Spent Fuel Characterization to Support NPP Krško Dry Storage Campaign

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Content

- Introduction
- NPP Krško
- Fuel characterization - work done at the JSI
- Conclusion
• Jožef Stefan Institute (JSI) performs scientific research related to all fuel cycle stages. It is the largest scientific institution in Slovenia covering the nuclear field and operating TRIGA Mark II research reactor. Beside basic research we provide technical support to our only NPP – Krško.

• NPP Krško intends to transfer some of its spent fuel currently stored in the spent fuel pool to the dry storage casks. The motivation is to build a storage facility that does not require any active systems.

• Contract has been signed with the Holtec International, however the project is somewhat in delay due to unexpected administration procedures needed for the construction permit of the dry storage building.
Introduction

• For the successful campaign a well done characterization of the spent fuel is needed.

• Some observables can be determined by the Non-Destructive Analysis (NDA) methods. However, since such measurements take considerable time, it is impractical to measure the entire fuel inventory.

• Calculations are thus required for full characterization of the spent nuclear fuel inventory.

• NPP Krško does not plan to do any NDA.
The Krško plant is a 2-loop Westinghouse PWR that began electricity production in 1981.

The start-up core had a rated thermal capacity of 1,876 MWt, and a 626 MWe gross electric power. Currently, the thermal rating is 1,994 MWt with 727 MWe gross electric power.

Original lifetime till 2023, currently planned extension until 2043.

The core consists of 121 fuel assemblies.

Each assembly has 235 fuel rods arranged in a 16×16 array. The remaining 21 positions contain guide tubes and are intended for control rods, neutron source and in-core instrumentation. Currently - STD fuel with VANTAGE+ features.

Only 3 NPPs in the world use the same fuel type.
• The core features 33 Reactivity Control Cluster Assemblies (RCCA) arranged in 6 banks.
A typical NPP Krško power distribution at BOC
Fuel characterization

- JSI is involved in several international initiatives regarding spent fuel characterization:
  
  - EURAD - European Joint Programme on Radioactive Waste Management: WP8 - Spent Fuel characterization and evolution until disposal
  
  - Blind Test Benchmark organized by the Swedish Nuclear Fuel and Waste Management Company (SKB)
  
  - Cooperation with EC Joint Research Centre Geel and Belgian Nuclear Research Centre (SCK.CEN)
  
  - IAEA initiative?
• NPP Krško support activities:
  ▪ to produce verified procedures to determine decay heat, activity, photon and neutron source term of spent nuclear fuel including realistic uncertainties
  ▪ to produce application for the fast determination of the source terms for more than 1300 NPP Krško fuel assemblies
  ▪ to develop cask loading strategy based on the constraints provided by the NPP Krško
Fuel characterization

- **Tools used:**
  - Serpent2 - stochastic neutron transport code
  - SCALE - deterministic codes:
    - TRITON/NEWT
    - ORIGEN/ORIGAMI

- **Data needed:**
  - JSI supports NPP Krško fuel management - perform independent nuclear design calculations to verify results of the fuel vendor with the in-house code system CORD-2
  - Results available for all 30 cycles of plant operation
  - Rudimentary fuel data – “as built” material composition, burnup, operating history, etc. stored also at NPP Krško under their data management system
Fuel characterization - performed analyses

- Influence of the fuel operational history and material composition (fuel burnup, enrichment, temperature, moderator temperature (density), soluble boron concentration, average power, and burnable absorbers) on the source term has been analyzed:

Fuel characterization - performed analyses

- Effects of boundary conditions:
  

- Comparison of Serpent2 and TRITON/NEWT
  
Fuel characterization - performed analyses

- Fast determination of the source terms:
Conclusion

- JSI performs scientific research and provides support to the NPP Krško dry storage campaign

- R&D work on the spent fuel characterization runs on 2 tracks:
  - Sensitivity analysis to reduce uncertainties
  - Development of tools for the fast determination of the source terms based on available databases able to generate also data for the cask optimization process

- Several analyses have already been performed

- Work still in progress
Thank you!

Questions?