ÚJV Řež, a. s.

UJV Activities in International Research Projects in the Field of RPV and RVI

Nuclear Regulatory Commission

International Workshop on Age-Related Degradation of Reactor Vessels and Internals

May 2019

Miroslav Žamboch,

History of the UJV

View of the land at the beginning of 50ties where NRI had been built

History of the UJV

Building of the UJV in late fifties(founded in 1955)

UJV from opposite bank of the Vltava river

UJV activities

Services for Czech NPP EDU and ETE

Preparation of building of new nuclear power plant in Czech republic

Renewal of fossil power plants

Nuclear medicine (diagnostic, cancer medicals)

SOTERIA

Safe long term operation of light water reactors based on improved understanding of radiation effects in nuclear structural materials

- **Funded by European Commission under Horizon 2020 research and innovation programme**
- **24 participants**

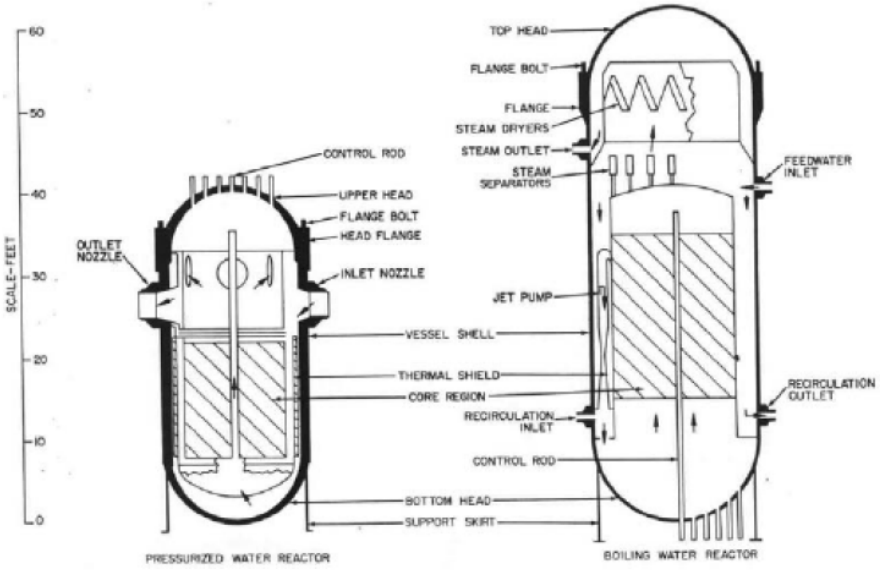


FIG. 6. Comparison of PWR and BWR RPVs with the same output.

TYPICAL PWR RPV

WWER-440 RPV

Vessels may weigh up to 800t with wall thickness up to ~330mm.

Scope of research

- **Experimental work focused on flux and fluence effect on RPV and RVI**
- **Effect of microstructure and composition on residual lifetime of the RPV,**
  - Development of synergic fracture toughness prediction formulas
- **Effects of chemical and radiation environment on RVI**
  - Base for developing of predictive tools for end users
- **Development of models for the assessment of ageing mechanisms in RPV and internals, setup of the platform for modelling**

- **Education of the nuclear engineer and nuclear community**

Age60+

The goal is to improve the access of workers across Europe to useful data on NPP components ageing which might be unpublished or published obscurely

- **Partly funded by the European Atomic Energy Community's (Euroatom) Seventh Framework Programme**
- **Encourage European researchers to share data in order to maximize its utility**
- **Consolidate the data in accessible formats**
- **Utilise selected accessible data to assess the applicability of current methodologies to cover 60+ year of operation**
  - To produce a new embrittlement trend curve for VVER 440 RPVs
  - To identify factors influencing embrittlement that are not properly described in current ETC for MnMoNi RPV steels
  - Identify method to reducing measurement uncertainty in the radiation induced shift of Charpy ductile to brittle transition temperature
  - Suggested improvements to Charpy measurement protocols
  - Provided a proof of principle for a more robust derivation of ETCs from Charpy or fracture toughness measurements

