AREVA

February 4, 2005

Letter No. 99008-05-001

ATTN: Document Control Desk
Director, Spent Fuel Project Office
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: Application for a Certificate of Compliance for the Mixed Oxide Fresh Fuel Package, Revision 1, DOCKET No. 71-9295

Reference: NRC Letter, "Request for Additional Information – Mixed Oxide Fresh Fuel Package – Docket No. 71-9295," dated December 8, 2004

Dear Sirs:

Packaging Technology, Inc. hereby submits our responses to the request for additional information made via the above referenced letter. Our response is comprised of two primary submittals. First, each request made in the referenced letter is provided, along with our response. Second, revised pages and drawings are provided, representing Revision 1 to the MFFP Safety Analysis Report.

Included within this application are the following documents:

- Responses to the Requests for Additional Information (RAIs).
- Ten paper copies of the revised pages for the Safety Analysis Report (SAR).
- Ten electronic copies of the SAR in PDF format.

The electronic copies are contained on ten CDs in an envelope labeled, "MFFP Docket 71-9295 Electronic Copy of Documents". Included with the revised SAR pages are detailed instructions for replacing pages from the Revision 0 SAR with new pages for this Revision 1.

In addition to providing the requested information, we have made minor changes to SAR content as a result of inconsistencies noted during the revision process. These changes/corrections included a revision to some of the benchmark cases utilized for the criticality evaluation, and modifying some dimensions and material specifications on the General Arrangement Drawings. The changes to the benchmark criticality calculations do not impact the previous conclusions of the criticality analysis as presented in Chapter 6 of the SAR. All changed information is annotated with a vertical bar in the right margin or other noted indicators for text pages, or by bubbles on the General Arrangement Drawings.

Add: Meraj Rahimi Paper Copy

1/10 9 Copies forwarded to Meraj Rahimi

NMSS01

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If you have any questions or comments regarding this submittal, please contact me at 678-362-7110 or at clindner@pactec-tn.com if you have any questions.

Sincerely,

Curt Lindner, Project Manager
Packaging Technology, Inc.

Enclosure: As Noted

cc: M. Rahimi, NRC/SFPO
J. Field
R. Clark, DCS
M. Klimas, DOE

Project File 99008

Attachment A

Contents of Electronic Media

This submission is composed of both paper copies and an electronic copy. The electronic copies are contained within an envelope labeled, "MFFP Docket 71-9295 Electronic Copy of Documents". The envelope contains ten discs of the following:

Title	Media Type:	Contents
MOX Fresh Fuel Package Safety Analysis Report	CD-ROM	One file of the complete text of the submittal: MFFP Safety Analysis Report, Rev 1.pdf (23,409 kb) (550 pages)

REQUEST FOR ADDITIONAL INFORMATION

Chapter 1 – Introduction

1-1 Provide the following information:

a. units for dimensions in Figure 1.1-2 and 1.2-1 and

b. cladding material in Table 1.2-1.

<u>Response</u>: The dimensional units (inches) have been added to the two figures. Table 1.2-1 has been revised to identify M5 cladding material for the fuel rods.

1-2 Provide the following information on the drawings:

a. specification on the lubricant to be used on the threads for impact limiter bolts as indicated on Drawing 99008-10 if the lubricant is important to safety;

b. specification on the lubricant to be used on the threads for the closure lid bolts on Drawing No. 99008-20, Rev. 0, Sheet 1. This is needed to ensure that an average "nut factor" of 0.157 as considered on Page 2.6-6 of the SAR, is applicable for bolt stress evaluation when the lid closure bolt is tightened with 175 – 220 lb_f-ft torque;

<u>Response</u>: Drawings 99008-10 and 99008-20 have been revised to include the critical characteristics (low-halogen, nickel-based nuclear grade) for the specified thread lubricant.

c. dimensions and material specifications for the annulus which forms the flange and is welded to the body shell;

<u>Response</u>: The annulus, which is shown in Detail R, Sheet 5, Drawing No. 99008-20, is Item Number 2, identified as the seal flange in the List of Materials on Sheet 1. The material for the seal flange is specified as ASTM SA-182, XM-19 austenitic stainless steel. To further clarify the seal flange configuration, supplementary dimensions have been added to Detail R.

d. packaging and content weight;

<u>Response</u>: Drawing 99008-10 has been revised to include the maximum weights for the package and the contents.

e. number, dimensions (including length), and positioning of each type of neutron poison plates on the strongback assembly and the fuel control structure with the steel angle plate, minimum acceptable areal density of boron-10;

<u>Response</u>: Drawings 99008-30 and 99008-34 have been revised to include specific details of the poison plates for the strongback structures and the FCSs. The minimum acceptable areal density for boron-10 has also been included as part of the applicable drawing note on each drawing.

f. missing poison plates on View C-C in Drawing 99008-30, Sheet 3, and View F-F on Sheet 4;

<u>Response</u>: View C-C of Drawing No. 99008-30 is identified as a weldment, which does not include the poison plates since they are attached by Item Nos. 17 and 18 to

the strongback longitudinal weldment. View F-F does include the three tangential poison plates (Item No. 10). The three radial poison plates (Item No. 10) on the strongback longitudinal weldment are shown in Assembly Section E-E on Sheet 6, Drawing No. 99008-30.

