September 5, 2012

Ms. Mary F. Shepherd
Vice President, Licensing and Special Projects
J.L. Shepherd & Associates
1010 Arroyo Ave.
San Fernando, CA 91340-1822

SUBJECT: APPLICATION FOR CERTIFICATE OF COMPLIANCE NO. 9363 FOR THE MODEL NO. BU650B PACKAGE – NOT ACCEPTED FOR REVIEW

Dear Ms. Shepherd:

This letter is to advise you that your application for Certificate of Compliance No. 9363 for the Model No. BU650B package, submitted on June 29, 2012, and supplemented on July 10, 2012, to provide missing drawings, does not contain sufficient technical information in scope and depth to allow the staff to complete a detailed technical review.

Staff had previously explained during the May 30, 2012, pre-application meeting (i) the importance of benchmarking an analytical approach reflecting the modeling attributes used in the design, (ii) the need for sensitivity analyses, (iii) the need to evaluate the worst configuration of the package, and (iv) the importance of properly addressing the deformation of the shielded liner from the hypothetical accident conditions (HAC) tests.

On August 28, 2012, staff held a public meeting to discuss with you some of the open technical issues resulting from the acceptance review of your application. The staff identified a number of significant deficiencies including the dimensions used in the shielding analyses are inconsistent with those shown on the licensing drawings, lead slump is not considered in the analysis while staff calculated a 3.2" gap at the top of the lead layer under HAC, thermal analyses did not consider the effect of a covered conveyance, and the application does not provide any data to demonstrate that the modeling approach is properly benchmarked to simulate the package structural performance for the 30-ft drop and puncture drop tests. These and other deficiencies are listed in the enclosure to this letter.

Because of the extensive nature of the information needed, NRC staff activities on the review have ceased and the associated Technical Assignment Control number has been closed.

We request that you review the open technical issues enclosed with this letter and inform us in writing, within two weeks of the date of this letter, of the actions you intend to take in light of the NRC staff's decision to stop the review of your application. Please note that the attached list of open technical issues should not be considered all inclusive, and we expect that you will holistically update or revise the application as necessary to meet regulatory requirements.

If you have any questions regarding this matter, please contact me at (301) 492–3408.

Sincerely,

/RA/

Pierre Saverot, Project Manager
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material
Safety and Safeguards

Docket No. 71-9363
TAC No. L24659

Enclosure: Open Technical Issues related to the Model No. BU650B package application

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Docket No. 71-9363
TAC No. L24659

Enclosure: Open Technical Issues related to the Model No. BU650B package application

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DATE	08/14/2012	08/20/2012	08/21/2012	08/21/2012	08/20/2012	08/23/2012
OFC	SFST E	SFST C	SFST C	SFST C	SFST	SFST
NAME	ZLi	MSampson	MdeBose	MWaters	DWeaver	MLombard
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DOCKET NO. 71-9363

OPEN TECHNICAL ISSUES

RELATED TO THE MODEL NO. BU650B PACKAGE

This list of open technical issues identifies information needed by the U.S. Nuclear Regulatory Commission (NRC) staff in connection with its acceptance review of the Model No. BU650B package application.

NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material," was used by the staff in its acceptance review of the application.

CHAPTER 1 GENERAL INFORMATION

1-1 Identify specific deviations from ASME Code Section VIII, Div. 1 or Section III, Subsection NF, for safety-related weld. Provide justification for the welding specifications indicated on the licensing drawings.

NUREG/CR-3019 recommends welding criteria per ASME Code Section VIII, Div. 1 or Section III, Subsection NF, for Other Safety-Related Welds. However, this criteria is not referenced on the licensing drawings. The licensing drawings provide specific weld and weld inspection notes instead of referencing these consensus industry standards.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.31(c).

1-2 Justify the use of ASTM A167 material. NUREG/CR-3854 recommends the use of ASME Boiler and Pressure Vessel Code (ASME Code) materials or equivalent ASTM materials. ASME materials are identified as being identical to ASTM materials in the corresponding ASME Code specification, as applicable. However, a corresponding specification for ASTM A167 is not provided in the ASME Code.

An understanding of the specific acceptance criteria and basis for evaluation is critical for all important to safety components. For components and materials that are not fabricated per acceptable consensus standards, detailed justification is needed.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.31(c).

1-3 Make the following corrections, changes, or clarifications to the certificate drawings (see tables below).

The certificate drawings must clearly communicate the part descriptions, assembly methods, and material specifications in sufficient detail to provide a sufficient basis for evaluation of the package.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.31(a)(1),(c) and 71.33(a)(5).

DRAWING NO.	**DISCREPANCY**
	PACKAGE ASSEMBLY
BU650B-PA	• Clarify referenced drawings in the "Part List." The referenced drawings should refer to the subassembly drawing indicated in the package assembly. For example, Item 1, top impact limiter, should refer to the top impact limiter assembly drawing, "BU650B-IL," instead of the impact limiter top plate, "BU650B-IL-1." Items 1, 2, 3, and 4 require corrected drawing references. • Specify assembly hardware or other attachment methods, as required.
BU650B-RA	• Clarify the quantity of Item 3, ¾ OD x ¼ W pipe. The top view shows eight 18-1/2" length pipes. The side view does not correspond to the top view, but appears to represent six of the eight 18-1/2" length pipes. The "Bill of Material" indicates one pipe is required.
	SHIELDED LINER ASSEMBLY
BU650B-SL	• The SAR indicated that various Shielded Liners may be fabricated as appropriate for the quantity of radioactive material being transported. Identify the different configurations of Shielded Liners that meet the design requirements in the drawings. • Reference subassembly drawings, not component drawings, where assembly details are shown on a subassembly drawing. The subassembly drawing does need to reference the applicable component drawings to provide a complete description of the shielded liner. Specifically, Items 10, 11, 12, and 13 should not be referenced on drawing BU650B-SL. The subassembly drawing BU650B-SL-6 should be referenced instead as it details the assembly welds. • Correct double-fillet weld joining Items 5 and 6 as there is not an appropriate joint configuration for the weld specified. Identify the weld required to join Items 6 and 9.
BU650B-SL-2	• This is the Shielded Liner Assembly drawing and should be shown on sheet 1 for clarity. • Correct drawing references to reference Shielded Liner subassemblies and components, as appropriate. The current references for the Lid Assembly are not applicable. • Correct reference to Item 5 shown in drawing, but not indicated in "Part List."