INCEFA, INCEFA+

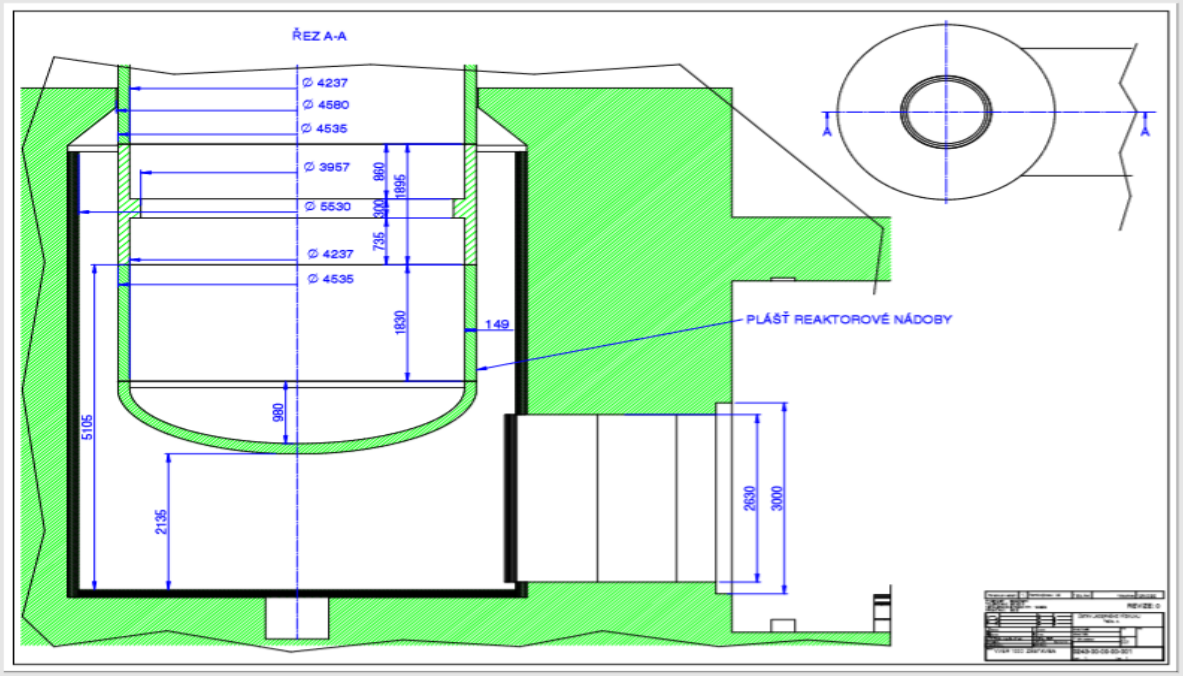
Increasing safety in NPPs by Covering gaps in Environmental Fatigue

- **Partly funded by the Euratom Research & Training programme**
- **Under NUGENIA Association**
- **16 participants**
- **Summarized state of art of environment influence on fatigue life evaluation**
- **Fatigue experimental program to refine the evaluation and prediction models and formulas**
  - Agreed testing protocol
  - LWR environment & air
  - SS304 common material, national materials
- **Development of the Fatigue Assessment Procedure**
- **Dissemination and Training**

