December 23, 2010

Mr. Scott P. Murray
Licensing & Liabilities
Global Nuclear Fuel – Americas, LLC
P.O. Box 780
Wilmington, NC 28402

SUBJECT: APPLICATION FOR RAJ–II TRANSPORTATION PACKAGE – REQUEST FOR ADDITIONAL INFORMATION

Dear Mr. Murray:

By letter dated July 13, 2010, as supplemented September 27, and October 29, 2010, you submitted an application for amendment of the Model No. RAJ–II transportation package, Certificate of Compliance No. 9309. You requested approval of changes made to reflect the addition of boiling water reactor (BWR) fuel designs. In the letter dated November 10, 2010, the application was accepted and a proposed schedule was provided for your review.

In connection with the staff's review, we need the information identified in the enclosure to this letter. We request that you provide this information by February 11, 2011. Inform us at your earliest convenience, but no later than January 28, 2011, if you are not able to provide the information by that date. To assist us in re-scheduling your review, you should include a new proposed submittal date and the reasons for the delay.

If you have any questions regarding this matter, please contact me at 301-492-3273.

Sincerely,

/RA/

Huda Akhavannik
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-9309
TAC No. L24456

Enclosure: Request for Additional Information

Mr. Scott P. Murray
Licensing & Liabilities
Global Nuclear Fuel – Americas, LLC
P.O. Box 780
Wilmington, NC 28402

SUBJECT: APPLICATION FOR RAJ–II TRANSPORTATION PACKAGE – REQUEST FOR ADDITIONAL INFORMATION

Dear Mr. Murray:

By letter dated July 13, 2010, as supplemented September 27, and October 29, 2010, you submitted an application for amendment of the Model No. RAJ–II transportation package, Certificate of Compliance No. 9309. You requested approval of changes made to reflect the addition of boiling water reactor (BWR) fuel designs. In the letter dated November 10, 2010, the application was accepted and a proposed schedule was provided for you review.

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Enclosure: Request for Additional Information
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OFC	SFST	SFST	SFST
NAME	HAkhavannik	MDeBose	RJohnson
DATE	12/22/2010	12/22/2010	12/23/2010

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Request for Additional Information
Global Nuclear Fuel – Americas, LLC
Docket No. 71-9309
Certificate of Compliance No. 9309
Model No. RAJ – II Package

2.0 Structural

2-1 Provide labels for tables and figures in Section 2.12.5.

This information is needed to determine compliance with 10 CFR 71.73.

2-2 Revise plot on p 2-92.

Plot of Total True Stress versus Plastic True Strain is plotted incorrectly or labeled incorrectly. The values shown in the plot are Total Engineering Stress versus Total Engineering Strain.

This information is needed to determine compliance with 10 CFR 71.73.

2-3 Provide additional tabular data for shear stress as defined by Load Curve 1006 for paper honeycomb material properties (pp 2-92, 2-93).

Reported material properties are for normal stress alone in the corresponding table.

This information is needed to determine compliance with 10 CFR 71.73.

2-4 Revise or clarify paper honeycomb stress strain curves.

The paper honeycomb stress strain curves (p 2-93) are representative of stress versus strain rather than stress versus volumetric strain, which is the required input parameter for LS-DYNA.

This information is needed to determine compliance with 10 CFR 71.73.

2-5 Revise or clarify the stress strain table for Ethafoam.

The stress strain table on p 2-94 for Ethafoam has the same values as the paper honeycomb in the table on p 2-93 and staff is unclear whether this is an accurate representation.

This information is needed to determine compliance with 10 CFR 71.73.

2-6 Revise or clarify the stress strain table for Ethafoam or revise Load Curve 1005.

The values input for Load Curve 1005 for *MAT_CRUSHABLE_FOAM do not match the values presented in the table on p 2-94 for Ethafoam.

This information is needed to determine compliance with 10 CFR 71.73.

2-7 Clarify the strain input values shown on p 2-95.

Staff is unclear if the strain input values labeled Plastic True Strain shown in the table are equivalent to volumetric strain.

This information is needed to determine compliance with 10 CFR 71.73.