BU650B-SL-4	• Provide the industry standard specification for the 304 stainless steel and 6061-T6 aluminum alloy indicated in the "Bill of Material."
BU650B-SL-3	• Include the lead fill on the Bill of Materials. Identify an acceptable material specification for the lead material and processing methods. Alternatively, justify the use of a non-standard material and/or processing method in Chapter 8 of the application.
BU650B-SL-15	• Correct "Bill of Material" to indicate correct Item number and material for lifting lugs.
BU650B-SL-17	• Provide the industry standard specification for Items 1 and 3 indicated in the "Bill of Material."
BU650B-SL-18	• Provide the industry standard specification for Items 4, 5, 6, and 7 indicated in the "Bill of Material."
LID ASSEMBLY	
BU650B-LA-2	• "Bill of Material" indicates 3/8" thick 304 stainless steel plate, while the subcomponent drawing thickness is ½" thick.
LOWER PACKAGE ASSEMBLY	
BU650B-LPA	• Specify assembly hardware. • Correct "Bill of Material," Item 1 and Item 2 drawing references.
IMPACT LIMITER ASSEMBLY	
BU650B-IL	• In the "Part List," correct the sheet referenced for Items 8 and 9. • Clarify items referenced in "Part List." Where appropriate, reference the subassembly drawing, including drawings BU650B-IL-10 (sheet 11) and BU650B-IL-11 (sheet 12), instead of the component drawings. The component drawings still need to be referenced in the appropriate subassembly drawings to ensure an adequate description of the package is provided. • Define or delete "or equivalent" as it relates to the 2" diameter plastic plug from MMC #9750K34. • Indicate welds or other attachment methods. Include weld specifications where applicable. • Indicate tolerances for dimensions (xx) which are not shown as decimals, fractions, or angles.

1-4 Revise the licensing drawings, as appropriate, to provide adequate description of design features for the packaging components important to safety. Examples on insufficient drawing clarity necessary for a safety evaluation consideration include:

a. Drawings BU650-PA and BU650-SL. Modify the drawings by necessary use of section/view cut symbols such that design features of the Shielded Liner can consistently be identified among drawings.

Drawing BU650-PA displays a larger and longer Shielded Liner base below the spacing/shoring plate (Item 9 of drawing BU650-SL). It is unclear whether the chamfered 31” x 31” x ½” plate is configured to allow lateral movement of the spacing/shoring plate such that a gap up to 4 inches can exist, as offset, within the 35-inch diameter cavity of the Lower Package Assembly.

b. Drawing BU650-SL-2. Identify the parts item associated with those of the Impact Plate.

The Impact Plate appears to be called both Items 4 and 5. However, only Item 4 is described in the Part List as Impact Plate.

c. Drawing BU650-SL-2. Verify that Item 2, Plug Assembly, is drawn to scale and parts terminology cited in drawing BU650-LA-3 is consistently used in all licensing drawings.

Drawing BU650B-SL-17 depicts the Shielded Liner Plug Assembly with much different apparent design features from those presented as “Plug Assembly” design in drawing BU650-LA-3, which is entitled, “Lid Assembly – Top Plate,” instead.

d. Drawing BU650-SL-5. Provide section/view cut symbols, as appropriate, for the sketches in the drawing to illustrate how they should be interpreted for depicting design details of the Impact Plate.

The sketches are not sufficiently annotated with symbols and dimensions to depict how the Impact Plate is designed and assembled.

e. Drawings BU650-SL-16, -SL-17, and -SL-18. Remove the licensing drawings, as appropriate, from the application if the optional plug assembly, as opposed to those depicted in drawings BU650-SL-3, and -SL-4, have not been evaluated in the application to satisfy the structural, thermal, and shielding performance criteria for intended functions.

It’s unclear whether Calculation Report, DAC-PO9YCW01-0001 000 00, has considered a bounding design configuration in the safety analysis to demonstrate the structural adequacy of the optional Plug Assembly.

f. Drawing BU650-LPA, Rev. B. Verify that the applicable revision edition of the subject drawing was used in analyzing the package test performance.

Section 1.3.2, “Drawings,” of the application identifies the subject licensing drawing, “Lid and Lower Package Assembly,” as Revision A, which was issued on June 28, 2012. However, as displayed in the revision record, Revision A is shown issued on July 8, 2011. It is, therefore, unclear whether the updated design details have been considered in performing safety analysis of the package.

The information cited in Questions a through f above is required by the staff to determine compliance with the requirement of 10 CFR 71.33(a)(5).

CHAPTER 2 STRUCTURAL EVALUATION

2-1 Clearly indicate which material properties were used in the structural analysis, including the source of the properties, assumptions made, and any deviations from the ASME B&PV Code. Correct discrepancies between the licensing drawings and the materials indicated in SAR Section 2.2 as well as discrepancies contained within SAR Section 2.2.

