AOS
Alpha-Omega Services, Inc.

Attachment A
AOS Response to RAI's
Dated 12/24/09

Docket 71-9316
TAC No. L24353

Attachment 'A'

AOS Response to RAIs Dated 12/24/09 (TAC # L24353)

Chapter 1 – General Information

1.1 Address the reason(s) for inconsistent values and parameters that appear throughout the application in multiple design areas. Justify that the AOS Quality Assurance program satisfies the requirements of 10 CFR 71.107.

The requirements in 10 CFR 71.107(b) state that the applicant shall establish measures for the identification and control of design interfaces and for coordination among participating design organizations. These measures must include the establishment of written procedures, among participating design organizations, for the review, approval, release, distribution, and revision of documents involving design interfaces. The requirements in 10 CFR 71.107(b) further state that, for the verifying or checking process, the licensee shall designate individuals or groups other than those who were responsible for the original design, but who may be from the same organization. The applicant for a Certificate of Compliance shall apply design control measures for the following: criticality physics, radiation shielding, stress, thermal, hydraulic, and accident analyses.

As indicated in this RAI letter, several inconsistencies listed in RAIs 1.4, 1.5, 1.9, 1.10, 1.11, 1.12, 1.13, 1.14, 3.32, 3.33, and 3.34 appear to indicate that this application does not establish a clear understanding of the fundamental weight of each AOS package. As indicated in RAI 3.6 below, it also appears that this application does not establish a clear understanding of the isotopic contents of each AOS package.

As indicated in RAI 4.1 below, it also appears that the application does not establish a clear understanding of the seals used in each AOS package. As indicated in RAI 3.29, the application does not ensure consistency between boundary conditions provided in the application and used in the thermal models.

The staff also notes that quality problems of a similar nature were previously identified, by letter dated June 13, 2008, in many of these same technical areas after the withdrawal of the original AOS application, as well as in our request for supplemental information, by letter dated July 31, 2009, after the application was resubmitted on June 19, 2009.

The applicant should demonstrate that appropriate design control measure have been established and that all values and associated analyses with the thermal and containment design (not limited to these RAIs) are accurate and reliable.

This information is required by the staff to determine compliance with 10 CFR 71.51 and 71.107.

Response:

Alpha-Omega Services, Inc. (AOS) provides to the NRC the following reason(s) for inconsistent values and parameters that appear throughout the application in multiple design areas, as identified under RAI 1.1.

AOS is not focusing the response to this RAI on the individual technical points identified, because they have all been addressed in their respective locations of the revised application. Rather, AOS recognizes their responsibility as applicant in accordance with the quality requirements of 10 CFR 71.107. Therefore, as a result, AOS initiated a Corrective Action Request on GEH, who held the contract to prepare the application; and AOS has been working with GEH to improve the quality of the application being submitted at this time. AOS has also initiated a Corrective Action Request on their QA Program for clarification of Design Control procedures relative to this project.

The root problem was lack of attention to detail by both GEH and AOS. GEH had a number of people working between the two US coasts (Wilmington, NC and Sunol, CA) involved in the preparation of the prior application. In addition to this there were personnel changes during the project. AOS did not provide adequate oversight of GEH to assure that all design responsibilities subcontracted to GEH were adequately met. As a result, responsibilities were not closely adhered to, procedures at GEH were not accurately followed and errors went undetected in the application by both GEH and AOS.

The key elements of the corrective measures are summarized as follows:

All drawings, specification and reports submitted by GEH to AOS have been reviewed, verified and verification records are contained in GEH document controlled system(s) and/or design record file eDRF 0000-0049-4417. All verifications performed by GEH are in accordance with GEH procedure # CP-03-09 that states:

Verification shall determine whether:

Inputs:

- Are verified or from acceptable published documents, such as approved codes and standards (e.g., ASME, IEEE), safety classification documents, design interface documents, design basis references, as well as specific analytical inputs or internal documents, or have clearly stated and justified assumptions, or other GEH or GNF component or customer requirements,
- Are appropriate to the application being verified, i.e., the application of an input shall be within the range of applicability of the input or justification provided.

Work performance method:

- Is appropriate to the application and correctly executed
- Uses the right equations or information within each calculation or evaluation,
- Uses information correctly within each calculation or evaluation; e.g., calculations were performed correctly

Output:

- Correctly reflects the calculation or evaluation results, including data transfer from one location to another (including from tables into plots or figures),
- Is adequate for the stated application, and
- Correctly supports, by the work provided, the conclusions reached.

GEH shall assure that all Drawings, Specifications and analysis reports submitted by GEH to AOS were verified and issued in accordance with GEH CP-03-09 prior to use. GEH shall not allow any unverified and un issued document or analysis to be incorporated into the application.

In addition to the changes in engineering practice, the GEH licensing team was augmented with a licensing consultant that has 43 years nuclear experience, including significant experience in packaging and transportation domestically and internationally.

AOS as applicant has the responsibility to review and approve the GEH submittals to assure they meet the contractual requirements and the quality requirements of 10 CFR 71.107. AOS has participated in the review of the design documents and has verified incorporation of the NRC's RAIs into the revised Safety Analysis Report.

1.2 Provide a complete list (table) of the contents that can be transported. Include physical characteristics, chemical composition, and isotopic composition for all contents. Specify that the package user shall ensure that "special form" requirements are met which includes the verification, before loading, that the contents have a DOT special form certificate or meet the special form testing requirements.

Only examples of "proposed typical contents" are provided in Section No. 1.4.2 of the application. If the requested information is not provided, the Certificate of Compliance (CoC) will be limited to those "example contents" that are sufficiently detailed in the application.

This information is required by the staff to determine compliance with 10 CFR 71.33(b)(3) and 71.4.

Response:

The application contains a complete revamped authorized content discussion that has been organized to follow the regulatory required format and details.

The contents will be limited to solid byproduct material in the form of metals. There will be no liquids and no fissile material authorized.

The material may be in "normal" form or "Special" form. When special form material is shipped in the package a COC will be required for the special form material and the operating procedures require this verification. However, due to the design of the AOS Transport Packaging System, the fact that special form material is being shipped should be of little concern during transport.

In Table 1-2 of the revised application there is a listing of isotopes that are approved for transport in the packages. These isotopes were used to determine the limits for the package. The decay heat must not exceed the authorized value in the table and the external radiation must be verified to meet the regulatory limits before shipment.

Reference Table 1-4 of the Application

MODEL	**TYPE**	**FORM**	**DECAY HEAT**		**WEIGHT[2]**	
			Watt	Btu/hr	Kg.	Lb
AOS-025A	Solid material.	Normal or "Special[1]" form	10	34.15	7	15
AOS-050A			100	341.50	27.2	60
AOS-100A			400	1366.00	227	500
AOS-100B						
AOS-100A-S						

(1) Evidence of current Certificate of Compliance, as Special form, required.

(2) Includes the weight of the contents, plus any additional shielding device and/or shoring device.

For detailed calculations of the above values, refer to Chapter 5, Appendix 5.5.2, "AOS Cask Isotopic Heat Load Calculations".

1.3 Provide calculations to support the claim that the AGR-1 Compacts are exempt from classification as fissile material, i.e., that such contents meet either 10 CFR 71.15(a) or 71.15(b) requirements.

The information pertaining to the AGR-1 Compacts on page No. 1-62 of the application does not provide adequate justification that the criteria in the regulations are met.

This information is required by the staff to determine compliance with 10 CFR 71.15

Response:

The application has been modified and does not include AGR-1 Compacts as an authorized content. Demonstration calculations are not provided in the application for this reason.

1.4 Clarify the difference between the packaging weight values for the Model No. AOS-50A in Table No. 1-5, and Table No. 2-10 or Table No. 3-1 of the application.

This information is required by the staff to determine compliance with 10 CFR 71.33(a)(2).

Response:

These tables have been rearranged and include the current data that has been verified to be accurate.

1.5 Provide calculations showing how the package category in Table Nos. 1-1 and 1-5 of the application is bounding for each isotope in Table 1-6 of the application. Modify the code criteria, as applicable, based on the revised package category for components that affect the structural integrity of containment of shielding.

Table Nos. 1-1 and 1-5 of the application list the Model Nos. AOS-25A, AOS-50A, and AOS-100B as Category III; and the Model Nos. AOS-100A, and AOS-100A-S as Category II. Based on the isotope activity in Table No. 1-6 of the application, the staff determined the Model Nos. AOS-25A, AOS-50A, AOS-100A, AOS-100A-S should be Category I because the isotope activity is greater than 30,000 Ci. Also, based on the isotope activity in Table No. 1-6 of the application, the staff determined the Model No. AOS-100B should be Category II because the isotope activity is greater than $30A_1$ *or greater than* $30A_2$*. See Table No. 1-1 of NUREG-1609, "Standard Review Plan for Transportation Packages of Radioactive Material" for definitions of package categories.*

This information is necessary to determine compliance with 10 CFR 71.31(c) and 71.51.

