Special coatings for severe service: experimental approach by DAFRAM test bench

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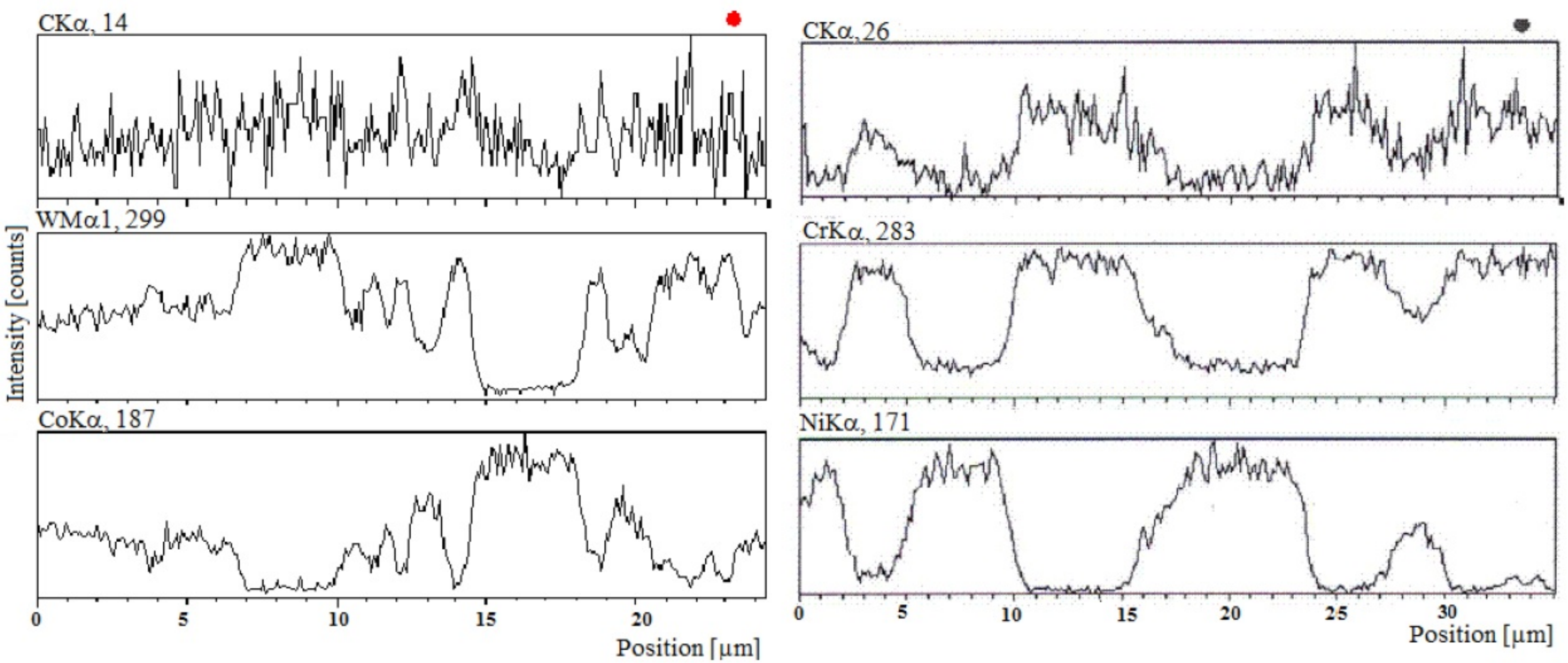
Introduction

- Higher and higher performances required in the Oil&Gas field
- Importance of durability in hard conditions
- Relevance of special coatings for valve metallic parts
- Avoid:
    - Galling
    - Erosion
    - Corrosion

Coating characterization: state-of-the-art

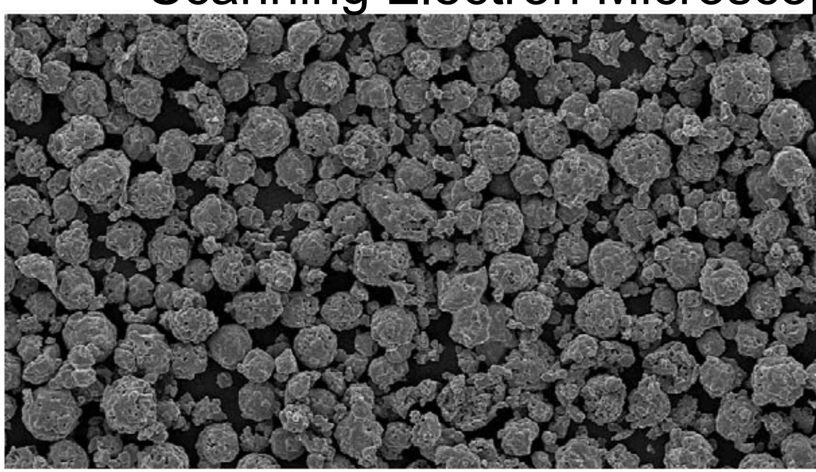
- Chemical characterization
  - X-ray spectroscopy

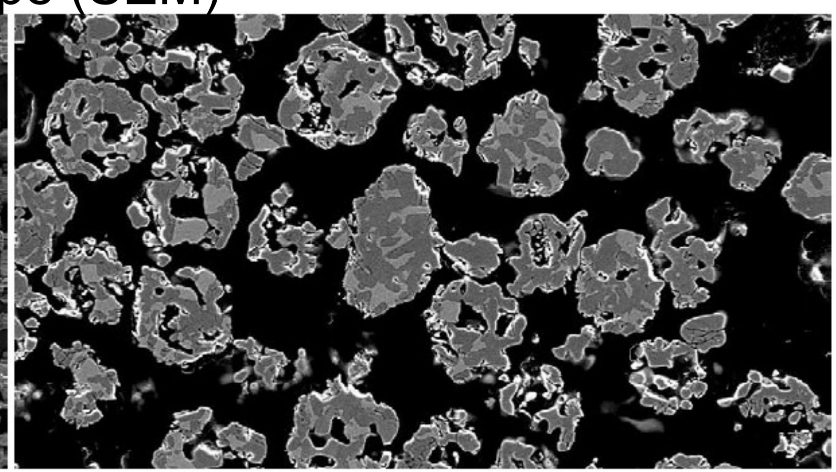


Coating characterization: state-of-the-art

- Chemical characterization
  - X-ray spectroscopy
- Metallographic characterization
  - Powder examination and microstructure:

    Scanning Electron Microscope (SEM)





Coating characterization: state-of-the-art

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  - X-ray spectroscopy
- Metallographic characterization
  - Powder examination and microstructure:

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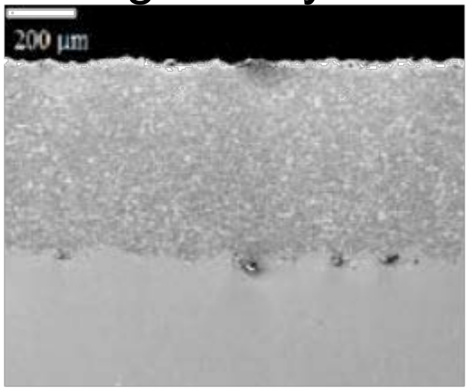
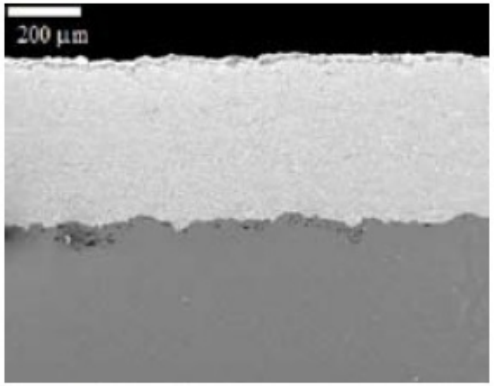
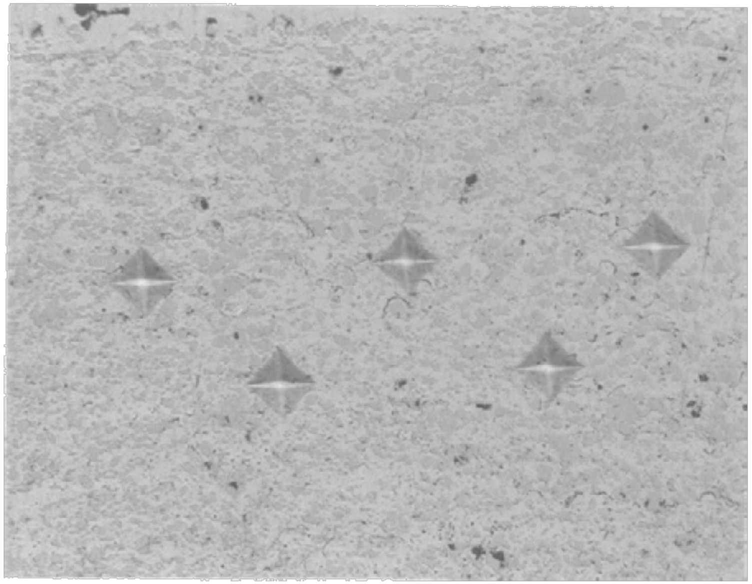
  - Porosity: image analysis