SAR Section 2.2.1.1 states that the structural components of the package are fabricated from grade 304 and/or 316 stainless steel materials. However, the licensing drawings indicate grade 304 and 316L stainless steel materials, carbon steel, GP3712 LAST-A-FOAM, and KAOLITE 1600. SAR Section 2.2.1.1 states that the "Closing Ring" is fabricated from grade 304 and/or grade 316 stainless steel; however there is no "Closing Ring" indicated in the licensing drawings. There is a "Ring Assembly" and a "Shielded Liner – Ring Detail," both of which are fabricated from ASTM A36 carbon steel. SAR Section 2.2.1.1 also references apparently incomplete material specifications (e.g., "SA-479/A479" in Section 2.2.1.1 instead of "ASTM A276 or A479" in the licensing drawings). There are several incorrect table references within SAR Section 2.2.1.1 that impede clear indication of the material properties used in the structural analysis. Table 2-5 summarizes the material properties (in customary units), but does not correspond exactly to the material properties (in SI units) detailed within this section. Table 2-5 includes properties for AISI 1010 and 1020 carbon steel which are not detailed in Section 2.2 or indicated in the licensing drawings, the purpose of which is unknown. Similarly, Table 2-8 provides properties of ASTM A240, Type XM-19 stainless steel which is not detailed in Section 2.2 or indicated in the licensing drawings, the purpose of which is unknown.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.31(c) and 71.33(a)(5).

2-2 Tabulate the upper-bound and lower-bound dynamic stress-strain curves used to analyze the impact limiters. Detail and justify any assumptions made and provide the data used to substantiate the curves and any assumptions made.

SAR Section 2.2.1.3 states that upper-bound and lower-bound dynamic stress-strain curves were developed considering the effects of crush direction, temperature, strain rate, and material variability. However, these curves are not provided and the data supporting their development is not indicated. The data used to bound anisotropic behavior, temperature dependency, strain rate response, and inherent material and processing variability is needed to support these bounding curves.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.31(c).

2-3 Clearly indicate the mechanical properties of Kaolite 1600 used in the structural analysis and the source of those properties. Provide the data used to substantiate these properties.

SAR Table 2-5 indicates mechanical properties of Kaolite 1600 and SAR Table 2-14 indicates physical and thermal properties of Kaolite 1600. However, it is not clear which properties are used in the analysis and what the basis for the utilized properties are. The data used to support the analysis is needed to support the analysis. Ensure that the properties provided are consistent with those used in SAR Chapter 3 for the thermal analysis.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.31(c).

2-4 Verify that the intended stress acceptance criteria are accurately stated, per ASME B&PV Code, Section III, Division 3, Subsection WB, for the non-pressure-retaining circumference welds and, per ASME B&PV Code, Section III, Division 1, Subsection NF allowable stress design criteria for Class 2 plate and shell-type supports.

The application states, "…the stress evaluation has been limited to key components which are illustrated in Table 2-3…" A close examination of the table reveals, however, that packaging components of vastly different performance and acceptance criteria are lumped together in the same table with less than clear summaries of what are generally tabulated in an application. A few examples are as follows.

a. The Table 2-3 caption is misleading in that, unless specific provisions of the ASME Code, Subsections WB and NF, are explicitly invoked and justified, the finite element analysis results for those components are all based on stress allowables, not "allowable strains" as suggested.

b. The package components with distinctively different acceptance criteria should be listed in separate categories and tables to facilitate staff review. For instance, the ASME Code, Subsection WB, components, which evaluated against stress intensities, should not be mixed with the Subsection NF components evaluated with allowable stresses. Also, for the polyurethane foam, the maximum crush deformation limits may need to be established to alleviate potential impact limiter lock-up. Similarly, for the Shielded Liner subject to the 30-ft drop and puncture drop tests, the lead slump and gross deformation acceptance criteria should also be established.

c. Verify that the Table 2-3 headings on stress/strain performance bases and criteria are properly defined and analysis/test results are accurately summarized. Examples of unclear listing include:

   i. There is no terminology, "Design Yield," defined in the ASME Code. Appropriate allowable stresses per Subsection NF and stress intensity limits per Subsection WB should explicitly be listed in the Table.

   ii. Use of terminologies, such as Rated Stress and Design Stress, is not consistent with the ASME Code, Section III, stress allowable definitions for the design strength consideration. If indeed the ASME Code Level D Limits are used for evaluating the hypothetic accident conditions (HAC), the stress allowables, not "Design Stress," should be noted for applicable Code Paragraphs and Subparagraphs, as appropriate

iii. The consideration of “Actual (%)” strain results is not consistent with the ASME Code stress based acceptance criteria.

iv. The maximum actual strains listed in the Table do not appear to be consistent with those reported in other parts of the application. For instance, the reported maximum calculated plastic strain of 0.5% for the “Inner & Outer Shell” in the table is not in agreement with those listed as 0.63% and1.37% for the Cask Body Inside and Outside Cylinder, respectively, in Table 2 of the attached Report, DAC-P09YCW01-0001 000 0, “Design Analysis and Calculation”. Also, the listed lead shielding deformation of 0.05% is markedly smaller than the 2.21% plastic strain reported in the Report for the top end drop accident condition.

This information, particularly the one cited in questions a through c above, is requested by the staff to determine compliance with the requirements of 10 CFR 71.31(c).

2-5 Clarify discussions on structural performance acceptance criteria and associated bases for the Lower Package Assembly components by citing only applicable provisions of the ASME Code, Subsections NF and WB.

Section 2.1.2.2 of the application, “Allowable Stresses,” commits the ASME Code, Subsections NF and WB, to evaluating the package components, including those of the Lower Package Assembly. However, these two Subsections do not recognize explicitly the “strain based” design criteria in the stress evaluation. As such, for individual Lower Package Assembly components, justification for invoking evaluation criteria different from those committed Code provisions should properly be noted and alternative compliance basis presented on a case basis.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.31(c).

2-6 Clarify the discussion on the application of appropriate finite element analysis codes on page 2-70, Section 2.7.1, “Free Drop Test”, Tables 2-10A and 2-10B.