Response:

Model numbers AOS-25A, AOS-50A, AOS-100A and AOS-100A-S will be designated as Category I because the isotope activity authorized is greater than

30,000 Ci. Model AOS-100B will be designated Category II because the authorized isotope activity is greater than 30 times the A1 value. The activities evaluated are shown in Table 1-2.

1.6 Clarify the inconsistencies in Licensing Drawing Nos. 105E9722, 166D8138, and 105E9713 between the drawings' sheets 1 and 2, specifically the item numbering inconsistencies between sheet 1 and sheet 2 for each drawing.

For example (but not limited to) Licensing Drawing No. 105E9722, sheet 1 of 2, lists item No. 13 as polyurethane foam, but Licensing Drawing No. 105E9722, sheet 2 of 2, lists polyurethane foam as item No. 11.

This information is required by the staff to determine compliance with 10 CFR 71.31.

Response:

The inconsistencies associated with listed item number(s) and description(s) in the licensing drawings have been corrected. The updated licensing drawings are included in the revised application.

1.7 Provide a parts list for Licensing Drawing No. 105E9712 on sheet 1.

This information is required by the staff to determine compliance with 10 CFR 71.31.

Response:

A parts list has been incorporated into the licensing drawings as requested. The drawings are included in the revised application.

1.8 Clarify if there will be fissile contents in any of the AOS packages under review.

Licensing Drawing No. 105E9711, sheet 2 of 2, lists the package type as "B(U)F" on the nameplate. The staff is under the impression that the AOS packages under review will not be licensed for fissile contents.

This information is required by the staff to determine compliance with 10 CFR 71.33(b).

Response:

The AOS packages currently under review will not be licensed for fissile contents. The nameplate illustrated in drawing 105E9711, sheet 2 of 2, has been corrected to "USA / 9316 / B(U)". This drawing is included in the revised application.

1.9 Categorize all model components according to NUREG/CR-6407.

All model components should have, on the Bill of Materials, the components safety category according to NUREG/CR-6407 (i.e., Category A, B, or C for components important to safety, or not important to safety).

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

Response:

The component safety category, in accordance with NUREG/CR-6407, has been incorporated into sheet 1 of the licensing drawings. These drawings are included in the revised application.

1.10 Clarify the inconsistency between the weight values on Drawing No. 105E9711, sheet 1 and sheet 2. Note No. 4 on sheet 1 states that the maximum package weight is 3677 kg +/- 10%; yet, the Model No. AOS 100A/A-S nameplates on sheet 2 lists the gross weights as 4109 kg, which is inconsistent with sheet 1. In addition, this exceeds the maximum tolerance provided on sheet 1.

This information is required by the staff to determine compliance with 10 CFR 71.33(a)(2).

Response:

The weight values for all AOS Transport Packaging System models have been re-calculated using Inventor (3-D model) drafting computer program. The correct weight values for the package, the cask, and impact limiters have been incorporated into the applicable licensing drawings, and are included in the revised application.

References to weight tolerances in the licensing drawings have been eliminated.

1.11 Clarify the inconsistency between Drawing No. 105E9713, sheet 1, and Table No. 3-1 of the application. Note No. 6 on Drawing No. 105E9713, sheet 1, lists the impact limiter weight as 215 Kg, while Table No. 3-1 lists the weight as 272 kg.

This information is required by the staff to determine compliance with 10CFR 71.33(a)(2).

Response:

The weight values for all AOS Transport Packaging System models have been re-calculated using Inventor (3-D model) drafting computer program, including the impact limits. The corrected impact limiter weight values for each AOS model under consideration has been incorporated into the applicable licensing drawings and are included in the revised application. In addition Table 3-1 has also been updated in the revised application.

1.12 *Clarify the inconsistency in gross weight values on the nameplates in Licensing Drawing Nos. 166D8142, sheet 2 of 2, and No. 166D8143, sheet 2 of 2. Similar inconsistencies also appear to exist for the Model Nos. AOS-50 and AOS-100 packages.*

The maximum weight of the package should include the packaging and its contents.

This information is required by the staff to determine compliance with 10 CFR 71.33(a)(2).

Response:

The gross weight values for all AOS Transport Packaging System models have been re-calculated using Inventor (3-D model) drafting computer program. The correct gross weight values have been incorporated into the applicable licensing drawings and will be documented in the revised application, as appropriate. The updated licensing drawings will be submitted with the revised application.

1.13 *Explain the discrepancy between the package weights shown in Section No. 2, Table No. 2-1, page 2-3 of the application, and those corresponding details shown in Drawing Nos.*

The package weights for the Model Nos. AOS-50A, AOS-100A, AOS-100B and AOS-100S, shown in Table No. 2-1, are different from those shown on Drawing Nos. 166D8137, 105E9711, 105E9712, etc.

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

Response:

The package weight values for all AOS Transport Packaging System models have been re-calculated, as noted in the above RAIs, using consistent material construction properties, dimensions and weight conversion factors. The correct weight values for the package, the cask, and impact limiters have been incorporated into the applicable licensing drawings and are included in the revised application.

1.14 *Remove the weight tolerances from the Licensing Drawings.*

Licensing drawings indicate that the maximum package weight tolerance for each package is +/- 10%. The large package weight tolerance does not appear to be physically possible if the dimensional tolerances on the licensing drawings are appropriately constrained.

This information is required by the staff to determine compliance with 10 CFR 71.33(a)(2).

Response:

References to weight tolerances in the licensing drawings have been eliminated.

1.15 *Provide additional information to confirm the design features of the AOS transport packaging system.*

(a) Drawing No. 105E9712 for the Model No. AOS-100 system does not contain all the necessary dimensions for the cavity shield. However, these dimensions are included on Drawing No. 105E9719 for the Model No. AOS-100A-S. Please confirm that the dimensions for the cask cavity shield in Drawing No. 105E9719 are applicable for the Model No. AOS-100 packaging system, as represented by Drawing No. 105E9712. Provide revised drawings including all necessary dimensions.

(b) The staff notes that the designation "TYP" (typical dimensions) is used for several parameters on the drawings (Section B-B and Lid Plug Assembly Detail). Per NUREG/CR-5502, the staff discourages the use of this designation. Explain why these dimensions are marked as "TYP" and what is done to ensure that the packaging system, as constructed, is within the parameters of the shielding analyses. Provide revised drawings with all required dimensions.

(c) Provide the entire axial thickness of the tungsten portion of the axial plug in Drawing No. 183C8491 for Section D-D.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.111.

Response:

The information requested and/or inconsistencies noted in RAI 1.15 have been incorporated and/or corrected in the applicable licensing drawings.

(a) The cask cavity dimensions have been included for all AOS models.

(b) The designation "TYP" has been eliminated.

(c) The axial thickness of the tungsten portion of the axial plug has been added.

These drawings are included in the revised application.

Chapter 2 – Structural Evaluation

2.1 *State the temperature at which the modulus of elasticity, given in Table 2-4 of the application, is applicable.*

The modulus of elasticity can be a function of temperature. The response of the material will be different if transportation is done at room temperature, ambient temperature, or an elevated temperature

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.51(a)(1) and 71.51(a)(2).

Response:

The modulus of elasticity given in Table 2-2 is at 78^{o}F. Additionally the following Note b is given in association with the F_{cr} column: "b. Considering E at - 100^o F, 2.91 x 10^6; and E at 600^o F, 2.53 x 10^6; the value of F_{cr} will changed by an increase of 4% and a decrease of 10%, respectably". The use of the module, at 78 ^{o}F, as the temperature does not significantly affect the conclusions, that buckling will not occur, as the buckling stress is 2.78 X 10^6 psi.

2.2 *Specify for which bolts the mechanical properties in Table 2.3.3 of the Appendix are applicable.*

The materials listed for the bolts in Table 2.3.3 are neither that for the lid bolts nor the trunnion bolts as indicated in Tables 2-15 and 2-16 of the application.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.51(a)(1) and 10 CFR 71.51(a)(2).

Response:

This information has been removed from the application.

2.3 *Specify the relevant reference pages to support the tensile and yield strengths for the lid bolts (ASME SB-637, UN N07750, Type 3) as indicated in Table No. 2-15 of the application.*

This information is required by staff to determine compliance with the requirements of 10 CFR 71.51(a)(1) and 71.51(a)(2).

Response:

The material properties have been shown in Table 2.10 for nickel alloy material ASME SB-637 Grade N07718.