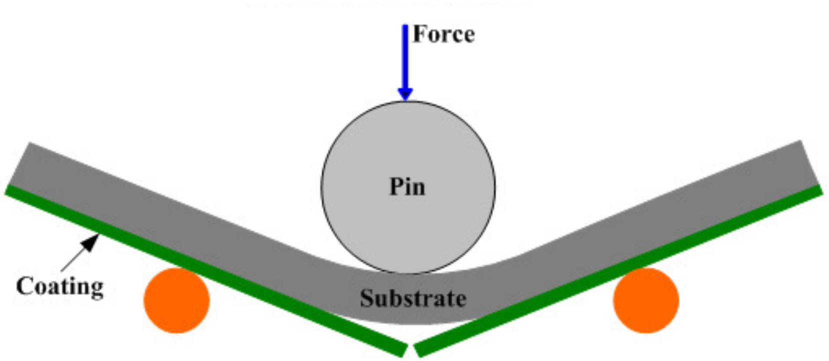
Coating characterization: state-of-the-art

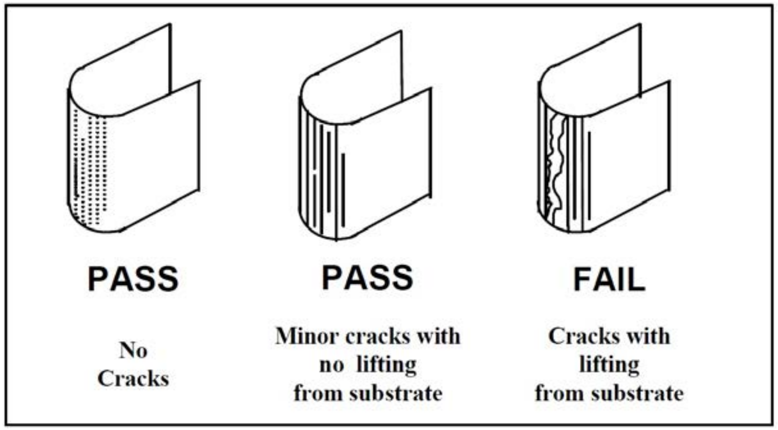
- Mechanical properties
  - Microhardness



Coating characterization: state-of-the-art

- Mechanical properties
  - Microhardness
  - Bend test





Coating characterization: state-of-the-art

- Mechanical properties
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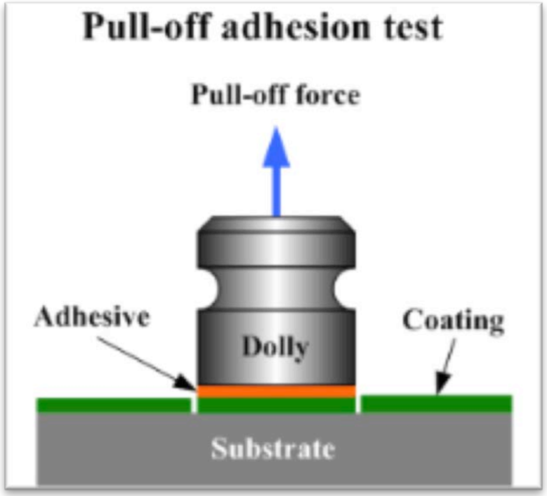
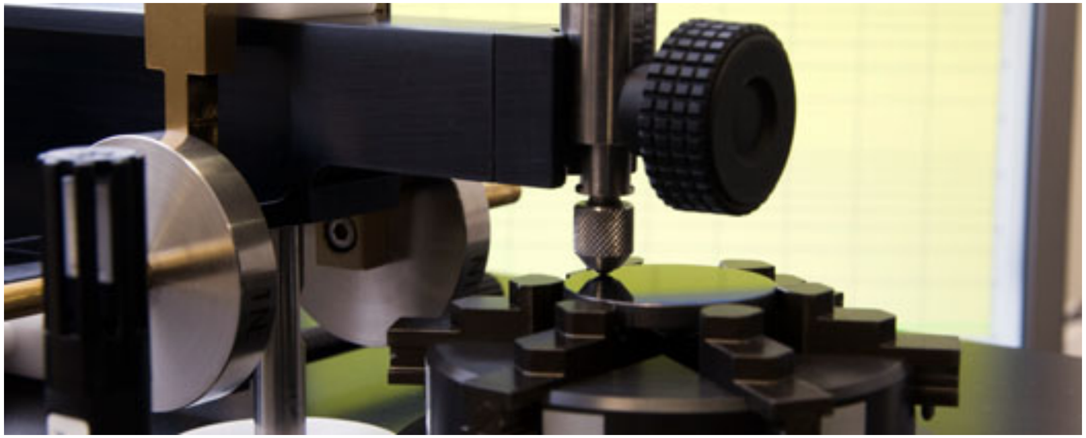
  - Bend test
  - Adhesion test (Pull-off, Scratch…)



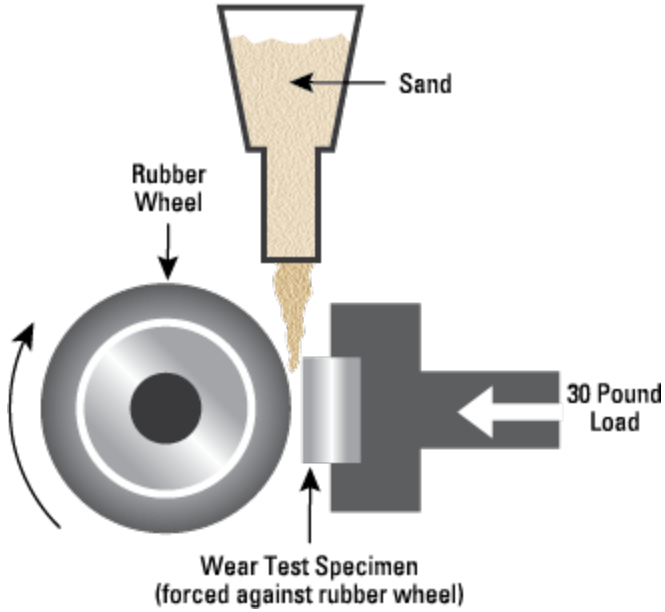
Coating characterization: state-of-the-art

- Mechanical properties
  - Microhardness
  - Bend test
  - Adhesion test (Pull-off, Scratch…)
- Tribological properties
  - Pin-on-disc



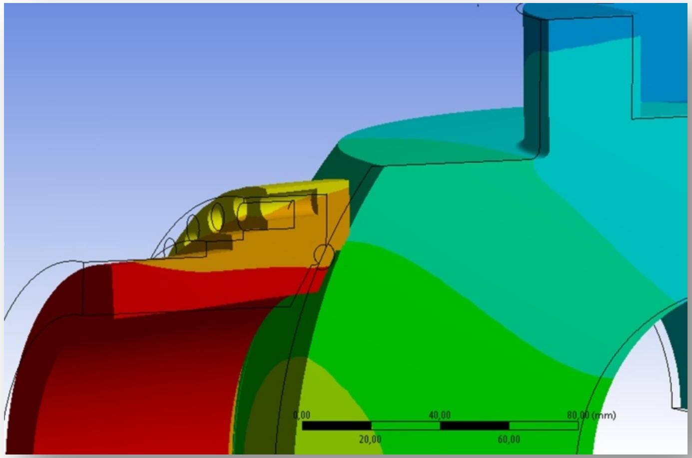
Coating characterization: state-of-the-art

