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General Comment

See attached file(s)

Attachments

Comments on ISG8 Rev 3

SUNSI Review Complete
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Add = A. Barto (ABB2)

May 30, 2012

Dear Sir/Ms,

Thank you for the opportunity to comment on the draft of ISG8 Rev.3. This new revision of ISG8 is a major improvement over the previous version and I want to congratulate the authors on their excellent work. This letter is providing comment to improve the ISG8 Rev. 3. Although these comments are significant they are small compared to the large forward step taken from Rev.2.

Again thank you for the good work,

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Specific Comments on ISG8 Rev 3:

1. **Applicability**:

"Intact fuel" originated in the "Topical Report on Actinide-Only Burnup Credit for PWR Spent Nuclear Fuel Packages," DOE/RW-0472. It was item 6 in the list of Range of Applicability (Section 7.3). I states:

> "*6. Reconstituted or Disassembled fuel is excluded. Also excluded are fuel assemblies which have had any of their original rods removed or replaced.*
>
> *Modified or non-**intact** fuel assemblies may not be bounded by design basis criticality analyses.*"

This restriction became the "intact" fuel restriction. Clearly the intent was to exclude significant fuel movement. ISG-1 calls fuel with pinhole and hairline defects in the clad as not intact. From a criticality point of view these defects are insignificant. If ISG-1 definitions are to be used then "intact fuel" should be changed to "fuel that is not grossly breached."

2. **Recommendations: 3. Code Validation – Isotopic Depletion 4th Paragraph: "*The burnup credit results should be adjusted using the bias and bias uncertainty determined for the fuel depletion code with regards to different control parameters such as enrichment, burnup, and cooling time.*"**

NUREG/CR-6811 shows a trend on burnup but does not discuss trends on enrichment or cooling time. We agree that a trend on burnup should be sought and applied as recommended by the ORNL work. The data for seeking an enrichment trend is much thinner especially if the set were required to contain fission

products. It is prudent to check for an obvious trend on enrichment but a full statistical approach is not needed. In the range of interest the increase in U-235 should have little impact on the physics. It would be more logical to seek a trend on a spectral index which has more effect on the physics. A trend on cooling time would be difficult to obtain from the chemical assay data. Since the two cooling time changes that are important are the Pu-241/Am-241 and Eu-155/Gd-155 decays then a seeking a trend on these ratios may be illuminating.

It is recommended that the enrichment and cooling time be eliminated from the referenced sentence. The remaining sentence would still say "with regards to different control parameters such as burnup." This sentence then suggests that the applicant carefully review the data and underscores the important parameter, burnup.

3. **Table 1 and Table 2**

It is excellent that values are given which can be directly applied. **The tables need to be clear that the values are the uncertainty in the bias and the bias to be used is zero**. The uncertainty can be statistically combined with other uncertainties. No statement on statistical combination is necessary unless the NRC is not allowing combination of this uncertainty with other uncertainties.

4. **Restrictions on Table 1: Codes used**

The results depend on the cross section library. They depend on the depletion code to a lesser extent. They should not depend much on the final criticality code (KENO vs MCNP). Please consider relaxing the restriction to "the same **depletion** code and cross section library." This will allow the use of MCNP which for the same isotopic content agrees very well with KENO. Alternatively, allow for some sample cross checking between KENO and MCNP to prove acceptability.

5. **Table 1 restrictions: similar initial assumptions?**

It is unclear what this means. The depletion assumptions for cask analysis will depend on the limiting conditions expected for the fuel to be loaded in the cask. These assumptions are different than using the actual conditions for a chemical assay. Please remove "initial assumptions and."

6. **Table 1 restrictions: code modeling options**

The code modeling options is also not clear. NUREG/CR-7108 does not provide input decks. However, for ENDF/B-V it is possible to use NITWAL rather than CENTRM and this will produce different results. It is recommended that Table 2 should specify CENTRM so this issue is removed. It is recommended to remove this restriction or provide more details about what it means.