2.4 *Provide evidence to supports the statement in Section 2.2.2 of the application, "AOS' experience in operating the Model No. 5979 Type B package, with* *content-similar arrangements, indicates that no chemical, galvanic, or other reactions between the cask cavity surface and radioactive material containers, or between these containers and their solid contents, occur."*

The applicant applies this statement as primary justification that there are neither galvanic nor chemical reactions taking place. Evidence and data that support this statement are necessary for the staff to make a regulatory finding.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.43(d).

Response:

Section 2.2.2. is revised to address chemical galvanic or other reactions between the cask cavity surfaces and its radioactive content.

2.5 Specify the elements of the testing series that constitute the acceptance testing of the stainless steel and foam listed in Table 2-17 of the application.

This information is required by the staff to determine compliance with the requirements of 10 CFR 71.51(a)(1) and 10 CFR 71.51(a)(2).

Response:

Acceptance testing is given in Paragraph 8.1.5.2.

2.6 Remove the Table 2.3.1 in Appendix No. 2.3 since there is no lead used in the casks submitted for review and approval. Delete all references to a package "fabricated from pig lead" as stated in the application.

This information is required by the staff to determine compliance with 10 CFR 71.7.

Response:

Table was removed.

2.7 Explain how the function of the personnel barrier is maintained during the NCT tests. Provide details regarding the deformed shape following the event and the structural analysis that was performed of the personnel barrier.

Simply referring to tables and appendices does not describe the deformed shape of the personnel barrier subjected to NCT loads. Modify and add details that describe the shape of the barrier into Section No. 2.6.7 of the application (See RAI 5.6).

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

Response:

Personnel barriers for AOS models AOS-025, AOS-050, and AOS-100 are of similar construction, aluminum angle frames and aluminum wire mesh sides. The same mesh and angle sizes are used in all three barriers. For normal conditions of transport (NCT) the casks are analyzed for 5g inertial accelerations in the vertical and forward direction, and these accelerations are applied in the barrier analysis. Only a stress analysis for model AOS-100 is presented, as barriers for models 025 and 050 are shorter than model AOS-100, and are qualified by comparison. In Paragraph 2.5.3.1, for model AOS-100 the maximum displacement is found to be 0.457 in, and the margin of safety is 2.9.

In the model 100 barrier stress analysis, the frame and wire mesh are considered to behave as Tension Field Beams, similar to aircraft skin and stringer structures. In the analysis of skin and stringer structures, it is assumed that the skin buckles under shear loading, and in-plane shear forces transmitted by diagonal tension. This concept applies directly to the personnel barriers, where the wire mesh transmits in-plane shear by tension forces. The wire mesh is, therefore, assumed to act as a thin panel, with panel thickness determined by equating panel and mesh volumes per unit surface area.

2.8 Provide the structural material, codes, analysis, etc., and details of the construction of the internal basket structure that is required to position the contents, e.g., "special form" radioactive material, for the applicable AOS packages.

The applicant indicates that the package will include contents, e.g., "special form" radioactive material. The staff needs this information and the discussions of the test results, as applicable, to determine whether the package will meet the requirements of the intended function.

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

Response:

With the exception of the liner for the Model AOS-025 (Dwg. 183C8485) and the Model AOS-100 shielding plates (Dwg. 183C8491), all of the devices are considered "shoring devices". The design approached taken in the SAR is to demonstrate that the established limits of the design preclude the need of any additional structures to satisfy safety requirements of the regulations. By applying the decay heat at the cavity walls, performing the shielding analysis by also placing the source at the cavity wall, and meeting the regulations, there is no need of special requirements for the content other than to prevent it from shifting during transport. This is provided by the shoring devices.

2.9 Provide justification(s), validated by test data presented in Chapter 8 of the application, for reduction in the impact limiter deformation values for head-on, *corner and side drop events. Reconcile results with those described in Section No. 3.4 of the application (page No. 3-97).*

The current documentation provided in the application for justification of the reduction in the deformation for the Model Nos. AOS-025, AOS-050, and AOS-100 packages is not adequate, especially since the density of the foam material for the Model Nos. AOS-050 and AOS-100 packages is approximately one-half to two-thirds the density of the Model No. AOS-165 package.

This information is required by the staff to determine compliance with 10 CFR 71.35.

Response:

Thermal analyses for fire conditions take into account damage due to the 30 ft, accidental drop events. In the thermal analyses for fire conditions, the over-pack is modeled with deformed dimensions, and the foam material density and conductivity properties are increased in proportion to the deformed size. In Appendix 3.5.4.2, the impact limiters, with reduced size and increased conduction properties, are referred to as "reduced impact limiters”.

The compressed model AOS-025, AOS-050, and AOS-100 impact limiter used in the thermal, fire analyses are based on the drop analysis of each model, and are not scaled from the drop analysis for AOS-165 prototype. Three different drop analyses, head-on, side, and cg/corner drops, were performed for each of the three AOS models. The deformed configurations used in the fire analysis are based on the deformations determined in the drop analyses for each particular model.

2.10 Provide documentation verifying that the Model No. AOS-050 package was subjected to a crush test. Provide the numerical values(s) of the deformation to the packaging due to the crush load applied to the Model Nos. AOS-025 and AOS-050 packages.

Section No. 2.7.2 of the application only describes the required crush test for the Model No. AOS-025 package. The gross weight of the Model No. AOS-50 package is shown as 157 lbs, which is less than 1,100 lbs. Therefore, the Model No. AOS-50 package should be subjected to the crush test per regulation requirements and relevant deformation results shall be provided in the application.

This information is required by the staff to determine compliance with 10 CFR 71.73(c)(2).

Response:

The weight of the Model AOS-050 is greater than the 500 kg therefore the crush test requirement does not apply to the Model AOS-050.

2.11 *Provide hard copies of the catalog "General Plastics – LAST-A-FOAM" that includes properties of the polyurethane foam used in the various AOS models.*

The staff could not verify the properties of the polyurethane foam material used for the impact limiters for the various AOS models. This is needed to verify the performance of the impact limiters under regulatory drop conditions.

This information is required by the staff to determine compliance with 10 CFR 71.33 and 71.35.

Response:

Copies of the catalog used are provided. It is important to note that catalogs change, however, when packages are manufactured the foam parameters requested for the package are specified to General Plastics, and they produce the foam ordered. The critical values are then verified and accepted in accordance with the criteria in Table 8.5.

2.12 *Provide structural design details of the axial shield plate shown on Drawing No. 105E9711, Revision A, Section A-A. Explain how this plate is assembled and discuss the behavior of this plate inside the package when the package is subjected to regulatory drops for NCT and HAC events.*

The staff found no evidence of the applicant addressing the design details of this component.

This information is required by the staff to determine compliance with 10 CFR 71.33.

Response:

The axial shield plate is a 6 inch diameter, 1.5 inch thick annular, Tungsten alloy disk. For both NCT and HAC the design load is a normal inertia loading. Under HAC the plate is loaded by a 250g-inertia load, and under NCT the plate is loaded by a 5g-inertia load.

The axial shield plate was analyzed by a Libra Finite Element Analysis. In the analysis, the 250g inertia load is applied normal to the shield plate. This analysis is presented in Paragraph 2.5.3.4.2, and the resulting minimum margin of safety is 4.4.

The shielding plates are placed under and above the shoring device along with the content.

2.13 *Provide a justification for the applicability of the formula from Reference No. 2.7 cited on page No. 2-22 of the application, to perform the bucking analysis.*

The staff needs justification for using the formula from the reference titled, “Flǘgge, Wilhelm, Ed., Handbook of Engineering Mechanics, McGraw-Hill Higher Education, New York, 1962, pp. 40-44, Case 4,” in order to verify the adequacy of the buckling analysis used for the transport packaging system.

This information is required by the staff to determine compliance with 10 CFR 71.35.

Response:

The cask buckling analysis is presented in Paragraph 2.1.2.3. See Appendix 2.12.5 for additional detail. The well-known formula for cylinder buckling is (see for example, ***Introduction to Elastic Stability***, George Gerard, McGraw-Hill, 1962, pp 141-144),

$$Fcr = [\pi^2 k_c E / 12 (1- \nu^2)] (t / L)^2$$

The AOS models AOS-025, AOS-050, and AOS-100 cylinder geometries all fall into the short to medium shell category, and for short to medium cylinders the formula for F_{cr} reduces to,

$$F_{CR} = k \cdot E \cdot t/r$$

The theoretical value for the coefficient k, for cylinders, is approximately 0.6 (see Roark's, ***Formulas for Stress and Strain***, 7th edition, pg. 534). Typically one would use a coefficient of 0.3 or higher for thick cylinders, typical of the AOS cask. However, in the SAR stress analysis the very conservative value of k= 0.182 is used.