g. specification on "#305 adhesive or equivalent" as indicated on Drawing 99008-33, Sheet 1 if the adhesive is important to safety;

<u>Response</u>: The specified adhesive is not important to safety of the MFFP.

h. revision to Item 15 of Drawing No. 99008-40, Rev.0, Sheets 1 and 2 for inner plate thickness of the impact limiter call-out form 1/4" to 5/16" in order to be consistent with the design changes discussed on Page 2.12.4-6 of the SAR;

<u>Response</u>: The inner plate referenced on Page 2.12.4-6 of the SAR is Item No. 11 on Drawing No. 99008-40, which lists the correct plate thickness as 5/16 inches. To clarify this issue, the drawing has been revised to identify this plate as "recessed end plate", which is the same terminology as used in the SAR section.

i. specification on electroless nickel plate identified by Note 8 to be used with item #38 on Drawing 99008-40, Sheet 1;

<u>Response</u>: Note 8 of Drawing No. 99008-40 has been revised to include the specification for electroless nickel plating.

j. indications where Item #38 is used.

<u>Response</u>: Item No. 38 on Drawing No. 99008-40 is specified in the packaging assembly drawing (Drawing No. 99008-10) in the List of Materials as Item No. 5.

Chapter 2 – Structural

2-1 Specify the full specification (e.g., class, type, heat treatment, etc.) of the materials in Table 2.2-1.

Staff is unable to verify all of the materials properties used in the structural analysis due to inconsistent use of UNS or Type designation for materials or incomplete alloy specifications.

<u>Response</u>: Table 2.2-1 of the SAR has been revised to include the UNS designation for the XM-19/FXM-19 material (S20910). The identification of an annealing temperature for the yield strength was incorrectly included from an older version of the ASME B&PV Code. The 2001 Edition, with the 2002 and 2003 Addenda, of the ASME Code does not include any annealing temperature requirement for the yield strength of XM-19/FXM-19 material. In addition, specification ASTM SA-276/A276, which is not applicable to XM-19 material, has been removed form Table 2.2-1.

2-2 Correct the following apparent underscored typographical errors, as appropriate:

- Page 2.2-4, Note 3 of Table 2.2-4: "ASME B&PV Code,... Table <u>2A</u>"
- Page 2.4-1, Material Property entries: Ultimate <u>Stress</u>, Yield <u>Stress</u>, Shear <u>Stress</u>

<u>Response</u>: The SAR tables have been revised to correct the typographical errors.

2-3 Revise Section 2.4.2 to recognize that, in addition to those of §71.45(b), the shear stress performance of the doubler plate-to-shell weld should also be evaluated as part of the containment body, per the NB-1132.2(d) jurisdictional boundary provisions of the ASME B&PV Code.

The package tie-down devices, as non-pressure-retaining structural attachments, are welded to the containment shell directly. As such, the ASME B&PV Code design criteria as committed by the application for evaluating the containment body must be followed.

Response: Section 2.4.2 of the SAR has been revised to use the ASME B&PV Code allowable shear stress in evaluating the doubler plate-to-shell weld. The resultant margin of safety (MS) is positive.

2-4 Perform an evaluation of effects of vibration on the three 1/2-inch diameter socket head cap screws, depicted in Drawing No. 99008-10, Rev. 0, which are used to hold the strongback to the containment body weldment during transportation.

Response: The primary purpose of the three socket head cap screws (SHCS) that secure the strongback in the body is to prevent movement of the strongback for operational considerations. The SHCS are not required for either NCT or HAC regulatory conditions. Therefore, the effects of vibration on these SHCS are not a concern. An evaluation of the tightening torque, which was increased to 70 - 75 lb_f-ft, has been added to a new section, Section 2.6.1.3.5, of the SAR.

2-5 Revise the application to provide the maximum allowable stress for XM-19 from published test data or manufacturer data at 1400 °F.

The staff is concerned that there maybe some underlying metallurgical reason why ASME B&PV Code, Section III, Subsection NH does not contain allowable stress for XM-19 at elevated temperature of 1400 °F as indicated in Section 2.7.4.3 of the SAR. Although Type 304 stainless steel has a lower tensile strength than XM-19, it is unacceptable to use the ASME code properties for different type or grade of material (304 stainless steel to try to extrapolate the properties of XM-19). It's not clear that as the temperature is raised the extrapolation of the properties of the two materials will track.

Response: Section 2.2.1 of the SAR has been revised to include a description of the high temperature data. Tables 2.2-1 and 2.2-2 have also been revised to provide material properties for Type XM-19 and Type 304 materials at elevated temperature up to 1,500 °F and 1,400 °F, respectively. The material property references consistently describe both Types XM-19 and 304 as austenitic stainless steels with excellent high temperature performance. Additionally, the elastic modulus for both Type XM-19 and Type 304 materials up to 1,500 °F is provided in ASME B&PV Code, Section II, Part D, Table TM-1, Material Group G (22Cr-13Ni-5Mn). From this information, the higher strength Type XM-19 material essentially parallels the Type 304 material strength at elevated temperatures.

