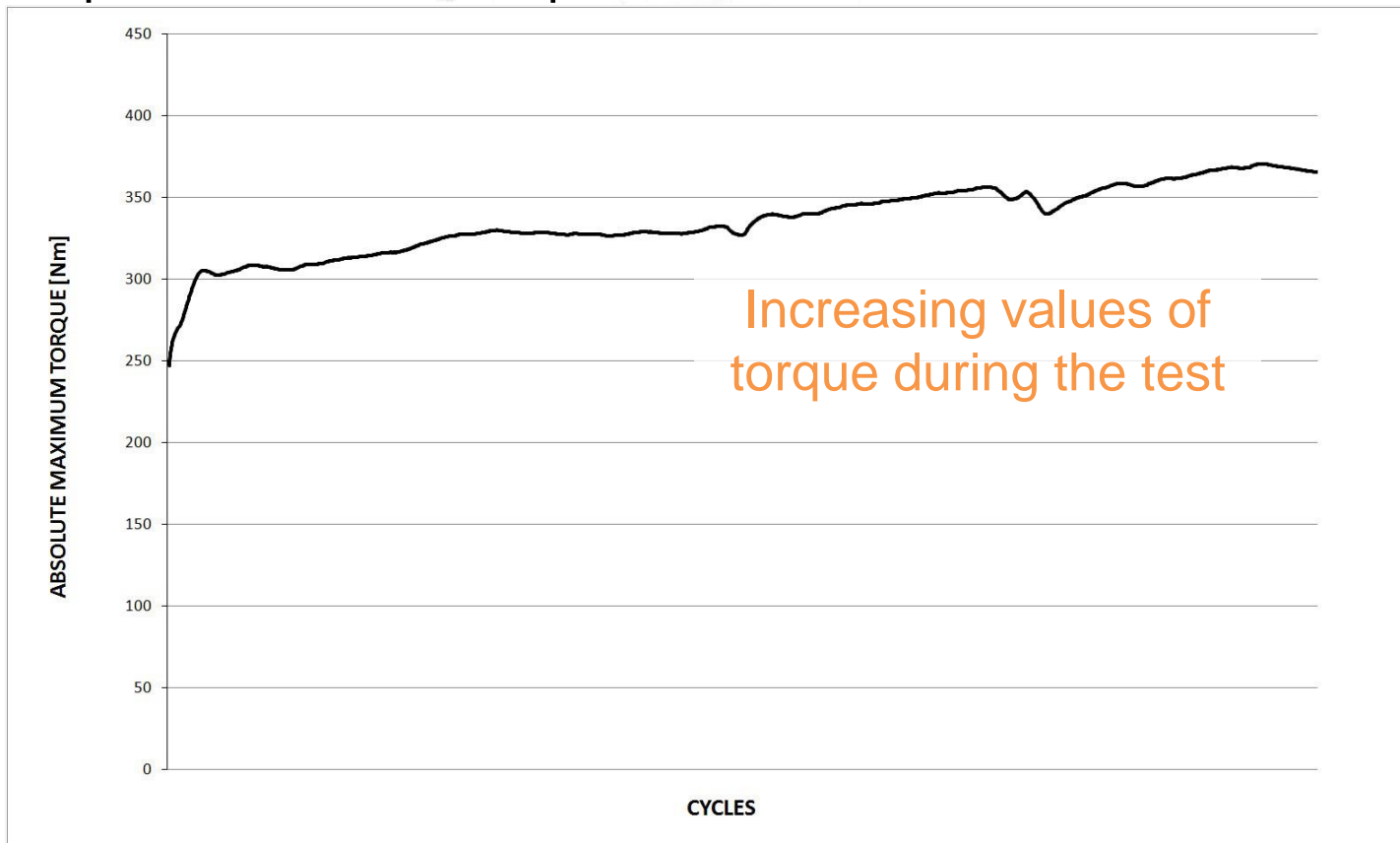
### Filtering & Data Presentation



# Surface Coatings

## DAFRAM Surface