Challenges in Ageing Management of VVER Main Components for LTO

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- Long Term Operation of VVER NPPs
- Ageing of Reactor Pressure Vessel and Internals
- Reactor degradation mechanisms
- Challenges for 80-Year Operation & Conclusions

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LONG-TERM OPERATION

From 30 to 80 Years of Operation

- Original design lifetime: 30 years
- Current operation: 40-60 years
- Target lifetime extension: up to 80 years

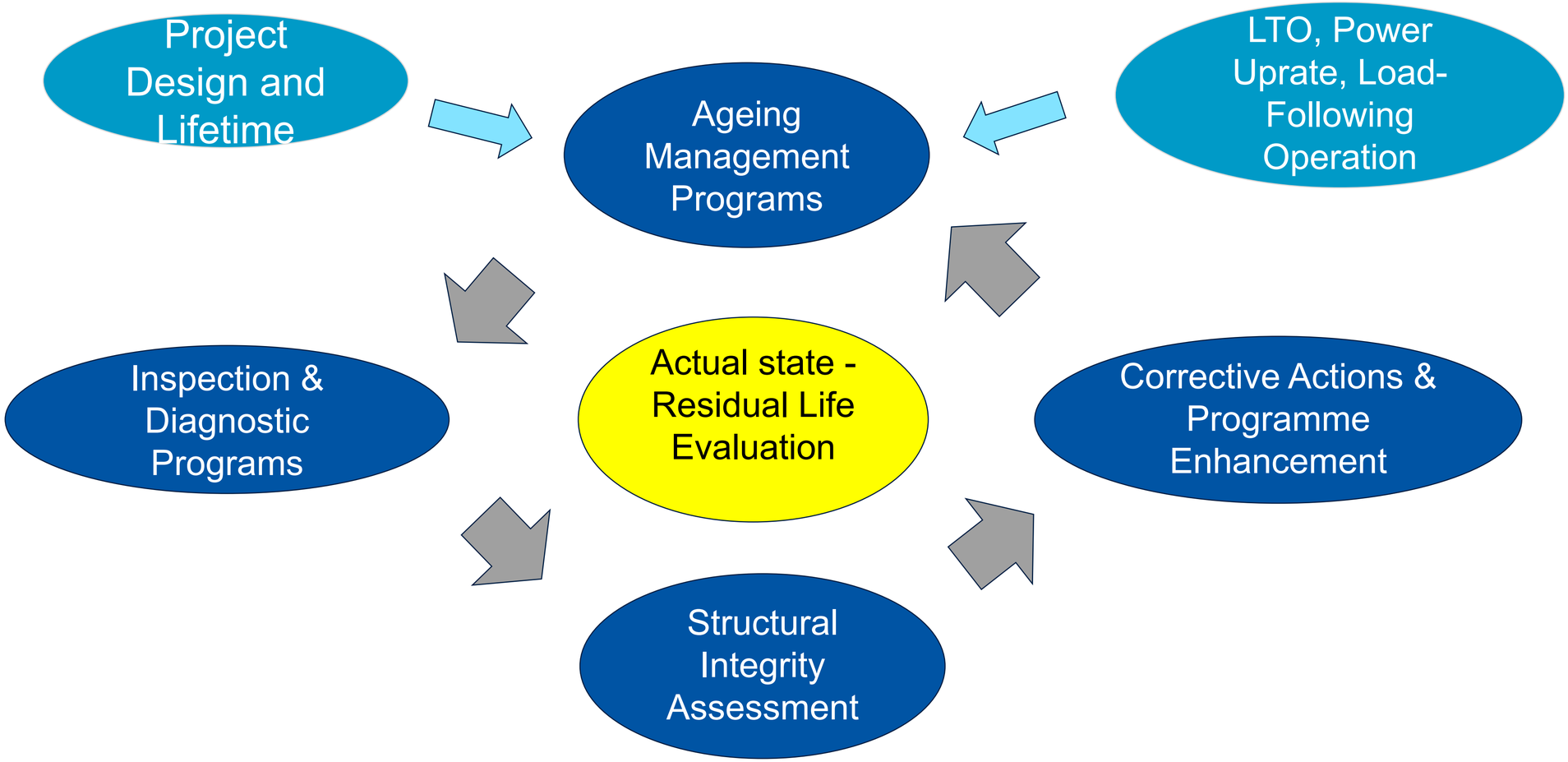
Demonstrating the capability of safety-critical components for operation up to 80 years.

- Ageing becomes increasingly important with operating time
- Lifetime assessments must account for operational changes and plant modifications

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LONG-TERM OPERATION FRAMEWORK

Objective: Demonstration of continued safe operation.



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LONG-TERM OPERATION FRAMEWORK

Key issues:

- Identification of degradation mechanism relevant to LTO and assessment of the impact.
- Mitigation measures and ageing management actions.

