

Update on ÚJV Group and ALTA Programmes on Enhanced ATF

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Update on ÚJV Group and ALTA Programmes on ATF

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Safety, reliability and security of nuclear fuel supply

- **Our global interest – safety, reliability and security of supply of nuclear fuel for NPPs operated in the Czech Republic.**

Since very beginning we have developed our knowledge (own R&D, international multilateral and bilateral cooperation) to the level to be able properly understand fuel safety and operational reliability in line with full responsibility of Czech NPPs' operator (ČEZ, a. s.) and licensing responsibility of Czech regulatory body (SÚJB).

- **If Enhanced Accident Tolerant Fuel will be implemented, it should be available also for NPPs operated in Czech Republic (up to now VVER 440/213 and VVER 1000/320) – and as minimum by two existing vendors.**

This is in line with both recently approved documents by Czech Government:

- Updated State Energy Strategy (approved 18 May 2015), and
- National Action Plan on Nuclear Energy (approved 5 June 2015).

Complete safety analyses for our reactors

- **Safety analyses of Czech NPPs as well as the support of licensing process are performed by Czech companies.**

This capability is supported by:

- Research and development,
 - Experimental research, and
 - International multilateral and bilateral cooperation.
- **Priority of our own research were focused on specific differences of VVER fuel:**
 - different water chemistry,
 - different (hexagonal) geometry,
 - different cladding and construction materials,
 - annular pellet,
 - assembly shroud, and
 - different control rod materials.
 - **Major focus was devoted on adequate complex fuel behaviour modelling under operational, transient and accident conditions.**

Fuel performance and system analysis methods (1/4)

- **In order to evaluate the ATF concept in VVER it is necessary to simulate its behaviour in the state of art models of the plant in:**
 - Normal operation and AOOs
 - no decrease of fuel reliability (pellet-cladding interaction)
 - no unacceptable economic penalty
 - frontend / backend issues (fresh and spent fuel storage criticality...)
 - Design Basis Accidents
 - no decrease in safety margins (esp. RIAs)
 - Design Extension Conditions (Severe Accidents)
- **ÚJV Řež is capable of performing such complex analysis thanks to significant experience with VVERs:**
 - Well developed and validated codes, models and methodologies for VVER-440/213 and VVER-1000/320
 - Experience with implementation of VVER specific materials (esp. E110 cladding alloy and its oxidation kinetics) – it is possible to easily implement any ATF concept into the chain of analysis tools
 - Excellent knowledge of VVER accident scenarios

Fuel performance and system analysis methods (2/4)

- **Some unique aspects of VVERs influencing accident progression**
 - Horizontal steam generators
 - High power density (VVER-1000)
 - 6 loops + valves on the loops (VVER-440)
 - Tandem mechanical reactivity regulation (fuel part + regulating part) (VVER-440)
 - FAs with shroud (VVER-440)
- **ÚJV Řež tools, models and methodologies developed in course of several VVER projects**
 - Update of the SAR after new fuel type implementation and power uprates on both VVER-440 and VVER-1000 (Dukovany, Mochovce 3,4, Kozloduj, Temelin....)
 - Preparation of SAMGs for Czech NPPs
 - Preparation of hydrogen mitigation strategies for Czech NPPs

Fuel performance and system analysis methods (3/4)