Coatings Test Bench

- Example of maximum torque trend

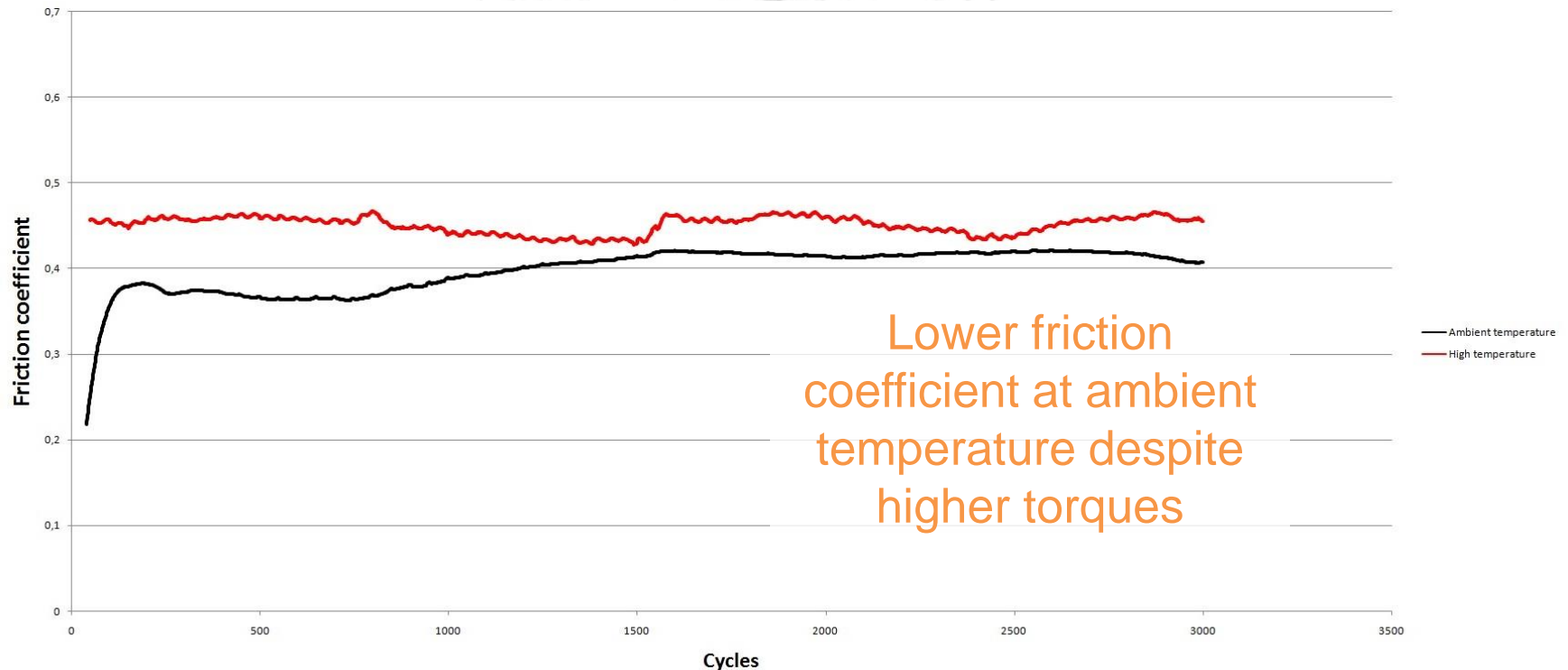




# Surface Coatings