The application notes that the LS-DYNA computer code is used to predict the rigid-body response of the package to each HAC free drop test. In the second paragraph, page 2-71, the application states, “Detailed stress analyses of the package and shield lid for HAC free drop loading are performed using linear-elastic equivalent-static finite element analysis method. The ANSYS Mechanical computer program,…is used for this analysis.” By this discussion, it is unclear whether a two-step finite element analysis of the package structural performance is implemented. However, the finite element analysis results of Tables 2-10A and 2-10B do not appear to have provided clear indication on which finite element analysis code, ANSYS or LS-DYNA, was used to calculate “detailed” maximum plastic strains for individual package components with markedly different stress/strain performance criteria.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.73(c)(1) and (3).

2-7 Provide sketches of parts deformation to depict whether the puncture pin is calculated to have pushed the intervening packaging components to close gap openings, including those between the lid assembly and the impact plate of the Shielded Liner Closure Plug, to cause additional plastic strains to develop in the Shielded Liner Lid Lead.

Regarding page 2-75, Table 2-19, BU650B Component Maximum Plastic Strains: "Cumulative Damage from 30-ft Top Drop (rotated 15 degrees) and 40 Inch Puncture Drop (Lid and Side)," it is unclear how additional plastic strains can be introduced to the Lid Lead during the puncture test of 71.73(c)(4). Part No. 104, Shielded Liner Lid Lead, is shown to have a calculated maximum plastic strain of 0.9% for the 30-ft end drop, which is markedly less than the maximum cumulative strain of 1.29% after the puncture drop accident.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.73(c).

2-8 Provide the maximum calculated plastic strain resulting from the 30-ft Top Drop accident to demonstrate that cumulative damage of the Liner Lead can properly be calculated and assessed. See Part No. 91, Shield Liner Lead, Table 2-19.

Table 2-10A, which lists component maximum plastic strains after the 30-ft package drop accident, provides no strain performance data for the Liner Lead. The application needs to demonstrate that the most damaging geometric configurations of the Shielded Liner resulting from the 30-ft drop accidents have been considered for the package shielding safety analysis.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.31(c).

2-9 Reassess, as appropriate, the Puncture Test "finite element analysis" results by noting that there could be more than one location on the Lower Package Assembly that is vulnerable to the puncture drop test. See page 2-77, last paragraph.

The application states, "The results of the Puncture Test indicate that the package closure and side wall will not yield,…" This is contradictory to the Table 2-19 results, for which Part No. 6, Package Body Top Closure Ring, and Part No. 76, Shield Liner Shell, are seen to have undergone the maximum plastic strains of 21.61% and 109.08%, respectively. The application needs to demonstrate that large plastic strains will not result in potentially large dents at key locations of the Lower Package Assembly that could compromise performance of the Kaolite1600 as a thermal barrier.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.73(c)(1) and (3).

2-10 Clarify, as appropriate, the statement, "The code has been well benchmarked and is widely used for the structural analysis of transportation package drop tests," by providing specificities of the modeling approach, not the computer code itself, that have been benchmarked for adequate finite element analysis numerical simulation of the drop tests for the Model BU650B transportation package. See page 2-86, Section 2.12.3.2, ANSYS LS-DYNA PC.

Section 2.5.5.2, “Evaluation by Analysis,” of NUREG-1609, “Standard Review Plan for Transportation Packages for Radioactive Material,” provides the following, “Verify that the computer codes, if used, are valid for the intended application; use methods that are consistent with standard practice and procedures, and are benchmarked.” Section 2.12.3 of the application notes that the ANSYS and LS-DYNA codes have been validated to demonstrate that the computer codes correctly solve the general classes of problems. Since the ANSYS equivalent-static modeling approach is known to be satisfactory for analyzing many classes of package components, the staff will focus the safety review primarily on finite element modeling assumptions. If properly implemented, the ANSYS code is considered acceptable for its intended use. However, no data is provided in the application to demonstrate that the LS-DYNA modeling approach is benchmarked finite element analysis simulation of the package structural performance for the 30-ft drop and puncture drop tests.

This information is required by the staff to determine conformance to the guidance in NUREG-1609, Section 2.5.5.2.

2-11 Submit for staff review the Confirmatory Test Report which demonstrates that test results are adequately correlated with the pre-test predictions. See page 2-87, Section 2.12.5.1, Confirmatory Test Report.”

The staff notes that confirmatory tests would provide necessary test data to be used for benchmarking the LS-DYNA modeling approach for calculating the package 30-ft drop and 40-inch puncture drop test performance. However, no packaging drop test results or test results for packaging sufficiently similar are presented in the application.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.73(c)(1) and (3).

2-12 Verify that the “Closing Ring” is part of the as-described Lower Package Assembly. See page 2-9 of the application.

Drawing BU650B-LP-6 identifies design features of the Lower Package Assembly and no Closing Ring can be found in the Parts List. If, however, the “Top Plate,” as Part No. 1, is alternately used in the drawing, it should properly be noted. The staff notes that consistent terminology should be used throughout the application to facilitate safety evaluation. For instance, it’s unclear, in Tables 1, 2, and 3 of the attached Report, DAC-P09YCW01-0001 000 0, “Design Analysis and Calculation,” Part No. 6, of the LS-DYNA model is alternatively identified as “Cask Body Top Closure Ring,” which may or may not be associated with the Closing Ring. (Note: The terminology, “Closing Ring,” also appears in many other parts of the application and its use needs to be properly aligned.)

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.33(a)(5).

2-13 Revise the description to limit discussion of the Shielded Liner configuration(s) only to those that have properly been analyzed in the application. See page 2-9 of the application.

Any suggested Shielded Liner optional designs that have not been analyzed are irrelevant to the present package safety review, and should not be discussed in the application.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.33(a)(5).

2-14 Revise, as appropriate, the application statement, "The NCT and HAC combinations are summarized in Table 2-1 and Table 2-2. (Tables 2-2 and 2-3 are provided in compliance to NRC Reg. Guide 7.8 format.)," by accurate citation of cross referenced evaluations and results. See page 2-16 of the application.