2.14 Provide a complete stand-alone description of the summary of damage to the various structural and shielding components (including the personnel barrier, etc.) for all AOS models.

The staff needs this information to evaluate that the requirements of 10 CFR 71.51(a)(2) are demonstrated with respect to potential configuration changes in the shielding and containment safety features of the AOS models.

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

Response:

Subsection2.6.11summarizes the damage for the Normal Conditions of Transport and subsection 2.7.8 summarizes the Accident Conditions.

2.15 Clarify the bolt size reported on page No. 2-40 of the application. The application reports lid bolts 7/8-9 UNC-1A ASME SB-637 UNS N07750 Type 3. The relevant drawings specify ¾” bolts.

Anfirmatory analysis shows that the larger bolt size is needed. Staff could not ascertain the correct size of the bolt used for the package to verify its adequacy.

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

Response:

The bolt information in Detail G is corrected to call out a 7/8- 9 UNC-1A bolt, ASME SB-637 GRADE N07718.

2.16 *Specify the equation used for the definition of "Margins of Safety", as stated in Section 2.1.5 of the application.*

To verify the compliance of the various packages proposed to be used with regulations, the staff needs to know how the "safety margins" are defined.

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

Response:

The Margin of Safety (MS) is given by the formula,

$$MS = F/f - 1$$

where, F is allowable stress, and f is the calculated stress.

See subsection 2.1.2 for the definition of Margin of Safety.

2.17 *Specify dimensions A and B on Figure No. 2-25 on page No. 2-138 of the application. Such dimensions A or B are referenced on page No. 2-137. Specify if the test comparison is made for a Model No. AOS-165 or Model No. AOS-100 package since the caption for this figure reads AOS-100.*

These details are needed by the staff to verify the adequacy of the impact limiters on various packages proposed to be used in this application.

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

Response:

These three questions, 2-17, 2-18, and 2-19, evolve from mislabeled and missing items in the SAR. The correct text and figures are explained here. The SAR section on drop analysis verification, Paragraph 2.7.1.1.3, has been corrected.

Analytical prediction of theAOS-165A prototype Impact Limiter deformation due to the 30 ft head-on test drop is shown in Figure 2-37. A correlation of analysis and test results is obtained by comparing Figure 2-37 with the photograph of the sectioned over-pack test specimen shown in Figure 2-30. A measurement of the compressed impact limiter height is obtained from the photograph and compared to deformation predicted by Libra analysis. In Figure 2-37, dimension A is used to scale photo and design dimensions, as this dimension is essentially unchanged by the impact. Dimension B is the compressed height, and the change in dimension B corresponds to the maximum displacement in Figure 2-30.

```
Design dimensions:        A = 46.6, B = 39.0
Photo dimensions:         A = 4.85, B = 3.60
Scale Factor:             X = 46.6/4.85 = 9.61
Compressed Height:        B' = X·B = 9.61·3.60 = 34.6 in
Defection:                δ = B - B' = 39.0 - 34.6 = 4.4
in
```

The deflection δ corresponds to a displacement of 5.5 inches for a cask weight 37,500 lbs. in Figure 2-37. The analysis and measured values differ by 25%.

2.18 *Provide the numeric value of the scaled height change for the 30 ft. drop discussed in Section No. 2.7.1.1.3 "Correlation of Head-On Drop Analysis and Test" on page No. 2-137 of the application.*

The regulatory drops were performed for the Model No. AOS-165 package, which is withdrawn from the current application. Correlations for the packages within the scope of this application, namely the Model Nos. AOS-025, AOS-050, and AOS-100, were done based on the tests performed on the Model No. AOS-165. Staff needs to know the actual numerical values for the Model No. AOS-100 package to verify the adequacy of the impact limiters used in various packages.

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

Response:

See response for RAI 2-17.

2.19 *Provide the numerical values used to arrive at the 19% difference in maximum displacements. Section No. 2.7.1.1.3 (page No. 2-137) of the application states that "Analysis and test values differ by 19%." Also indicate the locations of these displacements along the package.*

Staff needs to know these details to verify the adequacy of the impact limiters for the packages within the scope of this application.

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

Response:

See response for RAI 2-17.

2.20 *Provide relevant pages of the manual for the LIBRA program that describes what each command in the input files does.*

The applicant has performed finite element analysis of the package using the computer code LIBRA. Staff needs the relevant descriptions from the program manual to verify the accuracy of the input commands that were used in the regulatory drop condition analysis to establish the adequacy of the impact limiters for various packages within the scope of the application.

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

Response:

A copy of the LIBRA Manual has been provided.

2.21 *Provide chart comparisons between the Finite Element Model and the actual material stress-strain properties. The validity of the displacements utilized in the analyses presented in Section Nos. 2.6 and 2.7 of the application depends on accurate modeling of the impact limiter properties.*

A chart comparison of the actual material stress-strain properties reported by the vendor, and those properties used as an input in the finite element analysis model is required so that staff can verify the accuracy of the analysis performed for the impact limiters.

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

Response:

The following three property data sets are taken from Libra input files for the 30 ft drop analyses of AOS models AOS-025, AOS-050, and AOS-100. These data sets define foam stress-strain properties at 75° F. Each data set consists of three PR records. The first record points to the stress-strain data. Stress-stain data starts with the third item on the second record, and continues with the second item on the third record. The last item on record 2 is the continuation property record. The stress-strain data are coupled sets strain and stress values.

```
model 025 (20 lb @ 75F)
pr       1,  101
,      101,  0.05,  .1,1890,    .2,1915,   .3,1940,
.4,2168,   102  ,      102,          .5,2604,    .6,3561,
.65,4858,   .7,5397
```

```
model 050 (10 lb @ 75F)
pr       1,  101
,      101,  0.3,   .1,471,    .2,453,     .3,477,
.4,512,    102          102,                 .5,595,
.6,761,    .65,977,    .7,1124
```

```
model 100 (12 lb @ 75F)
pr       1,  101
,      101,  0.05,  .1,736,    .2,699,     .3,730,
.4,785,    102          ,       102,        .5,912,
.6,1186,   .65,1549,   .7,1774
```

The following data is taken from General Plastics, Last-A-Foam FR-3700 Manual, Impact Section.

Last-A-Foam FR-3700
Dynamic Crush Strength
75°F Parallel To Rise

Strain (in/in)	10 Lb Foam Stress (psi)	12 Lb Foam Stress (psi)	20 Lb Foam Stress (psi)
0.10	471	736	1893
0.20	453	699	1849
0.30	477	730	1938
0.40	512	785	2168
0.50	595	912	2604
0.60	761	1186	3561
0.65	977	1549	4858
0.70	1124	1774	5397

2.22 *Provide the numerical values for loads P (total impact force) and Q (pressure load) in the equation used on page No. 2-136 of the application (Section No. 2.7 “Hypothetical Accident Conditions of Transport”) to compute the load intensity in the 2-D cask model.*

The staff needs these values to verify the appropriateness of the analysis presented for the Head-On Free-Drop for the package.

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

Response:

Loads applied in the 30 ft accidental drop analyses are listed in the detailed description of the30-drop analyses given in Paragraph 2.7.1.5.2.1. The head-on impact load distribution is axisymmetric, as shown in Figure 1. The applied traction, q, is given by the total impact force, P, divided by the impacted surface area, A.

$$q = P/A$$

In the Libra program q is entered on a LE -4 records.

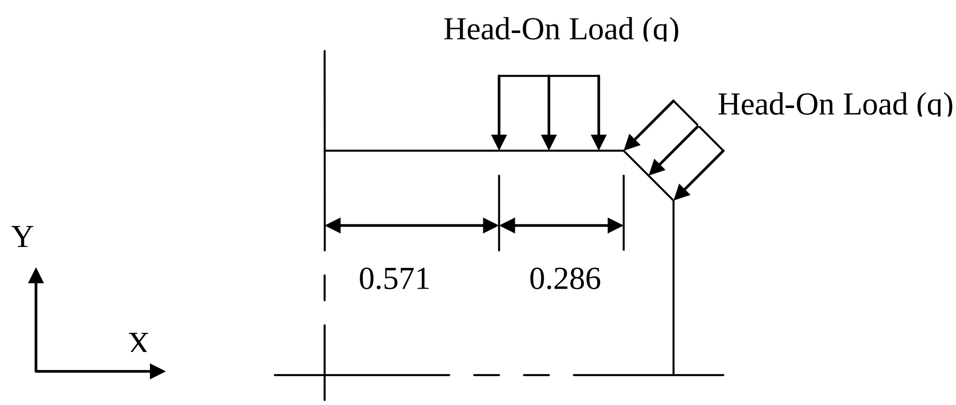


Figure 1. Axisymmetric Head-On Impact Load Distribution

2.23 *Describe the form that the inertia body force takes. Section No. 2.7.1.1.2 (page No. 2-136) of the application states that "In addition to the impact load, an opposing inertia body force is applied to the cask. Displacements are fixed along the cask base to account for non-equilibrium of pressure and inertia forces." Provide the magnitude of this force. Show where the fixed nodes are located and list the magnitude(s) of the force(s) at each node.*

The staff needs this information to verify the appropriateness of the analysis presented for the Head-On Free-Drop for the package.