2-8 Provide acceleration time history for lower tie plate indicating a peak G load of 75 Gs is conservative.

This information is necessary to determine if appropriate loading or deformation for the fuel rods is consistent with that seen in the tests.

This information is needed to determine compliance with 10 CFR 71.73.

2-9 Provide dynamic analysis of lower tie plate and fuel rod.

A static analysis of fuel performance is not adequate to capture the potential damage from dynamic effects. The rigid body peak deceleration for packaging, whether from test or analysis, has been shown to be deficient when considering loading to the payload.

This information is needed to determine compliance with 10 CFR 71.73.

2-10 Provide damage comparisons (displacements, stresses, etc.) with FEA models and CTUs.

Simple comparison of peak decelerations is not sufficient when attempting to simulate test results with an analytical model.

This information is needed to determine compliance with 10 CFR 71.73.

2-11 Provide damage comparisons (displacements, stresses, etc.) for FEA models and fuel rods.

Peak G loads alone do not provide a complete engineering record with respect to overall package damage or the potential for damage. Staff does not have reasonable assurance that peak G loads alone are sufficient for making a safety determination for this package.

This information is needed to determine compliance with 10 CFR 71.73.

2-12 Provide sensitivity study demonstrating that rigid fuel payload is conservative.

Staff does not have reasonable assurance that the assumption of rigid payload is conservative. Previous analyses performed by NRC staff have indicated that payload stiffness is a significant contributor to package response.

This information is needed to determine compliance with 10 CFR 71.73.

2-13 Provide a component study that demonstrates correct performance of paper honeycomb material.

A simple crush evaluation for a representative honeycomb block when compared with test data provides reasonable assurance that the honeycomb block is providing the correct structural response with appropriate material properties.

This information is needed to determine compliance with 10 CFR 71.73.

2-14 Provide dynamic FEA analysis of end drop and CG over corner for RAJ-II.

Staff requests this analysis to provide reasonable assurance that the assumptions used in the fuel assembly evaluation are reasonably conservative.

This information is needed to determine compliance with 10 CFR 71.73.

2-15 Provide comprehensive engineering comparison of the RAJ-II and the RA-3D package to demonstrate similarity.

The applicant states that these packages are similar but no objective information is provided to demonstrate that this statement is accurate.

This information is needed to determine compliance with 10 CFR 71.73.

2-16 Provide dynamic FEA analysis(es) of the RA-3D package.

Since the RA-3D is being represented as a reasonable analogue of the RAJ-II, staff requests that a representative sample of analytical models be provided to demonstrate the similarity.

This information is needed to determine compliance with 10 CFR 71.73.

2-17 Justify the tuning of the modulus of elasticity of the paper honeycomb to achieve a peak G load of 145Gs.

Tuning material properties to achieve desired results is not considered a best practice when attempting to benchmark an analytical model against a test. Absent an evaluation of other test markers for damage such as deformation or strain, which would indicate that published values for elastic modulus are erroneous, this practice is not considered a reasonable approach for benchmarking.

This information is needed to determine compliance with 10 CFR 71.73.

2-18 Clarify the following discrepancy:

On p 2-90 reference is made to the RAJ-III top drop test, which refers back to Section 2.12.2.3. Section 2.12 specifically references certification tests on the RAJ-II.

This information is needed to determine compliance with 10 CFR 71.73.

2-19 Provide accelerometer locations on both tested CTUs and acceleration time history sampling points on FEA models.

This information is necessary for evaluating the robustness of the analytical model in capturing dynamic behavior.

This information is needed to determine compliance with 10 CFR 71.73.

2-20 Provide overlay plots of the acceleration time histories for CTUs and FEA models.

Acceleration time history shape as well as peak values are important to verify whether an analytical model is sufficiently robust to capture dynamic behavior.

This information is needed to determine compliance with 10 CFR 71.73.

2-21 Demonstrate that the delay of leak testing due to transport did not result in a “false negative” leak test.

Section 2.12.1.3, “Test Performance,” indicates that the CTU packages were tested at Oak Ridge and then transported to Lynchburg, Virginia, where they were disassembled, examined, and leak tested. Staff is concerned that the delay in leak testing could have resulted in no detection because no gas would remain in or around the fuel rods after the period of time required for transport.

