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ÚJV Řež, a. s.

Sealing pre-qualification for extreme operation conditions

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“EQ meeting“

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Content

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- Common conditions
- Required conditions
- Example of accident profiles
- Initial considerations
- Possible set of experiments
- Unexpected difficulties
- Example of results – 1
- Example of results – 2
- Example of results – 3
- Summary
- Discussion

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Common conditions

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Typical conditions in nuclear power plants (NPP):

- Temperature: ≤ 65 °C
- Dose rate: ≤ 1 Gy/h

Typical equipment parameters:

- Lifetime: 10 to 40 years
- Thermal degradation energy E_A: ~ 1.0 eV (0.9 – 1.3 eV)

Common qualification conditions:

- Temperature of thermal ageing: ~ 110 °C (90 – 150 °C)
- Thermal ageing times: 2 – 10 months
- Total doses: 20 – 250 kGy (does not include accident dose)

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Required conditions

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Required conditions for the sealing qualification:

- Temperature: ≤ **220** °C
- Dose rate: ≤ 1 Gy/h

Equipment parameters:

- Lifetime: 6 to 24 years
- Thermal degradation energy E_A: 1.0 eV

Accident conditions:

- Temperature: peak **150** °C (lower than working conditions!!!)
- Accident dose: 40 kGy

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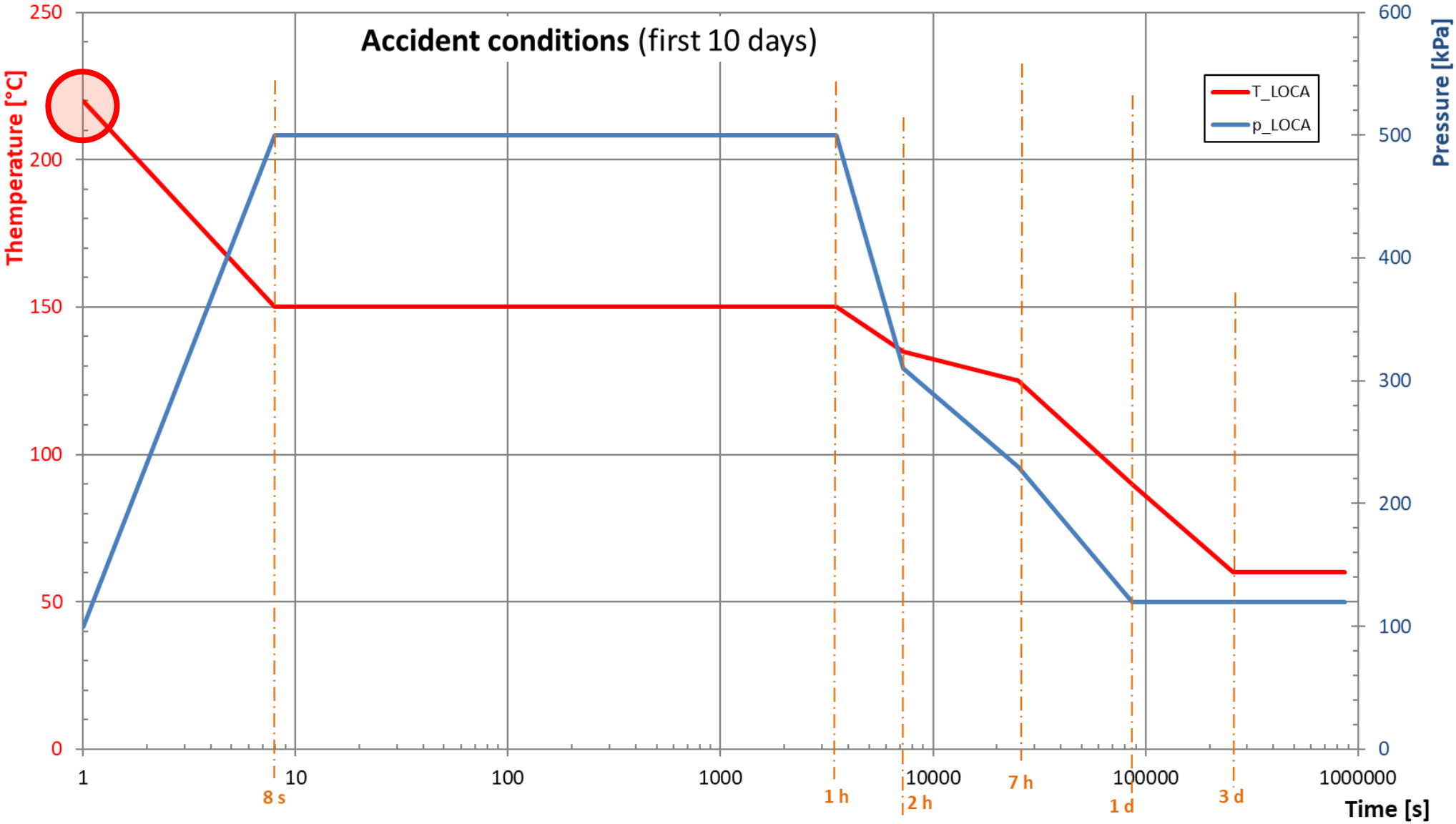
Example of accident profiles



