ÚJV Řež, a. s., Czech Republic

PSA Applications for Dukovany NPP

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Presentation Outline

- Overview of Living PSA project for Dukovany NPP
- Regulatory Decrees and guides for PSA applications
- Performed PSA applications for Dukovany NPP
- Main outputs
- Main insights and conclusions

PSA for Dukovany NPP

- **Dukovany NPP**
  - VVER-440/213 type plant in the Czech Republic
  - four almost identical units, 500 MWe each
- **Living PSA Project**
  - developed and maintained in ÚJV Řež, a. s., for Dukovany NPP
    - RiskSpectrum® PSA software
  - basis for PSA applications at Dukovany NPP
    - evaluation of Technical Specifications (TS)
    - selection of important components
    - risk monitoring (the most extensive one, Safety Monitor™ is utilized)
    - analysis of occurred events, analysis of modifications etc.
  - the first two applications are subject of this presentation

Living PSA Scope

- **Full-scope Level 1 & Level 2 PSA**
  - all plant operating modes
  - internal initiating events (IEs), internal and external hazards,
  - risk from reactor core as well as from spent fuel pool (SFP)
    - Core Damage Frequency (CDF)
    - Fuel Damage Frequency (FDF) = CDF + frequency of fuel damage in SFP
- **Fully integrated PSA model**
  - all plant operating states (POSs) and IEs are modeled in the same PSA project
    - no separate PSAs for shutdown operation, hazards or SFP risk

Regulatory Decrees and Guidelines

- **Czech implementing Decree 162/2017**
  - requires to use PSA applications for the selected purposes
- **Czech regulatory safety guides**
  - support some PSA applications incl. those required by Decree
  - BN-JB-2.5 (analogous to IAEA SSG-3)
    - supports PSA applications generally
  - BN-JB-2.6 (analogous to US NRC RG 1.174)
    - supports RIDM for changes initiated by plant
  - BN-JB-2.7 (analogous to US NRC RG 1.177)
    - supports TS evaluation
  - BN-JB-2.8 (analogous to NEI-00-04)
    - supports PSA based selection of important components

Evaluation of Technical Specifications

- **Implementing Decree 162/2017**
  - it requires to assess both the need for TS modifications and acceptability of TS changes initiated by plant
- **Regulatory safety guide BN-JB-2.7**
  - supports TS changes initiated by plant as well as AOT adequacy
    - incremental conditional core damage probability (ICCDP) ≤ 5×10^{-7}
    - incremental cond. large early release probability (ICLERP) ≤ 5×10^{-8}
    - acceptable yearly risk increase is defined in BN-JB-2.6 (not applicable for evaluation of AOT adequacy since it is not related to change)
  - guideline and discussion for comparison of alternatives
    - when plant would choose this option to justify TS change
    - approximately the same level of conservatism should be applied in models for compared alternatives

Evaluation of Technical Specifications

- **TS evaluation performed recently for Dukovany NPP**
  - main objectives
    - identification of the eventual need for TS modification
    - identification of potential for AOT extension
    - comparison of alternatives for the cases selected by plant
  - scope of evaluation
    - more than 250 cases for various combinations of limiting conditions for operation (LCOs) and AOTs
    - diverse and mobile (DAM) requirements for availability were included
    - risk associated with AOT in Mode 1 was assessed, several evaluations were done also for other Modes
    - unit No. 1 was selected as a representative one
    - internal and external hazards were included in calculation of AOT risk

Evaluation of Technical Specifications

Main features

- entry into LCO selected for calculation
  - identified most unfavorable case of entry into each LCO
  - limited to single failure or single common cause failure (CCF)
  - conditioning of CCF was applied when components redundant to failed one are not subsequently tested (if CCF is credited in PSA)
- calculation of risk associated with AOT
  - such risk was compared with criteria for ICCDP and ICLERP
  - determination of maximal AOT for given LCO, it allows plant to identify potential proper candidates for AOT extension
- RiskSpectrum PSA software was used for calculations

Evaluation of Technical Specifications

Main outputs

- all evaluated LCOs have been found adequate
- a few exceptions were identified
  - some cases of motor operated valve (MOV) unavailability when CCF conditioning was applicable
- TS modifications for Dukovany NPP were proposed
  - mainly to decrease risk associated with AOT for several cases of MOV unavailability
  - they include new TS requirements to test MOVs in the other redundant divisions when one of the redundant MOVs fails
  - sensitivity analyses to show benefit of modifications were performed
- finally, plant made several changes in TS based on these proposals

