June 25, 2003

Mr. Peter Hastings
Licensing Manager
Duke Cogema Stone & Webster
P.O. Box 31847
Mail Code FC12A
Charlotte, NC 28231-1847

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION - MIXED OXIDE (MOX) FUEL FABRICATION FACILITY NUCLEAR CRITICALITY SAFETY

Dear Mr. Hastings:

We received your letter dated June 13, 2003, addressing an open item related to nuclear criticality safety referred to as NCS-04 in the Nuclear Regulatory Commission (NRC) "Draft Safety Evaluation Report on the Construction of Proposed Mixed Oxide Fuel Fabrication Facility, Revision 1," dated April 30, 2003. We reviewed the material provided in your letter and find that the material provided did not address the concerns and questions raised in the meeting held on March 20, 2003. Much of the material provided in your letter had already been provided to NRC, either in a letter or verbally at a meeting.

Based on the initial review of the Criticality Code Validation Report dated January 2003, the NRC staff identified several major concerns which were discussed at the March 20, 2003, meeting. At that meeting, the Duke Cogema Stone & Webster (DCS) staff partially answered some of the NRC questions and stated that additional information would be provided. In particular the DCS staff stated that the areas of applicability would be further defined in order to address the NRC staff's concerns about clusters of data and lack of benchmark data throughout specific areas of applicability. After reviewing your letter, our concerns remain.

Attached is a request for additional information related to the validation report. This information was discussed with your staff during conference calls June 18 and 19, 2003. These questions need to be answered appropriately in order to resolve item NCS-04. Since the NRC staff has not completed its review of the validation report, additional questions may arise. We are proceeding with our review and performing independent confirmatory analysis of the validation report. In order to facilitate our review in an effective and efficient review, we have also included a request for case data in the attachment.

Docket: 70-3098

Enclosure: MFFF Validation Reports-
Request for Additional Information

Because of schedule, we request that you respond by July 3, 2003.

Sincerely,

/RA/

Andrew Persinko, MOX Project Manager
Special Projects Section
Special Projects and Inspection Branch
Division of Fuel Cycle Safety
and Safeguards
Office of nuclear Materials Safety
and Safeguards

Docket: 70-3098

Enclosure: MFFF Validation Reports-
Request for Additional Information

cc: James Johnson, DOE
Henry Porter, SC Dept of HEC
John T. Conway, DNFSB
Louis Zeller, BREDL
Glenn Caroll, GANE
Diane Curran, Esq., DCS
Donald Silverman, Esq., GANE

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MFFF Validation Reports–Request for Additional Information

The following major issues and questions have been identified during review of the MOX Validation Report (VR), submitted in January 2003. For each major issue, specific examples are provided. In addition, Question 7 describes additional information that is needed to resolve NCS-04.

NOTE: Several of these questions contain multiple parts.

1. For several areas of applicability (AOAs), the range of important physical and neutronic parameters covered by the chosen benchmark experiments does not adequately cover the range of parameters needed by the anticipated design applications. For each AOA, state the range of parameters for which you consider the code validated. If the parametric range exceeds that covered by the benchmark experiments, justify the extension of the AOA. This extrapolation should be consistent with your commitment to ANSI/ANS-8.1-1983 (R1988). This commitment stated that where extensions to the AOA are needed, either supplemental calculational methods or additional margin will be employed.

   Apparent areas where the range of parameters covered by benchmarks disagrees with that covered by design applications include:

   AOA(1): Design applications will include cadmium and borated concrete absorbers, but there are few plutonium nitrate benchmarks with cadmium and none with borated concrete. The range of boron and cadmium absorber loading for which AOA(1) is considered valid should be described and justified.

   AOA(2): Design applications require the use of concrete and borated shield (composition not given), whereas the benchmarks do not contain these materials. The plot of bias as a function of energy of average lethargy causing fission (EALF) (Figure 6-6) shows a slight decreasing trend with increasing EALF. The design application range (Table 5-4) extends up to 1 eV, while the benchmark data only extends up to 0.91 eV. Because of the decreasing trend from 0.91 to 1 eV, the upper safety limit (USL) thus derived may not be conservative. In addition, the chosen benchmarks have somewhat different isotopic ranges than that assumed in the design applications.