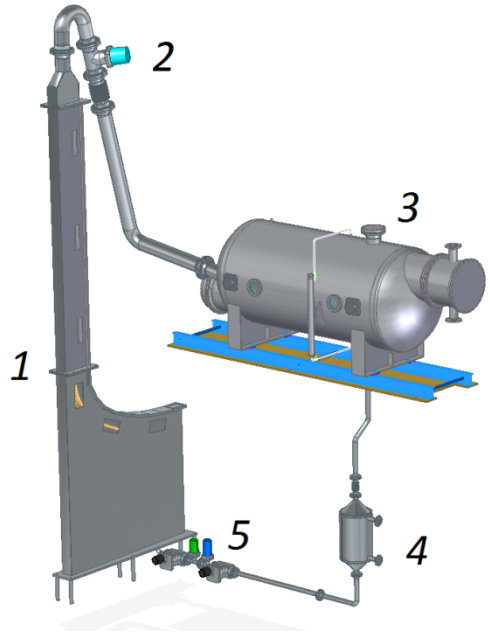
THS 15 – In Vessel Retention Research

Justification of IVMR strategy for VVER reactors 1000/320

- **100 small scale experiments**
- **Requirement (necessity) for large scale experiments with fully justified geometry**
- **Developed and assembled in UJV Řež, a.s.**
- **Tests of surface influence on cooling**



VVER 1000 cavity configuration



3D model of the cooling channel and primary circuit

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THS 15 – In Vessel Retention Research, cont.

From instalation of the equipment …

Installation – because of the dimension through the roof

View of the condenser and upper part of the cooling channel

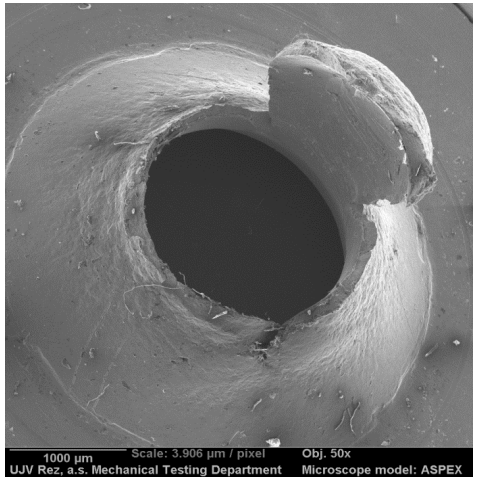
Defi - Prosafe

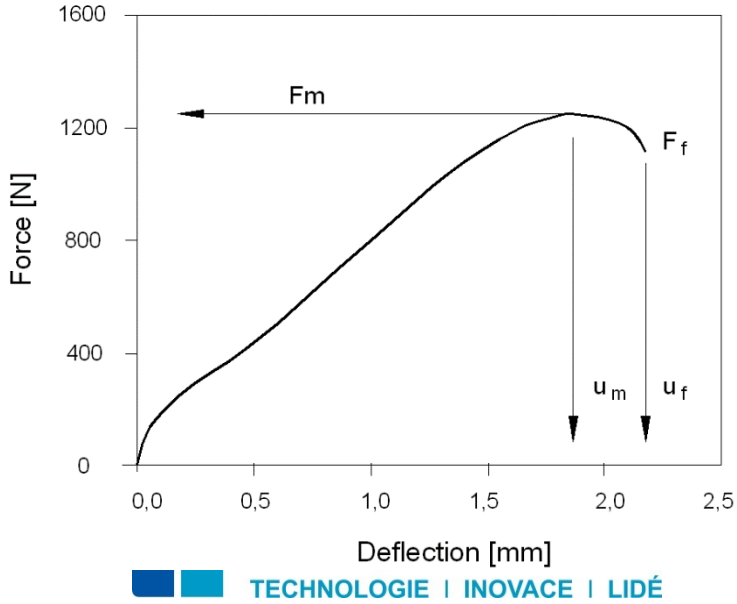
Benchmark focused on probabilistic assessment of RPV integrity

- **Partly funded by the European Atomic Energy Community's (Euratom) Seventh Framework Programme FP7/2007-2013 under grant agreement No. 604965**
- **In Europe the resistance against fast fracture based upon deterministic approach, probabilistic voluntary (supplementary)**
- **Several benchmarks project performed in the past with unsatisfying results and questions still opened, Defi – Prosafe project is continuation of former work performed**
- **The objectives are to support utilities in the assessment of the regulatory margin justification in their structural integrity assessment of the RPV by demonstrating a low risk of sudden failure in the case of a request for long-term operation as well as to progress on the acceptance within Europe to use a probabilistic approach for integrity.**
  - Determination of the limiting material reference temperature based upon RPV defects distribution, material properties distribution, and TH uncertainties