This information is needed to determine compliance with 10 CFR 71.73.

6.0 Criticality

Unless otherwise stated, the following are required in order to ensure that the package contents are adequately described, per 10 CFR 71.33:

6-1 Revise the application to clearly state the dimensions of each fuel assembly and rod type to be transported in the Model No. RAJ-II package, as well as the tolerances for each of these dimensions that have been evaluated in the criticality safety analysis. Include in the list of dimensions and tolerances: pellet diameter, clad thickness, rod outer diameter, maximum active length (for full and partial rods), and rod pitch.

Although the applicant provided a list of rod nominal dimensions in Appendix 6.9.5, and a sample of assembly parameters in Section 1.3 of the SAR, the specific fuel contents and their associated dimensions remain unclear. Additionally, although the applicant provided an evaluation of material uncertainties in the criticality analysis, it is not clear how the uncertainties evaluated translate into dimensional tolerances that can be referenced in the Certificate of Compliance. Note that the aforementioned dimensions and their associated tolerances will be included as limits in the package Certificate of Compliance in order to prevent shipment of contents that have not been evaluated in the criticality analysis.

6-2 Revise Section 6.1.2.1 of the SAR to clarify the statement regarding fuel lattices that do not have fissile material.

Criteria number five for restraints on the placement of burnable absorber (BA) rods states that “No BA rods are required in fuel lattices that do not have fissile material (natural uranium defined as uranium containing a mass percentage of uranium-235 that does not exceed 0.72%) or is fissile excepted (uranium enriched in uranium-235 to a maximum of 1% by weight).” The SAR should be revised to clarify that fuel assemblies which are non-fissile or exempted from the fissile material requirements of 10 CFR 71.15 are intended as allowable contents in the package.

6-3 Revise Section 6.2 of the SAR to clarify the enrichment and gadolinium content of the BA rods required for fuel assemblies with BA rods.

Item three under the description of the fissile material contents states that “A minimum number of eight gadolinium oxide fuel rods with a minimum 2.0 weight percent is assumed for the BA rods in every lattice zone of the fuel bundle.” It is unclear if the 2.0 weight percent refers to the gadolinium oxide content or the ^{235}U enrichment. Revise this SAR section to clarify.

6-4 Revise Figure 6-3 of the SAR to include a similar schematic for one of the 9x9 fuel assemblies (either the GE11 or GE13).

This figure provides a schematic layout for several 10x10 fuel assemblies, but does not provide a similar representation of the 9x9 fuel assembly contents. The SAR should be revised to show a representation of the 9x9 fuel assembly.

6-5 Revise Section 6.3.1.1 of the SAR to clarify the dimensions of the protective case.

This section states that the height of the protective case is 84 centimeters, and appears to be a typographical error. Revise this section to include the actual height of the protective case.

This information is needed to ensure that the packaging is adequately described, per 10 CFR 71.33.

Unless otherwise stated, the following are required in order to ensure that the package will meet the criticality safety requirements of 10 CFR 71.55 and 71.59:

6-6 Revise the criticality analysis to justify the assumption of char density considered in the model configuration.

Section 6.3.2.9 of the SAR states that the theoretical density of char is assumed to be 2.1 g/cc, but does not state why this value is chosen and if it is conservative or not. The SAR should be revised to justify this assumption.

This information is needed to ensure that the package will meet the criticality safety requirements of 10 CFR 71.55(e) for single packages under hypothetical accident conditions, and of 10 CFR 71.59 for package arrays.

6-7 Revise Section 6.6.2.1.2 of the SAR to clarify the rod pitches evaluated for the fuel rods without rod containers.

Table 6-37 of this section shows evaluated rod pitches of rod outer radius, 1.3 inches, and 1.6 inches, with reported k_{eff} increasing with pitch. The SAR should clarify that this largest pitch evaluated is the largest that the inner container will allow for the 25 rod limit. Additionally, if this is the largest pitch allowed by the package dimensions, the SAR should demonstrate that larger pitches with fewer rods are not more reactive.