The staff notes that there are numerous inconsistencies in cross referencing the package safety analyses and results as presented in the application. For instance, in addition to the above cited inconsistency, in the first paragraph of the same page, Section 2.12.5, other than Section 2.12.4, should have been cited for the reported stress evaluations.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.33(a)(5), 71.71, and 71.73.

2-15 Clarify the application statement, "When fitted with lifting eyes of 1" diameter there is a safety factor of 1.5 on each lifting eye," by noting that in Section 2.12.6, not Section 2.12.5 as cited, the capability against catalogue rating for lifting the Shielded Liner is only 1.37. See page 2-12 of the application.

The calculated safety factor of 1.37 for a single lifting eye does not meet the 10 CFR 71.45(a) requirements, which provide that lifting devices must be designed with a minimum safety factor of three against yielding when used to lift the package in the intended manner. The pair of the lifting eye bolts must be selected with adequate yield strength accordingly.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.71(c)(7).

2-16 Clarify the application statement, "Shield liners are designed to withstand the effects of free-drop (end, side, or angle) to an unyielding surface from a distance of one meter,…" by submitting calculation or testing results, as appropriate, to substantiate the conclusion made on the one-meter free drop performance of the Shield Liner. See page 2-13 of the application.

The Shield Liner may be subject to a high impact deceleration g-load upon a one-meter free-drop. As a result, effects of the structural damage, including those associated with potentially large lead slump or plastic deformation, on the Shield Liner performance should be evaluated.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.71(c)(7).

2-17 Clarify, as appropriate, the last sentence, on ASME Code stress classification and stress design criteria by recognizing that qualification of special form radioactive material, per 10 CFR 71.75 provisions, is beyond the scope of the present package design certification review. See page 2-21 of the application.

The discussion on membrane stress intensity and membrane plus bending stress intensity as the basis for stress evaluation is misleading. There is no need to discuss stress evaluation of the sealed sources.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.31(c).

2-18 Clarify, as appropriate, the statements noted in Table 2-4A on page 2-35 of the application, including:

On Item 4, submit the report on "scaled test" for staff review to substantiate the Alternative Compliance Basis justification statement, "The package Impact Limiter Assembly is designed by analysis and confirmed by scaled test…"

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.31(c).

2-19 Revise, as appropriate, the statements noted in Table 2-4B, page 2-38 of the application, including:

On Item 7, revise the Alternative Compliance Basis justification statement, "Closure bolts…are evaluated in accordance with the guidance and design criteria provided in NUREG/CR-6007," by noting that the subject report deals with closure bolts of shipping cask containment boundary for which bolts are essentially not allowed to undergo any plastic deformation. However, as reported in Table 2-3, the package closure bolts and Shielded Liner bolts are shown to have undergone plastic strain to 3% and 12%, respectively. As such, a general reference to NUREG/CR-6007 does not constitute an adequate justification for allowing plastic strains to develop in the closure bolts.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.31(c).

2-20 Provide calculation examples for using the regression coefficients Y_{int} and S of Table 2-13 for determining applicable at-temperature dynamic crush strengths for the foam subject to a range of strain response at 10%, 20%, and up to 70%. See page 2-55, Table 2-13, "Static to Dynamic Crush Strength Adjustment," GP Last-A-Foam, FR3712. See also the equation on page 2-51 relating the foam dynamic crush strength to the static crush strength

The staff notes that the regression coefficients of 1.2971 and 1.0330 for Y_{int} and S, respectively, in Table 2-13, are markedly smaller than those of 4.1342 and 1.8957 listed in Table 2-12B. Examples should be provided for using appropriate correlation factors to calculate dynamic crush strengths of the impact limiter foam material.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.33(a)(5).

2-21 Clarify the description, “BU650B package damage resulting from the HAC tests is provided in Tables 2-10A and 2-10B,” by noting that the puncture test, per 10 CFR 71.73(c)(3), must also be performed for sequential test results as summarized in Table 2-14 for the follow-up thermal or fire test per the 10 CFR 71.73(c)(4) requirements. See page 2-70.

The application states that the predicted damage is considered in the BU650B package thermal, containment, and shielding HAC evaluations. For this matter, cumulative damage, including those associated with the puncture drop test must also be considered as a boundary condition for the thermal test.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.73(c)(3) and (4).

2-22 Clarify, as appropriate, the statement, “Table 2-16 identifies the maximum impact damage (true plastic strains) in the BU650B packaging components after the cumulative damage from the worst-case 30-ft top drop (rotated 15 degrees).” See page 2-72, Section 2.7.1.1, of the application.

The subject table, which is not included in the application, should be included in the application.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.73(c)(1) and (3).

2-23 Provide summary details of the damaged state of the packaging resulting from the “Confirmatory Tests,” as reported in Section 2.12.5 of the application.

Clarify what is considered as the boundary condition for the puncture drop finite element analysis per the 10 CFR 71.73(a) sequential test provision. See page 2-75, Table 2-19, of the application.

A number of inconsistencies are seen comparing the cumulative damages listed in Table 2-19 to those in Table 2-10A resulting from the preceding 30-ft 15-degree-off top drop of the packaging. For instance, puncture test strains should be additive to the resulting 30-ft drop test. However, the listed cumulative strains are seen as less than those corresponding to the 30-ft drop accident. In addition to the decreased plastic strains in the “welds,” other strain inconsistency examples include:

a. Part No. 100, Shield Linder Lid Closure Shell, strain decreases from 44.2% to 39.19%.

b. Part No. 119, Cask Body Bolts Core, strain decreases from 16.13% to 15.73%.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.73(c)(1) and (3).

2-24 Provide sketches of calculated permanent gap openings between key packaging components, if any, for the finite element modeling consideration for evaluating the thermal test per 10 CFR 71.73(c)(4). See page 2-75, Table 2-19, of the application.