- Mechanical properties
  - Microhardness
  - Bend test
  - Adhesion test (Pull-off, Scratch…)
- Tribological properties
  - Pin-on-disc
  - Sand abrasion test (ASTM G65 and ASTM G105 - 02)



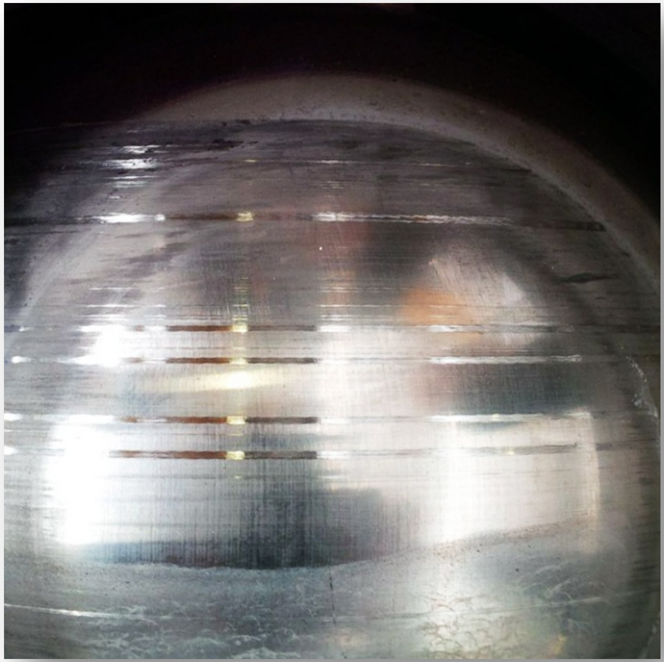
Coating characterization: state-of-the-art

- Nevertheless, traditional analysis presents some limits of adherence to reality
  - Deformations of parts under pressure



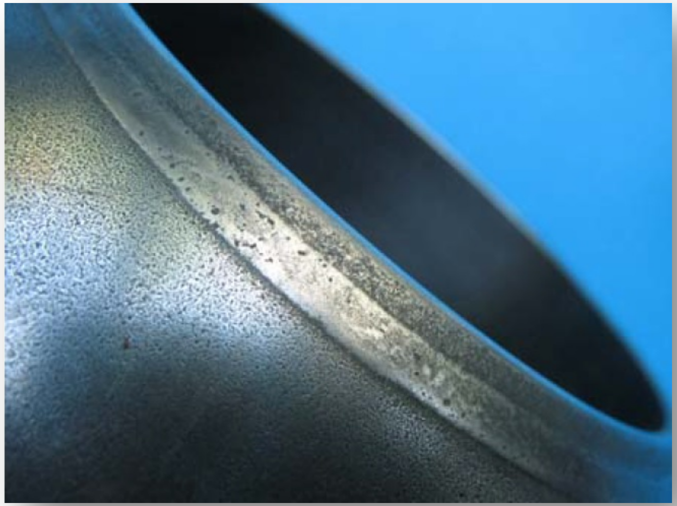
Coating characterization: state-of-the-art

- Nevertheless, traditional analysis presents some limits of adherence to reality
  - Deformations of parts under pressure
  - Contact between ball and seat rings

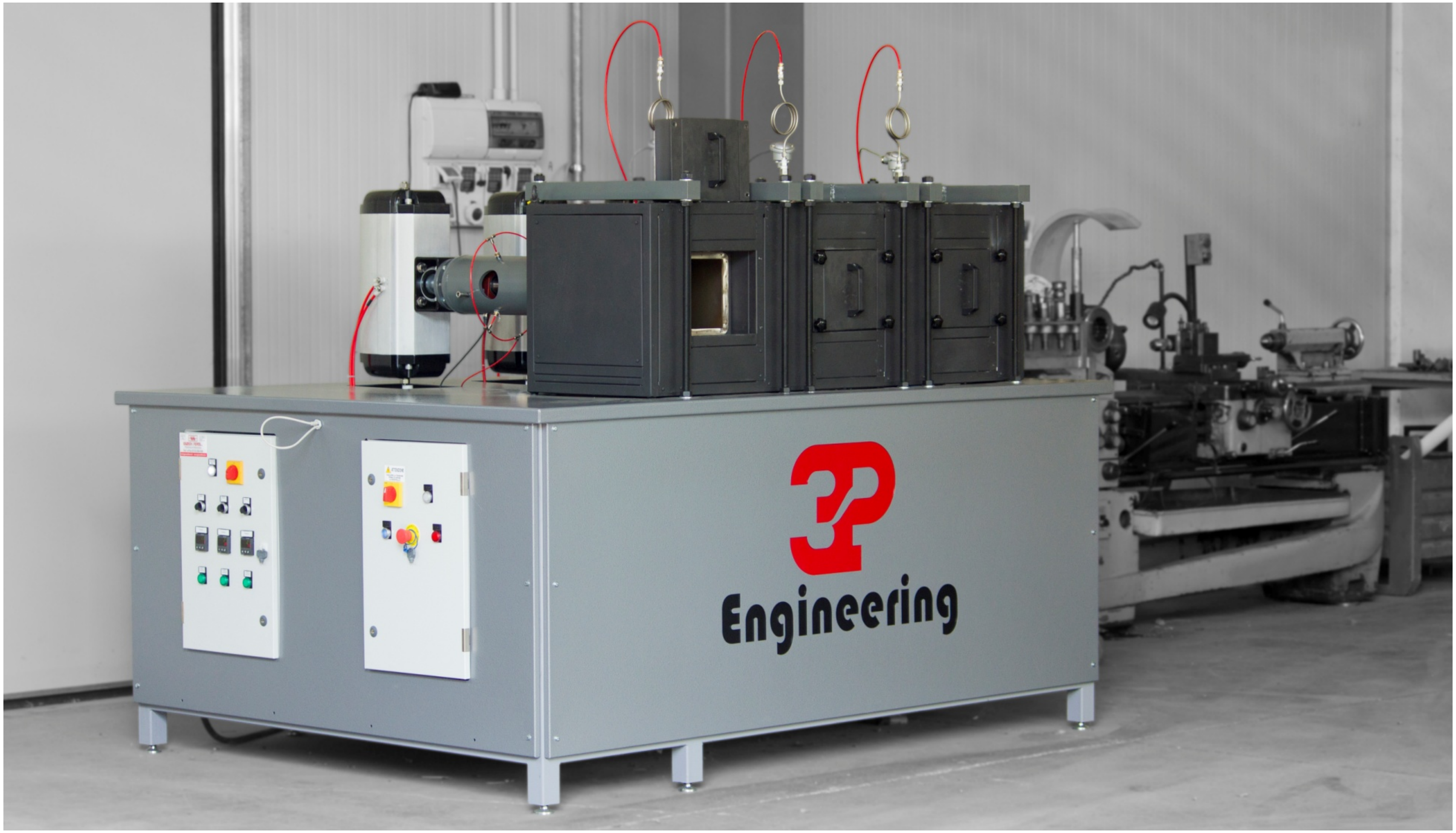


Coating characterization: state-of-the-art

- 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)

