November 7, 2003

MEMORANDUM TO: Joseph G. Giitter, Chief
Special Projects and Inspection Branch
Division of Fuel Cycle Safety
and Safeguards
Office of Nuclear Material Safety
and Safeguards

FROM: Margaret Chatterton, Team Leader /RA/
Criticality Team
Special Projects and Inspection Branch
Division of Fuel Cycle Safety
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Office of Nuclear Material Safety
and Safeguards

SUBJECT: NOVEMBER 7, 2003, SUMMARY OF PHONE CALL WITH THE APPLICANT: CRITICALITY SAFETY OPEN ITEM NCS-4 FOR THE MIXED OXIDE (MOX) FUEL FABRICATION FACILITY

On November 7, 2003, the U.S. Nuclear Regulatory Commission (NRC) conveyed questions via phone to Duke Cogema Stone & Webster (DCS) regarding the remaining criticality safety open item, NCS-4. The questions resulted from the staff's review of Revision 3 of Part II of the Validation Report submitted to NRC on October 10, 2003. The purpose of this memorandum is to document statements and requests that were made by NRC staff regarding the open items during the phone call. The purpose of the call was to prepare DCS for an open meeting scheduled for November 13, 2003, at NRC Headquarters. The statements are provided as an Attachment.

cc: P. Hastings, DCS
L. Zeller, BREDL
G. Carroll, GANE
J. Johnson, DOE
J. Conway, DNFSB
D. Curran, GANE
D. Silverman, DCS
H. Porter, SCDHEC

Attachment: Phone Call Summary

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Phone Call Summary

Review of Validation Report Part II, Revision 3 (Submitted October 10, 2003)

Questions on Screening Criteria

1. For Revision 3 of the Validation Report, has DCS evaluated the newly included experiments in the September 2003, version of the International Handbook of Evaluated Criticality Safety Benchmark Experiments? If not, why not? If so, state which of these new experiments would be applicable to a validation of PuO_2 or MOX powder systems.

2. Describe the difference between parameters that are "logarithmically important" and those that are "non-logarithmically important". Fully justify the extension factors of 5 and 2 on page 24 of the Validation Report for these types of parameters respectively.

   The classification of parameters as "logarithmically important" or "non-logarithmically important" appears based on how the data for these parameters are typically displayed, rather than on any intrinsic properties of the parameters. There are no definitions provided or discussion of how to differentiate between "logarithmically important" and "non-logarithmically important" parameters. The values of the extension factors must be fully justified. The stated justification that there is no discernable trend in the bias as a function of the energy of average lethargy causing fission (EALF) and H/(U+Pu) ratio is not sufficient. The graph of k_{eff} as a function of a particular parameter may not reveal any trend, even when the benchmarks are unrelated. For instance, lack of a trend involving a set of uranium and plutonium benchmarks would not provide any information on the behavior of the bias for a particular subset of plutonium systems.

3. The justification for the screening criteria extension factors relies on the observation that there is no discernable trend in the bias as a function of EALF and H/(U+Pu) in Figures 3-3 and 3-4. Regarding this conclusion, address the following: (1) an apparent trend in k_{eff} at high EALF ($\geq 5\times10^4$ eV); and (2) the effect of the fact that the analysis was performed on the entire set of 308 benchmark experiments, even though only 70 have been found applicable to AOA(3) and 59 to AOA(4). Justification that relies on an empirical analysis of data that is not applicable to the AOAs being validated is not conclusive.

4. The methodology in Section 2.5 of NUREG/CR-6698 does not contain any provision for extending the screening criteria without employing an additional margin of subcriticality. Justify including Step 4 in Section 3.6. The methodology described in NUREG/CR-6698, Section 2.5, states:

   > "The analyst needs to consider the overall parametric span and try to ensure that experiments provide a spectrum of critical experiments throughout the range...It may be desirable to include additional critical experiments in the validation. Often experiments within these ranges do not exist or are not readily available. In such cases, a larger margin of subcriticality will be needed".

Attachment

"Guidance for extrapolation in LA-12683 gives typical extrapolation ranges for the parameters presented in Table 2.3. These values are provided for information. Should extrapolation of critical experiments area of applicability be required, justification should be documented. Margin will be affected by extrapolation as described in Section 5." [emphasis added]

5. Explain the procedure outlined in paragraphs A through D on page 25 of Part II. In particular, clarify whether the discussion about including additional benchmarks meeting one of the four criteria pertains to: (1) experiments identified as being outside the initial screening criteria but within the revised screening criteria; or (2) those experiments still not included after applying the revised screening criteria. Also, for each of the four conditions listed, justify fully why this is an acceptable basis for inclusion and answer the following questions:

   A. Explain how a parameter whose value is outside the screening criteria range could be found not to be of primary importance. Presumably, parameters included in the primary screening criteria are those that are considered of primary importance to the determination of the bias and its uncertainty. Therefore, this appears self-contradictory.

   B. Explain why a benchmark outside the screening criteria is acceptable as long as it has the same neutron energy range as the application. This appears to elevate the EALF to greater importance than other system parameters, without justification provided. As an example of this, a uranium benchmark could have the same EALF value as a plutonium design application, but would still not have any applicability to plutonium systems.

   C. Explain what is meant by "...and its/their inclusion help(s) to reduce gaps between benchmark cases within the range." It would appear that the determination of whether a benchmark experiment is applicable should be independent of whether it is helpful to reducing gaps in the data.