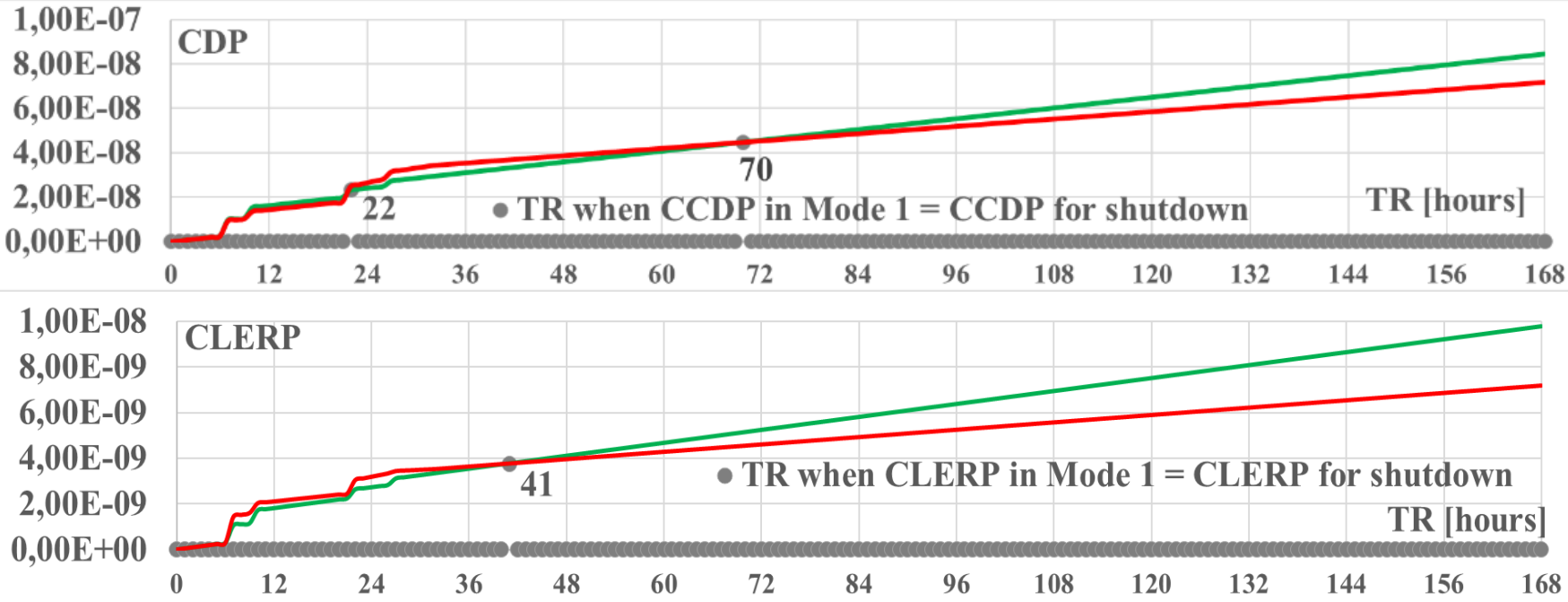
Evaluation of Technical Specifications

Comparison of alternatives

- the following alternatives were compared for selected cases
  - risk from continuation at power with unavailable component
  - vs. risk from shutdown after AOT expires
  - for the same time period
- main insights
  - continuation at power operation has not been found to be better option in the analyzed cases
  - output of comparison is often highly dependent on expected time to repair, duration of transition states, etc.
  - output of comparison was not often decidable, e.g. when output based on CCDP comparison gave results different from output based on CLERP comparison for the same component unavailability

Comparison of Alternatives

- **Unavailability of essential service water (ESW) division**
  - CCDP and CLERP dependent on time to repair (TR) is shown



continuation of operation in Mode 1; shutdown after AOT expires

Note: Risk from time interval corresponding to startup in shutdown case (just after repair is completed) is added at the beginning of calculation for both alternatives

Selection of Important Components

- **Regulatory Decree 162/2017**
  - requires to identify components with impact on plant safety using PSA for various purposes
- **Regulatory safety guide BN-JB-2.8**
  - support for PSA based selection of important components
    - regardless of the purpose (it is not specified here)
    - importance measures are utilized to assess (non-negligible) impact
  - important component
    - FV (Fussell-Vesely) for sum of component failure modes ≥ 0.005
    - the highest Risk Achievement Worth (RAW) ≥ 2 (including CCF)
    - either in FDF calculation or in LERF calculation
    - either for internal IEs (incl. internal hazards) or for external IEs

Selection of Important Components

- **Performed for components at Dukovany NPP**
  - both for plant and for regulator
  - PSA based using importance measures
  - integrated PSA model was used
    - importance measures were not determined separately for shutdown states nor for internal hazards
- **List of important components based on PSA**
  - mostly safety or safety-related components
  - some non-safety components
    - added to plant list of „non-categorized equipment with impact“ for graded treatment

Main Insights and Conclusion

Living PSA project for Dukovany NPP

- effective tool to control and reduce plant risk level
  - in accordance with requirements of Regulatory Decree
  - especially, PSA is used to propose measures at plant if necessary
  - evaluation of TS adequacy to identify the need for TS changes contributes to this PSA objective as well
- provides support for risk informed decision making at Dukovany NPP
  - for changes initiated by plant
  - it includes also identification of potential for such kind of changes
- provides support for site inspectors of Czech regulator as well
  - list of important components based on PSA importance measures is used as a support to determine significance of issues and findings

Thank you for your attention