This information is needed to ensure that the package will meet the criticality safety requirements for package arrays in 10 CFR 71.59.

6-8 Revise Section 6.6.2.2.2.1 of the SAR to clarify the assemblies selected for the criticality evaluation of inner container spacing within the outer container, as well as the contents of Table 6-40.

Table 6-40 contains information related to the k_{eff} effect of the position of the inner container within the outer container of the package. The applicant should justify the selection of assemblies used to demonstrate this effect. Additionally, it is not clear what is meant by the k_{eff}s reported for “Fuel Channel” and “Inner Container” in this evaluation.

This information is needed to ensure that the package will meet the criticality safety requirements for package arrays in 10 CFR 71.59.

6-9 Revise Figure 6-17 and associated text of the SAR to justify the selection of the GNF2 fuel assembly for the evaluation of k_{eff} due to outer container dimensional variation.

Figure 6-17 shows the variation of the hypothetical conditions of transport package array k_{eff} with changes in the spacing between the packages, for the GNF2 fuel assembly and fuel bundle. However, the associated text does not make clear why this assembly was selected for this evaluation.

This information is needed to ensure that the package will meet the criticality safety requirements for package arrays in 10 CFR 71.59.

6-10 Revise the application to describe how the apparent non-uniform pitch in the SVEA fuel assembly (see Figure 1-11) is accounted for in the criticality analysis, particularly with respect to the resonance self-shielding calculations performed as part of the SCALE CSAS6 calculation.

Figure 1-11 of the SAR shows that fuel rod pitch in the SVEA bundle lattice is not uniform across the assembly (see dimensions D, E, F, and G). Section 6.3.4.1.2 of the SAR describes the multiregion unit cell developed to account for redistribution of polyethylene in the package, but the criticality analysis does not describe how the unit cell is developed for the non-uniform pitch in the SVEA, or other, assembly types. The application should be revised to expand the discussion of unit cell development, specifically to include that for the SVEA assembly, but also for any other evaluation where the unit cell cannot be represented in a standard latticecell due to material or geometry considerations.

6-11 Revise Section 6.3.1 of the SAR to justify the replacement of wooden thermal insulator with alumina silicate in the inner container.

This section of the SAR states that wooden insulator in the inner container is replaced with alumina silicate in the criticality model configuration, but does not state why this is done. Any simplifications in the criticality model from the actual configuration should be justified to be conservative with respect to package k_{eff}.

6-12 Revise Section 6.3.1 of the application to justify the lattices used for the loose rod evaluation.

This section states which type of lattice (square or triangular) is used to evaluate loose rods in the various rod containers. The applicant should justify that the use of square lattices is conservative, considering that a triangular pitch lattice may allow for a greater mass of fissile material in the rod containers with similar rod-to-rod spacing. Note that the infinite array analysis to determine the most reactive rod in Appendix 6.9.5 is performed assuming a triangular pitch.

6-13 Revise Section 6.3.1.3 of the SAR to clarify the modeling of the WEC rod box for shipping loose fuel rods.

This section states that the WEC rod box shell has large punched holes, which are modeled as solid in the criticality model configuration. Modeling the rod box this way may be non-conservative, as it reduces the water volume and increases parasitic neutron absorption in the steel. This section should be revised to justify that this modeling simplification is conservative.

6-14 Revise the application to clarify why the polyethylene in the criticality model configuration is represented as a mixture of actual densities, and if it is conservative to do so. Also, clarify the equation used to combine the densities, as ρ_I does not appear in the equation, and both ρ_I and ρ_T are listed as the density of the mixture. Additionally, clarify why a volume weighted density is used for the normal conditions of transport model, while the standard material density is used for hypothetical accident conditions, and how this modeling approach is conservative. Lastly, revise the application to state the maximum mass of polyethylene that may be present in the package, and ensure that this maximum mass is considered in the criticality analysis.

The representation of polyethylene in the criticality model configuration can have a large impact on calculated k_{eff}, due to its potential to have a higher hydrogen density than water. For this reason, it is important that the representation of polyethylene is adequately described in the criticality analysis.

6-15 Revise the SAR to provide documentation of the approach used for the TSUNAMI-3D calculations, particularly any confirmatory direct perturbation calculations that have been performed.