7. **Table 1 restrictions: GBC-32 system design.**

The appendix is clearer on what this means but does not actually give an acceptable range for the H/X or EALF. It is recommended that specific range for these parameters be determined and that range included in the Appendix where this is discussed.

8. **Code Validation – K_{eff} Determination, Fission Product and minor actinide credit**

Use of "combined bias and bias uncertainty" should be avoided. Uncertainties are statistically combined but biases are added. Please replace:

> *A conservative estimate for the combined bias and bias uncertainty associated with minor actinide and fission product nuclides of 1.5% of their worth may be used. This estimate is appropriate provided the applicant*

With

> *"1.5% of the worth of the minor actinides and fission products conservatively covers the bias due to these isotopes. Due to the conservatism in this value no additional uncertainty in the bias needs to be applied."*

9. **Code Validation – K_{eff} Determination, Fission Product and minor actinide credit**

The combined minor actinide and fission product worth for high burnups is close to 0.1 in k_{eff}. For example in one case it was calculated as 0.11 in k_{eff}. The range of data used in NUREG/CR-7109 can justify a higher limit for the range of applicability. Please raise this to 0.13 to give more margin for various designs.

10. **Code Validation – K_{eff} Determination, Fission Product and minor actinide credit**

The recommended bias of 1.5% of the worth of minor actinides and fission products depends mainly on the cross section library and should be the same for codes other than SCALE. Proof of this for other codes is not possible yet but the factor of 2 increase in the bias should not be needed. Comparison of fission product and minor actinide worth between SCALE and code of choice could be used to confirm applicability to other codes. For this comparison a benchmark should be set up showing the isotopic worths in SCALE and then other codes could be compared to this benchmark. At this time it is recommended to remove the requirement to use the SCALE system.

11. **Page A-2 discusses "intact" fuel. Here, the discussion seems to follow the original intent on "intact" fuel but is inconsistent with the ISG1 definition. The concern is over Reconstituted, disassembled or grossly damaged fuel. The term "intact" needs to be replaced.**

12. **Page A-3 middle paragraph provides the limits discussed in Comments 4-7. Please update to be consistent with responses to Comments 4-7.**

13. **Top of Page A-12. It seems to suggest that the applicant calculate end effects. The applicant should not be required to calculate the uniform burnup k at burnups where the end effect is a positive contribution to reactivity. The applicant will have to assure the more limiting burnup profile is used in the burnup range of transition but calculation with the non-limiting profile should not be required. "*demonstrate that the Δk value(s)*" should be removed.**

14. **Second paragraph on page A-13: It is conservative to assume fuel is not blanketed and use the limiting axial profiles. The current writing of the paragraph may lead one to believe there is not a solution for blanketed fuel. Axial burnup distributions from blanketed fuel has been used in spent fuel pool analysis. In these cases the axially blanketed fuel represents a separate category of fuel from the non-blanketed fuel. There is insufficient data in public domain for generic shapes for axially blanketed fuel for cask designs and it is unlikely that the data will be available. It is non-conservative to model the axial blankets in the cask analysis while using the non-blanketed burnup distributions. The rest of the paragraph starting with: "While the database included some assemblies with axial blankets" should be deleted or rewritten.**

15. **The entire section labeled *Depletion Analysis Computational Model* (starting on page A-14) should be deleted. It seems to being trying to support ORNL codes and code development.**

    First, the statement on "over 1000 nuclides" is not supported. From a spectrum point of view SCALE does not support more than 388 isotopes. Precursors to the 28 nuclides credited do not require 1000 isotopes. There is no documentation that approaches using less isotopes produce poorer results. This paragraph is on a non-issue and should be deleted unless there is a real issue with a code system that could be used.

    Second, X-Y plane at each segment is used for power reactors but since for PWR cask analysis axial variation of enrichment is rarely credited this discussion is not relevant to cask criticality. Most cask criticality calculations use a uniform axial temperature assumption. More complicated assumptions would be hard to justify for a cask. This paragraph has no value and should be deleted.