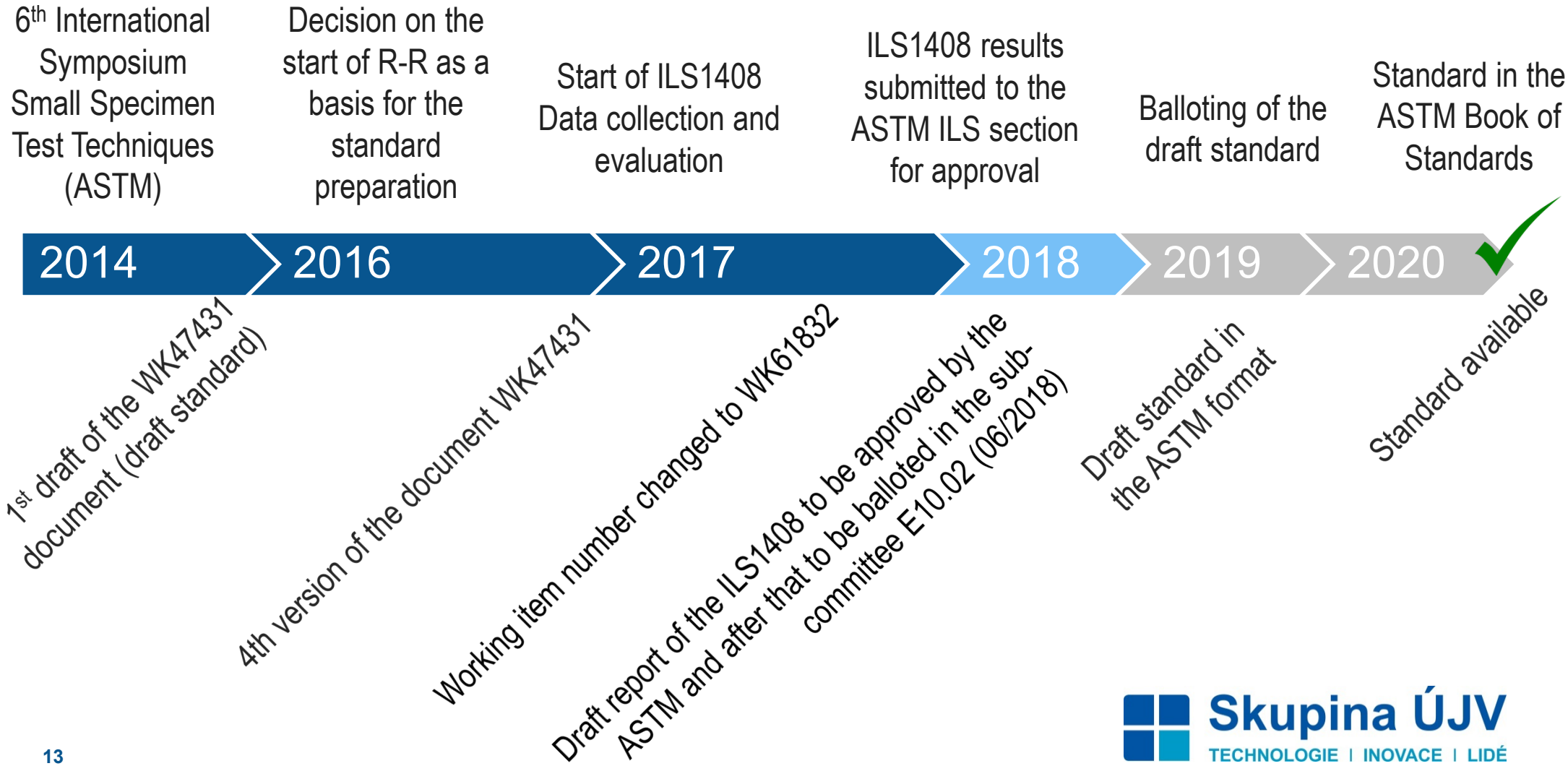
Project of Small Punch Test Standardisation within ASTM