Initial considerations

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Questions like:

- Which rubber can survive more than 220°C?
- What is „minimal“ lifetime of the rubber?
- What is “real“ lifetime of the rubber?
- Is anti-adhesive paste required?
- Which anti-adhesive paste can survive more than 220°C?
- Could the anti-adhesive paste be used in NPP?
- Could be used maximal heating rate?
- Would “screws“ get stuck?
- Should we measure compression set?
- Is there some “tightness criterion“?
- Should the tightness be measured at 220°C?
- Etc…

(© Wikipedia)

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Possible set of experiments

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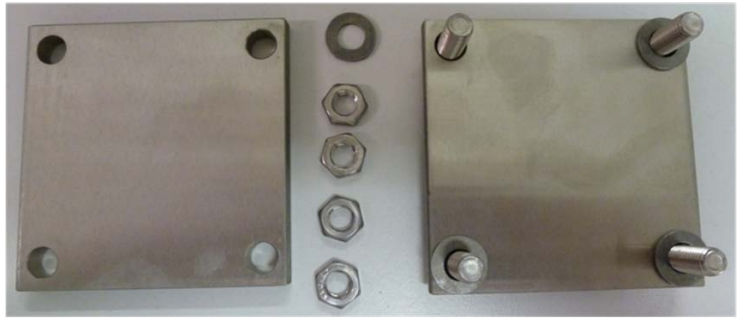
- **Temperatures of thermal ageing (ThAg)?**
  - **260** °C → **127** days of thermal ageing (to simulate 6 years of operation)
  - 250 °C → 192 days of thermal ageing
  - **240** °C → **297** days of thermal ageing
- **Lifetimes?**
  - 1 year → 32 days
  - 4 years → 128 days
  - 6 years → 192 days
  - **12** years → **384** days
- **How to simulate “geometric“ conditions?**
  - Compression plates according to ISO 815
  - Model of real geometry 1:1?



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Unexpected difficulties

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- Current anti-adhesive paste is stable to 240°C only
- Stable anti-adhesive paste is corrosive for NG steel

- Compression set is high, and does not improve much in time
- Screws of compression plates get stuck, but real models sometimes come loose