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

Response:

All loads applied in the 30-ft HAC drop analyses are listed in the detailed description of the 30-ft drop analyses given in Paragraph 2.7.1.5.2.1. Only the loads for AOS model AOS-100 are discussed here. Loads for the other models are determined in the same manner as model AOS-100, and are given in Paragraph 2.7.1.5.2.1

The following discussion references Table 1 and Table 2, as well as Figure 1 and 2 below. These tables and figures are duplicates of Paragraph 2.7.1.5.2.1 for the model AOS-100, and are presented here for clarity. Impact loads determined in the drop analyses and applied in cask stress analyses are summarized in Tables 1 and 2 given below. Table 1 presents impact loads found in the over-pack drop analyses. Table 2 presents actual loads applied in the cask stress analyses. The actual applied loads, P', in Table 2, should equal or exceed the loads P in Table 1. Explanations of all factors in Table 1 are given in Paragraph 2.7.1.5.2.1. An inertial acceleration, A' in Table 2, is applied in the cask stress analyses in addition to the impact load, P'. The inertial acceleration forces react the impact load and prevent large support loads, while having only a marginal affect on local stress values. The accelerations A' are listed in the second table, and are based on the actual impact load and the weight of the stress model, M, also given in Table 2.

The total out-of-equilibrium force in the stress analysis, R, is the impact loading less the inertia forces,

$$R = P' - A' \cdot M$$

R is the reaction force given in the Libra output file, and the Libra values for R are listed in Table 2. The ratio R/P' listed in Table 2 provides a check on the input loading. In all cases R/P' is less 0.01, within round-off error of calculation values.

Table 1. Model AOS-100 Loads Determined in Drop Analysis

Case	$\mathbf{f_T}$	$\mathbf{f_S}$	$\mathbf{f_G}$	**f**	**I** (lb)	**P** (lb)
301	1.0	1.0	1.0	1.0	$1.42x10^6$	$1.42x10^6$
302	1.0	1.2	0.5	0.6	$1.36x10^6$	$8.16x10^5$
303x	1.0	1.0	0.5	0.5	$6.25x10^5$	$3.12x10^5$
303y	1.0	1.0	0.5	0.5	$8.05x10^5$	$4.02x10^5$
304	1.4	1.0	1.0	1.4	$1.42x10^6$	$1.99x10^6$
305	1.4	1.2	0.5	0.84	$1.36x10^6$	$1.14x10^6$
306x	1.4	1.0	0.5	0.70	$6.25x10^5$	$4.38x10^5$
306y	1.4	1.0	0.5	0.70	$8.05x10^5$	$5.64x10^5$

f_T - temperature load factor
f_S - slap down load factor
f_G - geometric load factor
f - total load factor, $f = f_T \cdot f_S \cdot f_G$
I - impact force from drop analysis load-displacement curve
P - drop analysis impact load, $P = f \cdot I$

Table 2. Model AOS-100 Loads and Accelerations Applied In Cask Stress Analyses

case	**P'** (lb)	**A'** (g)	**M** (lb)	**R** (lb)	**R/P'**
301	$1.42x10^6$	189.4	7498	$1.93x10^3$	0.001
302	$8.16x10^5$	220.2	3706	$0.29\ x10^3$	0.000
303x	$3.54x10^5$	95.5	3706	263.9	0.001
303y	$4.54x10^5$	122.4	3706	315.9	0.001
304	$1.99x10^6$	265.5	7498	$3.28\ x10^3$	0.002
305	$1.14x10^6$	307.6	3706	$4.61x10^3$	0.004
306x	$4.96x10^5$	117.1	3706	214.0	0.001
306y	$6.35x10^5$	154.1	3706	384.8	0.001

P' - applied impact force
A' - applied body acceleration
M - FEA cask model weight
R - total reaction force from FEM cask analysis, $R = P' - A' \cdot M$

The fixed nodes where the reaction forces are located are shown schematically on Figures 1 and 2.

