Performing $k_{\text{eff}}$ Validation of As-Loaded Criticality Safety Calculations Using UNF-ST&DARDS: Sensitivity Calculations

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Outline

1. Introduction and background
2. F*(r) mesh selection
3. Number of latent generations
4. Conclusion
5. Future work
Introduction and background

• UNF-ST&DARDS performs many analyses for as-loaded SNF canisters: criticality safety, shielding, thermal-hydraulic, containment
  – Overall plan for NCS validation presented by Clarity in Minneapolis
  – Experiment selection presented in next paper

• Sensitivity data generated for each cask using TSUNAMI-3D sequence
  – CLUTCH method only option in SCALE 6.2.3 for such large models
  – 32 PWR assemblies in 18 axial zones with 29 isotopes per zone
Introduction and background (continued)

• CLUTCH method uses $F^*(r)$ function for importance instead of an explicit adjoint calculation

• $F^*(r)$ is tallied by voxel during inactive cycles using the IFP method
  – Input for number of latent generations for the IFP calculation (CFP)
  – User-supplied mesh for $F^*(r)$ function (MSH or GridGeometry block)
  – NPG and NSK for tallying $F^*(r)$ function

• Direct perturbation calculations (DPs) are used to check the accuracy of the sensitivities calculated by TSUNAMI-3D
F*(r) mesh selection

• Generic guidance for F*(r) function:
  – Mesh spacing is 1-2 cm Cartesian mesh
  – Number of histories to tally is 10 – 100 histories per voxel
  – Developed based on testing with critical experiments

• For MPC-32, this would result in an approximately 86×86×183 mesh: ~1.35 million voxels
  – 13.5 – 135 million histories to tally F*(r) function

• Small mesh will also have large uncertainty

• Essentially all sensitivity in the top few feet of the fuel
F*(r) mesh selection (continued)

- F*(r) function can be output and visualized in Fulcrum
  - Large relative uncertainties and evident statistical fluctuations in importance values

- Coarse mesh structures investigated
  - Half or full storage cell in X and Y
  - Variable axial mesh with large intervals in the lower portions of the model

- Ultimately, half cell in X and Y (each storage cell quartered) and variable Z intervals selected
F*(r) mesh selection (continued)
Number of latent generations

• Generic guidance for CFP is “usually between 5 and 10”

• Higher numbers should be more accurate, but will increase uncertainty because fewer fission chains last long enough to contribute to tallies

• Increasing CFP to 20 and 30 yielded better agreement with DP results
  - Additional calculations with CFP increased to 40, 50, and 60 performed for this paper

• H-1 sensitivity most challenging, large magnitude sensitivity to calculate accurately with TSUNAMI-3D
Number of latent generations (continued)

$^{1}H$ Total Sensitivity

$^{235}U$ Total Sensitivity
Conclusion

• Sufficiently accurate sensitivities were calculated using:
  – F*(r) mesh based on half cell size in X and Y, variable axially
  – 30 latent generations
  – 50,000 neutrons per generation
  – 500 skipped generations to tally the F*(r) function
  – 1,500 active generations

• Sensitivities used for critical experiment selection, as discussed in the next presentation
Future work

• TSUNAMI-3D
  – Determine if this large number of latent generations is needed for accurate results in IFP as well
  – Further investigate impact of $F^*(r)$ function uncertainties on accuracy of sensitivity calculations

• UNF-ST&DARDS
  – Implement parameters and mesh for automated TSUNAMI-3D calculations
  – Expand number of cask types examined, especially to BWR systems
Questions?

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