OAK RIDGE National Laboratory

Validation of k_{eff} Calculations for Extended BWR Burnup Credit Calculations

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Outline

- Application models
- Generation of sensitivity data
- Critical experiments considered and potentially applicable experiments
- Bias and bias uncertainty estimates
- Reactivity margins for unvalidated isotopes
- Conclusions

Application models

- GBC-68 generic BWR cask used with fuel at 2 different discharged burnups and 2 different isotope sets
- Burnups of 25 and 50 GWd/MTU considered
  - 25 GWd/MTU is above peak reactivity
  - 50 GWd/MTU is a little above typical discharge burnup
- Actinide only (AO) and actinide and fission product (AFP) isotope sets
  - AO includes 9 actinides and O-16
  - AFP adds 16 fission products and 3 minor actinides

Generation of sensitivity data

- SDFs generated using both CLUTCH CE TSUNAMI-3D and MG TSUNAMI-3D
  - Demonstrate accuracy of both approaches
- Compared SDFs with both c_k and E integral parameters
  - c_k uses covariance weighting, E does not
- For all 4 cases, c_k was above 0.98 and E was above 0.99
- Deficiency for ^{56}Fe sensitivity in steel basket identified in MG TSUNAMI-3D results, but very small impact overall
- CE-generated SDFs used for similarity assessments

Critical experiments considered

- 1643 LEU and MIX critical experiments considered
- Suite had previously been generated for earlier BWR BUC peak reactivity work
- Includes:
  - Everything from NUREG/CR-7109 except French fission product cases
    - HTC experiments included in this effort
  - Everything in the VALID suite
  - NEA-generated LCT, MCT, and MST SDFs
  - Total includes over 1100 LEU and over 475 MIX experiments

Potentially applicable experiments

- TSUNAMI-IP in SCALE 6.2.2 used for similarity assessment
  - 56-group covariance library based on ENDF/B-VII.1 and other sources
- A variety of LCT and HTC experiments identified as potentially applicable
- Potential for correlations among HTC cases and among the limited number of LCT evaluations as well

Burnup	Isotope Set	LCT Exps.	HTC Exps.	Total
25 GWd/MTU	AO	71	101	172
	AFP	0	68	68
50 GWd/MTU	AO	26	147	173
	AFP	0	126	126

Bias and bias uncertainty estimates

- Bias and bias uncertainty values generated for 4 applications
- Values determined using inverse variance weighted nontrending technique and trends on EALF and c_k

Burnup GWd/MTU	Isotope Set	Nontrending		EALF Trend		c_k Trend	
		Bias	Bias Unc	Bias	Bias Unc	Bias	Bias Unc
25	AO	-0.00172	0.00530	-0.00182	0.00649	-0.00674	0.00762
	AFP	-0.00236	0.00672	0.00044	0.00724	-0.00050	0.01556
50	AO	-0.00173	0.00581	-0.00206	0.00646	-0.00132	0.00562
	AFP	-0.00132	0.00562	-0.00120	0.00680	-0.00502	0.00723

Reactivity margins for unvalidated isotopes

- No experiments contained fission products of minor actinides
  - Penalties (reactivity margins) needed to cover unvalidated isotopes
- Models with residual Gd BA need factor for ^{155}Gd
  - Gd absorption in ^{Nat}Gd dominated by ^{157}Gd
  - Separate factors developed for ^{155}Gd and remaining FPs and MAs
  - ^{155}Gd factor: 0.59% at 25 GWd/MTU and 0.60% at 50 GWd/MTU
  - FP & MA factor: 1.37% at 25 GWd/MTU and 1.27% at 50 GWd/MTU
- No residual Gd penalty needed if residual BA material not credited
  - Margin ranges from 0.97% at 20 GWd/MTU to 1.03% at 50 GWd/MTU

Conclusions

- Sufficient critical experiments are available for validation of extended BWR BUC k_{eff} calculations
- Accurate sensitivities can be generated with both MG and CE TSUNAMI-3D
- Validation accomplished with LCT and/or HTC experiments
- Bias generally around -0.2% $\Delta k \pm 0.6\% \Delta k$
- Reactivity margins generated for unvalidated fission products, minor actinides, and residual BA ^{155}Gd

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Are there any questions?