2-6 With respect to the weight difference between the design basis package of maximum gross weight of 14,130 lbs and the No. 2 Certification Test Unit (CTU) of 13,234 lbs, perform structural analysis or conduct drop testing, as appropriate, to demonstrate that the closure lid will continue to maintain leak-tightness after the 30-ft free drops.

Page 2.7-4 of the SAR identifies that the No. 2 CTU weighs 896 lbs less than the design configuration (14,130 – 13,234 = 896 lbs). per Table 2.1-3 of the SAR, the closure lid/bolt assembly can potentially be subject to puncture shear resulting from being impacted by the strongback and its payload, which weights a total of 7,640 lbs (2,900 + 4,740 = 7,640 lbs). Therefore, contrary to the SAR assessment of only a 6.3% weight difference between the design basis package and the No. 2 CTU, there exists a much higher percentage weight difference for which the puncture shear effect must be considered for evaluating the end-drop accident.

Response: The difference in MFFP contents weight between the No. 2 certification test unit (CTU) and the weight listed in Table 2.1-3 of the SAR is 734 lbs. This quantity is mostly due to the addition of the FCS, which was not present in the test. The remainder is due to potential variations in the manufactured weight of the strongback. Section 2.7.1.2 of the SAR has been revised to more clearly show that the weight of the strongback is carried into the closure lid through relatively strong load paths (such as the closure lid outer forging or central stiffening ring), rather than through membrane loading of the closure lid inner plate. Because of this load path, the minor weight increase due to the FCS would not produce significantly higher stresses. Thus, puncture shear of the closure lid is not of concern.

2-7 Specify which of the cross-sectional widths are plotted in Fig. 2.12.3-19 and how do the two widths differ.

Note that an assembly has two cross-sectional widths. After the assembly is dropped, they may not be the same.

Response: The cross-sectional widths plotted in Figure 2.12.3-19 are based on measurements taken normal to the axis of the body. The figure has been revised to identify the direction of measurement and explanatory text has been added to Section 2.12.3.8.2.4(g) of the SAR.

2-8 Specify the original distance from the top of the rods and the underside of the top end plate in Fig. 2.12.3-23.

From the figure, it appears that eight rods displaced above the top of the upper end plate. Further, it appears that more have come in contact with the underside of the end plate.

Response: Section 2.12.3.8.2.4 of the SAR has been revised to describe the original distance from the top of the rods and the underside of the top end nozzle, which is 1.14 inches. Additional text has also been provided to fully describe the position of the fissile portion of the fuel with respect to the fuel poison.

2-9 Define, in SAR Section 2.12.1, the "shape factor" and justify its application in calculating crush strength curves for polyurethane foams.

The application is unclear as to the derivation of and basis for the force-deflection curves used for the impact limiter evaluation.

Response: The shape factor is a calculation technique used to "flesh out" a stress-strain curve for polyurethane foam for use in analysis. The technique is based on crush strength data at strains of 10%, 40%, and 70%, and by using known ratios to crush strength at other strain values, it generates a smooth curve through the intermediate strain points. A more detailed description of this technique has been added to Section 2.12.1.1 of the SAR.

2-10 Justify the impact angle of 15° to the horizontal for the most damaging shallow angle slap-down test.

Because of the relatively large slenderness ratio of the package, the slap-down effect on package performance can markedly be accentuated than usual. A sensitivity analysis is needed to demonstrate that the 15° impact angle has properly been determined for the most damaging drop orientation.

Response: Section 2.12.1.7 has been added to Appendix 2.12.1 of the SAR to demonstrate that an impact angle of 15° results in the worst-case impact accelerations.

2-11 Provide the basis for using the video records taken of the impact limiter crushing to estimate package decelerations for the drop test. If only constant decelerations were assumed for the duration of impact, obtain and justify peak deceleration estimates and perform structural re-analyses, as appropriate, for package.

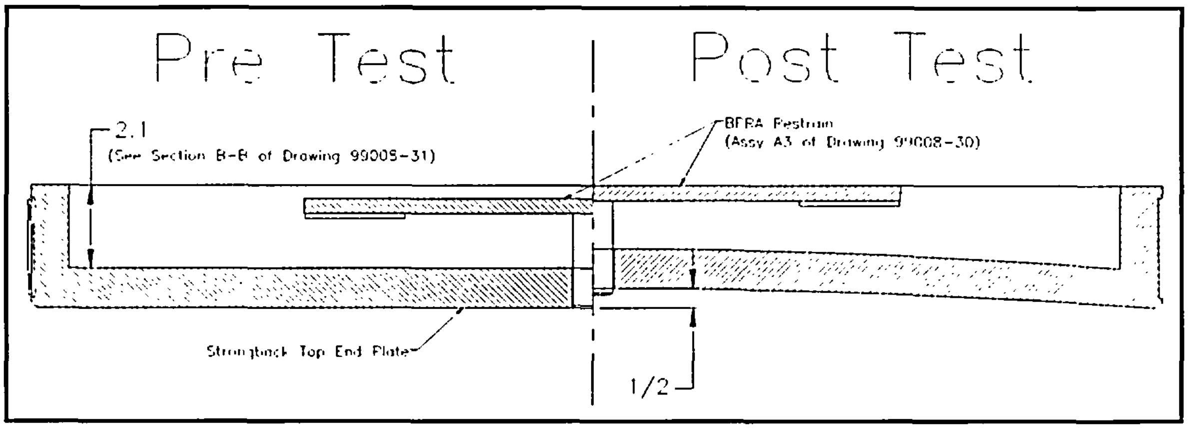
It is unclear as to how the video records were used to obtain package decelerations, average or peak.