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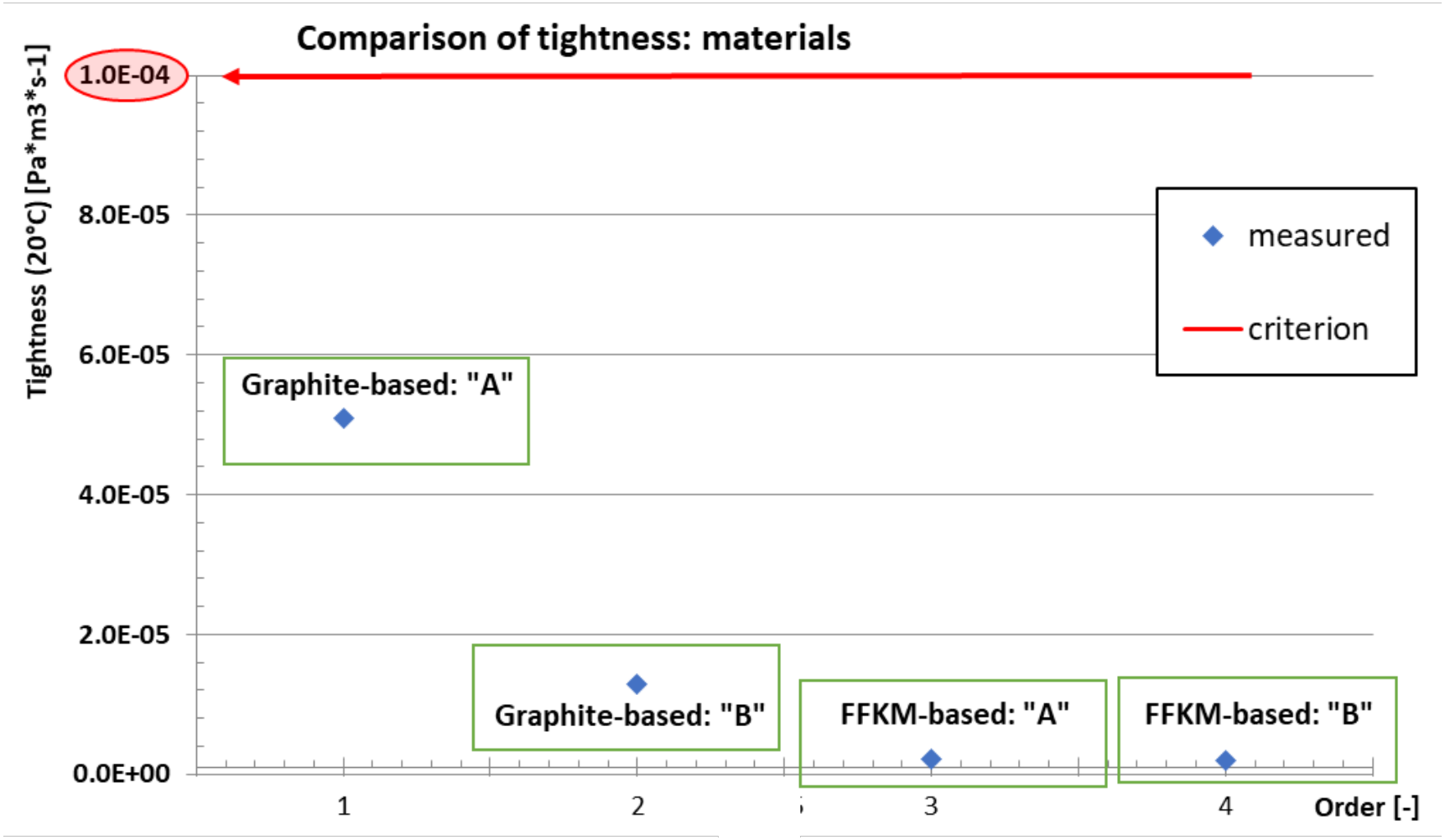
Examples of results – 1