TSUNAMI sensitivity coefficients are generated using first-order linear perturbation theory. They are valid only where the system response (e.g., k_{eff}) changes linearly as a function of the perturbed parameter.

When using TSUNAMI-3D, it is important to adequately sample both the forward and adjoint calculations to ensure convergence of the flux moment solutions. It is also necessary to adequately resolve the spatial distribution of the flux solutions using the uniform mesh (MSH and MFX in the parameter data block) or with a grid geometry (read grid block and MFX parameter).

Once appropriate values have been input, it is necessary to confirm the integral sensitivity data with direct perturbation calculations. Some guidance on and examples of direct perturbation calculations are provided here: (http://www.ornl.gov/sci/scale/tsunami/references/topical2005-2.pdf).

The SCALE team at Oak Ridge National Laboratory (ORNL) provides the following guidance for production calculations with TSUNAMI-3D:

A. Verify Input Model
- Verify number densities against benchmark or design specifications for an exact match.
- Verify dimensions against benchmark or design specifications for an exact match.
- Review modeling assumptions and approximations to ensure they are reasonable.

B. Unit Cell Data
- Verify proper use of multiple unit cell specifications to reduce modeling approximations.
- Remove use of More Data with input Dancoff factors to specify multiple fuel types (SCALE 4 style input).
- Consider the necessity of separate unit cell input for wet/dry portions of fuel rods.

- Consider the necessity of multiregion unit cells to properly account for implicit effects in interacting materials.

C. Parameters

- Use mesh fluxes where possible and turn off transform. Initial mesh size is 1/10th of the smaller outer dimension of the active fuel (MSH=xxx MFX=yes TFM=no). Use of grid geometry input is appropriate to define a custom spatial mesh.
- Set tight convergence criteria with the SIG and ASG parameters, with large numbers of generations for forward and adjoint calculations: GEN=10000 NPG=10000 SIG=0.0005 ASG=0.001.
- For fast systems, set APG to a larger number as needed. The default APG is 3×NPG.
- Leave PNM at the default value of 3, unless excess storage is needed for mesh fluxes, then set PNM=1.

D. Verification of Proper Execution

- Examine the forward case for k_{eff} normality.
- Ensure the forward calculation is well converged by examining the plot of average k_{eff} by generations skipped (second KENO plot).
- For benchmarks, verify that the forward k_{eff} is close to the expectation from measured results.
- Inconsistent k_{eff} values require investigation.
- Inexplicable inconsistent results should be noted and discarded.
- Ensure forward and adjoint k_{eff} values are in good agreement, < 0.5% difference. If they disagree, consider the need to increase APG and repeat the calculation.

E. Direct Perturbation

- Verify the sensitivities of important nuclides with direction perturbations for each distinct model type with CSAS calculations.
- Verify the most important fissile nuclide and most important moderating nuclide.
- If the model is intended to validate a specific component, test those nuclides as well (e.g., absorber materials, fission products, reflector materials).
- Set tight convergence criteria to see effect of perturbation: GEN=10000 NPG=10000 SIG=0.0001.

6-16 Revise the application to provide representative input and output files for key TSUNAMI calculations.

NUREG-1609, *Standard Review Plan for Transportation Packages for Radioactive Material*, recommends that, for computer codes used in the criticality analysis, at least one representative output file (or key sections) should be included in the application.

6-17 Revise Table 6-9 of the SAR to provide the number of histories per generation and convergence criteria (SIG value), if used.

This table provides relevant information regarding the SCALE CSAS6 code parameters used in the criticality evaluation, but does not provide the total number of histories per generation, or the convergence criteria.

6-18 Revise Table 6-10 of the SAR to provide the number of histories per generation and the adjoint convergence criteria (ASG value), if used. Additionally, provide the spatial meshing strategies and direct perturbation approach used in the TSUNAMI evaluation.

This table provides relevant information regarding the SCALE TSUNAMI code parameters used in the criticality evaluation, but does not provide the total number of histories per generation, or the adjoint convergence criteria.