Response: The package decelerations extracted from the video records were determined by numerically differentiating the displacement versus time twice of several fixed points on the body. With a frame speed of 1,000 frames per second (fps), each time step was 0.001 seconds per frame. Using a known package dimension to benchmark the video image scale, the displacement of the selected body fixed points were then determined for each time step, from immediately prior to and to the end of the impact event. The displacement-versus-time data then was used to calculate velocity (first derivative) and acceleration (second derivative). This method ensured that the peak accelerations were detected and evaluated rather than using an average deceleration for the impact event. Figure 2.12.3-16 illustrates this technique for comparing the velocity of two different tests of the same drop orientation.

2-12 For the 30-ft C. G.-over-corner drop of Test Series 2, provide a discussion of structural damage, if any, to the closure lid/bolt assembly.

Item d, page 2.12.3-10, states, "The top plate of the strongback was permanently deformed outwards (towards the lid) by approximately 1/2 inch." Section A-A of Drawing 99008-10 appear to show a nominal gap of less than 1/2 inch between the strongback top and the closure lid, which is less than the reported 1/2-inch outward deformation of the strongback top. This suggests that the closure lid/bolt assembly could have been subject to a puncture shear by the strongback and, thereby, damaged during the test.

Response: Additional discussion, including supporting figures and pictures, has been provided in Section 2.12.3.8.2.4 of the SAR. The top plate deformations described are the maximum, which occurs at the center of the strongback top plate. The design of the top plate is such that there is a 2.1 inch thick 'rim' at the outer diameter, which provides the central portion room to deform. See the schematic below that shows the type of deformation, and where the deformation measurement was taken.



Schematic of Strongback Top Plate Deformation

2-13 Provide sketches depicting the accelerometer installation plan for the drop Test Series 3 and 4.

The application should include accelerometer locations on the test articles for test results evaluation.

<u>**Response:**</u> Sketches of the accelerometer locations have been added to Section 2.12.3.8.3.1 and Section 2.12.3.8.4.1 of the SAR for Test Series 3 and Data Test (Test 11), respectively.

2-14 Revise the calculation, on Page 2.12.5-4, for the reaction load, P_a, which is assumed to be required to prevent the outer most row of fuel rods from undergoing further lateral displacement of more than 0.2 inch after buckling initiation. Revise, as appropriate, all other analyses of the application that are based on this reaction force estimate.

The application underestimates the reaction force, P_a, by one half. The staff notes that, by considering moment equilibrium for the forces depicted in the free-body diagram of Figure 2.12.5-3, the following equation applies:

$$[P_r - P_a(\tan\alpha)] \times L/2 = P_a \times \delta$$

After rearranging and transposing,

$$P_r = P_a\{[\delta/(L/2)] + \tan\alpha\}, \text{ and}$$

By again recognizing that, for a small angle, α, $\tan\alpha$ can be estimated as δ/(L/2),

$$P_r = P_a(\tan\alpha + \tan\alpha) = 2P_a \tan\alpha\,,$$

Which is twice the value considered on Page 2.12.5-4.

<u>**Response:**</u> The analysis presented in Section 2.12.5.7 has been completely revised to correct errors in the original analysis. The revised analysis also removes excessive conservatism that was included in the original analysis. With these corrections and revisions, the resulting applied load to the FCS is slightly lower than presented in Revision 0 of the SAR. Sections of the appendix that were affected by the changes in Section 2.12.5.7 have also been revised accordingly.

2-15 With respect to the plastic analysis method used in Sections 2.12.5.10, "FCS Finite Element Analysis (FEA)," and 2.12.5.19, "Evaluation of Strongback Response to FCS Loads," provide stress-strain curves to demonstrate proper implementation of the strain-hardening effect in modeling material properties for the analysis.

The application invokes, in Table 2.12.5-3, stress allowable limits for criticality control structures in accordance with those of ASME B&PV Code Section III, Appendix F. The staff notes that, per Paragraph F-1321.4 (b) and NB-3123.24, properly justified stress-strain curves and associated strain hardening characteristic must be considered in the analysis.

Response: Section 2.12.5.4 of the SAR has been revised to include a thorough discussion of the tangent modulus development for XM-19 and Type 304 materials utilized in the FCS plastic analysis. To bound the range of the materials' plastic response, the three load cases were analyzed using both a low and high tangent moduli, and then the results were compared. As shown in Table 2.12.5-3 of the SAR, there are minor differences between the two tangent modulus cases for stress and displacement. These differences have no significant effect on the FCS structural analysis. Sections of the appendix that are affected by the changes in Section 2.12.5.4 have been revised accordingly.