Part No. 10, Package Outer Bolts, and Part No. 119, Package Body Bolts Core, are seen to have undergone large plastic strains of 16.71% and 15.73%, respectively. Large strains are indicative that permanent gaps or openings may have developed at key locations of the package, which may need to be assessed for establishing bounding boundary conditions for the thermal test.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.73(c)(1), (3) and (4).

2-25 Explain how the calculated maximum strain of 225%, which grossly exceeds the elongation limit of 28% of the AISI 1010 carbon steel, is treated in the finite element analysis solution process after material rupture failure.

Also, provide sketches of the deformed Shield Liner as a bounding configuration for the package shielding safety analysis. See page 62 of 87, Figure 46, Part No. 76 – Shielded Liner Outer Shell: Excessive Plastic Strains Show Major Deformation of the Lower Sheet Metal Shoring/Spacing Lip during Side Impact in Report DAC-P09YCW01-0001 000 00.

Considering the maximum strains listed in Tables 2-10A, 2-10B, and 2-19, as example, it is unclear how the calculated maximum strains are screened for determining bounding configurations of the deformed Shielded Liner, after the package drop and fire tests, for performing the shielding safety evaluation. Tables 2-10A and 2-10B list no maximum plastic strains for Part No. 76 and Table 2-19 lists, nevertheless, the maximum "cumulative" strain of 109.08%, which is markedly less than the 225% strain reported for the package side-drop accident.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.33(a)(5).

2-26 Considering the fringe plot maximum plastic strain of 138%, which exceeds the elongation limit of 55% of the Grade 316L steel of the impact limiter attachment assembly, justify why the analysis results can be used for determining that the impact limiter will not become dislodged from the cask body after a 30-ft package drop accident. See page 71 of 87, Figure 55, Impact Limiter Attachment Lugs, Mounting Plates and Ring, in Report DAC-P09YCW01-0001 000 00.

It is unclear whether the impact limiters are designed to remain attached to the Lower Package Assembly after the 30-ft drop plus the 40-inch puncture tests. The present design-by-analysis results appear to suggest that the impact limiters will become dislodged from the package body.

This information is required by the staff to determine compliance with the requirement of 10 CFR 71.33(a)(5) and 71.73(c)(1).

CHAPTER 3 THERMAL EVALUATION

3.1 Provide a description of the physical burn test and the test data/results.

Page 3-19 of the SAR states: "*These calculated temperature differences may be added to physical test data to estimate package temperatures for parameters that cannot be easily included in a test* …" Likewise, the Abstract of the calculation package indicates "… *this work determines the temperature adjustments to be made to the burn test data for the Hypothetical Accident Conditions (HAC*)".

In addition, page 14 of 42 of the calculation package mentions **"**furnace testing". The results and description of the physical thermal test should be provided so that it can be evaluated.

This information is required by the staff to determine compliance with 10 CFR 71.73.

3-2 Provide the input and output ANSYS files used in the thermal analysis.

The ANSYS input and output files (.inp, .db, .mac, etc.) should be provided, including input text files that allow copying of ANSYS commands into the software's command line. Likewise, comments that indicate boundary conditions, properties, emissivity, absorption coefficient, heat transfer coefficients, etc., and their units, should be included.

This information is needed to determine compliance with 10 CFR 71.71, 71.73, and 71.107.

3-3 Provide a description of the covered conveyance and a corresponding thermal analysis for NCT conditions.

Page 1-6 of the SAR states: "Due to the capability of transport by covered conveyance, a tie-down mechanism is not a functional part of the package, as the package can be safely blocked, utilizing blocking bars, into a covered van or trailer." A thermal analysis at NCT should consider the effects of the covered conveyance.

This information is required by the staff to determine compliance with 10 CFR 71.71 and 71.73.

3-4 Provide further details, explanations, calculations, etc. associated with the thermal analysis for both NCT and HAC.

The thermal analysis chapter is lacking information, etc., in a number of areas, including:

- Drawings provide no information of the shoring, although pages 1-6, 1-7, 1-8, and 3-15 of the SAR mentions that there is shoring to support sources. Details of the shoring should be provided, including the temperatures during NCT and HAC.

- There should be a discussion of the different possible shielded liner arrangements and how the analyzed geometry is bounding. For example, page 9 of 42 of the calculation package shows a single shield liner ANSYS model (Figure 1). A discussion should be provided that explains the reasons that the modeled shielded liner arrangement is bounding. Example considerations include whether a smaller shielded liner with 450 w decay heat, which would have a larger volumetric decay heat (W/m3) and larger air gap, would be bounding; another consideration is the arrangement associated with shoring.

- The NCT ANSYS thermal analysis should include the impact limiters, since they form a sizable thermal resistance in removal of the decay heat. The maximum temperatures of the top and bottom impact limiters, including top plate, outer cylinder, LAST-A-FOAM, etc., also should be included in the tables that list component temperatures.

- Page 3-7 of the SAR states there were NCT thermal margins of 173.5° F, 113.4° F, and 286.6° F and a HAC thermal margin of 89° F. Further explanation, including the basis of these values, should be provided.

- The temperature of the components for the condition of 450 W decay heat, 100° F ambient temperature, and no insolation should be included to confirm that the maximum surface temperature is below 85 deg C (per 71.43(g)).

- Table 3-1, Table 3-2, etc., includes component temperatures during NCT and HAC. However, not all components and materials were included. The maximum NCT and HAC temperatures of the package's contents, components, and materials, as well as their allowable temperatures (maximum and minimum, see Section 3.5.2.2 of NUREG-1609), should be included in the SAR. Components should include content/source, impact limiter liner and foam, lid, lid plug, bottom plate, outer shell, inner shell, Kaolite, lead, etc.