Focus on main component:

- Difficult replaceable: Steam generators, Pumps, Valves, Reactor Internals
- Non-replaceable: Reactor Pressure Vessel, Containment Structures



RPV of VVER 1000

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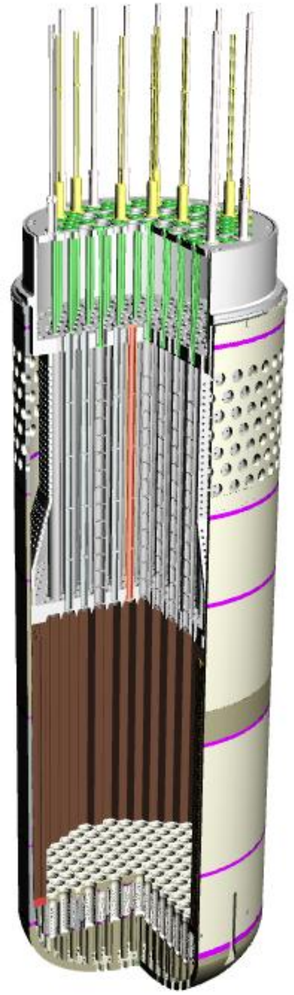
LONG-TERM OPERATION - REACTOR

Effects of Long-term operation:

- Accumulated irradiation exposure
- Accumulation of operating cycles
- Progressive material degradation

Degradation mechanisms:

- Neutron embrittlement
- Thermal ageing
- Fatigue
- Environmentally Assisted Fatigue
- Stress Corrosion Cracking (SCC) / IASCC
- Irradiation swelling (primarily VVER-1000 internals)



VVER 1000 Internals

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REACTOR PRESSURE VESSEL

Radiation embrittlement of RPV

- Radiation embrittlement increases susceptibility to brittle fracture - evaluated by the RPV **surveillance program**.

- Supplementary surveillance program - archive and supplementary materials for new test specimens

- Modification of the surveillance specimen withdrawal schedules

- Neutron fluence measurements and predictive calculations

→ to demonstrate RPV integrity during planned operation X) correction action (thermal annealing)

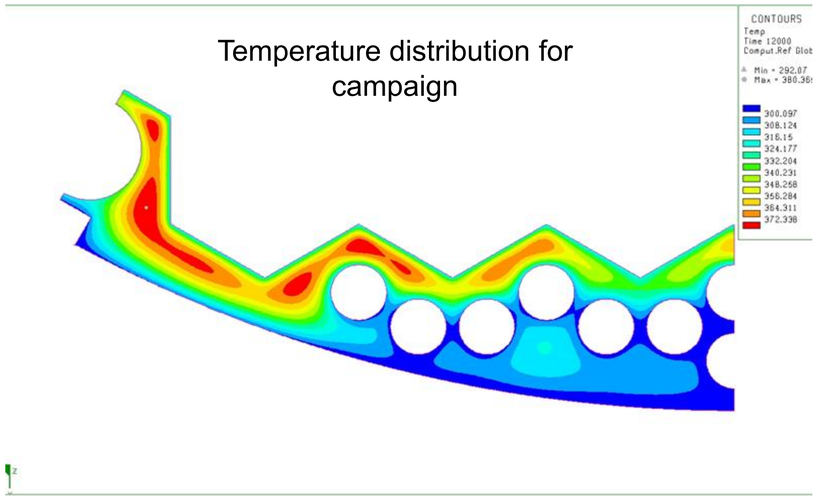
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REACTOR INTERNALS – CORE BAFFLE

Irradiation swelling

- change in microstructure (Frankel loops, dislocation density increase, nanocavities, microcavities)
- increase in volume of heavily loaded area of material (neutron flux & temperature)

= **core baffle**



Temperature distribution for campaign

Example of temperature distribution of core baffle



Core baffle of NPP Temelin

Conditions for swelling

- high temperature over 350 °C
- high accumulated neutron fluence

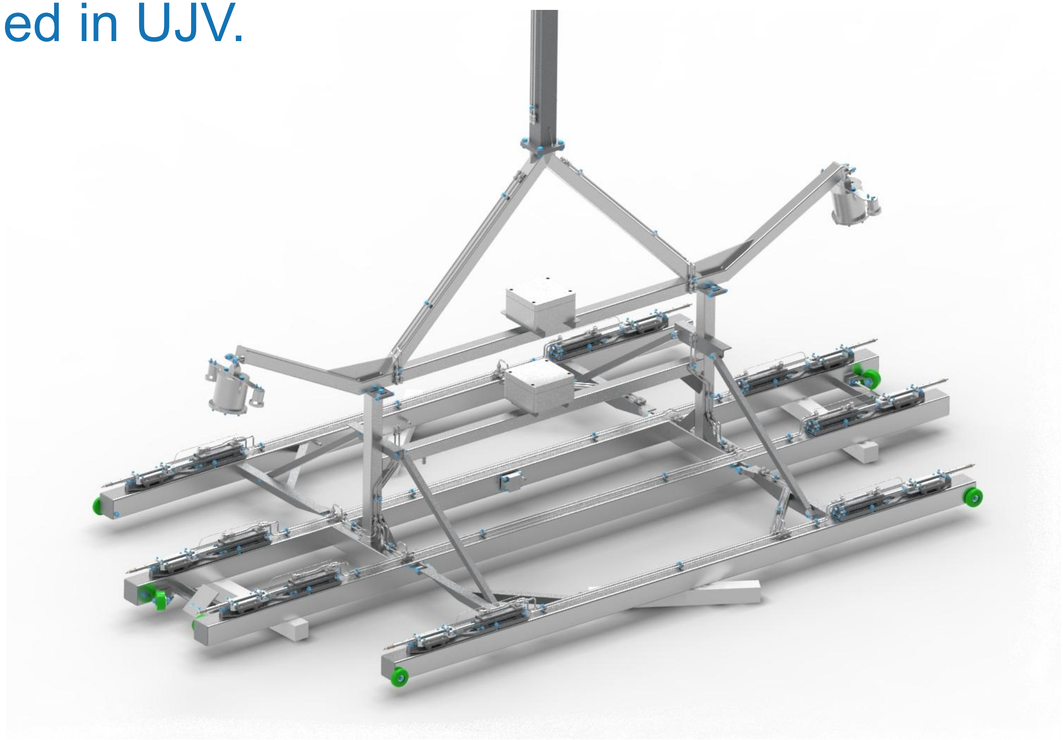
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REACTOR INTERNALS – CORE BAFFLE