   D. Explain why a comparison of fission spectra is sufficient to permit a conclusion that the benchmark is applicable to the subject design applications. The fission spectrum contains only partial information about the overall neutronic behavior of the system. There are other nuclide-reaction pairs that may also affect the bias.

6. Explain the purpose and usage of the secondary screening criteria. It appears that they were not used in selecting benchmark experiments. If so, what is their purpose?

7. In Section 3.6.2, fully justify using parameter correlations to expand the allowable range in ^{240}Pu rather than contract the range in ^{239}Pu. Table 2.3 of NUREG/CR-6698 contains the allowed range of ±10% in ^{239}Pu and ±4% in ^{240}Pu. Because they are correlated for Mixed Oxide Fuel Fabrication facility (MFFF) operations (i.e., ^{239}Pu + ^{240}Pu = 1), the screening criteria have been revised to allow a variation of ±10% in ^{240}Pu. This is the least conservative way of reconciling the screening criteria in these two parameters, but justification is not provided. Also, similar arguments are made with regard to correlations between H/(U+Pu) and EALF, but it is not clear how this information is used.

8. The primary screening criteria of Table 3-3 do not include the total Pu content, although this is known to be one of the most important parameters. Justify not including the Pu content in the set of primary parameters.

9. Provide the basis for the screening criteria for the ^{238}U wt%. This does not appear to be drawn from NUREG/CR-6698, Table 2.3, and no other reference is provided.

Questions on Specific Benchmark Experiments

10. Justify including an H/Pu of 0 in the description of design applications for AOA(3). The use of such a low moderation does not appear physically reasonable or consistent with commitments in Construction Authorization Request (CAR) Section 6.3.4.3.2.6. This and the parameters in CAR Tables 6-1 and 6-2 indicate that bounding moderation levels of at least 1wt% H_2O are assumed in MFFF operations. This corresponds to an H/Pu of ~0.3.

11. Given the geometrical and physical differences between anticipated design applications (PuO_2 and MOX powder intimately mixed with water) and Pu metal benchmarks (dry, high-density metal surrounded by water), fully justify their inclusion in the benchmarks for AOA(3) and AOA(4). NUREG/CR-6698, Table 2.3, states that geometry and physical form (i.e., metal, solution, oxide, or compound) should be as close as possible to the system being evaluated.

12. Given that only certain experiments have been chosen from some benchmark experiment sets, justify including the chosen benchmarks and excluding the remainder from those benchmark sets (such as for PU-COMP-MIXED-001 in Section 5.1.1).

13. With regard to the comparison of fission spectra used to justify inclusion of specific benchmark experiment sets, provide information on the design applications used in the comparisons. These apparently differ from the design applications used in Revision 2 (e.g., AOA 3-1, 3-2, etc.), but there is no information regarding the assumed composition or geometrical configuration. This information is necessary to understand the significance of the spectral comparison.

14. Justify the comparison of fission spectra in the fuel region (and the consequent neglect of other materials and reactions) as an acceptance criterion for benchmark selection. There are a large number of nuclides and reactions that may affect the calculated value of k_{eff}, but these are not considered. A benchmark may have a very similar fission spectrum to a given design application but may still not be applicable. An example would be a uranium benchmark with a similar fission spectrum to a plutonium design application.

15. Describe the standard used to determine satisfactory agreement between the fission spectra of candidate benchmarks and design applications. Many of the comparison figures in Section 5 show considerable disagreement between the candidate benchmark data and that of the design application.

16. Describe and justify what code options (in particular, cross section treatment options) are considered within the scope of Part II of the Validation Report, Revision 3. The

previous version of the Validation Report limited the validation to the INFHOMMEDIUM cross section treatment option, in response to an NRC question regarding code options. This material has been removed from Revision 3. Section 5.4 of Revision 2 stated:

> "One qualitative parameter defining the AOA requires special attention. The geometric form of the material is characterized simply based on whether the fissile material is a single contiguous mass or an array of such masses...due to the multigroup energy treatment employed in KENO-VI, the potential for code bias exists as a result of the resonance processing performed in the Material Information Processor (MIP) of SCALE...For single contiguous units or for arrays of large units...the INFHOMMEDIUM treatment is used."

17. Address the following differences between anticipated design applications and the various sets of benchmark experiments for AOA(3). Explain why systems that are so physically dissimilar in terms of geometric configuration and material composition can be judged to be similar based only upon comparison of the fission spectra. In particular, justify using benchmarks modeled with the LATTICECELL treatment to validate design applications using the INFHOMMEDIUM treatment (NOTE: Each of the cases with LATTICECELL treatment have significantly different geometry from previously described applications.)

PMF003: Benchmark models contain large amounts of interspersed metals and use the LATTICECELL treatment.

PMF016: Benchmark models contain large amounts of interspersed metals and use the LATTICECELL treatment.

PMF017: Benchmark models contain large amounts of interspersed metals and use the LATTICECELL treatment.

PMF033: Benchmark models contain large amounts of metals and have low Pu content.

PMF037: Benchmark models contain interspersed water and use the LATTICECELL treatment.

BNWL2129T4: Benchmark models contain low Pu content.

NSE55T5: Benchmark models contain low Pu content.

PU-29: Benchmark models contain low Pu content.

18. Address the following differences between anticipated design applications and the various sets of benchmark experiments for AOA(4). Explain why systems that are so physically dissimilar in terms of geometric configuration and material composition can be judged to be similar based only upon comparison of the fission spectra.

PCM002: Benchmark models contain H/(U+Pu) ratio and Pu content outside the screening criteria.

PU-8: Benchmark models contain H/(U+Pu) outside the screening criteria.