Chapter 3 – Thermal

3-1 Specify the component where the Delrin plastic is used as indicated in Section 3.2.2 of the SAR. Further, submit the manufacturing data sheets for the type to be used in the package.

Staff does not have enough information to determine if this is the appropriate plastic for its application in package since an initial review from the internet has shown that there are over 70 types of Delrin plastics.

Response: Delrin is a registered DuPont trademark for acetal resins, which are a crystalline plastic formulated by the polymerization of formaldehyde. In the MFFP, the Delrin material is utilized as wear pads on the top plate and bottom plate assemblies of the strongback (Item No. 16, Drawings 99008-31, and Item No. 12, Drawing 99008-32, respectively). These wear pads assist in the insertion and removal of the strongback for loading and unloading operations of the MFFP. The wear pads serve no safety function, and are not required for either NCT or HAC conditions. Small Delrin caps are also used at the ends of item 13 of Drawing 99008-31, which provides a top end plate to FA adjustable interface. As noted in Section 3.5.3.2 of the SAR, all of the Delrin material is conservatively assumed to be volatilized in determining the maximum pressure during the HAC thermal event. With this thermal assumption, any acetal resin material is suitable for its operational application. Section 3.2.2 of the SAR has been revised to identify the Delrin plastic material that was utilized for the thermal material properties in the analyses.

3-2 Identify whether any other kind of radioactive or heavy metal impurity may be present and contributing to the heat source in the MOX fuel. Provide a more mathematically precise description of the proposed isotopic contents (radionuclide inventory).

With relatively short half-life (approximately 13 years) for Pu-241, one would expect some amount of Am-241 (half-life of 458 years) to be present in the fuel, unless the Americium is to be separated from Plutonium prior to fuel fabrication. The amount of heat generated by the decay of Am-241 is about 3 times greater than the heat from the Pu-239 decay. The radionuclide inventory shown in Table 1.2-2 can lead to misinterpretation. For example, the fuel heavy metal content could consist of 94$^{w}/_{o}$ of uranium, 4$^{w}/_{o}$ of plutonium and the remaining 2$^{w}/_{o}$ of something else.

<u>Response</u>: Table 1.2-2 has been revised to clarify the inventory description. As noted in Table 1.2-2, plutonium is limited to a maximum of 6.0$^{w}/_{o}$, with uranium making up the balance of the heavy metals. PacTec acknowledges that Am-241 can be a source of relatively significant heat generation. However, the MOX powder is created using an aqueous polishing process on the front-end to remove Am-241 and other impurities in the plutonium oxide to trace quantities prior to fuel fabrication. Any licensed user of the MFFP is required to certify that the maximum decay heat does not exceed the limit specified in Section 1.2.3.3 of the SAR.

3-3 Provide the supporting analyses for the hypothetical accident condition (HAC) fire involving multi-package shipping (more than one MFFP per truck or train container) scenario.

Describe the most limiting array of MFFP packages that are expected to be inside a closed shipping container (e.g., tarpaulined vehicle, canopy). Address how close the packages can actually be to each other. Provide a bounding calculation for the multi-package scenario. Consider the effect of this bounding calculation upon the fire event result, since the HAC starting conditions would be different from what is presented in the current application.

<u>Response</u>: Even though the package qualifies as a nonexclusive shipment per 10 CFR §71.43(g), loaded MFFPs will be transported individually within a closed container (e.g., enclosed van), due to its width, length and weight. Therefore, the most limiting array of MFFPs for thermal evaluation is a single package, which is the case analyzed in the SAR for NCT conditions.

3-4 Provide details regarding the boundary conditions and modeling options for the impact limiter region under the HAC fire.

The application seems to indicate that some of the foam was "replaced" by void (or air) when simulating the fire, as a way of accounting for the crushing of the foam upon impact/drop. Also inferred from the application is that forced convection boundary conditions are being applied at the external wall of the impact limiters. This Is not a conservative assumption since one would expect the internal "empty" space to be occupied by and/or providing a path for hot gases resulting from the outside fire as well as the combustion of the foam itself. As a result, some of the heat source is brought a lot closer to the O-ring seals region than what is considered in the application. Section 3.5.2.2 of the application clearly indicates that, above 500 °F, vigorous outgassing and an indeterminate amount of heat generation is seen from the foam material.

The proposed semi-circular chimney path is placed at an orientation that is parallel to the package axial orientation, which indicates the package is at a vertical position. One would expect instead a horizontal position to be most probable for the package during the HAC fire. The meltable plastic pipe plugs in the impact limiters not only help release internal pressure but also can help the formation of these chimney paths. A very probable scenario would be the fire feeding fumes through the open weld joint, which would cause the foam to react, and the meltable plastic pipe plugs would provide an easy exit to the expanding gases. The expected chimney effect would be actually going around the remaining foam, with some of this foam still being consumed. As fire continues, the chimney path may widen and allow more of the foam to be in direct contact with the flame. The fire heat source is now located a lot closer to the O-ring seals region than what was considered in the application.

Response: The RAI raises several issues that are addressed individually in the following paragraphs.