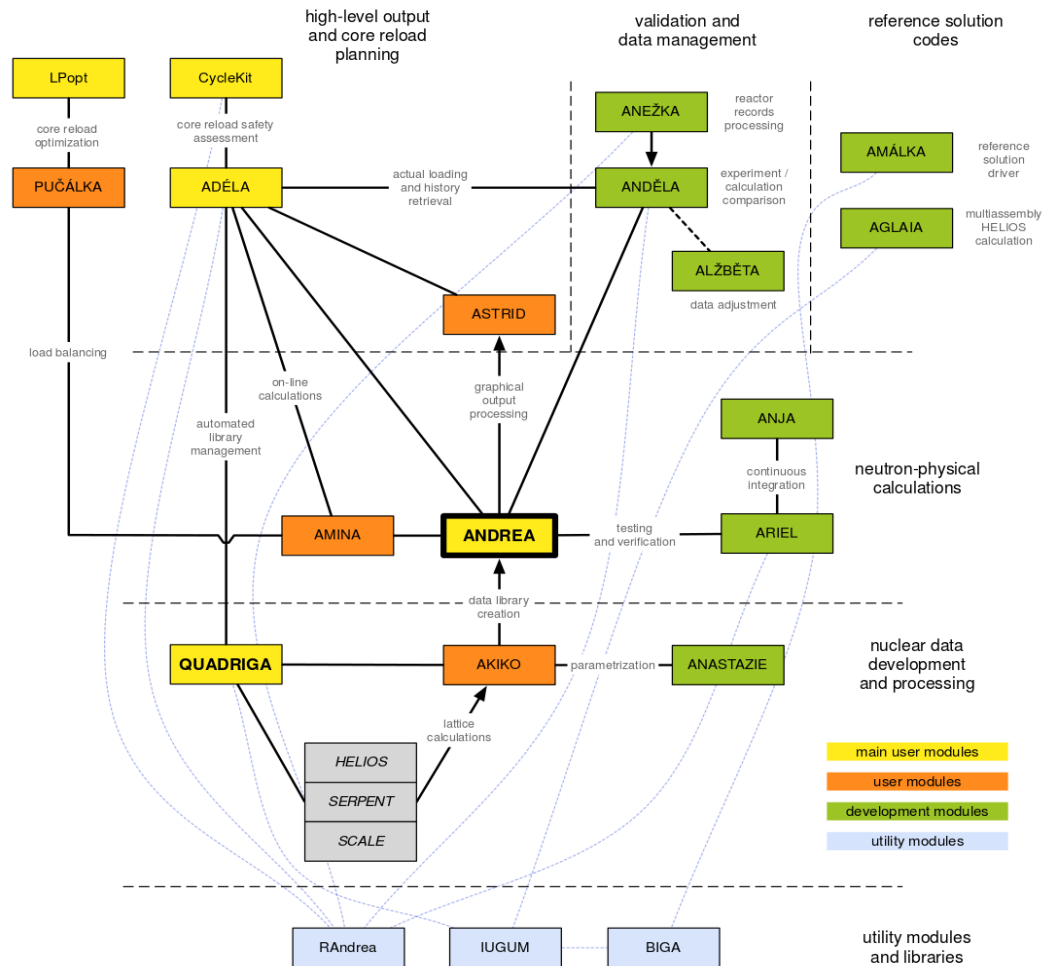
Normal operation and AOOs - complex methodologies for core design safety evaluation

• Nuclear Design

- Modular suite of codes for the core reload design and long term optimization
- Automated interface to Fuel Rod Performance

• Fuel rod performance

- TRANSURANSUS adapted at ÚJV for VVER fuel,
- ABAQUS for detailed 2D/3D FEM modelling



Fuel performance and system analysis methods (4/4)

- **Design Basis Accident Analysis**
 - RELAP, ATHLET, DYN-3D,...
 - Coupling of codes for specific scenarios (ATHLET + DYN-3D for reactivity initiated accidents....)
 - Fuel rod performance by TRANSURANUS or FRAPTRAN
- **Severe Accident Analysis**
 - MELCOR, ASTEC
 - Models for fuel in reactor / fuel in SFP during shutdown scenarios
 - Currently involved in the VVER in-vessel retention project