## DAFRAM Surface Coatings Test Bench

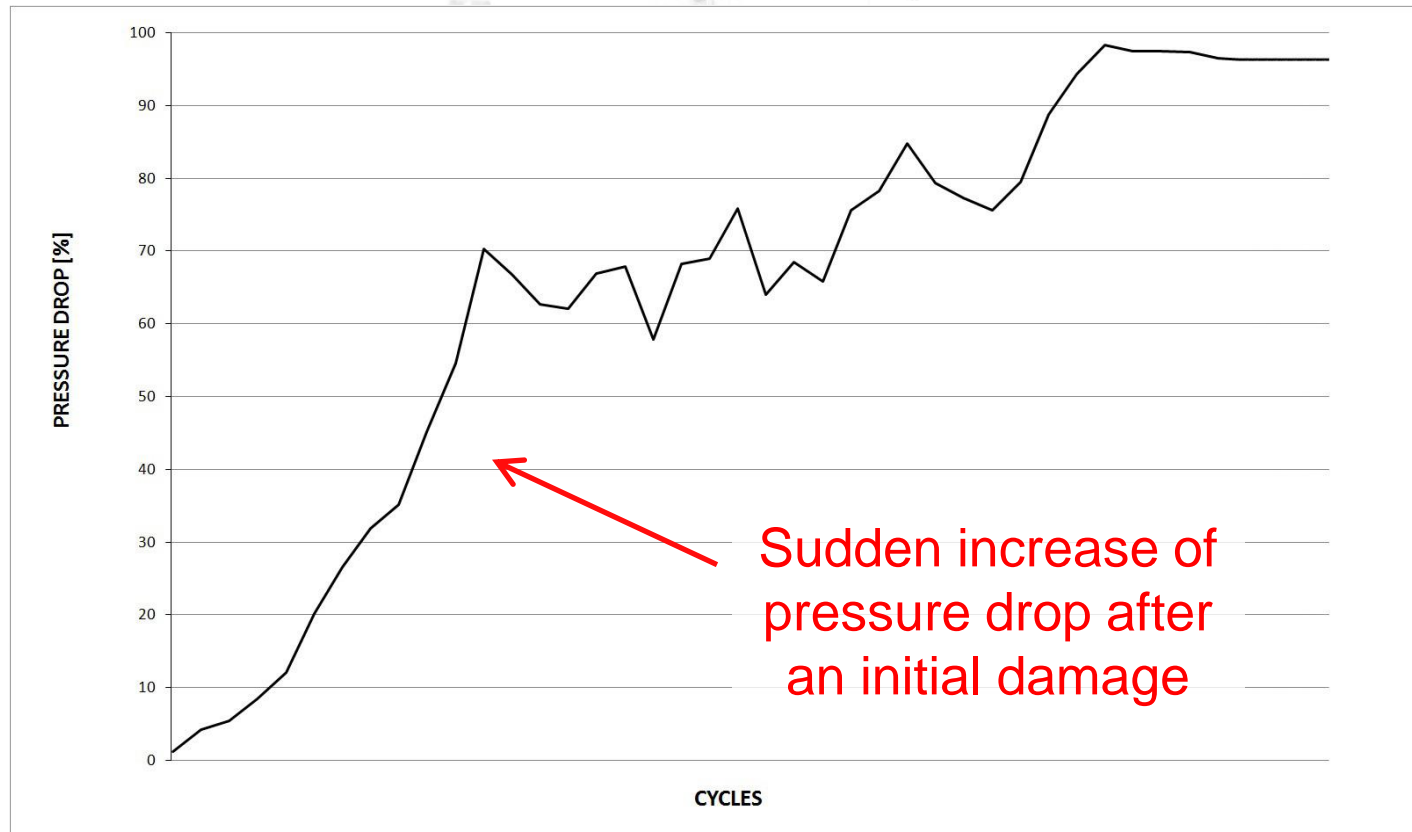
- Example of friction coefficients trend