- Discuss how the maximum temperatures presented in the SAR tables (e.g., Tables 3.1, 3.2, etc.) were determined from the ANSYS results. For example, explain whether the maximum temperatures represent the peak node value of the component or an average of nodes.

- A section of the SAR should explicitly state the MNOP and pressure within the package during HAC.

- The HAC thermal analysis was based on an undamaged configuration, according to page 22 of 42 of the calculation package. Likewise, page 23 and 24 of 42 in the calculation package indicate that adjustments are only based on insolation and decay heat. However, page 3-18 of the SAR states: "Considered in the model were the cumulative effects of the 30-foot drop and puncture tests." It should be confirmed whether there was any damage (such as dimensional changes, etc.) during the 30-foot drop tests or puncture HAC tests that should have been included in the ANSYS thermal model.

- The third paragraph of page 22 of 42 of the calculation package mentions temperature differences that should be added to the Table 6 HAC results. Specifically, the SAR states "… calculated temperature differences may be added to physical test data to estimate package temperatures for parameters that cannot be easily included in a test (i.e., content heat load or insolation during cooldown)." There should be additional explanation of how the temperature differences could be used to obtain the maximum component temperatures. Likewise, applying the temperature differences to the physical burn test data is not possible because test data was not provided. The applicant should perform all necessary calculations (include all adjustments) and provide a table that lists the maximum temperature of the package components during HAC.

- Temperature versus time plots of the package components during HCT and post-fire should be provided as part of the thermal analysis (similar to Figure 5 for NCT). The analyzed time should include the period when the peak temperatures of the components have been reached and their gradual trend downward in temperature. This time period is very often much longer than the 24 hours analyzed in the current SAR (page 3-19 and page 22 of 42 of the calculation package).

- Although the package ships in the vertical orientation, it is stated on page 14 of 42 of the calculation package that the horizontal package orientation represents the condition during the "furnace testing." However, furnace testing details and results were not provided. Confirm that the horizontal orientation is the bounding orientation for determining maximum package temperatures during HAC. Likewise, the testing details should confirm that the package was oriented to expose the damaged parts of the test package to the hottest part of the fire/furnace.

- The "Note" on the bottom of page 3-7 is confusing. Please confirm that the lead in the package did not reach its melting temperature and, therefore, did not melt during NCT and HAC. The lead temperature should be included in Tables 3-1, 3-2, 3-4, 3-7, etc.

- Page 1-6, 1-7, 1-8, and 3-15 of the SAR states that multiple sources (page 3-6 "multiple small sources"), up to 450 watt decay heat, are mounted in metal (aluminum or stainless steel) racks/spiders/cages located in the cavity. However, page 7 of 42 of the calculation package indicates that the shoring was not modeled. The effect of the 30-foot drop tests on the internal cavity's racks/spiders/cages should be discussed (did they remain structurally sound?). If the internal support/shoring did not survive the 30-foot drop, the uniform flux decay heat assumption in the analysis may not be appropriate (especially if multiple sources were being shipped within the package). This would indicate an unanalyzed condition; additional, bounding analyses with non-uniform heat distributions should be performed.

- Page 13 of 42 of the calculation package indicates that an overall exchange factor of 0.7347 was used to model the radiation heat transfer during the fire. Per the regulations, the fire emissivity should be 0.9 and the surface absorption coefficient should be 0.8, or larger; an overall exchange factor for the HAC thermal analysis should not be used.

- Page 3-19 of the SAR and page 22 of 42 of the calculation package state that the 30-minute fire was simulated by applying natural convection and radiant exchange boundary conditions to the container body's external surfaces. However, when modeling a fire analytically, it is also necessary to impose a convection heat transfer coefficient to the surfaces based on the induced gas velocities (see the reference by M.E. Schneider, L.A. Kent, "Measurement of Gas Velocities and Temperatures in a Large Open Pool Fire," Heat and Mass Transfer in Fire, HTD, Vol. 73, which reports velocities approaching 10 m/sec). The convection heat transfer of the fire to the package surfaces should be included in the analysis.

This information is needed to determine compliance with 10 CFR 71.33, 71.71 and 71.73.

3-5 Derive the constant used in Equation 16 of the calculation package.

Page 17 of 42 of the calculation package indicates a constant value of 3.4123 in Equation 16. A derivation of this constant should be provided.

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

CHAPTER 5 SHIELDING EVALUATION

5-1 Correct the dimensions if necessary on the drawings and revise Chapter 5 of the BU650B package Safety Analysis Report to reassess the package shielding performance with the corrected dimensions.

On page 5-6, the Safety Analysis Report for the J.L. Shepherd Co-60 and Cs-137 transportation package indicates that the cavity of the Shielded Liner can vary from ½" to 8-1/8" in diameter and 1' to 19" in height. However, based on the dimensions shown on licensing drawing BU650B-SL, sheet 1, the maximum cavity of the Shielded Liner is 7.0" in diameter and 9-5/8" in height. In addition, on page 5-24, the shielding analysis used 18.75" as the distance between source located at the center of the cavity and the package surface. Based on the drawings BU650B-SL, sheet 1, BU650B-LP-6, and BU650B-PA, at the side, the distance between the source and the outer surface of the package is 22.5". The effective shielding thickness is 9.5" of lead and 1" of carbon steel (total). It was not clear how the 10.125" of lead and 1.125" of carbon steel/stainless steel were derived from the drawing. There seems to be a large discrepancy between dimensions showed on the drawings and what were used in the shielding analyses. With the discrepancies between dimensions on licensing drawings and what were used in the safety analyses, the shielding analysis results could be erroneous and hence this application may be not acceptable. The applicant needs to perform a complete review and revision of the shielding analyses. The staff requests the applicant to review and correct the dimensions if necessary and revise Chapter 5 of the BU650B package Safety Analysis Report to reassess the package shielding performance with correct dimensions.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.47 and 71.51.

5-2 Provide shielding analysis for the BU650B Package under Hypothetical Accident Conditions.