   AOA(3): Design applications require the use of cadmium and borated concrete, whereas the benchmarks do not include these strong absorbers. In addition, the benchmarks only cover the range up to H/Pu of 210, while design applications require up to 1900. The benchmarks only cover the range down to 1 eV, while design applications require down to 0.05 eV.

   AOA(4): Design applications require the use of water and concrete, whereas the benchmarks contain only plexiglass reflectors. In addition, the benchmarks only cover the range up to an H/Pu of 210, while design applications require up to 291.

   AOA(5): Design applications require the use of cadmium and borated concrete, whereas the benchmarks do not include these strong absorbers. The chemical forms of plutonium for which the code is validated is also not well described. In addition, the benchmarks only cover down to 0.135 eV, while design applications must cover down to 0.1 eV. The benchmarks only cover up to an H/Pu of 858, while the design applications may extend up to 83,000; the benchmarks also do not cover the range in H/Pu from 49.6 to 78. Section 4.1 of Part III states that fissile solutions will be analyzed at optimal moderation, but calculations do not appear to be specifically limited to this in the definition of the AOA. (NOTE: The range that is required to be covered by design applications is based on the worst-case combination of values from Part III Tables 4-1, 4-2, and 5-2. There appear to be some discrepancies between the tables so the broadest range of parameters was taken.)

For each AOA, the apparent deficiencies need to be addressed.

2. For AOA(3) and AOA(4) the design applications modeled cover a small portion of the range (especially in terms of H/Pu and EALF) stated to correspond to the anticipated design applications. Specifically, there are no design applications taken from the high H/Pu, or the high and low EALF, portions of the AOAs. In light of these results, it appears that the benchmarks may not be applicable to design applications across the entire AOA. Furthermore, the results of the sensitivity/uncertainty (S/U) study in Validation Report Part II (for AOA(3) and AOA(4)) show that the set of applicable benchmarks depends strongly on changes in the parameters of the design applications used as input to the S/U study (e.g., AOA 3-1). Therefore, for AOA(3) and AOA(4), demonstrate that the chosen benchmarks are applicable to design applications across the entire AOA, justify validating the entire range as a single AOA, or break the AOA into smaller areas and justify each of them.

For the use of S/U methods in Part II:

A. Describe the design applications for AOA(3) and AOA(4) in sufficient detail to permit an independent confirmation of your results.

B. Show that the design applications are representative of the entire range of parameters that must be covered by the AOA.

C. Provide additional justification for relaxing the acceptance criterion to $c_k \leq 0.7$ for some of the design applications. VR Part II justified this based on the following: (1) the USL was determined based on non-parametric methods, which uses the minimum observed k-effective value; and (2) there were no experiments applicable only to the affected design applications (AOA 4-4-Critical and 4-4-P163). Although the USL was determined using the lowest observed k-effective, reducing the number of applicable benchmarks could result in an increase in the non-parametric margin. Although there are no experiments applicable only to AOA 4-4-Critical and 4-4-P163, the lower correlation implies a lower degree of benchmark applicability to parts of the AOA. Given this lower degree of correlation, justify not applying additional margin to compensate for the lower correlation.

D. Because different sets of benchmark data were found to be applicable to different design applications in AOA(3) and AOA(4), justify using the entire set of benchmark experiments identified using the S/U technique to determine the bias across the entire AOA. For instance, AOA 3-1 had 30 benchmarks found to be applicable, AOA 3-2 had 60 applicable benchmarks, and AOA 3-3 had 61 applicable benchmarks. However, all 90 experiments found applicable to one or more design applications were used to determine the USL for the entirety of AOA(3). Benchmark experiments that are shown to be inapplicable to certain portions of the AOA (such as the 60 experiments inapplicable to AOA 3-1) should not be used to validate that portion of the AOA.