The void space incorporated into the thermal model of the impact limiter for HAC conditions is not a way of accounting for crushing of the foam. On the contrary, the foam crush is modeled explicitly by modifying the geometry of the impact limiter prior to the initiation of the HAC event to account for the flattening of the limiter. As indicated in SAR Figure 3.5-2, the side drop event is projected to result in the flattening of the OD of the limiter by 7 inches under hot conditions. The extent and degree of foam compaction associated with the side drop event was captured by changing the geometry for the thermal model of the impact limiter to account for this flattening. This increase in apparent foam density in the same region was conservatively ignored since, while the thermal conductivity of the foam vs. density changes little, the thermal mass would have increased. Figure 3.5-3 of the SAR illustrates the damaged vs. the undamaged impact limiter geometry used in the thermal modeling. The creation of a void space discussed at the end of Section 3.5.2.2 is not related to the drop damage, but is a modeling approach used to conservatively bound the response of the LAST-A-FOAM® FR-3700 under HAC conditions as noted from fire tests conducted on specimens of the foam material as well as from previous burn tests of packages using the same material and similar densities.

As the last figure in the 'Fire Protection' section of the LAST-A-FOAM® FR-3700 product literature (*LAST-A-FOAM FR-3700 for Crash and Fire Protection of Nuclear Material Shipping Containers*) indicates, the LAST-A-FOAM® material undergoes a non-linear thermal response when exposed to elevated temperatures. Little or no decomposition occurs at temperatures below 500 °F, but decomposition increases non-linearly with temperature until only about 5% to 10% of the original mass is left by the time temperatures have reached 1,500 °F. However, despite this weight loss, the material does not typically 'burn away', but instead develops a char layer that has a similar thickness and which acts thermally like a layer of still gas with multiple layers of radiation planes. By modeling this layer as a 'void' space, the thermal model not only captures the thermal conductivity of the layer, but conservatively estimates the level of radiation heat transfer occurring across the depth of the char layer, and it conservatively accounts for possibility that, under limited situations, a portion of the foam material may be carried outside of the impact limiter skin by the force of the outgas flow.

Forced convection can not occur at the faces of the foam unless the barrier provided by the impact limiter skin has been significantly breached. As the LAST-A-FOAM® FR-3700 product literature states, the foam will expand as it chars and, therefore, tends to fill in any void region or 'gouge' in its surface. Even in the presence of a breach, the foam located away from immediate vicinity of the breach will not experience forced convection unless sufficient damage exists to create an inlet and an a outlet to allow the unimpeded flow of gases over the surface of the foam. The meltable plastic plugs are too small to allow any significant forced convection due to the presence of an exterior flame alone. Instead, the flow through the meltable plugs and any other relatively small breach in the impact limiter skin will be outward and not inward due to the volume of gas leaving the outer layers of the foam as it undergoes decomposition. Full-scale burn tests of other NRC-licensed packages (e.g., TRUPACT-II (NRC Docket 71-9218) and HalfPACT (NRC Docket 71-9279)) that utilize the same polyurethane foam have shown that even when small cracks and/or small holes/tears from free and puncture drops are present, chimney formation has not been observed.

The RAI suggests that the formation of a chimney through the foam assumed by the SAR analysis is improbable due to fact that the orientation of the package would need to be vertical. While this is true, the proposed chimney geometry is the only one which could conceivably occur since opening of the meltable plugs alone is not sufficient to create a chimney and the drop tests demonstrated that a the puncture bar would not cause a failure in the weld joint (see Figure 2.12.3-13) or tear a hole in the side of the impact limiter. As such, the modeling addressed the only scenario deemed plausible which would create the upper/lower openings required to initiate the formation of a chimney: this scenario is the weld failure shown in Figure 2.12.3-9 from a side drop and a subsequent puncture bar attack on the recessed end of the limiter (see Figure 2.12.3-11). It is the combination of these two openings that result in the orientation of the hypothetical chimney as assumed in the SAR.

Further, as noted in Section 3.5.2.1 of the SAR, the weld joint that cracked and opened in the certification testing was re-designed to prevent any pathways into the polyurethane foam for the HAC thermal event. The structural behavior of the revised joint design was demonstrated via bench testing and is discussed in SAR Appendix 2.12.7. With the weld joint closed, there is no possibility under any condition that a chimney will form with the package in either the vertical or horizontal orientation. Despite this fact, the inclusion of this joint damage was assumed for the MFFP to provide additional conservatism in the HAC thermal analysis.

Sections 3.5.2.1 and 3.5.2.2 of the SAR have been revised to emphasize the conservatism built into the HAC thermal model.

3-5 Provide a copy of the reference that indicates that a 3.0 inch thick layer of undamaged 12 lb_m/ft^3 polyurethane foam or an 8.5 inch layer of undamaged 3 lb_m/ft^3 polyurethane foam is sufficient to withstand a 30 minute fire, as indicated in Section 3.5.2.2 of the application.

<u>Response</u>: A copy of the reference, *LAST-A-FOAM FR-3700 for Crash and Fire Protection of Nuclear Material Shipping Containers,* has been provided with this submittal. The statement in question was taken as an example for foam densities from another application. Since a somewhat more detailed discussion is warranted in this area, the data in question is no longer used directly, and a slightly different approach is taken in order to improve clarity. However, the revised approach makes use of data from the same reference, and reaches the same conclusion. Section 3.5.2.2 of the SAR has been revised to include the added detail.