# 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

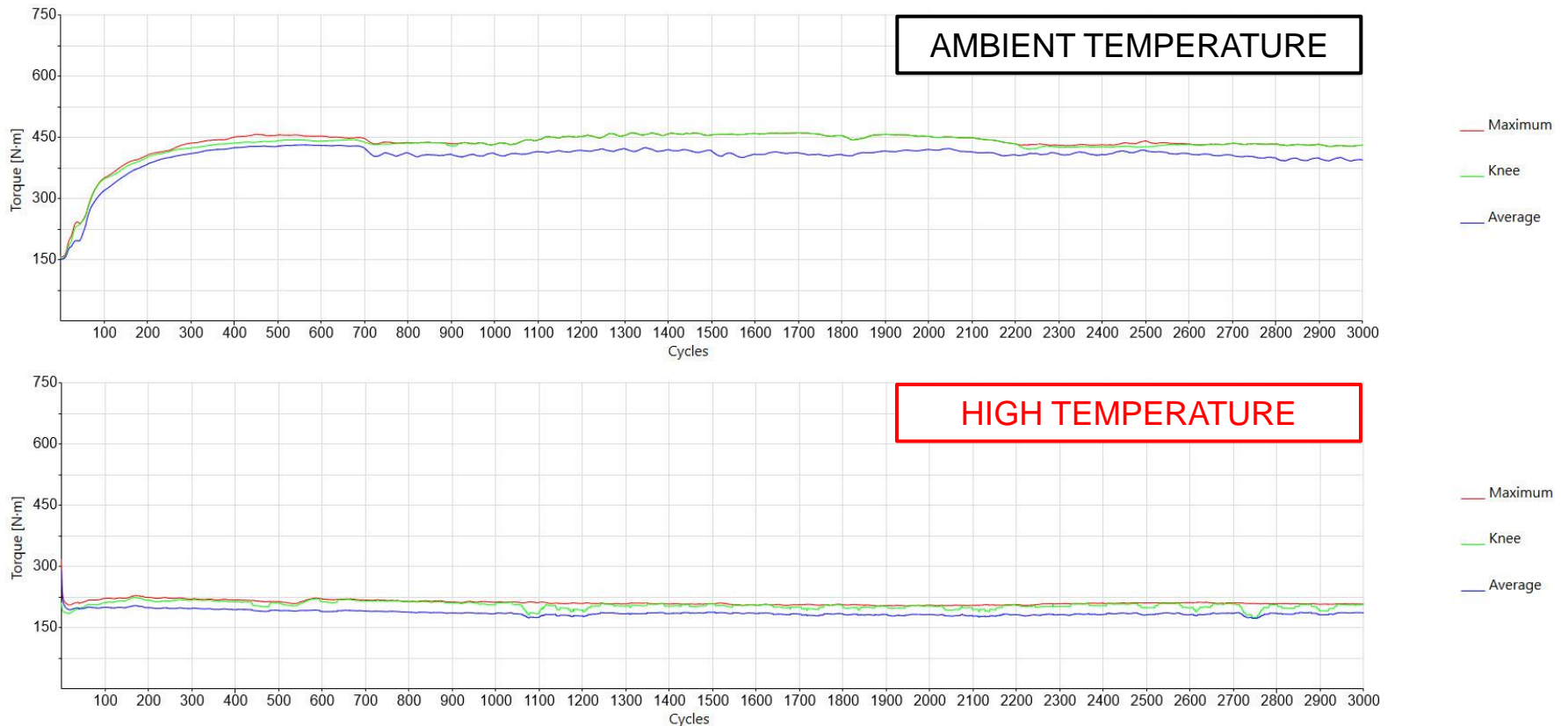
## Design validation

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

# Case Study

## Coating selection

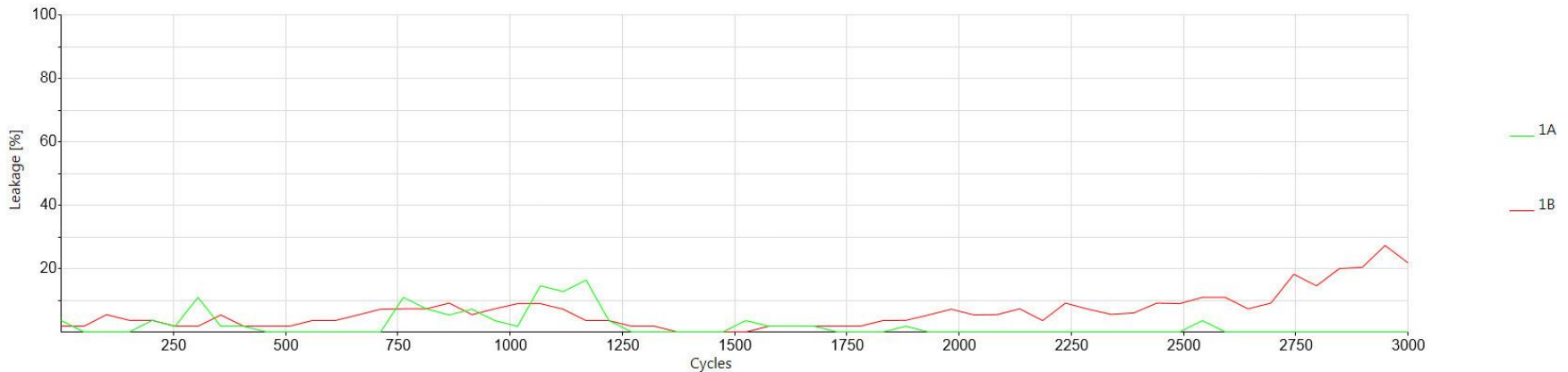
- Coating A: ambient and high temperature (650 °C) torque trends