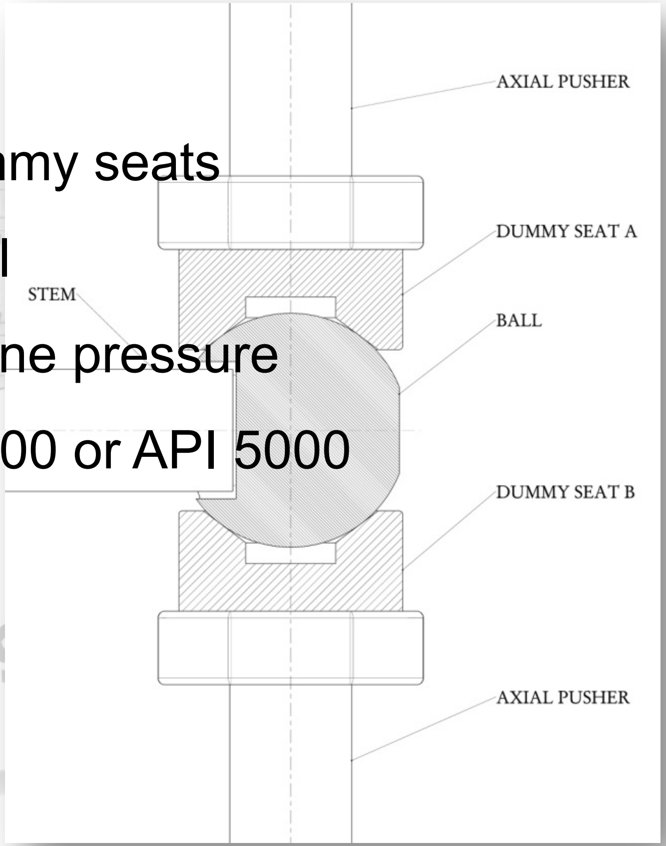


A more practical approach: tests on surface coatings



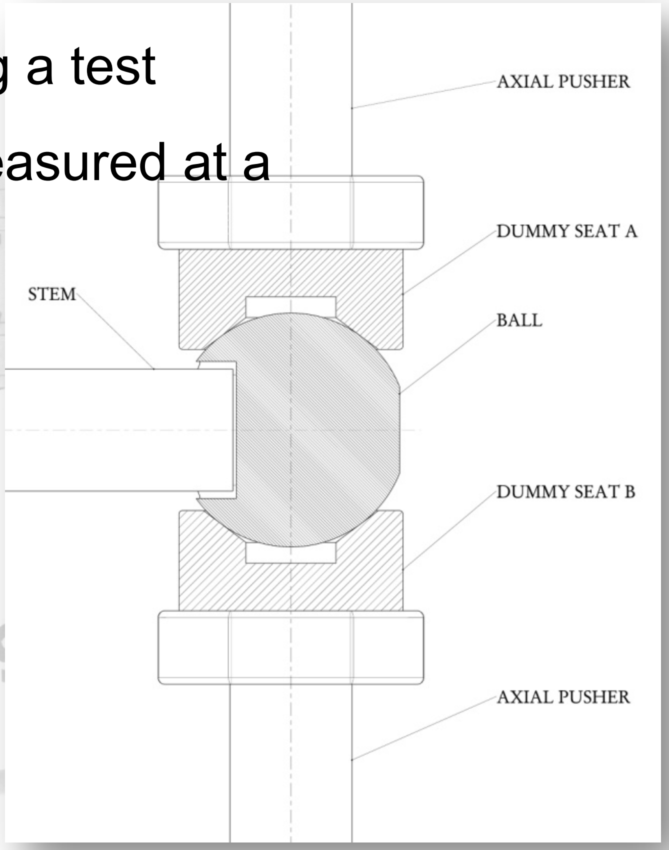
A more practical approach: tests on surface coatings

- 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 resistences
- Tests under abrasive media