6-19 Revise Section 6.3.3.3 of the SAR to provide sample direct perturbations used to verify the validity of the uncertainty evaluation approach for material and fabrication tolerances.

This section of the SAR provides the following reaction rate equation:

$$\Delta R = \frac{N_A}{M}\Delta\rho\sigma = N\Delta\sigma,$$

and makes the assertion that:

"The equation above demonstrates that the reaction rate of a material, and therefore its relative effect on system reactivity, will change by the same amount given an identical percentage change in either material density or absorption cross section. TSUNAMI has been used to define the change in reactivity for a system on a 1% change in cross section basis for a given material. The change is defined as the sensitivity coefficient of the material, and is represented by the following equation.

$$\frac{\frac{\Delta keff}{keff}}{\frac{\Delta\Sigma}{\Sigma}}.\text{"}$$

This assertion is only true if the perturbation is sufficiently small that the first-order linear sensitivity coefficients of TSUNAMI are valid for the perturbation of interest. For large perturbations, non-linear effects are often observed. Sample direct perturbation calculations should be used to verify the validity of the approach for the intended application.

Also, it is necessary to include the effect not only of the perturbed material with the manufacturing tolerance, but also of the surrounding materials that are impacted by the uncertain dimension (e.g., effect of cladding tolerance and pitch on quantity of moderator).

6-20 Revise Section 6.3.3.3 of the SAR to provide a parametric evaluation comparing direct calculations to TSUNAMI results for the uncertainty evaluation for material and fabrication tolerances.

It is not clear that conservation of mass is equivalent to conservation of sensitivity, as asserted on p 6-28 of the SAR and represented in the following equations:

$$\frac{\Delta V}{V} \equiv \frac{\Delta \rho}{\rho} \text{ for constant V,}$$

$$\left(\frac{\Delta keff}{keff}\right)_i = \left[\frac{\frac{\Delta keff}{keff}}{\frac{\Delta \Sigma}{\Sigma}}\right]_i \cdot \left(\frac{\Delta V}{V}\right)_i$$

This assumption may be valid for very small changes in volume, but the applicable range of this procedure needs to be assessed with a parametric evaluation where direct calculations are compared with TSUNAMI results.

6-21 Revise Section 6.3.3.3 of the SAR to remove the assertion that simple summation of individual relative uncertainties provides conservatism in the analysis.

On p 6-28 of the SAR, the applicant states that:

“The individual relative uncertainties are aggregated as a simple sum instead of combining using a statistical sum such as route mean square. This results in a conservative estimate of the uncertainty as the simple sum ignores the possibility that the material tolerances are independent of each other.”

This approach is appropriate, but does not introduce added conservatism. Uncertainties are added quadratically (i.e., route mean square), but sensitivities should always be added linearly.

6-22 Revise Section 6.3.3.3 of the SAR to justify the validity of the assumption that $\Delta k_{eff}/k_{eff}$ is independent of the absolute value of k_p.

This section of the SAR states, on p 6-28, that:

"The total absolute uncertainty associated with the material tolerance, Δk_u, is obtained by multiplying the relative uncertainty by k_p =1.0 with the assumption that $\Delta k_{eff}/k_{eff}$ is independent of the absolute value of k_p that is calculated for the package system."

This section should be revised to justify the validity of this assumption, and to clarify what effect this would have on the evaluation if this assumption is not valid.

6-23 Revise Section 6.3.4.1.1 to demonstrate that spatial self-shielding effects are not important when using a small amount of Gd_2O_3 to assess sensitivity for the actual Gd_2O_3 content in the system.

As more Gd_2O_3 is added, it is possible that the sensitivity decreases due to decreased effectiveness of Gd_2O_3 at the center of the pin, which is shielded by the increased density of Gd_2O_3 at the edge of the pin. A parametric evaluation of ^{157}Gd sensitivity as a function Gd_2O_3 density would clarify this issue.

6-24 Revise Section 6.3.4.1.2 of the SAR to demonstrate how the moderator radius is defined in the cylindrical multiregion unit cell used to correct for resonance self-shielding. Additionally, clarify if this unit cell is used only in the lattice pitch expansion evaluation, or whenever polyethylene packing materials are assumed to be in the lattice.