# Case Study

## Coating selection

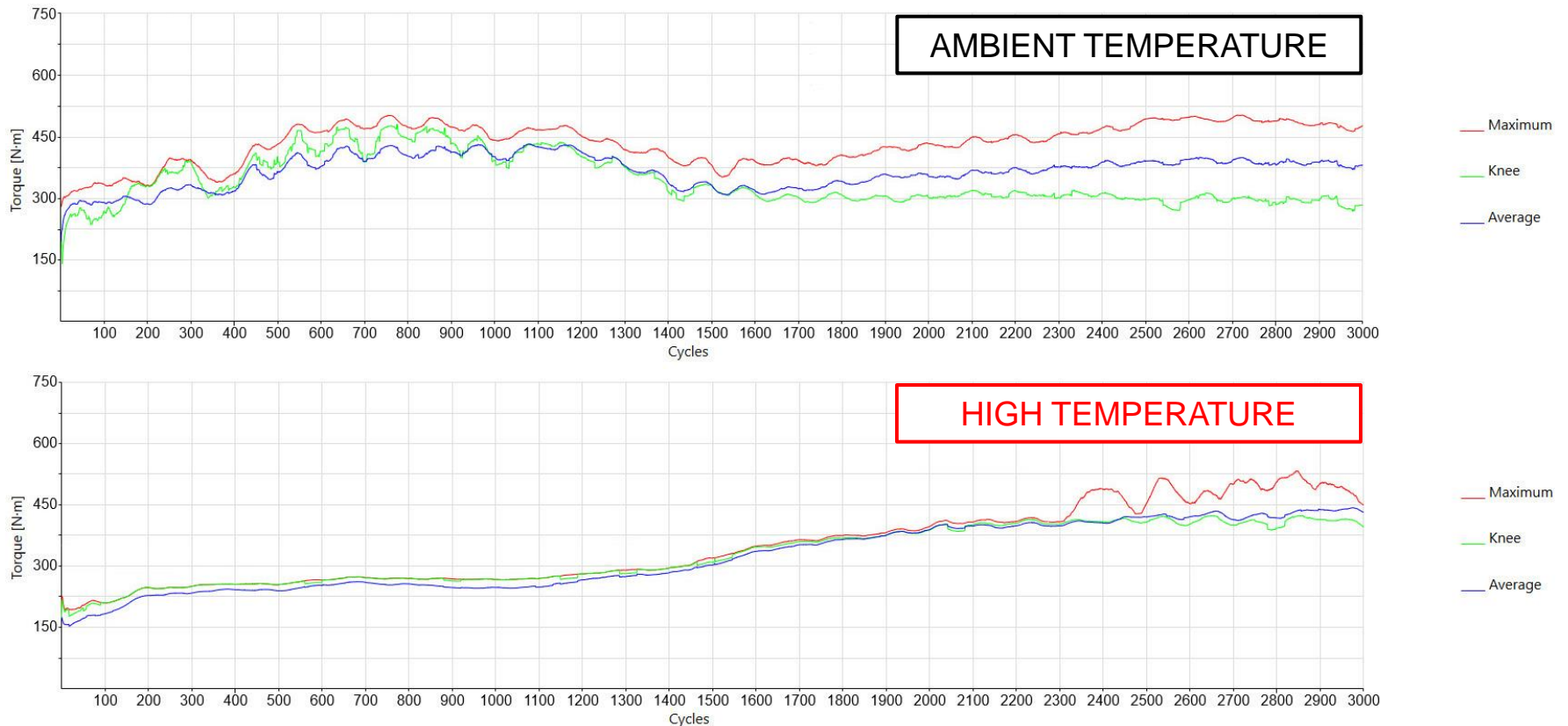
- Coating A: high temperature leakage trend (ball 1, seats A and B)