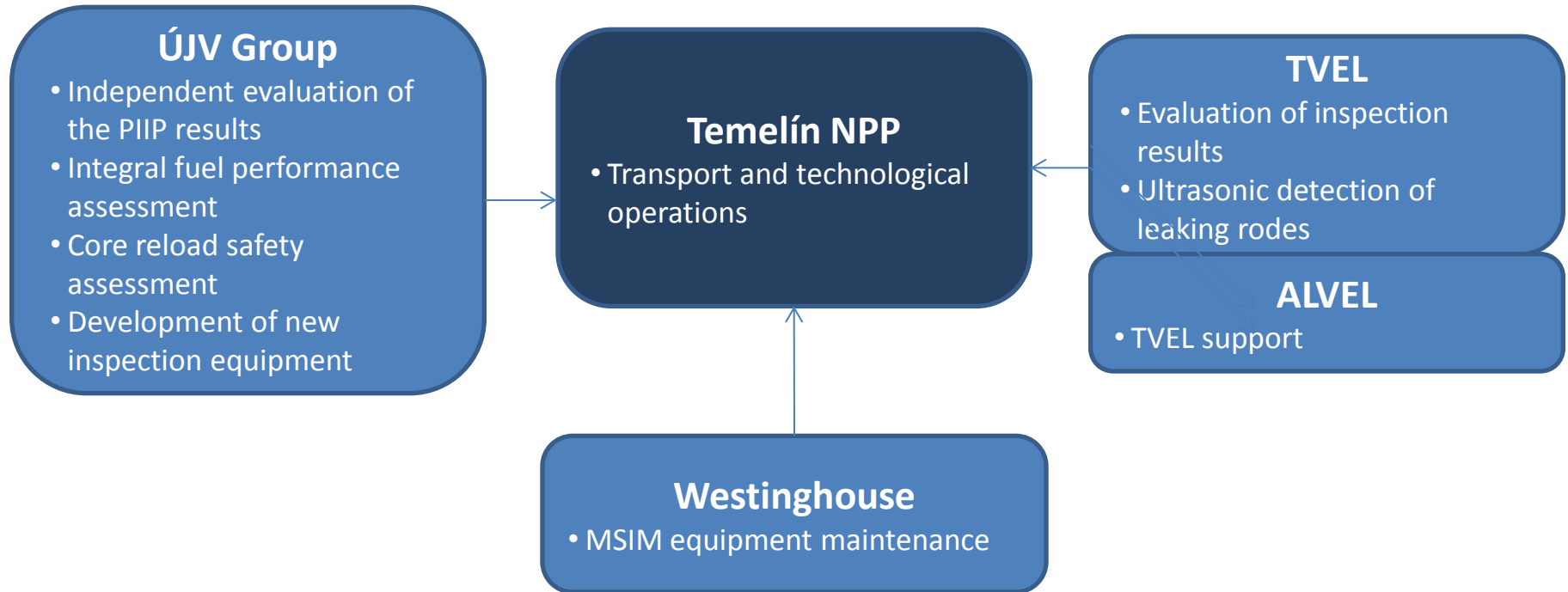
Activities and international cooperation in fuel R&D ^(1/4)

- **Autoclave cladding behaviour studies at UJP Praha**
 - High temperature oxidation in steam (currently up to 1300°C, planned >1500 ° C)
 - Long term corrosion tests (PWR / VVER chemistry)
 - Long term creep tests (dry storage conditions)
 - Burst tests
 - Fast deformation burst testing (RIA timescales)
 - Post test examination at various collaborating laboratories (UJV, Czech Technical University) – SEM, TEM, SIMS...
- **In-pile corrosion and water chemistry testing at CV Řež**
 - Corrosion testing in pile with real water chemistry (PWR or VVER) comparison of in-pile and out-of-pile conditions
 - Experimental testing of fuel behaviour in operation (crud deposition)
 - Program for new cladding irradiation testing (SiC/SiC, etc.)

Activities and international cooperation in fuel R&D (2/4)

- **Fuel performance modelling at ÚJV Řež**
 - Development of 2D / 3D finite element models of fuel rod
 - Simulation of crack initiation and development in cladding in collaboration with VNIINM / ALVEL
 - Pre-test and post-test simulations of experiments for the Studsvik Cladding Integrity Project (SCIP)
- **Poolsite Fuel Inspections at Temelin NPP**
 - ÚJV Group performing fuel inspections since the transition of Temelin to TVSA-T fuel in 2009

Activities and international cooperation in fuel R&D (3/4)



Activities and international cooperation in fuel R&D (4/4)

- **International and bilateral cooperation was focused on:**
 - Fuel behaviour modelling and verification,
 - Material research,
 - Complex in pile and out of pile experiments and its impact on cladding corrosion and crud deposition.