On p 6-39 of the SAR, the applicant states that "the effect of polyethylene packing materials on resonance self shielding is accounted for in the cross-section processing by specifying a cylindrical multiregion unit cell as shown in Figure 6-13." This section should be revised to clarify if a uniform lattice is considered, and how the radius is corrected to preserve the Dancoff factor. Also, although this discussion appears in the lattice expansion section of the analysis, it appears that this unit cell approximation would be necessary any time there is polyethylene in the lattice, which also occurs in the unexpanded lattice. The applicant should clarify if this approach is used for resonance self-shielding calculations elsewhere in the analysis, and if not, what approach is used.

6-25 Revise the criticality analysis to clarify how resonance self-shielding calculations were performed for various axial regions of the fuel assembly with and without partial length fuel rods.

The SAR does not discuss how resonance self-shielding calculations were performed for axial sections of the fuel assembly which may have fewer rods due to the inclusion of short and long partial length fuel rods. The effect of the partial length rods is to remove fuel and add moderator to the lattice, requiring a correction to the self-shielding calculations in these regions to account for more moderator. The criticality analysis should be revised to contain a comprehensive discussion of resonance self-shielding evaluations for the varying number of rods in different axial segments of the assembly, as well as for different moderation conditions (i.e., polyethylene versus water).

6-26 Revise Section 6.3.4.1.3 of the SAR to clarify the selection of fuel assemblies for the criticality evaluation with and without BA rods.

Although the evaluation discusses the key differences between several classes of fuel assemblies, it is unclear why the GE14C and GE14G assemblies were chosen for the evaluations with and without BA rods, respectively, and what the difference is between these assembly designs.

6-27 Revise Section 6.3.4.2 of the application to clarify the spacing of fuel assemblies in the inner container under hypothetical accident conditions.

On p 6-43 of the criticality analysis, the applicant states that the “polyethylene foam cushion, represented as region 2 for normal transport conditions, may redistribute from region 2 to the fuel bundle due to melting at elevated temperature during a fire event.” Although this situation would allow for the two fuel assemblies to move closer together in the inner container, it is unclear if this situation has been evaluated in the criticality analysis.

6-28 Revise Sections 6.4.2.2, 6.5.2.2, and 6.6.2.2 of the SAR to clarify for which package configurations the material and fabrication tolerance uncertainty evaluations are performed.

These sections state that material and fabrication tolerance uncertainty evaluations are performed, and provide tables containing the results of these evaluations. It is unclear, however, which configuration in each section these analyses are performed for (i.e., fuel assemblies, bundles, or rods). These sections should be revised to adequately describe the evaluated configuration, and justify why each configuration was chosen for the evaluation.

6-29 Revise Table 6-22 of the SAR, and any similar table in the evaluation (e.g., 6-29, 6-38, 6-39) to include statistical uncertainties in the sensitivity coefficients from the Monte Carlo calculations.

The referenced tables provide the results of the applicant’s uncertainty evaluation for material and fabrication tolerances, and include relevant sensitivity and k_{eff} information from the analysis. Missing from these tables are the statistical uncertainties in the sensitivity coefficients from the Monte Carlo calculations performed as part of this analysis. These tables should be revised to provide this information.

6-30 Revise Section 6.8.2 of the SAR to provide the results of the normality tests to ensure the applicability of the statistical approach for the selected benchmarking data set.

For USLSTATS analysis, the results of the normality tests, whether those from USLSTATS or other statistical packages, need to be provided to ensure applicability of statistical approach for the selected data set. Additionally, the sufficiency of applicable benchmarks should be discussed, especially for Figure 6-23 where only 9 data points are shown.

6-31 Revise Appendix 6.9.3 of the SAR to provide direct calculations to demonstrate the validity of the TSUNAMI data for the BA rod worth evaluation.

The sensitivity of k_{eff} to the ^{157}Gd cross section is not necessarily equivalent to its worth in terms of reactivity. As noted earlier, the TSUNAMI sensitivity coefficients are based on first-order linear perturbation theory. The reactivity effect of removing a BA rod is likely a non-linear effect. Direct calculations should be performed and documented to demonstrate the validity of the TSUNAMI data for the intended application.