    The suggestion that CASMO or HELIOS would not be adequate for analysis of depletion for a cask is dismaying. The presence of some lumped fission products does not disqualify a depletion code. Decomposing a lumped fission product to some of the 28 allowed isotopes would be surprising. If that were attempted the regulator would of course have to be very careful. This paragraph should be deleted.

    Third, the paragraph on 1D approaches seems to show little acceptance that the supercell approach had been worked out. It is doubtful that anyone will use a 1D approach in the future but it is disrespectful to not recognize that our elders had worked out these issues. This paragraph should be deleted.

    The final paragraph seems to be making an issue out of reactor operating history. The previous sections have dealt with these issues. Both the time and space meshing used in the analysis should be converged. This is tested by decreasing the time and space mesh until the changes in the results are consistent with the desired accuracy. This paragraph can be deleted without loss.

16. **Page A-16: "*A uniform loading of SNF at a specified assembly average burnup…*" There is no reason a uniform loading is required. The NRC has already approved a burnup credit design with zoned loading. This sentence should be removed.**

17. **Page A-16: "*18-20 uniform axial regions*" 24 nodes is <u>very</u> common. Please increase 20 to 24.**

18. **First paragraph on Page A-17. Please provide reference so the reader will know what type of source assumption can cause troubles.**

19. **Page A-18 first paragraph: Only two samples contain all 28 isotopes. This would seem to be a problem with the second sentence. Cs-133 is based on only 7 samples. Ag-109 has only 14 samples, Ru-101 and Mo-95 have only 15 samples, Rh-103 has only 16 samples. The comment on the sample size should be 30 is clearly not the case for the basis for the recommended biases. This paragraph deals with an ideal world that does not exist. Recommend deleting this paragraph.**

20. **Integral Validation (page A-25)**

    The second paragraph points out that there could be compensating errors that are not able to be found by the integral approach. This is true but misses the fact that there may be compensating errors in our standard approach. We do critical experiments that use cross sections for a large number of isotopes. We have errors in our U-235 cross sections which are compensated for by errors in our U-238 cross sections. We look for these errors by our trend analysis but we certainty do not get rid of the compensating errors. In the integral approach we may indeed have errors in the isotopic content. We try to understand these errors through chemical assays. Unfortunately, the chemical assay data is much more uncertain than our measurement of core reactivity so all we can do with the chemical assays is see gross errors. We feel good about our criticality validation if it is representative of the critical condition of concern. The CRC have a high c_k values. The c_k values for the CRC's are higher than the c_k values for the critical experiments that will be used for our validation. Should we not worry more about compensating errors in critical experiments than the compensating error between our depletion and criticality codes?

    The third paragraph raises concerns that were addressed in the TSUNAMI analysis. The one valid complaint is the complexity of the modeling. Missing is the main reason the EPRI work was done: the maximum core average burnup is 33 GWD/MTU. This core average burnup is a volume weighted value and the importance weighted burnup would be less.

    It is recommended that this section be reduced to:

    ANSI/ANS 8.27-2008, *Burnup Credit for LWR Fuel*,[34] provides a burnup credit criticality validation option consisting of analysis of applicable critical systems consisting of irradiated fuel with a known irradiation history. This is known as integral, or "combined," validation, since the bias and bias uncertainty associated with the depletion calculation method is inseparable from

that associated with the criticality calculation method. Commercial Reactor Critical (CRC) state points have been used in the past to support burnup credit. CRC state points have been shown to be similar to cask-like environments, with respect to neutron behavior, in NUREG/CR-6951, *Sensitivity and Uncertainty Analysis of Commercial Reactor Criticals for Burnup Credit.*[35] Recently, EPRI has proposed using a set of benchmarks using data from power reactors for combined validation (References A and B). The staff has not yet reviewed an application based on the combined approach and therefore is not providing guidance on this approach.

References:

A. *Benchmarks for Quantifying Fuel Reactivity DepletionUncertainty*, Electric Power Research Institute, Palo Alto, CA: August 2011. 1022909.

B. *Utilization of the EPRI Depletion Benchmarks for Burnup Credit Validation*, Electric Power Research Institute, Palo Alto, CA: April 2012. 1025203.