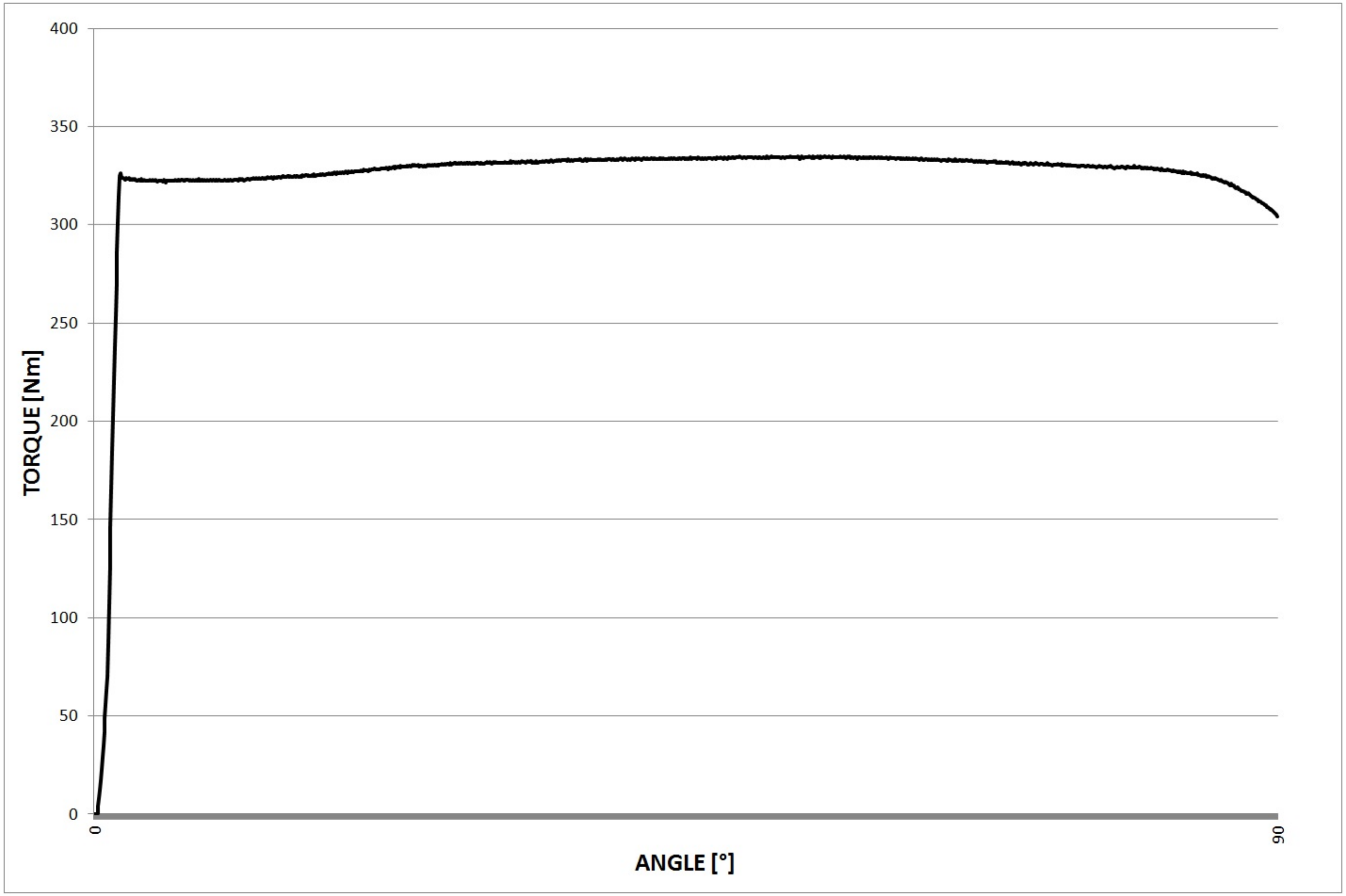


A more practical approach: tests on surface coatings

- 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



Test results: torque – angle graph



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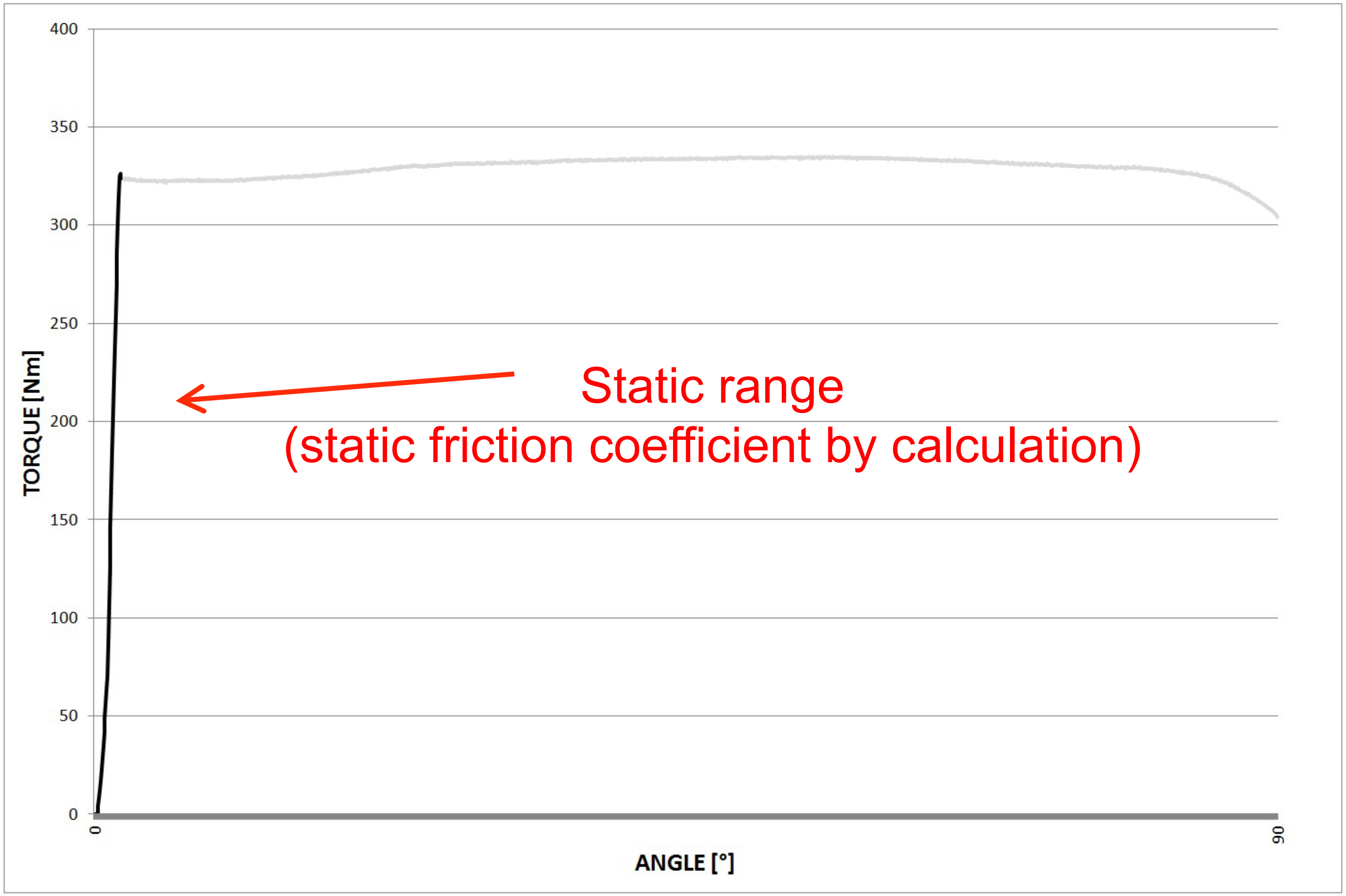