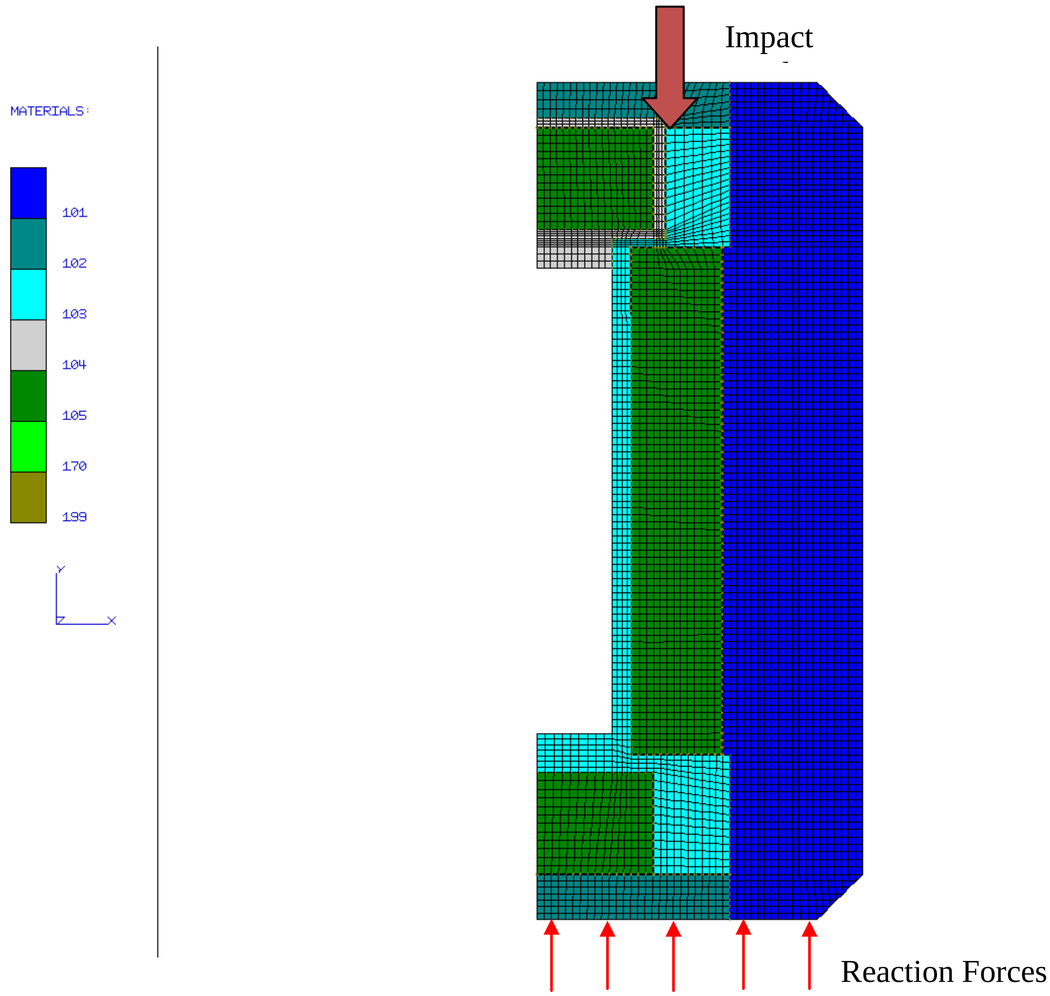


Figure 1. Head-On Drop Cask Model

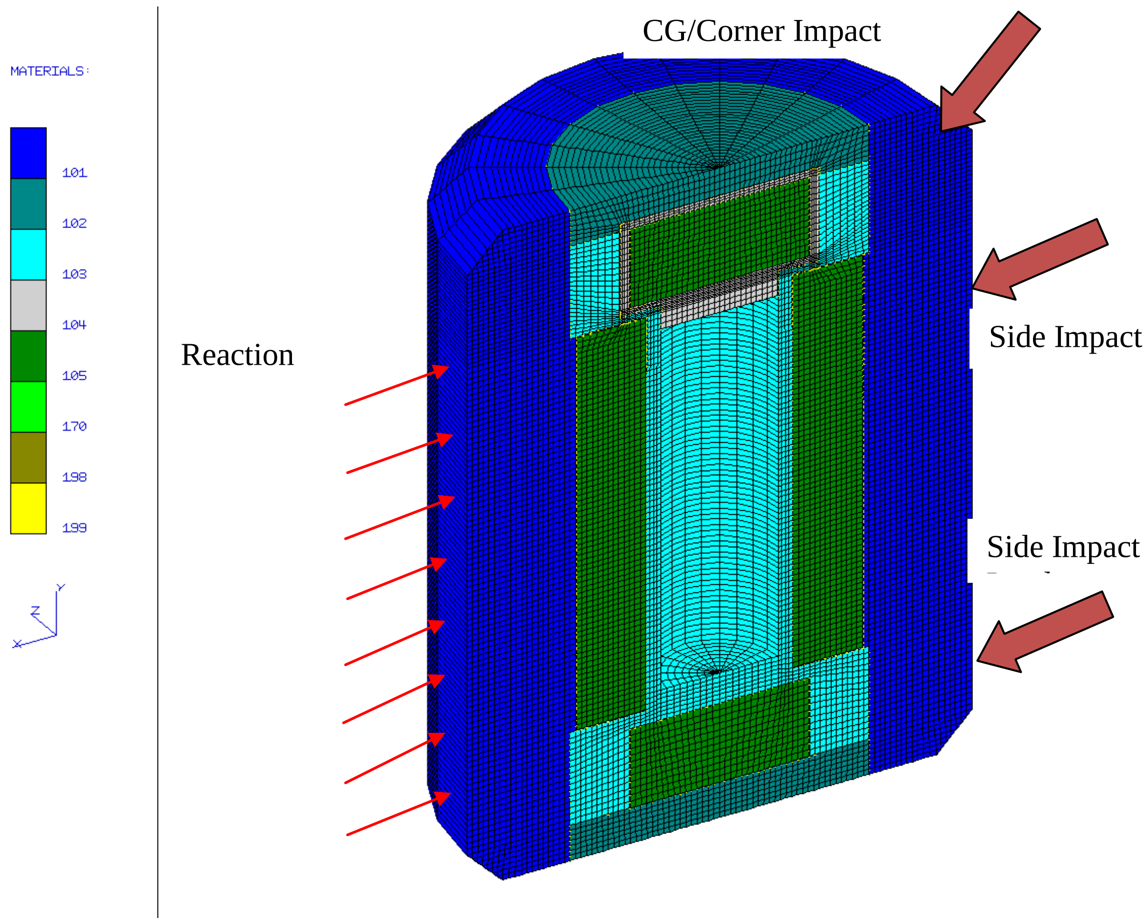


Figure 2. Side and CG/Corner Drop Cask Model

2.24 *Justify comparing the maximum analysis displacement to the post-test deformation reported in Section No. 8 of the application. The implication by the applicant is that there is no elastic behavior of the impact limiter.*

The staff did not find sufficient and accurate justification for the applicant to assume a totally inelastic behavior of the impact limiter materials. A justification is required to determine the magnitude of the damage sustained by the package subjected to regulatory drops, and to verify the adequacy of the impact limiter design.

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

Response:

The post-test Dimensional Inspection Report is moved from Section 8 and is now located in Appendix 2.12.7.

The foam material used in the impact limiter structure exhibits little restitution. The cask rebound observed in the 30-ft, head-on drop test was approximately 3 ft, indicating an overall restitution of approximately 10%. In addition, a part of restitution can be attributed to the impact limiter steel shell.

It is conservative to ignore foam restitution in correlating analytical and photographic results. The maximum test deformation determined from the photograph would be increased by the amount of restitution, and this would bring the photographic and analytical values closer.

2.25 *Provide the leak-rate test values for the drop tests discussed in Section No. 8.3.2 "Impact (Free-Drop) Test Report" of the application.*

The leak-rate values subsequently to the regulatory drop tests are not shown in the application. Staff needs these values to determine if these leak rate values are acceptable to insure the leak tightness of the package.

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

Response:

The leak-rate test values obtained in the seal joint after each 30 Ft Free Drop test are given below:

HEAD ON DROP:

TEST RESULTS: (Seal Joint)
Pre-Cal. Rate: 2.3 x 10⁻⁹ Leak Rate 2.3x10⁻⁹ Post-Cal Rate: 2.4 x 10⁻⁹
Test Results: Accept/Reject. Performer: R. Bonaro Level: III Cert. No. GE026

TEST RESULTS:
Pre-Cal. Rate: 2.3x10⁻⁹ Leak Rate ~~9x10⁻⁹~~ x 10⁻⁹ MP 3/26/07 Post-Cal Rate: 2.3x10⁻⁹
Test Results: Accept/Reject. Performer: R. Bonaro Level: III Cert. No. C260

SIDE DROP:

TEST RESULTS: (Seal Joint)
Pre-Cal. Rate: 2.4 x 10⁻⁹ Leak Rate 2.6x10⁻⁹ Post-Cal Rate: 2.6 x 10⁻⁹
Test Results: Accept/Reject. Performer: R/P Level: III Cert. No. 0260

TEST RESULTS:
Pre-Cal. Rate: 1.97x10⁻⁷ Leak Rate 2.3x10⁻⁸ Post-Cal Rate: 1.97x10⁻⁷
Test Results: Accept/Reject. Performer: RP Level: III Cert. No. 0260

SLAP DOWN DROP:

TEST RESULTS: (Seal Joint)
Pre-Cal. Rate: 2.5 x 10⁻⁹ Leak Rate 2.3x10⁻⁸ Post-Cal Rate: 2.5x10⁻⁹
Test Results: Accept/Reject. Performer: RP Level: III Cert. No. ~~062~~ MP 4.3.07 0260

Chapter 3 – Thermal Evaluation

3.1 *Correct and justify the values for the specific heat and the conductivity listed in Table No. 3.6 of the application.*

The values of the specific heat and the conductivity listed in Table No. 3.6 of the application appear to be interchanged and have the incorrect temperature dependence. (e.g., see http://www/electronics-coolong.com/articles/1999/1999 jan techdaat.php).

The values reported in the application came from an independent laboratory's test of an alloy that has the normal composition of 95W-3.57Ni-1.43Fe. The values of these parameters are significantly different from pure tungsten. Table No. 5-12 of the application indicates that the tungsten shields are 100% tungsten; thus it is not clear that the independent testing on the less pure alloy is relevant to this package.

This information is required by the staff to determine compliance. With 10 CFR 71.33

Response:

The tungsten material used in the AOS packaging design is a Tungsten Alloy, 95W-3.57Ni-1.43Fe, with a density value of 18.11 gram per cc. This information is given in the Certification drawings and throughout different Chapters of the SAR. Properties given in Table 3.8 were obtained by testing the actual material used in the AOS-165 prototype. However, Chapter 5 identified the material as pure Tungsten, because pure tungsten is less dense than the alloy, 17.8 gram/cc vs. 18.11 gram/cc.

3.2 *Justify the use of properties from two different ASME B&PV Code alloy Groups in Table Nos. 3-7 and 3-99 of the application.*

The thermal conductivity and thermal diffusivity for the carbon steel were checked against the ASME B&PV code. It appears that the conductivity was for alloys in Group A, while the thermal diffusivities were for a material in Group B.

This information is required by the staff to determine compliance with 10 CFR 71.51(a)(1) and 71.51(a)(2).

Response:

Table 3-9 and Table 3-81 have been updated to reflect properties from Group A.

3.3 *Clarify the applicable set of values for the thermal conductivity of the Last-A-O-Foam given in Table No. 3-106 of the application. Justify the use of a particular set of data.*

Two sets of values for the thermal conductivity of the Last-A-O-Foam are given in Table No. 3-106. There appears to be an implication that the newer set of values is the more accurate.

This information is required by the staff to determine compliance with 10 CFR 71.51(a)(1) and 71.51 (a)(2).

Response:

The application (Table 3-11) has been updated to include the applicable values for the LAST-A-FOAM used in all models and these are the values used when performing the analysis.

3.4 *Justify the thermal conductivities given in Table No. 3-8 of the application.*

The thermal conductivities given in Table No. 3-8 do not agree with the values given in Table No. 3, "Thermal Properties", of the manufacturer's Design Guide provided in the appendix to the structural section of the SAR.

This information is required by the staff to determine compliance with 10 CFR 71.51(a)(1) and 10 CFR 71.51(a)(2).

Response:

Table 3-11 has been updated showing the applicable manufacturer's data.

3.5 *Provide a justification for the impact limiter temperature criteria given in Table No. 3-4 of the application. Provide a justification for a lower operation temperature unit.*

No basis for this limit or any limit is provided in the application. Also no lower temperature limit is provided in the application.

The information is required by the staff to determine compliance with 10 CFR 71.51(a)(1) and 71.51(a)(2).