# Case Study

## Coating selection

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

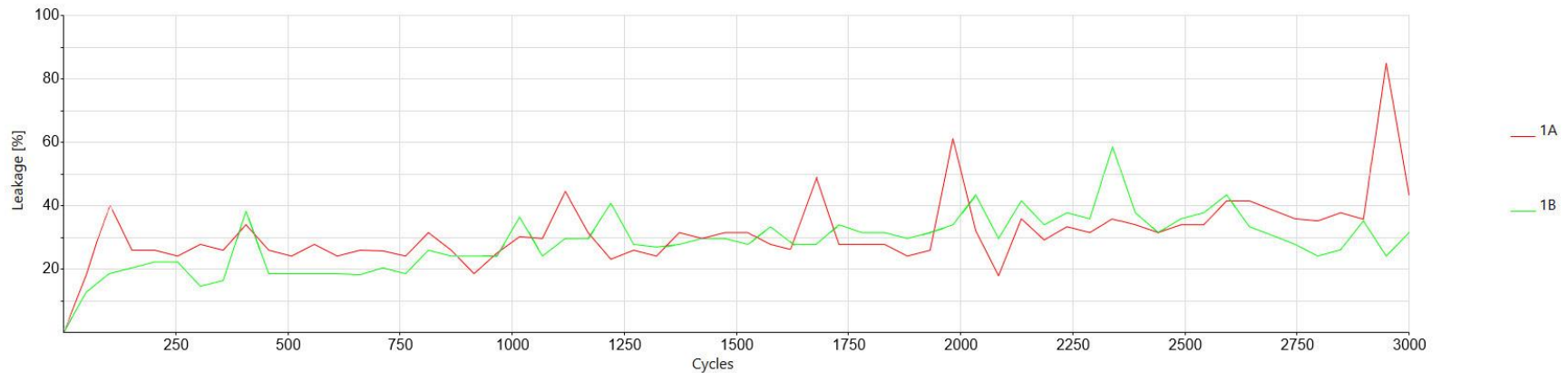




# Case Study

## Coating selection

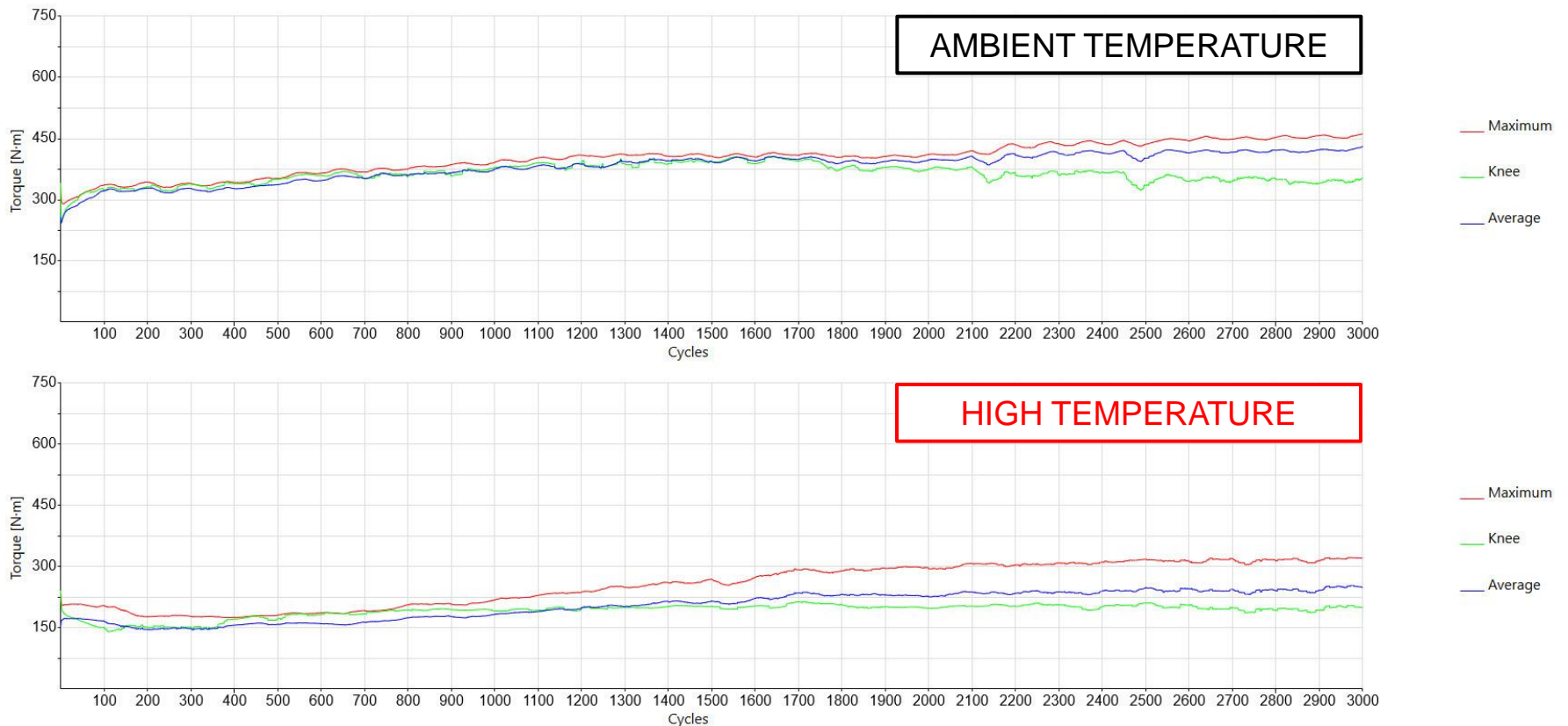
- Coating B: high temperature leakage trend (ball 1, seats A and B)