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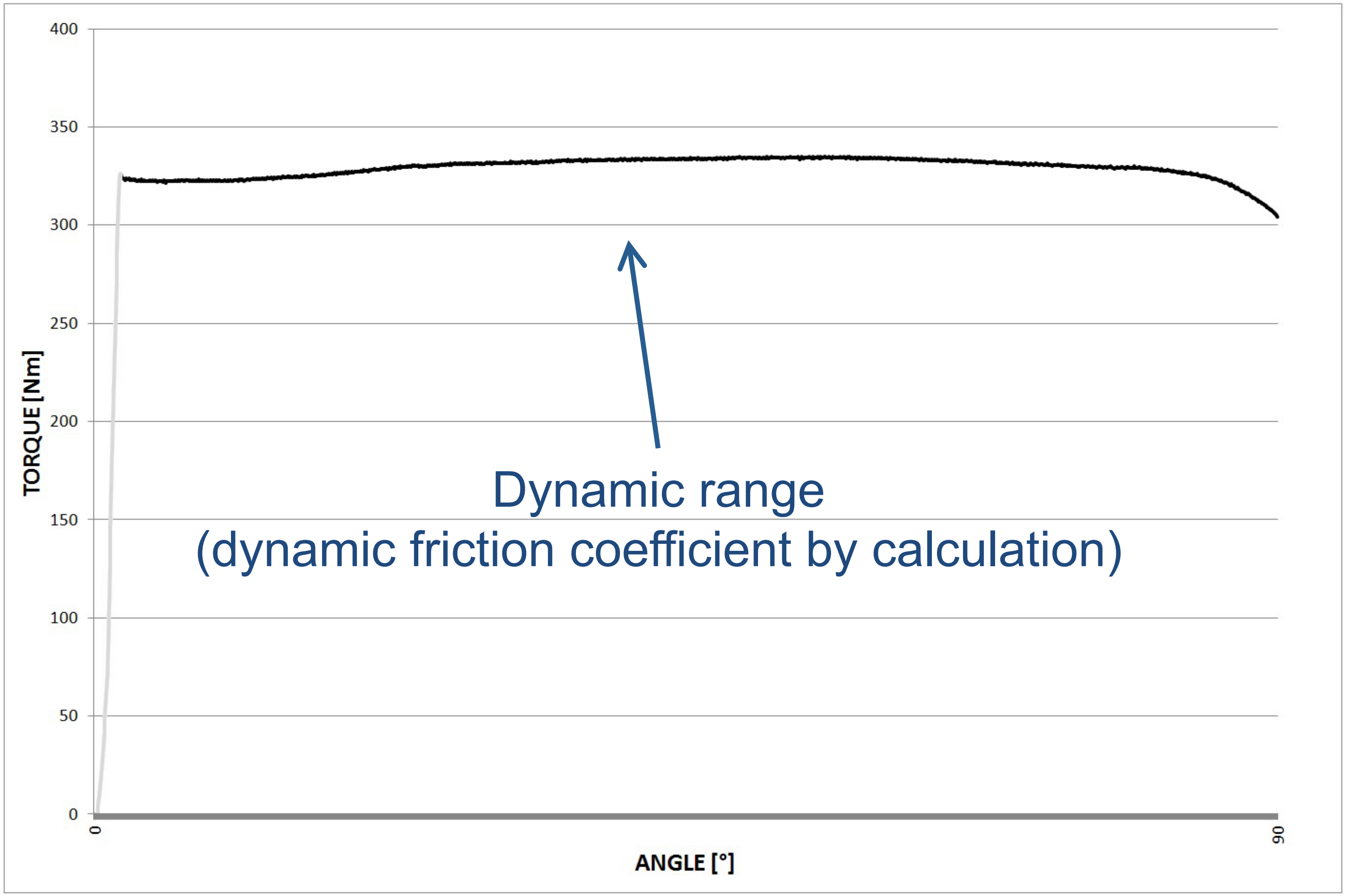
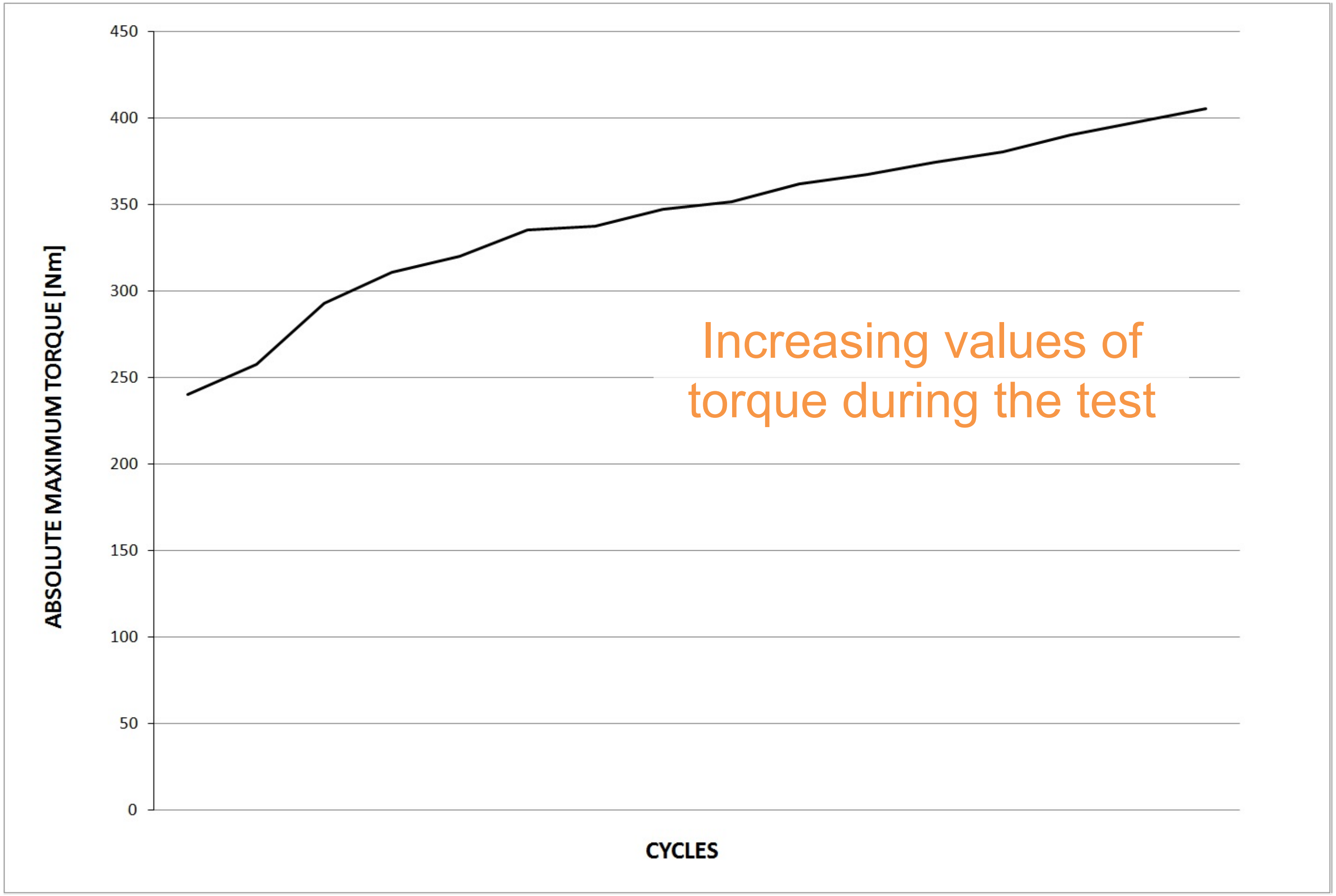
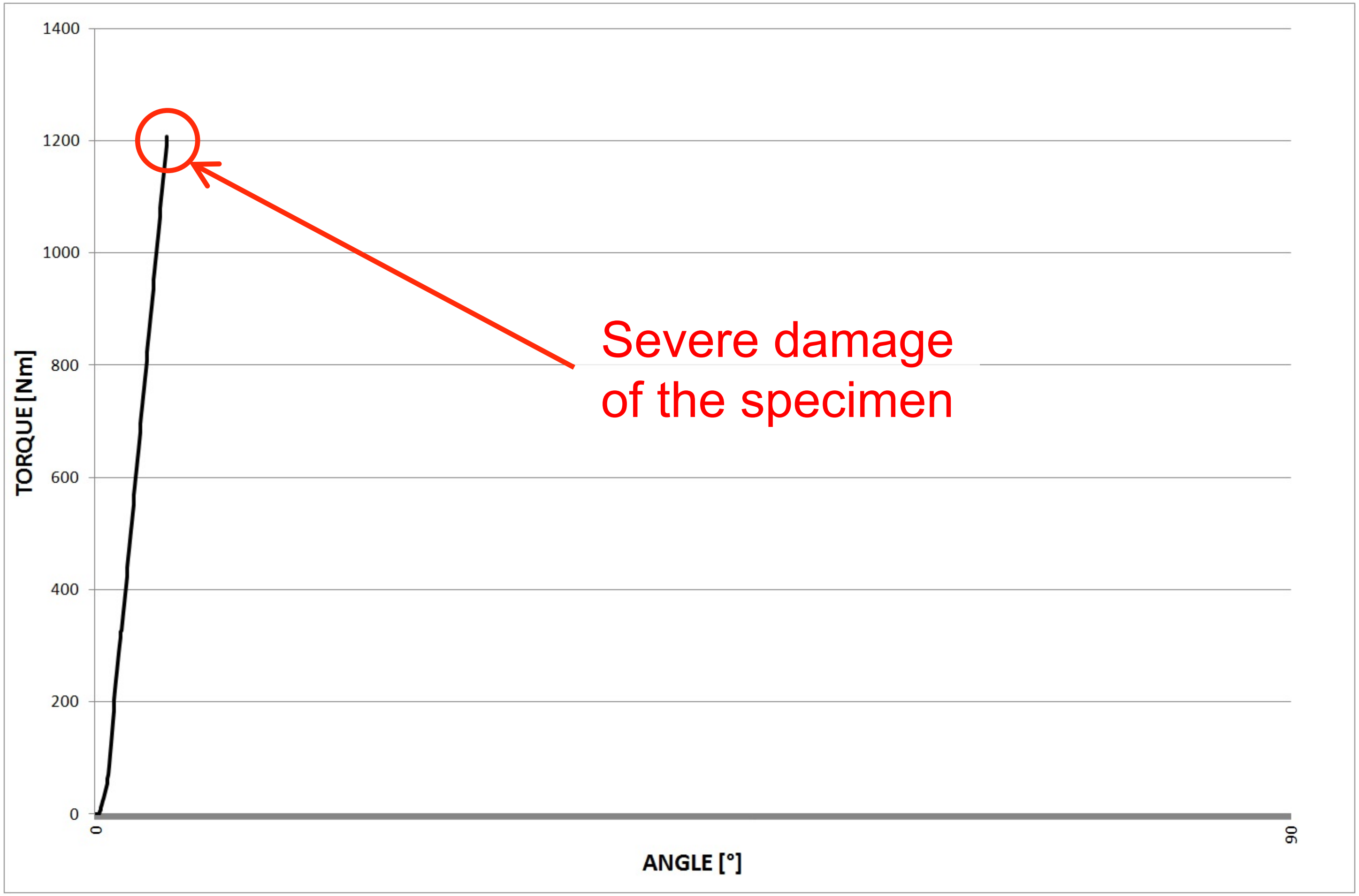