3. Several AOAs show apparent “data clusters”, or groups of experiments that appear to have a lower calculated k-effective than the rest of the benchmark experiments. This does not appear to be a statistical fluctuation, but could be indicative of systematic effects that result in increases in the bias. Justify why it is appropriate to lump these benchmarks in the bias calculation with the remaining benchmark experiments.

4. Different techniques were used to determine benchmarks for validation, in each part of the Validation Report. Part I used a comparison of neutron absorption spectra as one of several arguments to conclude that the code is validated for plutonium nitrate systems containing strong absorbers. Part III used a comparison of EALF values to conclude the code can be used for systems with different chemical forms, geometric shapes, and absorbing and reflecting materials. The justification for these methods was not sufficient. Provide further justification for these methods.

   A. For Part I, justify that the similarity in neutron absorption spectra in uranium and plutonium systems implies that the bias for these systems is affected similarly by neutron absorbers. NRC calculations show that the systems are relatively insensitive to neutron absorption as compared to other nuclide-reaction pairs for the reactions considered, and therefore, the relevance of this comparison is questionable. Also, it has not been shown that the conclusions are valid for less thermal (lower H/Pu) plutonium systems.

   B. For Part III, show that a comparison of EALF values is sufficient to show a high degree of applicability between systems (i.e., that it accounts for all important nuclear effects that can influence the bias).

   C. For Part III, state what difference in EALF values is considered sufficient to demonstrate applicability between cases considered. Part III, Section 4.3.2, states that differences that are less than 2% constitute good agreement. Section 4.3.3 states that a 20% difference constitutes good agreement. In several cases, the energy of the design applications falls outside the range of experimental data (Tables 4-6, 4-7, and 4-8). Also, state why the validation is acceptable when a large difference in EALF values is observed (in the low H/Pu range, with H/Pu $\leq$50).

   D. For Part III, justify the density used for PuO_2F_2, since the theoretical crystal density is not used (as stated in Footnote 5 to Table 4-3).

5. In Part I, Section 3.1, what is the relationship between the calculational uncertainty Δk_s and the statistical Monte Carlo uncertainty σ_k. Does $\Delta k_s = \sigma_k, 2\sigma_k, 3\sigma_k$, or some other factor?

6. There is no mention of non-parametric margin (NPM) for data that is not normally distributed in Part III. The USLSTATS output claims that: (1) the data is normally distributed, but also (2) that the normality test may be unreliable due to the lack of data. The histogram in Figure 6-1 shows a double-humped distribution, indicating that a non-parametric method may be necessary. Justify the basis for the conclusion that the data is normally distributed, or else apply non-parametric techniques to compute the USL.

7. During the January 2003 meeting on NCS open issues, it was agreed that the normal condition k-effective limit would not be part of the design basis, but the methodology for determining the normal condition margin was part of the design basis. Describe in detail how the k-effective limit for the normal condition will be determined.

Data Needs:

To enable an efficient and effective review of the Validation Report, the following additional information is needed:

For Part II:

1. The KENO-Va output decks, and ".sdf" files, used in the S/U analysis.

a. Output decks: Contain the model information (echoes the input deck) needed for the staff to understand the benchmark model. While input decks have been submitted, they are in KENO-VI format, which cannot be used by the SCALE 5 S/U sequences. The output decks also contain statistical information that can be used to test adequate convergence of the direct and adjoint cases.

b. SDF files: These are used by the SCALE 5 S/U sequences to generate correlation coefficients and integral parameters. While they can be generated from the KENO-Va input decks, running the cases will be very time consuming, and having these files will significantly expedite the analysis.

2. The SCALE input decks for all design applications. These cases are not described in full detail in the VR. While there is some information provided, this is not sufficient to enable staff to reconstruct the results to compare with benchmarks.

For Part III:

1. Electronic version of the input decks for the design applications (sensitivity studies) used in the MOX VR Part III.

2. Electronic versions of the input decks for any benchmark experiments not included in the CD-ROMS provided for Parts I and II.