- **Material of the seal:** FFKM-based and graphite-based O-rings



Examples of results – 2

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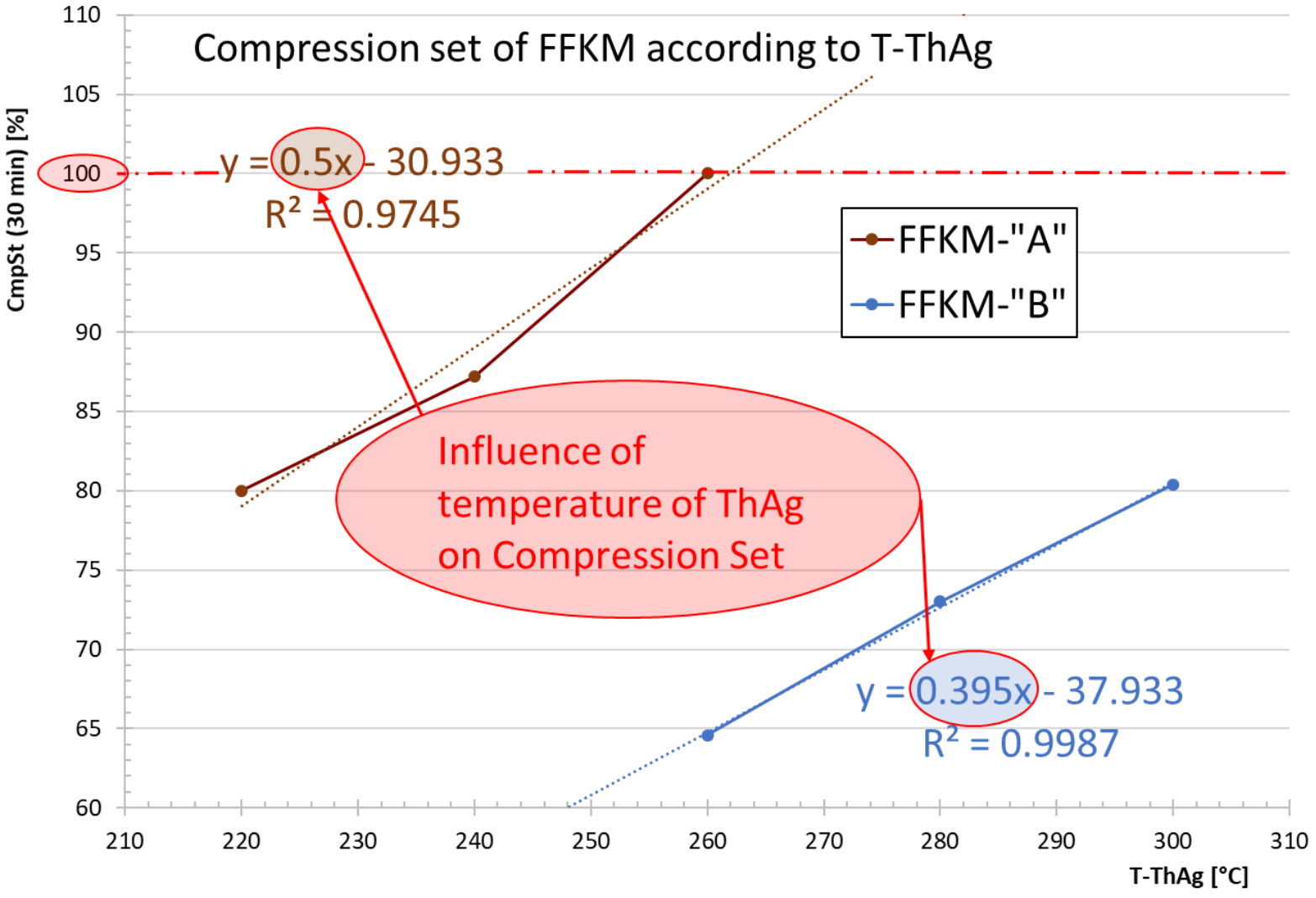
Compression set of FFKM and temperature of ThAg