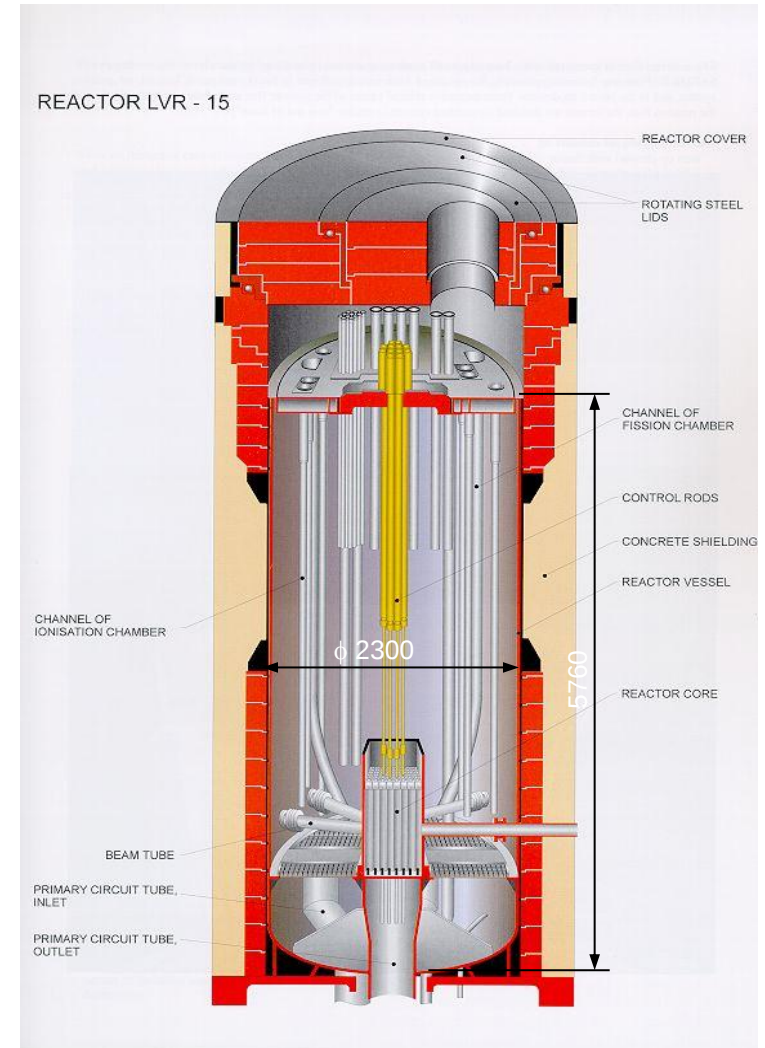
Our test facilities, and experience gained were used also for bilateral research both, for VVER and PWR fuel. Bilateral research or cooperation were performed with a lot of international partners, including key fuel vendors: ROSATOM, Westinghouse, AREVA etc.

Experimental facilities (1/3)

Main infrastructure at CV Řež:

LVR-15 research reactor

- VVER and PWR loops for corrosion / crud deposition testing
 - VVER loop used extensively for the cladding corrosion tests in the past
- $1.5E^{13} \text{ cm}^{-2}$ fast flux $E > 1 \text{ MeV}$ in loop
- Up to 3x higher fluence in fuel channel (capsules)
- Availability of hot cells for extensive PIE



Experimental facilities (2/3)

New SUSEN (SUStainable ENergy) facilities:

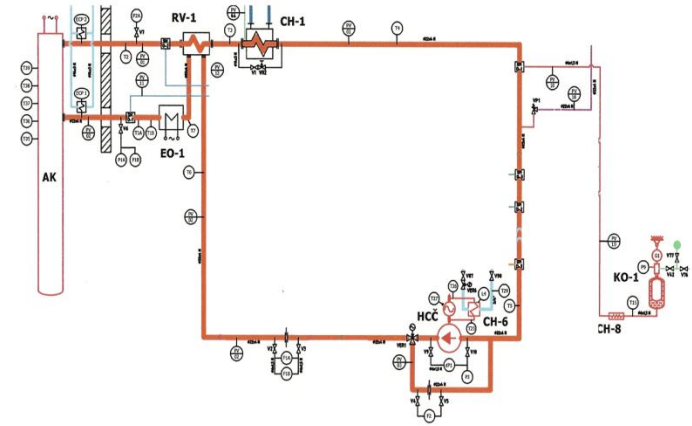
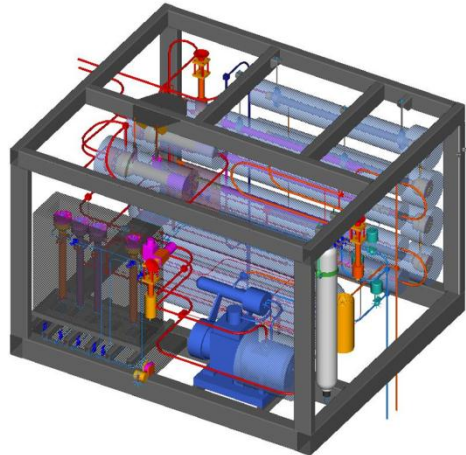
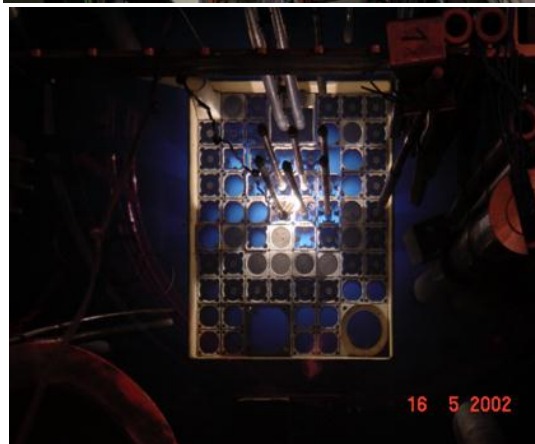
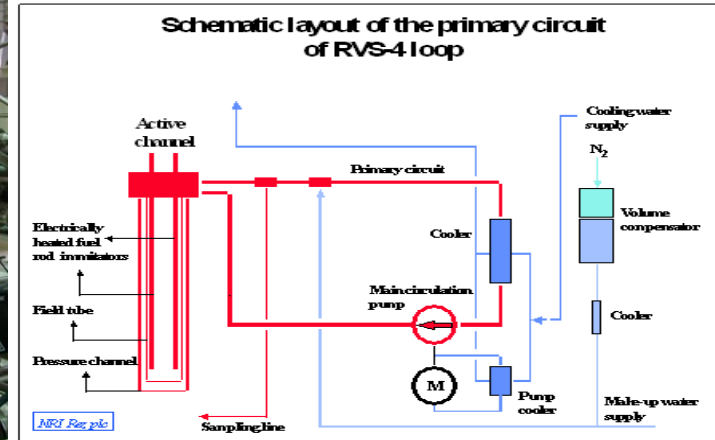
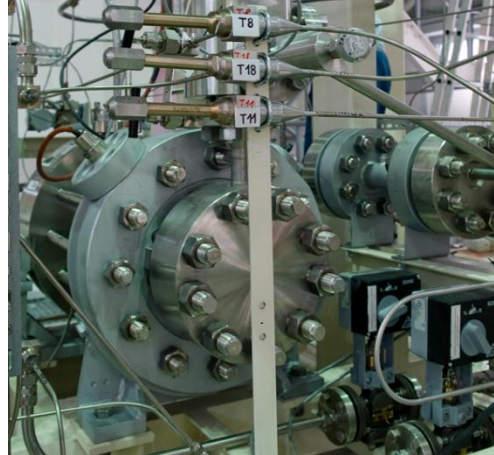
- **Hot cells**

- Study of the microstructure degradation and mechanical properties
- Very high temperature testing (up to 1200°C) of mechanical properties,
- CGR at cyclic loading, a development and implementation of low-cycle fatigue testing with creep interaction (fatigue-creep), and creep testing
- Autoclave with water loop
- The microscopes (SEM, LOM) will be placed in the semi-hot cell also with nanoindentation device.

- **Centre of Highly Sensitive Analytical Instruments**

- Light Optical Microscope (LOM) with Microhardness Tester (MHV)
- Scanning Electron Microscope with Focused Ion Beam (SEM-FIB) and analytical detectors EDS, WDS a EBSD
- Transmission Electron Microscope (HR-STEM) with atomic resolution and very low detection limits of chemical elements
- Secondary Ion Mass Spectroscopy (SIMS) for isotopic analysis

Experimental facilities (3/3)

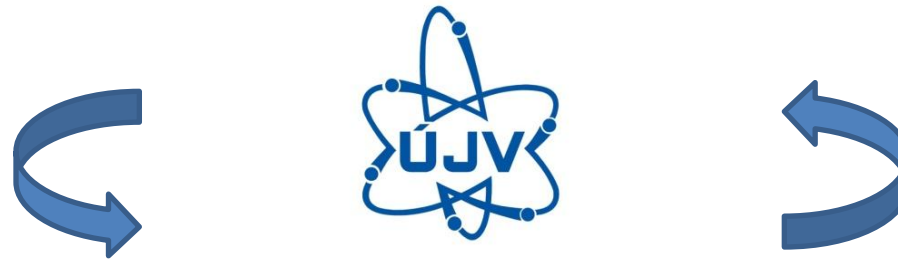


Conclusions

Our focus in EGATFL is on:

- **Inventions in new cladding materials – new alloy and coatings**
- **Applicability of new fuel concepts also for VVER type reactors specific conditions**
 - geometry, chemistry, materials, accident scenarios, etc.
- **Possible experimental testing on available experimental facilities**

Shareholders:



Subsidiaries = synergy



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Thank you for your attention!!!