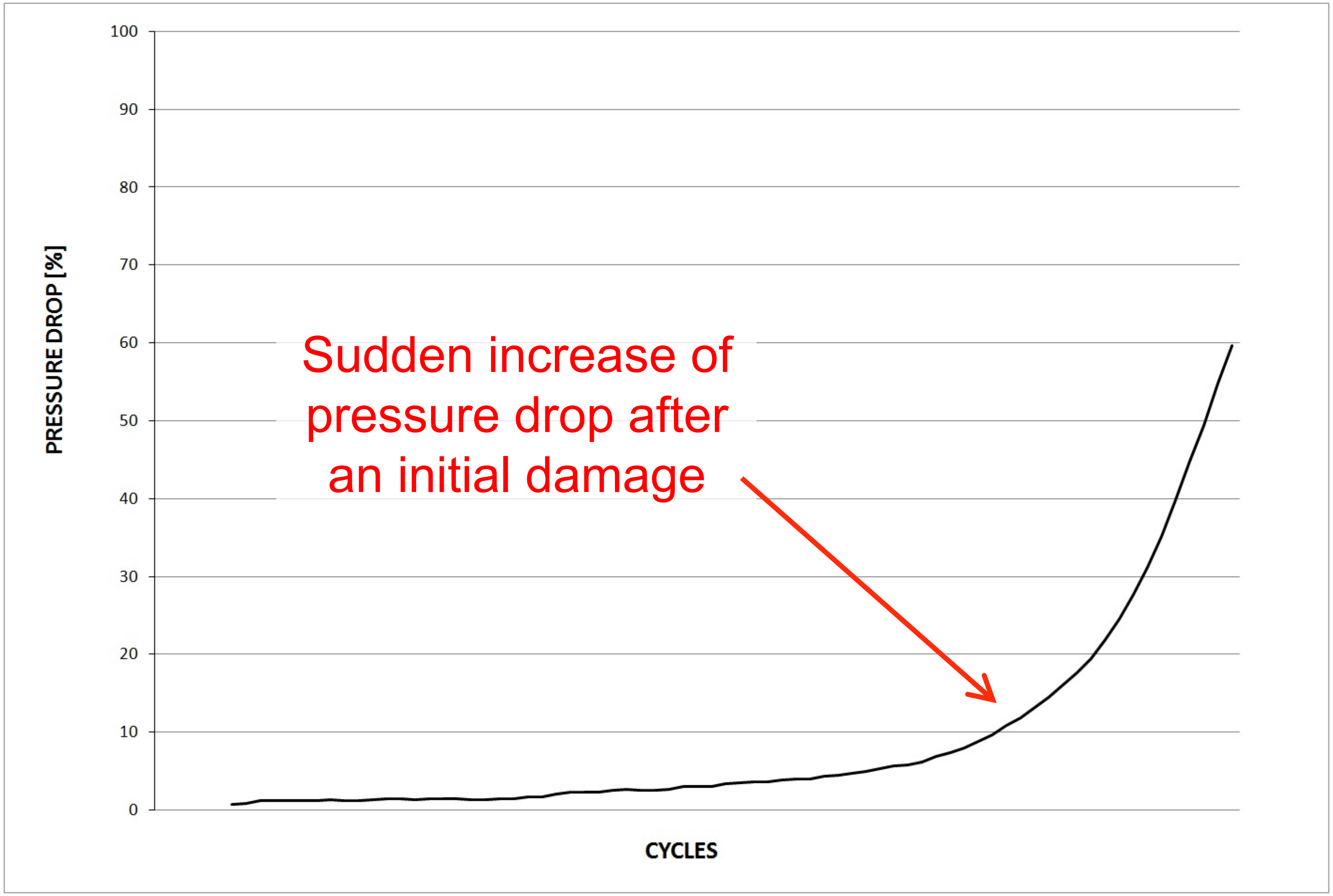
Test results: maximum torque trend



Failure caused by galling of the specimen



Failure caused by detected leakage



Case study application: test conditions

- Simulated pressure class: ANSI CL 1500
- Ball-seats: ASTM A479 gr. F51 - WC coated
- Test #1: 1000 cycles at room temperature
- Test #2: 1000 cycles at 250°C
- Focus on leakage and torque trends
- Test results as average of each set (3 specimens)

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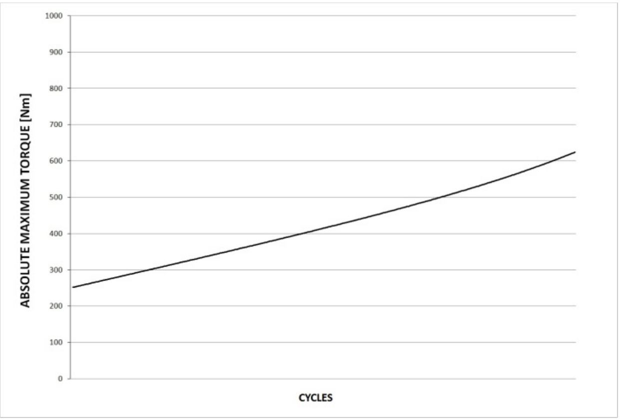
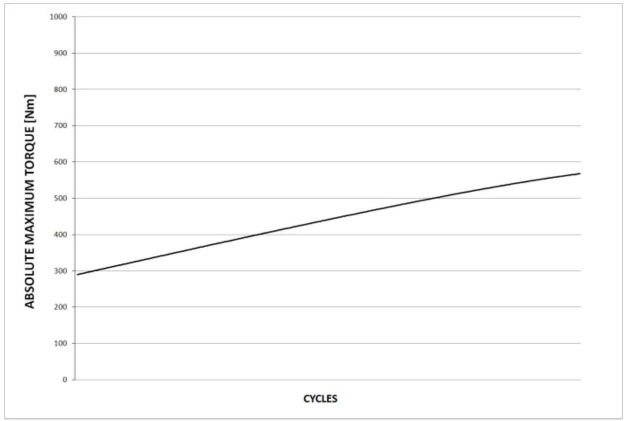
Case study application: room temperature test

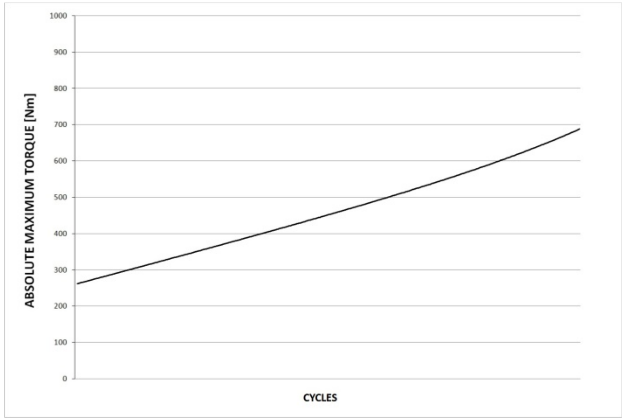
A



B

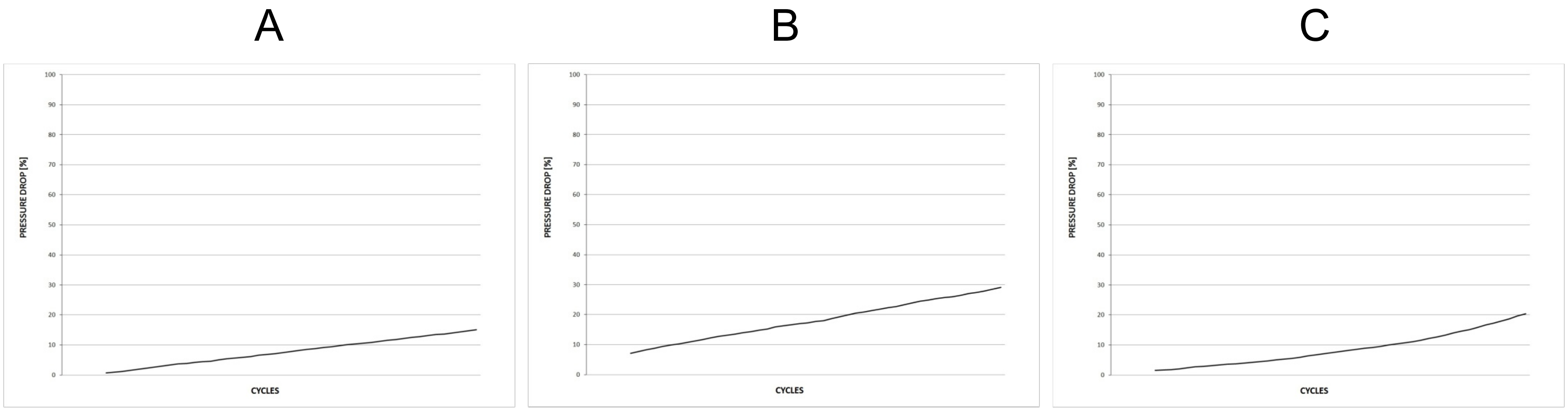


C



- Maximum torque value (for each cycle)
- Room temperature
- 1000 cycles

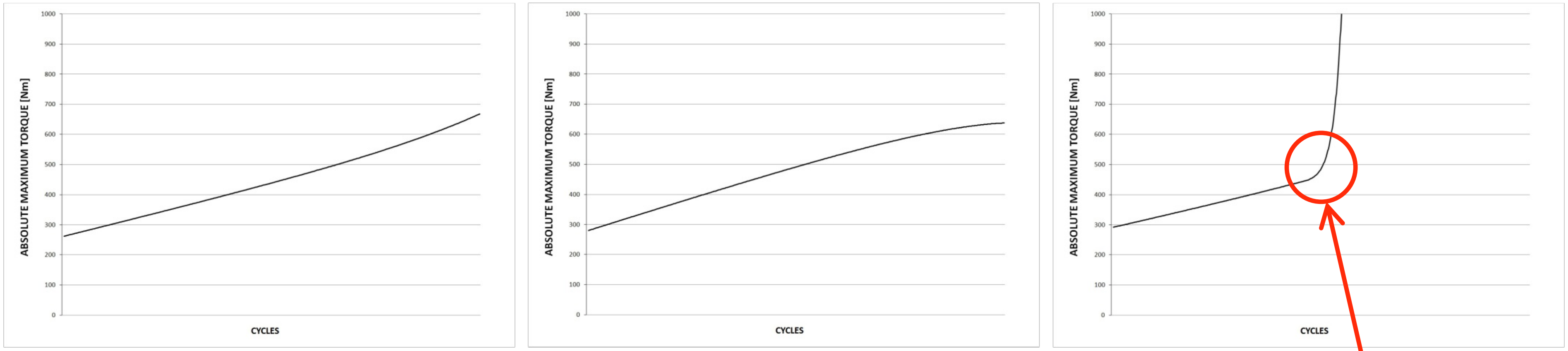
Case study application: room temperature test