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Examples of results – 3

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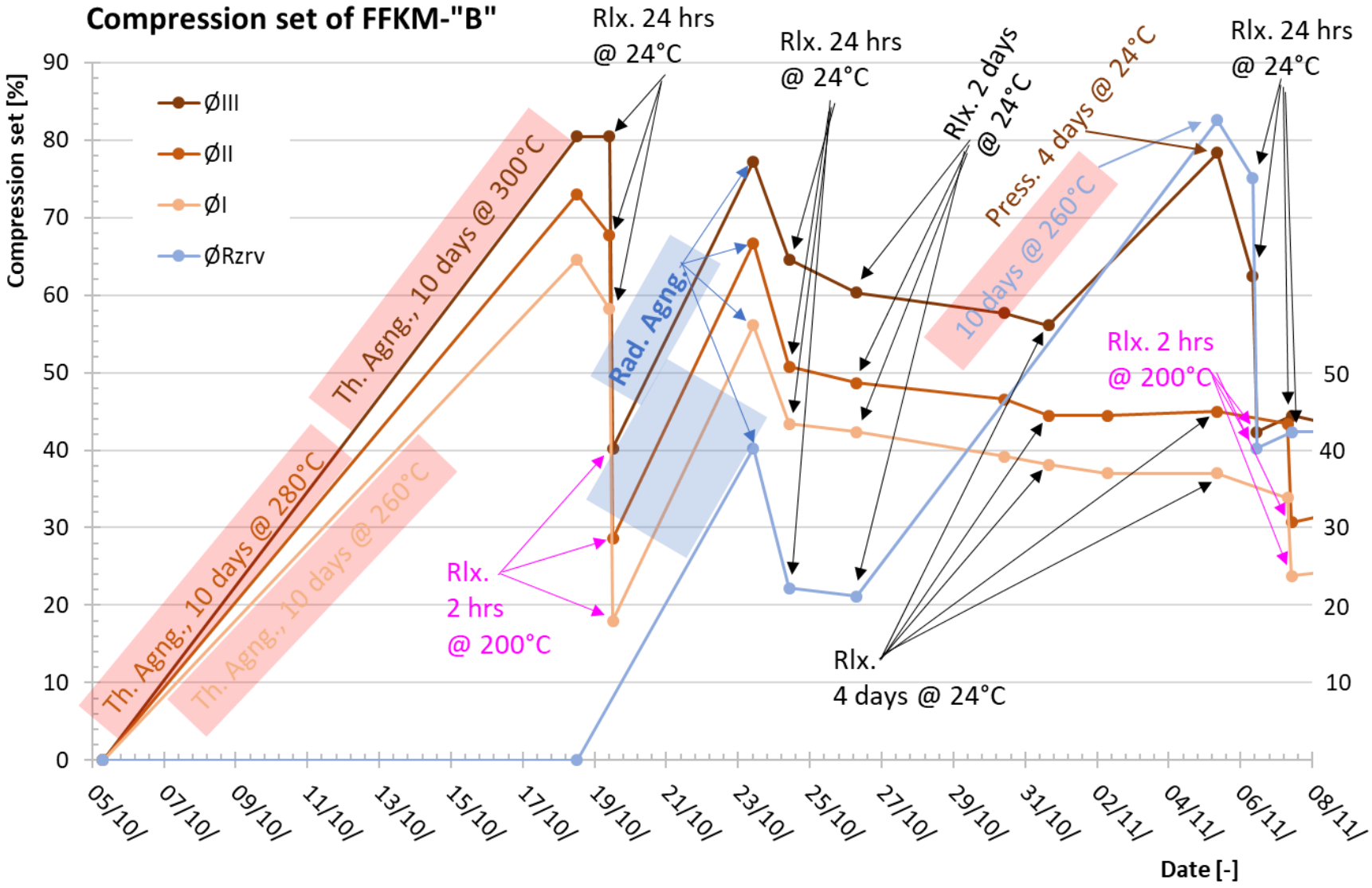
- **Compression set of FFKM-“B“ during different tests**



Thermal ageing

„Relaxation“

@ 24 °C

@ 200 °C

Radiation agng.

„Relaxation“

@ 24 °C

@ 200 °C

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Summary

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Recommendations for pre-qualification:

- Usually, several parallel series of pre-tests are required
- Expect „unexpected“ results

Recommendations for qualification:

- Some materials could be used, even if “beyond limits“
- Use 2 temperatures for thermal ageing, “optimistic“ and “pessimistic“
- Use “flexible design of testing“:

At least two “sampling“ points at different times (during ageing). Then:

result at 1st point is:
- “**better**“, 2nd point could be “extended“ (harsh conditions)
- “**worse**“, 2nd point could be “shortened“ (lower T_{ThAg} = longer t_{ThAg})

- Choose professional partners / suppliers (materials and services)

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Discussion

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Thank You for attention!

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