The Safety Analysis Report does not include shielding analysis for the package under HAC. In accordance to 10 CFR 71.51(a)(2), all type B package must include a shielding analysis to demonstrate that the dose rate at 1 meter from the surface of the package under HAC, as specified in 10 CFR 71.73, does not exceed 10 mSv/h. Although the SAR states on page 5-11 that the HAC results do not differ from NCT, the applicant has not established this conclusion through test data, particularly with consideration of lead slump. The staff requests the applicant to provide a shielding analysis for the BU650B package to demonstrate that the package meets the regulatory requirement of 10 CFR 71.51.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.51.

5-3 Demonstrate via test result that there is no lead shrink in the lead liner of the BU650B package.

The Safety Analysis Report for the J. L. Shepherd Co-60 and Cs-137 transportation package states: "The Shielded Liner body [of the package] is constructed from carbon steel parts, fully welded and then poured, via prescribed process, with molten lead, into the vacant spaces within the Shielded Liner, creating a no-void fill. The shield plug is constructed in a similar manner and designed with a shoulder or step diameter to prevent radiation streaming." The Safety Analysis Report, however, does not include information on the potential shrink of lead after solidification. The staff's understanding is that lead shrink in the solidification process, after poured into mold, is a common physics phenomenon and the lead shrinkage is approximately 7% when it completes solidification.

Consequently, the thickness of the lead layer in the radial direction will be reduced and a gap will be created at the top of the lead shell. It is not clear why such a natural phenomenon would not occur for the lead layer in the Shielded Liner and its plug of the BU650B package. The staff requests the applicant to demonstrate with test data that the molten lead did not shrink during solidification process.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.47.

5-4 Demonstrate via test result that there is no lead slump in the lead layer of the Shielded Liner of the BU650B package under HAC or revise the shielding analysis to include consideration of the lead slump under HAC.

Based on licensing drawing BU650B-SL, sheet 1 of 18, the radial thickness of the lead layer in the Shielded Liner is 9.5” and the height of the lead layer is 22-1/8” (up to the shoulder of the liner) as shown in the drawing. Based on the staff’s calculation, there would be a 7% x 9.5 = 0.665 inch gap in the radial direction and 7% x 22.125 = 1.55 inch gap in the axial direction of the liner due to lead shrink when the molten lead solidifies after being poured into the space between the inner and outer shells of the Shielded Liner. This created a void space for the lead to fill when it slumps under impact. The gap created by lead slump can also be estimated by the available volume. Based on the staff’s calculations, the estimated volume of void created by lead shrink is about 890 cubic inches, which is equivalent to 1.66 inches gap at the top of the lead layer, in addition to the 1.55” gap at the axial direction, created during solidification of lead, if lead were to slump under HAC. The lead slump creates gaps to allow the gamma particles to stream through and create high dose rate at certain spots outside the package, e.g., 1 meter from the surface. The staff requests the applicant to demonstrate via test result that there is no lead slump in lead layer of the Shielded Liner of the BU650B package under Hypothetical Accident Conditions or revise the shielding analysis to include consideration of the lead slump under HAC.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.51.

5-5 Correct the dose rate data (namely the gamma constant) used in the shielding analysis and redo the shielding calculation completely using the correct gamma constant.

The applicant used gamma constant data from a 1954 version of the National Bureau of Standard Handbook 54. The staff reviewed the data and found them are outdated and will produce non-conservative results. The currently accepted gamma constants are the data in Publication ORNL/RSIC-45/R1. As a result, all the shielding calculations performed in the Safety Analysis Report are invalid and need to be revised. The staff requests the applicant to update the data it used in the analysis and revise its shielding analyses for the BU650B package and resubmit its application.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.47 and 71.51.

5-6 Correct the dose rate calculations with consideration of buildup factors.

The applicant calculated the dose rates on and one meter from the surface of the package using linear attenuation formula. This linear attenuation equation assumes that all photons that interact are removed and ignores Compton scatter and pair production photons. Particle buildup was not considered in the calculation. As a result, all the shielding calculations performed in the Safety Analysis Report are invalid and need to be revised. The staff requests the applicant to revise its shielding analyses for the BU650B package and resubmit its application with inclusion of buildup in the shielding analysis.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.47 and 71.51.

CHAPTER 7 OPERATING PROCEDURES

7-1 Include procedures to ensure the package is limited to 450 w decay heat.

Procedures to ensure that the package is limited to 450 w should be included in Chapter 7, "Operating Procedures", of the SAR. This is especially relevant considering that multiple sources may be placed inside the package.

This information is required by the staff to determine compliance with 10 CFR 71.107.

CHAPTER 8 ACCEPTANCE TESTS AND MAINTENANCE PROGRAMS

8-1 Provide acceptance criteria for foam testing per J.L. Shepherd & Associates Engineering Specification ES-002 or provide the specification containing this information, including the test matrix for the foam formulation, batch, and pour.

Provide evidence that the as-poured impact limiter foam density will be consistent with the acceptance test density. Alternatively, calculate the as-poured density for each impact limiter to demonstrate that it will be within the acceptable tolerance.

Additionally, justify the impact limiter damage criteria of a 6-inch deep puncture and/or 4-inch deep depression (SAR Section 8.1.5.3).

An understanding of the specific acceptance criteria and basis for evaluation is critical for all important to safety components. For components and materials that are not fabricated per acceptable consensus standards, the basis for the design is needed.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.31(a)(1),(c), and 71.33(a)(5).

8-2 Describe the acceptance tests and acceptance criteria for Kaolite 1600 or include specifications containing this information (SAR Section 8.1.5.6).

An understanding of the specific acceptance criteria and basis for evaluation is critical for all important-to-safety components. For components and materials that are not fabricated per acceptable consensus standards, the basis for the design is needed.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.31(a)(1),(c), and 71.33(a)(5).