# Case Study

## Coating selection

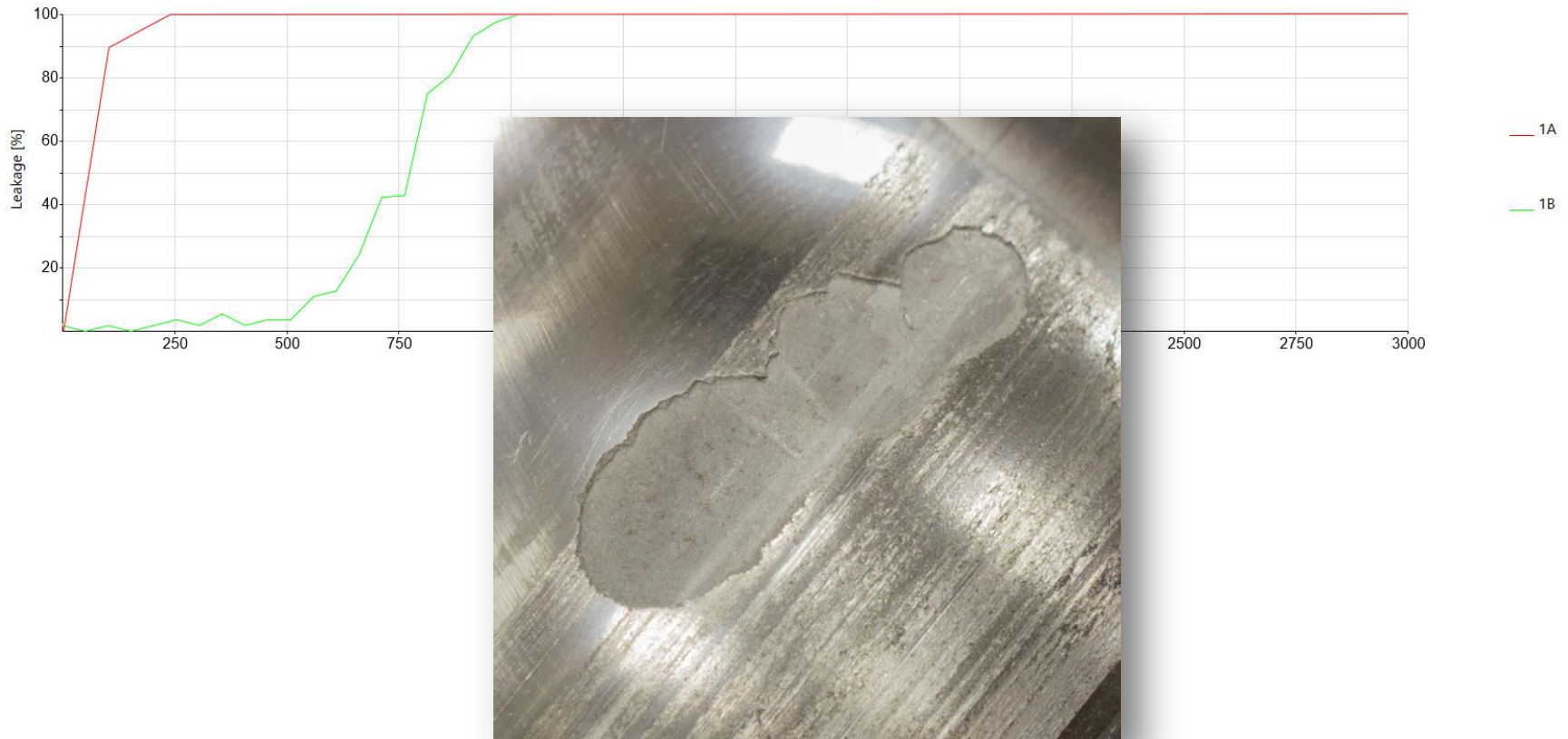
- Coating C: ambient and high temperature (650 °C) torque trends



# 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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