6-32 Revise Appendix 6.9.3 of the SAR to provide k_{eff} or k_{inf} calculations to demonstrate that the BA rod pattern resulting from the BA rod worth evaluation is more reactive than other typical BA rod patterns.

The applicant provides a thorough summary of the BA rod worth sensitivity calculations performed to generate most reactive BA rod patterns for each assembly type in Appendix 6.9.3. This evaluation should be revised to include representative k_{eff} or k_{inf} calculations to provide reasonable assurance that the resulting BA rod patterns are in fact the most reactive.

6-33 Revise Appendix 6.9.4 of the SAR to justify the assertion that the sensitivity to changes in lattice pitch is greater for an individual package configuration than for the package array configuration.

This section states that this assertion is valid due to the limited lattice expansion assumed in the analysis, which would affect the individual package evaluation more so than an array evaluation due to the relative fraction of fissions in the water reflected system versus the array. It is not clear from the discussion in this paragraph on p 6-97 that this assertion is true. This section should be revised to provide the results of analyses that demonstrate that the effect of lattice expansion is larger in the individual package than in the package array.

6-34 Revise the SAR to discuss the possible relocation of polyethylene packing material into higher density regions under both normal conditions of transport and hypothetical accident conditions. Additionally, discuss how the additional polyethylene packing material recommended to be used for packing loose rods in Section 7.0 of the SAR, with or without a rod container, is accounted for in the criticality analysis.

Given that there are no controls on how the polyethylene packing material is placed in the package, it would be reasonable to assume that the same impact that might produce lattice expansion in one end of the assembly, would also tend to concentrate polyethylene packing material in that same region. The criticality analysis as described assumes that the polyethylene packing material will be uniformly distributed throughout the package contents, which may not be the case under either normal conditions of transport or hypothetical accident conditions. Additionally, several sections of the package operating procedures give the option of including additional polyethylene packing material when packing loose rods, either with or without a rod container. This potential for additional moderating material should be considered in the criticality analysis.

6-35 Revise Appendix 6.9.5 of the SAR to consider loose fuel rod designs within the proposed rod containers, or within the package inner container.

This appendix provides an infinite triangular pitch array evaluation of individual fuel rod designs to determine the most reactive type for inclusion in the loose rod criticality evaluation. This evaluation should be revised to consider rods within the package and rod container, as reflection conditions within the package and the mass of fissile material allowed by the assumed pitch, rod radius, and container envelope, may have a significant effect on calculated k_{eff}. Also note that this evaluation is performed assuming triangular pitch infinite array, whereas most of the evaluations within the package are modeled with a square pitch.

6-36 Revise Appendix 6.9.6 of the SAR to clarify whether the effect of packaging materials is evaluated considering fuel assemblies with or without BA rods.

This appendix provides an evaluation of the effect of packaging materials on calculated k_{eff}, but does not state whether this evaluation is performed with or without BA rods in the assembly. This evaluation parameter would be expected to have an effect on the results of the analysis, and as such should be clarified and justified in the description.

6-37 Revise Section 6.9.6.2 of Appendix 6.9 to clarify the modeling assumptions for the packaging array package material effects.

The text of this section states that package array is evaluated with void in significant portions of the model, while Table 6-53 shows that these same portions are evaluated with water. The table and related text should be revised to clarify this issue.

Editorial Requests:

2.0 Structural

2-1 Provide an additional hardcopy of the input and output structural modeling files for LTP, Cladding, and Impact Analysis, previously submitted in the September 27, 2010 submittal.

This information is required in order to provide a complete submittal of the September 27, 2010, supplemental information to the Document Control Desk to have the record updated.

2-2 Please correct the figures on pp 2-104 and 2-105 as the content of the graphs is missing.

This information is needed to determine compliance with 10 CFR 71.73.

7.0 Package Operation

7-1 Fix the numbering in Chapter 7.1.2.1, “Outer Container Lid Removal,” to have the numbering begin with the number “1” instead of the number “6.”

This information is required in order for the staff to ensure that the application will meet the requirements of 10 CFR 71.33.