- Leakage monitored (in terms of pressure drop) every 50 cycles
- Room temperature
- 1000 cycles

Case study application: high temperature test

A B C

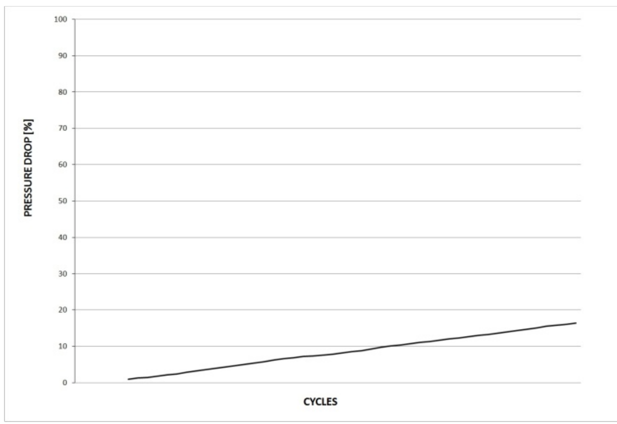


Severe damage of one of C-set specimens resulting in test interruption

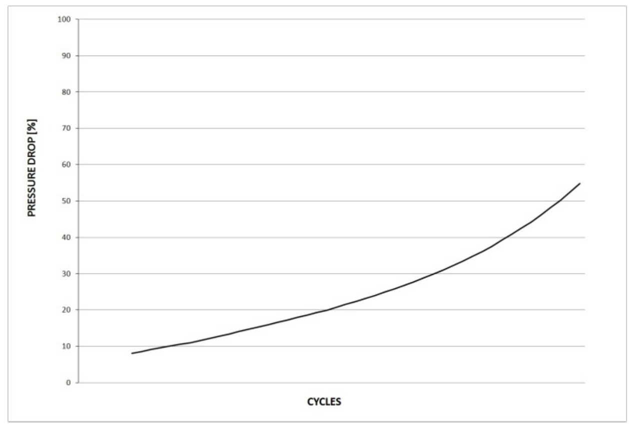
- Maximum torque value (for each cycle)
- Test temperature: 250°C
- 1000 cycles

Case study application: high temperature test

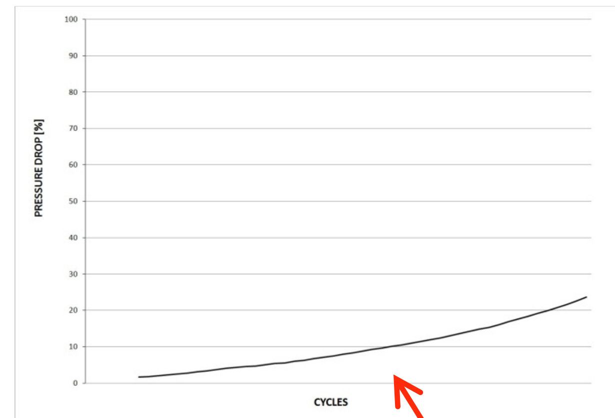
A



B



C



- Leakage monitored (in terms of pressure drop) every 50 cycles
- Test temperature: 250°C
- 1000 cycles

Average value of the two undamaged specimens

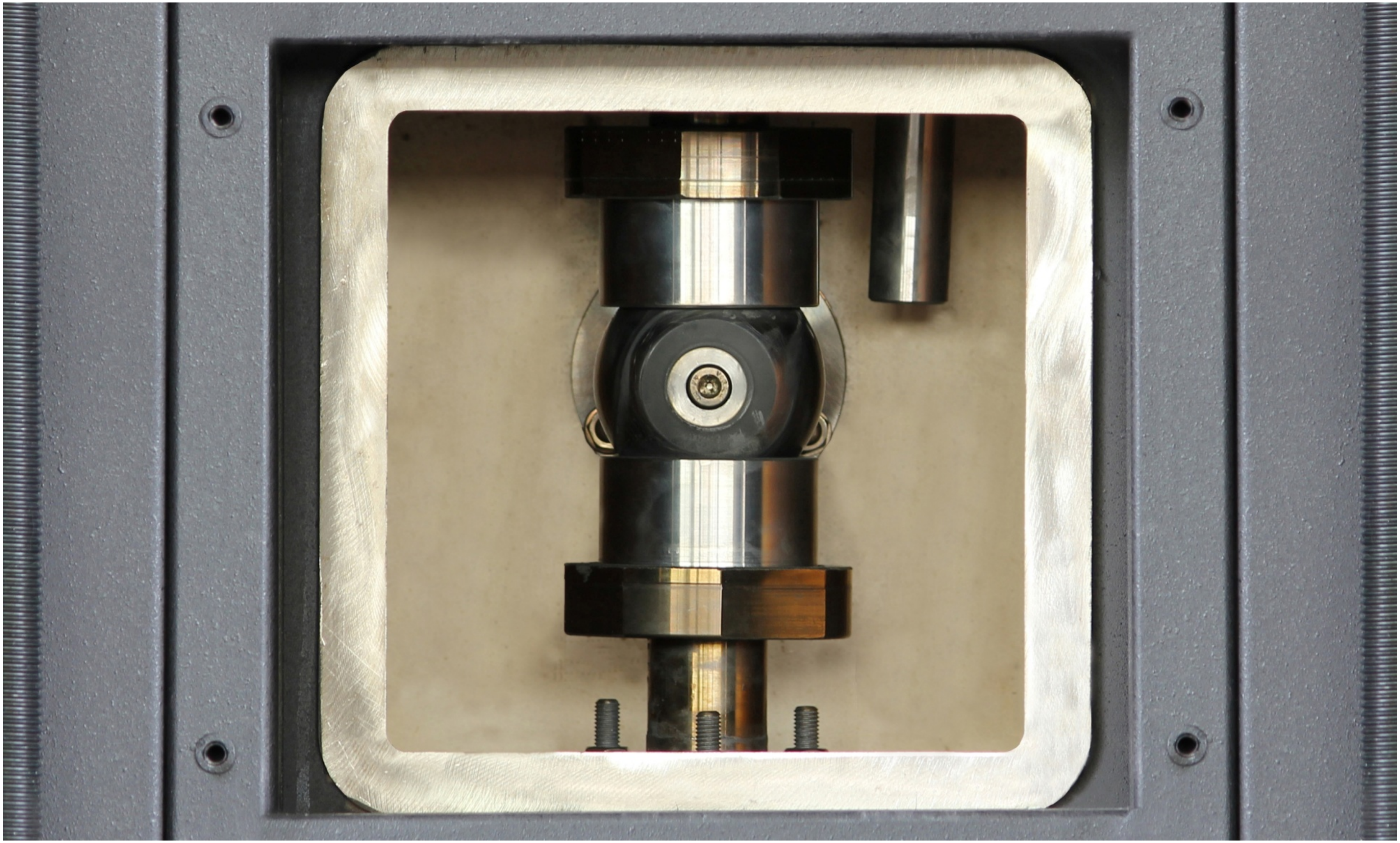
Case study application: final comparison

- Coating A: moderate leakage, maximum torques 626 Nm (at room temperature) and 670 Nm (at high temperature)
- Coating B: leakage starting from first cycle (room temperature), remarkable leakage at high temperature (no galling), maximum torques 568 Nm (at room temperature) 638 Nm (at high temperature)
- Coating C: moderate leakage, maximum torque at room temperature 690 Nm, galling occurred during high temperature test for one of the specimens: test failed

Conclusions

- Accurate simulation of real working conditions of coated valve components
- Reliable ranking between different coatings (wear and galling resistance, friction)
- Evaluation of expected lifetime of real applications
- Useful tool to develop new coating solutions
- Support for End Users on specific applications and processes

Questions ??



Thank you for your attention

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