Chapter 6 – Criticality

6-1 Justify why a calculated density is used instead of specifying a fuel density for manufacture in the note of Table 6.3-2.

The note states that the fuel density is calculated from the dimensions. The applicant should be aware that there can be errors in this density due to the dishing in the pellets and chamfer.

<u>Response:</u> The note in Table 6.3-2 is unnecessary and has been deleted. Table 6.2-3 also has been modified to note the maximum theoretical density of the MOX fuel and that an effective density was utilized in the calculations. The effective density corresponds to the maximum theoretical fuel mass averaged over the pellet stack height and is bounding.

6-2 Indicate the alloy and composition for each zirconium cladding type to be transported.

In Section 6.3.2 and Table 6.3-4 no information has been provided on the cladding types.

<u>Response:</u> Table 6.3-4 of the SAR has been revised to clearly identify M5 as the cladding material that was used in a majority of the MCNP models with a niobium content of 1.2%. The SAR analysis also demonstrates that modeling pure zirconium is slightly more reactive than M5 and that any niobium content in the range of 0-3% is acceptable from a criticality perspective. At this time, no cladding material other than M5 has been identified.

6-3 Provide a complete list of specific conditions and restrictions to be included in the Certificate of Compliance (CoC).

The proposed condition will be used to clearly determine what provisions the applicant is requesting in order to assess whether these provisions have been adequately justified. For example, Note 7 on Sheet 1 of Drawing No. 99008-30 and Drawing No. 99008-34 will be included in the CoC with reference to the current version of Section 8.1.5.2 by date, not just by general reference. Another example of conditions to be included in the CoC is that any covering including bags or protective sheets around the individual fuel assemblies must be open at the ends or slitted to allow prompt draining of the covering should the package become flooded.

<u>Response:</u> The MOX fresh fuel assemblies that will be transported in the MFFP will not be covered in any material (i.e., bags, protective sheets) as these materials would result in unacceptable internal pressures in the MFFP body during the HAC thermal event. In addition to the payload content limitations identified in Section 1.2.3, the other requirement that relates to criticality safety is the boron-10 minimum areal density of the neutron poison plates, as noted in Section 8.1.5.2 of the SAR, and the revised Note 7 on Drawing Nos. 99008-30 and 99008-34. There are no other specific conditions and/or restrictions than those identified above for the MOX FAs.

6-4 Show that the poison plates cover the active length of the fuel assemblies under both normal conditions of transport and hypothetical accident conditions.

The drawings need to clearly specify the axial position of the poison plates. Also it is not clear from Figures 6.3-6 and 6.3-7 how the active fuel region and the poison plates on the strongback and fuel control structure match up. Address the alignment of the active fuel and poison plates under normal conditions. Also, discuss any shifting of the poison plates or active fuel region under the accident conditions including any collapsing of the fuel assembly end hardware during a drop on either end. Information given in the structural section of the SAR indicates that there was some axial movement of the fuel rods during the end drop test.

Response: Figure 6.3-8 and Figure 6.3-9 have been added to Section 6.3 of the SAR to clearly identify the normal axial position of the neutron poison plates relative to the active fuel for both the top and bottom ends, respectively. As demonstrated in the certification tests, the strongback structure, including the neutron poison plates, essentially was undamaged from any of the HAC free drops. As noted in the response to RAI 2-8, the maximum clearance above the fuel rods is 1.14 inches, which results in a maximum potential top-end axial fuel rod movement of less than 3 inches. The top level of the active fuel is located approximately 7.3 inches from the end, below the plenum, which results in no portion of the fuel exposed beyond the poison plates.

It is considered unlikely that fuel rods could break through the FA bottom end fitting. In any case, shifting of rods downward through the FA bottom end fitting would have negligible impact on the reactivity.

As demonstrated in the certification tests and the FCS structural analyses, none of the neutron poison plates will shift from their installed positions for any of the HAC free or puncture drop tests.

6-5 Confirm the maximum allowed Pu loading in the fuel is 6 weight percent of the total weight of uranium + plutonium.

Table 6.2-3 implies that the uranium contents may be "up to" 94.0 weight percent of the total mass of uranium + plutonium. It appears that the uranium content should be 94.0 weight percent or greater.

Response: The maximum allowed plutonium (Pu) loading in the fuel is limited to 6 weight percent, as indicated in Table 6.2-3. Based on this limit, the total uranium loading is then 94 weight percent or greater. Table 6.2-3 and Table 1.2-2 of the SAR have been revised to clarify that the correct total uranium loading range is "94.0 w/o or greater".

6-6 Describe the size and location of the neutron poison holders discussed on page 6.3-2 of the SAR and identify where these items are shown in the drawings.

These poison holders appear to be the only protection for the exposed boral plates on the strongback against the wear and damage of fuel loading and unloading operations. Describe the extent to which the boral plates are covered and protected. Are the neutron poison holders the same as the cover plates listed in the drawings?