Response:

Former Table 3-4 has been separated into Table 3-3, dealing with Normal Conditions of Transport, and Table 3-4, addressing the Hypothetical Accident Conditions. In these Tables is included a column showing the Regulatory-Specified, or Component Limit imposed by manufacturing data.

3.6 *Justify the reason for inconsistent radioisotope activity values in the application. When values appear in multiple tables throughout the application, ensure that the values are consistent and have been appropriately applied in the NCT and HAC assessments.*

Radioisotope activity values in Table No. 3-1 of the application are not consistent and one is less conservative compared to values in Table No. 1-6 of the application. Based on the inconsistent values presented, the application should be revised to list each table, used by multiple disciplines, once the application (i.e., in Chapter No. 1 or Chapters No. 7 or 8) and then reference the table's number in other parts of the application.

This information is required by the staff to determine compliance with 10 CFR 71.31.

Response:

This application has been modified to eliminate inconsistent data and repetition of tables where appropriate.

3.7 Separate regulatory/component criteria into two columns, one for NCT limits and one for HAC limits, in Table No. 3-4 of the application. Also, separate Case 3 into two columns in Table No. 3-4 of the application: one providing maximum temperatures during the fire and the other one providing maximum temperatures during the post-fore steady-state condition, as well as the time at which these temperatures occur after fire initiation.

In addition to the components currently listed in Table No. 3-4 of the application, add the following components: lid, bottom plate, outer shell, and inner shell. Clarify if the cask cavity temperature is the maximum temperature of both the cavity surface of the inner shell and the cavity surface of the lid plug. Finally, clarify if the shielding temperature is the maximum for all shielding in the package (i.e., the maximum of the radial, lid plug, and end plug shielding).

In order to verify the temperature results, the applicant should provide maximum component temperatures in one table containing NCT, fire, and post-fire maximum temperatures, as well as component temperature limits; or two tables separating NCT maximum temperatures and associated component temperature limits. Currently the staff has to review and interpret numerous tables located throughout Chapter No. 3 of the application to determine the maximum component temperature.

The current summary of temperatures in Table No. 3-4 is misleading in that the maximum temperatures appear to be provided in the table. The application should also report temperatures for the lid, bottom plate, outer shell, and inner shell because they are structural components. The cask cavity temperature should be the maximum of both the cavity surface of the inner shell and the cavity surface of the lid plug. The shielding temperature should be the maximum temperature for all shielding in the package.

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

Response:

The information in the application has been reformatted in Table 3-3 and Table 3-4, and now presents maximum values for all cask assembly components. Temperatures are now given for the outside shell, inside cavity shell, lid, lid plug, bottom plate, shielding, bottom surface, top surface, and impact limiter. Also in the tables, cask cavity maximum temperatures on bottom surface, side surface, and top surface are now listed.

The temperatures shown under "Shielding Materials" are the maximum temperature in this material, in all locations.

Table 3-4 now lists the time during the fire and cool down event.

3.8 *Justify the lid seal temperature limit of 572°F.*

In the Licensing Drawings No. 166D8143 and No. 166D8137 for the Model No. AOS-25A and AOS-50A package respectively, the lid seal free height is 0.11 inch. Using the information provided in Section No. 3.5.7 "Lid Seal," the maximum temperature of a Helicoflex spring energized seal with a silver jacket and a cross-section of 0.098 inch is 536°F. The next cross-section dimension is 0.118 inch which is greater than the lid seal free height in the Licensing Drawings.

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

Response:

The temperature limits on the seal material are given by the manufacturing drawing presented in Section 4.l. The use of 572°F in the application is considered conservative since the seal manufacturer allows a maximum surface temperature of 800°F, as shown in their drawings. Refer to Appendix 4.5.3.

3.9 *Clarify if the elastomeric silicone based seal is Parker compound S1224-70 and not 51224-70. Provide the minimum temperature limit for the elastomeric seal. In addition, provide a component technical specification for the metallic lid seal (also see RAI 4.1 below).*

The metallic lid seal will be designed by the manufacturer based on the flange design, if this has been performed. Complete information on the metallic lid seal including the manufacturer, part number, materials of construction, and minimum and maximum temperature limits should be proved in the technical specifications. If this seal design has not been performed, metallic lid seal information that includes the materials of construction, and minimum and maximum temperature limits, is necessary in the technical specification to preclude an amendment to the certificate.

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

Response:

The typographical mistake has been corrected in the application.

3.10 *Clarify if the shielding is modeled with four-node quadrilateral conduction elements. Also explain in more detail how convective elements are being used to model the decay heat as well as solar insolation.*

In the first paragraph of Section No. 3.3.1, state if the shielding has been modeled with four-node quadrilateral conduction elements. A more detailed explanation is necessary to understand how the decay heat and solar insolation were modeled using convection elements.

This information is required by the staff to determine compliance with 10 CFR 71.33.

Response:

The four-node quad element is used to model shielding material conduction in axisymmetric analyses. However, convection at boundary surfaces is modeled by two node convective elements superimposed on the quad elements.

3.11 *Label, in Figure No. 3-4 of the application, the six air gaps given in the numbered list on page No. 3-22 of the application by providing the air gap numbers on the figure. Ensure this figure is consistent with Figure No. 3-2 in the contact resistance appendix, as well as with Figure No. 3-2 in the air appendix of the application, as well as with the description in Section No. 3.3.1 of the application. Verify that the final figure is consistent with the thermal models and report results.*

The application needs to clearly and consistently present how the package was thermally modeled. This includes the air gaps that are represented in the model. Figure No. 3-4 of the application and Figure No. 3-2 of the contact resistance and air appendix of the application appear to inconsistently show where the air gaps are located.

This information is required by the staff to determine compliance with 10 CFR 71.33 and 71.51.

Response:

The inconsistencies have been corrected and the information in Figure 3-4 of the application is consistent with the thermal models and the reported results.

3.12 *Provide sensitivity studies on enclosed air space gap sizes and contact resistance values used in the thermal models.*

It appears the same gap size values and contact resistance values were used in the NCT, fire, and post-fire cooldown models. Using the same value for all three cases does not produce maximum temperatures. Enlarging gaps during the NCT and post-fire cooldown and reducing the gap sizes during the fire would produce maximum component temperatures. Increasing contact resistance during the NCT and post-fire cooldown and reducing the contact resistance during the fire would also produce maximum component temperatures.

A sensitivity study should show the effects of changing the gap sizes and contact resistance values on maximum component temperatures. Based on the sensitivity studies, show that the values currently used in the thermal models are appropriate to produce maximum component temperatures or modify and rerun the models to produce maximum component temperatures.

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

Response:

The analytical model is changed to enlarge the gap during normal conditions of transport, and post fire event by a dimensional tolerance value of 0.01 in. During the fire event all gaps are closed, and their contact resistance are decreased by a factor of 10. Refer to Section 3.3.3.

3.13 *Justify the assumption that* $\varepsilon_1 = \varepsilon_2 = 0.52$ *2 for all air gaps.*

Air gaps listed in the numbered list on page No. 3-22 of the application are not all "stainless steel to stainless steel," as is assumed in the radiation calculation on page No. 3-.28 and discussed on page No. 3-29 of the application.

Justify the conservatism of this assumption during NCT and HAC.

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

Response:

The emissivity values for all metal-to-metal gaps have been adjusted to the appropriate value. Air gap 6, stainless steel to tungsten or stainless steel to carbon steel, has been adjusted to the correct value of each metal. Refer to Paragraph 3.3.3.2.

3.14 *Justify taking credit for each air gap in the thermal models since many gaps are within the tolerances provided on the licensing drawings.*

Many air gap dimensions in Table No. 3-12 of the application are within the dimensional tolerances presented on the licensing drawings. If justification cannont be given, the gaps should be removed and the thermal models rerun to provide updated maximum temperatures.

Tolerances on the engineering drawings to the 2nd decimal are in 0.01 inches. Many air gaps are less than this tolerance. Therefore the use of the gaps in the thermal models needs to be justified and, if they cannot be justified by possibly adjusting the tolerance if physically possible, they need to be removed and the thermal models rerun without the gaps.

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

Response:

The treatment of the air gap in the analytical model is adjusted to produce the worst-case scenarios, by either closing or opening of the air gaps in the analysis of thermal conditions. Details of this approach are discussed in RAI 3-12.

3.15 Justify the following assumptions presented in Section No. 3.3.1.2 of the application.

a. The application states, "Table 3-11 lists air gaps 1,2,3,5, and 6 with a temperature of 300 k (26.85°C, 80.33°F) and a delta T = 5.6°C (42.08°F)." Show how these chosen temperatures provide bounding values for all conditions (NCT and HAC) of the models. Also, a delta T = 5.6°C is not equivalent to a delta T = 42.08°F, clarify the correct value.

b. Table 3-11 of the application shows values for the AOS-165. It would be more appropriate to use bounding values for the Model Nos. AOS-25, AOS-50, or AOS-100, packages that have been accepted for review.