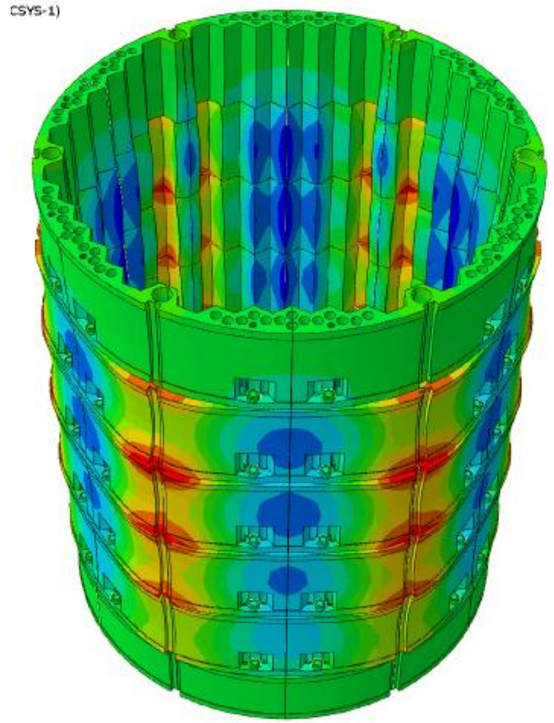


- Based on the computational evaluation of radiation swelling, operational experience of other VVER units, a dedicated measuring device was developed.

- Design and manufacture of measuring equipment was perfomed in UJV.



Measuring device



Deformation of core baffle

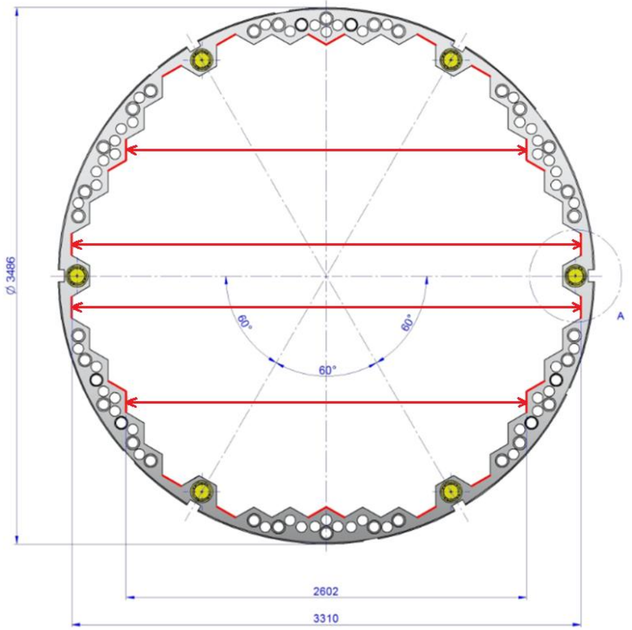
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MEASUREMENT OF CORE BAFFLE



The measurement principle

- Measurement of the distance between selected surfaces of the core baffle (areas around the threaded rod and the middle segment).
- Measurement at selected height levels (according to z axis).
- Measurement at three angular position (rotation twice by 60 °).
- This method of measurement is similar to the measurement performed during assembly Inspection.



The measured distance in core baffle

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MEASUREMENT OF CORE BAFFLE

Measurement

- Provides the information about the actual state of core baffle and demonstrate the functionality of the component for the next operation.
- Repeatedly measuring the same component locations allows prediction of irradiation swelling development.
- To verify and to refine the computational model of irradiation swelling development.

→ Provides a technical basis for reactor internals lifetime assessment and safe operation (up to 80 years)

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CONCLUSION

- Long-term operation requires reassessment of ageing mechanisms
- Ageing management must focus on major safety-significant components,
- Degradation mechanisms must remain within acceptable. Where necessary, corrective actions and programme enhancements shall be implemented.
- Accurate degradation predictions support safe operation up to 80 years

Thank You for Your Attention.



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