Response: The "neutron poison holders" are the same as the "cover plates" listed on the packaging general arrangement drawings. The SAR text has been revised to utilize consistent terminology. Except for the contact area that is covered by the cover plates, one surface of the boral plates is exposed, both on the strongback and the FCSs. Prior to each shipment, visual inspection is required per Section 7.1.2.1 of the SAR to ensure that the boral plates comply with the requirements of the packaging general arrangement drawings. Any noted wear or damage must be repaired prior to using the package, which ensures that the boral plates will always perform their criticality safety function.

Chapter 8 – Acceptance Criteria Maintenance Procedures

8-1 Include dimensional measurements and visual examination of the neutron poison plates for defects and cracks as part of the component and material acceptance test.

Response: Section 8.1.5.2 of the SAR has been revised to include dimensional and visual examinations of the neutron poison plates.

Delete/Insert Instructions
Revision 1 to MFFP Safety Analysis Report
(10 Copies)

Please incorporate the attached Revision 1 SAR pages as follows:

SAR Section	Delete	Insert
Cover & Spline	Revision 0	Revision 1
Title Page	Revision 0	Revision 1
Table of Contents	Revision 0	Revision 1
1.0	• 1.1-1 thru 1.1-2, Rev. 0 • 1.2-3 thru 1.2-8, Rev. 0 • 1.4.2-1 thru 1.4.2-2, Rev. 0	• 1.1-1 thru 1.1-2, Rev. 1 • 1.2-3 thru 1.2-8, Rev. 1 • 1.4.2-1 thru 1.4.2-2, Rev. 1
1.4.2	• Dwg 99008-10, Rev. 0 • Dwg 99008-20, Rev. 0 • Dwg 99008-30, Rev. 0 • Dwg 99008-31, Rev. 0 • Dwg 99008-33, Rev. 0 • Dwg 99008-34, Rev. 0 • Dwg 99008-40, Rev. 0	• Dwg 99008-10, Rev. 1 • Dwg 99008-20, Rev. 1 • Dwg 99008-30, Rev. 2 • Dwg 99008-31, Rev. 1 • Dwg 99008-33, Rev. 1 • Dwg 99008-34, Rev. 2 • Dwg 99008-40, Rev. 1
2.0	• 2.1-7 thru 2.1-8, Rev. 0 • 2.2-1 thru 2.2-8, Rev. 0 • 2.4-1 thru 2.4-4, Rev. 0 • 2.6-7 thru 2.6-16, Rev. 0 • 2.7-3 thru 2.7-16, Rev. 0	• 2.1-7 thru 2.1-8, Rev. 1 • 2.2-1 thru 2.1-8, Rev. 1 • 2.4-1 thru 2.4-4, Rev. 1 • 2.6-7 thru 2.6-16, Rev. 1 • 2.7-3 thru 2.7-16, Rev. 1
2.12.1	2.12.1-1 thru 2.12.1-22, Rev. 0	2.12.1-1 thru 2.12.1-24, Rev. 1
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2.12.3	• 2.12.3-9 thru 2.13.3-14, Rev. 0 • 2.12.3-29 thru 2.13.3-30, Rev. 0 • 2.12.3-33 thru 2.13.3-46, Rev. 0	• 2.12.3-9 thru 2.13.3-14, Rev. 1 • 2.12.3-29 thru 2.13.3-30, Rev. 1 • 2.12.3-33 thru 2.13.3-50, Rev. 1
2.12.5	2.12.5-3 thru 2.12.5-82, Rev. 0	2.12.5-3 thru 2.12.5-94, Rev. 1
3.0	• 3.2-1 thru 3.2-4, Rev. 0 • 3.5-1 thru 3.5-16, Rev 0	• 3.2-1 thru 3.2-4, Rev. 1 • 3.5-1 thru 3.5-18, Rev 1
6.0	• 6.2-1 thru 6.2-2, Rev. 0 • 6.3-1 thru 6.3-10, Rev.0 • 6.3-13 thru 6.3-14, Rev. 0 • 6.3-17 thru 6.3-18, Rev. 0 • 6.4-1 thru 6.4-4, Rev. 0 • 6.5-1 thru 6.5.2, Rev. 0 • 6.6-1 thru 6.6-2, Rev. 0 • 6.8-1 thru 6.8-14, Rev. 0	• 6.2-1 thru 6.2-2, Rev. 1 • 6.3-1 thru 6.3-10, Rev.1 • 6.3-13 thru 6.3-14, Rev. 1 • 6.3-17 thru 6.3-20, Rev. 1 • 6.4-1 thru 6.4-4, Rev. 1 • 6.5-1 thru 6.5.2, Rev. 1 • 6.6-1 thru 6.6-2, Rev. 1 • 6.8-1 thru 6.8-14, Rev. 1
7.0	• 7.1-3 thru 7.1-4, Rev. 0 • 7.2-3 thru 7.2-4, Rev. 0	• 7.1-3 thru 7.1-4, Rev. 1 • 7.2-3 thru 7.2-4, Rev. 1
8.0	8.1-13 thru 8.1-14, Rev. 0	8.1-13 thru 8.1-14, Rev. 1