- There does not exist standardised procedure for very small specimen that can by used for evaluation of mechanical properties specially in nuclear industry
- Within American Society for Testing and Materials the procedure developing project was started:
- Based upon interlaboratory study with selected material ILS1408
  - 14 laboratories from Europe, Asia, USA
- Continuation with tests of 6 selected materials – 7 states
- 8 parameters recorded during the tests





Expected schedule (after E10 committee meeting in June 2018)



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NURESIM, NURISP, NURESAFE

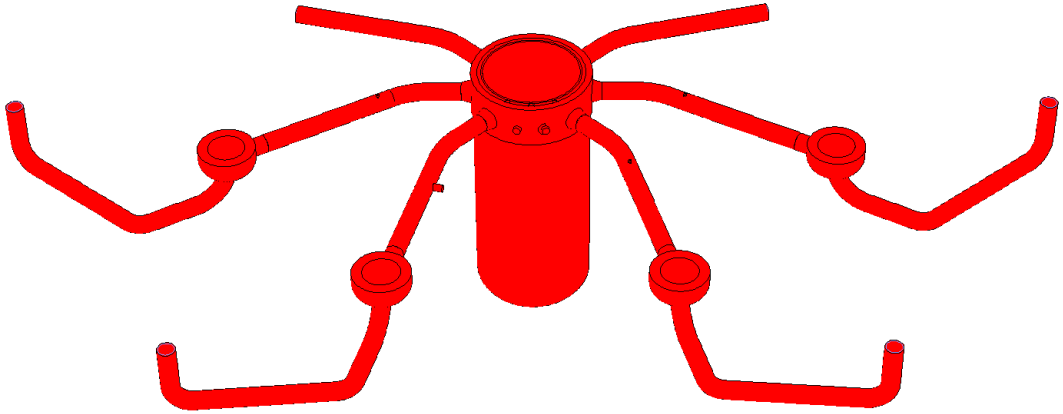
European platform for nuclear reactor simulations

- **Generally describing mixing phenomena relevant for safety analysis and particularly for structural integrity evaluation**
- **Development of the computer fluid dynamic simulation NEPTUNE**
- **The data from commissioning test used (Sizewell-B for PWRs, Loviisa and Paks for VVER), TOPFLOE, ROSA**
- **Recommendation for applicability of CFD codes for turbulent mixing problem**
- **Improving and validation simulation tools for modelling scenarios relevant to safety analysis of LWR (LOCA, PTS …)**
- **Multi-scale analysis and multiscale coupling of thermal hydraulics tools with others disciplines to investigate safety issues Pressure Thermal Shock (PTS), Critical Heat Flux (CHF), Loss of Coolant Accident (LOCA)**

Safety Analysis of VVER NPPs

Continual development, verification of new techniques / tools in safety analysis of the PWR/VVER reactors ,

- **As rupture of the RPV due to PTS and consequent LOCA is outside design accidents**
- **Continual process since 1999 (first analysis)**
- **Wider deployment of CFD in PTS analysis**
- **Verification of CFD results with respect to the older simple mixing results**
- **As results the less overconservative modelling of TH processes are acquired as important input for following RPV/RVI evaluation**
- **Still open question – CFD modelling of two phase cases scenarios**



Computational Domain – CFD model VVER 440

- 2.1M computational cells, 1.4M cells in fluid domain, 0.7M cells in solid walls
- Calculations of long transients (~1hour or longer)
- Initial and boundary conditions for CFD are taken over from RELAP5 simulation.
- Goal of the CFD simulation: temperature fields on wetted walls in cold legs and on RPV wall in downcomer
- Depending on the solved case, some parts can be deleted from the computational domain, e.g. cold legs without operating injections.

Thank you!