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

Response:

The calculations for the Grashof number for all 6 gaps have been redone and the values shown to be less than 1700, therefore the assumption of simple conduction across the gap is valid.

3.16 Provide the assumptions used to reduce the effective conductivity equations in Table No. 3-12 of the application to a function of one temperature. Justify the conservatism of this assumption during NCT and HAC. Also show an example of the derivation of these equations.

In Table No. 3-12 of the application, the effective conductivity equations are a function of one temperature when it was previously stated in the application that the effective conductivity is a function of radiative heat transfer across the air gaps which is a function of both temperatures on either side of the air gap. The applicant has not justified the use of the equation in Table No. 3-12 of the application for both NCT and HAC conditions.

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

Response:

The polynomial shown in Table 3-13 represents an equivalent conduction property accounting for heat conduction and radiation, as discussed in Paragraph 3.3.3.2. The prior application contained a typographical error, where Ka was shown as K, on the label of the polynomial columns.

3.17 Justify the Grashof Number lower bound values in Section No. 3.3.1.2 of the application.

Some Grashof Number lower bound values in Section No. 3.3.1.2 of the application are different from the cited reference.

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

Response:

This typographical error has been corrected. The lower bound values for both equations are 2×10^4 and 2×10^5.

3.18 Provide justification and a reference for the statement that a horizontal curved surface can be assumed to be flat if the length is relatively short compared to the radius.

The staff notes that Section No. 3.3.1.3.3 is for convection from a horizontal cylinder which is in disagreement with the statement above from Section No. 3.3.1.3. Clarify if that sentence in Section No. 3.3.1.3 of the application is referring to the Model Nos. AOS-25 and AOS-50 that are oriented vertically, the vertical curved surfaces can be assumed to be flat and vertical.

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

Response:

The analyses are modified, and now use curved surfaces convection values defined in Paragraph 3.3.3.3 for Model AOS-100. Table 3-14 and Table 3-15 are updated.

3.19 Explain how the length and width values in Table No. 3-13 of the application relate to the licensing drawings and how the length and width values in Table No. 3-14 of the application relate to the licensing drawings and the results of the drop tests. Also, remove surface convection on some package surfaces during normal conditions of transport based on the licensing drawings.

It is not clear how the length and width values in Table Nos. 3-13 and 3-14 of the application compare to the dimensional values in the licensing drawings or the results of the drop test. Ensure that all values used in calculations compare to the licensing drawings or hypothetical accident conditions damages as appropriate. The staff does not believe that it is appropriate to model convection during normal conditions of transport on certain surfaces of the package based the inclusion of a pallet on the licensing drawings (i.e., including, but not limited to, the surfaces 1,2, and 3 of the Model No. AOS-025A).

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

Response:

The length and width dimension shown in Table 3-14 and Table 3-15 are obtained from the figures in Paragraph 3.5.4.2. The dimensions in this figure were verified against the Certification drawing of the AOS Transport Packaging System.

The surface convections on Surfaces 1, 2, and 3, are removed from the analytical model for the normal conditions of transport.

3.20 Define the Ralyleigh number and its component variables.

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

Response:

The definition of the Rayleigh number and its components has been added to Paragraph 3.3.3.4.

3.21 Support the Rayleigh Number limits in Section No. 3.3.1.3.2 of the application.

The Rayleigh Number limits in Section No. 3.3.1.3.2 of the application are different form the staff's reference "Incropera, Frank P., David P. DeWitt, *Fundamentals of the Heat and Mass Transfer, Wiley, John & Sons, Incorporated, 4th Ed., 1996.”*

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

Response:

The limits have been changed per the reference above.

3.22 *Modify the gray body shape factor in Section No. 3.3.1.3.5 to be 0.8 rather than 0.7347.*

In the fire thermal model, the gray body shape factor should be the absorptivity = 0.8 based on 10 CFR 71.73. 10 CFR 71.73 requires a flame emissivity of at least 0.9 provided in the test when the specimen is fully engulfed in the fire, and a package surface absorptivity of at least 0.8 used in the calculation when the package is fully exposed to the fire. All surface convection equations in the fire models should be modified to include this new gray body shape factor of 0.8 rather than 0.7347.

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

Response:

The analysis is revised to use a gray body shape factor value of, 0.8. Results are presented in Paragraph 3.3.3.8.

3.23 *Replace LAST-A-FOAM materials properties with air during the post-fire cooldown if the melting point has been exceeded. Rerun post-fire cool down thermal models to provide maximum component temperatures.*

It appears from the application that the LAST-A-FOAM reaches 1471°F during the fire while the glass transition temperature from the General Plastics LAST-A-FOAM appendix is 279°F.

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

Response:

The Post Fire analyses now uses air properties in place of the LAST-A-FOAM properties.

3.24 *Include a table in the application showing the modified foam properties for all models due to the damage during the drop tests.*

The applicant states in Section No. 3.4 that the foam properties have been modified due to the reduced volume from damage during the drop, but has not provided the modified LAST-A-FOAM material properties in the application.

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

Response:

The modified foam properties used in the analyses are shown in Table 3-11.

3.25 Describe for each model, i.e, AOS-25, AOS-50, and AOS-100, the HAC drop effects and any dimensional modifications made to each thermal model. Describe any damage due to the crush test for the Model Nos. AOS-25 and AOS-50 and any dimensional modifications made to each thermal model. Provide figures for each model with dimensions clearly showing the damage due to drop tests and crush tests.

It is not clear how the dimensions provided in Section No. 3.4 of the application have been translated from the Impact (Free-Drop) Test Report in Section No. 8.3.2 and the Dimensional Inspection Report in Section No. 8.3.3 of the application. The staff needs to have a clear understanding as to how each model was modified due to drop or crush damage.

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

Response:

Condition 3 is the 30-minute fire with a post fire cool down transient. The analyses uses the deformed geometry resulting from the free-drop event. Appendix 3.5.4, Modeling Data, presents a detailed account of the analytical model for this event.

3.26 Justify linearly scaling the drop effects for each thermal model considering the impact limiter foam density is different for each model.

Section No. 3.4 of the application states that, "…the reduced impact limiter effects are linearly scaled by their cask size." The staff notes that the impact limiter foam density is different for each model.

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

Response:

The drop effects are not scaled. The change in geometry for each model is based upon the predicted crush values of each model. The crush geometries are shown in Appendix 3.5.4.

3.27 Include a table showing the maximum cask cavity pressure due to hypothetical accident conditions for all models in Section No. 3.1 of the application. Also reference this table in Section No 3.4.3 of the application.

The table showing the maximum cask cavity pressure due to hypothetical accident conditions currently appears in Chapter 2 of the application, but would be more appropriate in Section No. 3.1 of the application. Currently Table No. 3.3, "Maximum Cask Cavity Pressure Due to Normal Conditions of Transport – All Models" is referenced in Section No. 3.4.3 of the application.

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

Response:

Table 3-6 gives the maximum cavity pressure due to the hypothetical accident conditions for all models.

3.28 Modify Table No. 3-4 of the application to include maximum component temperatures as stated in Section No. 3.4.3 of the application (See RAI 3-7)

The staff compared Table No. 3-4 of the application to the numerous maximum component temperature tables located in Section Nos. 3.4.6, 3.4.7, and 3.5.2 of the application and found that values exceeded those reported in Table No. 3-4 of the application. See RAI 3-7 for further clarification on reporting the maximum component temperatures.

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

Response:

Table 3-3 and Table 3-4 are modified to include the maximum component temperatures of the AOS Transport Packaging System for all thermal conditions. This subject is also discussed in the RAI 3-7 response.

3.29 Rerun all thermal models taking into account the information below and provide updated maximum component temperatures (see RAI 3-7) and temperature plots in the application. Provide LIBRA input and output files for all thermal models that have been changed.

a. *For the AOS-25 and AOS-50 thermal models, include solar insolation on all surfaces according to 10 CFR 71.71(c)(1) during normal conditions of transport and post-fire cooldown. Currently the LIBRA AOS-25 NCT and post-fire cooldown models do not have solar insolation on surfaces 1,2 and 3 (see Figure No 3.5 of the application). Also, the LIBRA AOS-50 NCT and post-fire cooldown models do not have solar insolation on surfaces 1, 2, 3, and 7 (see Figure No. 3.5 of the application).*

b. *AOS-25 polynomial coefficients for the 0.0303 inch air gap in the AOS-25 normal conditions of transport model and post-fire cooldown model do not match values in Table No. 3-12 of the application. Also, the AOS-50 polynomial coefficients for the 0.009 inch air gap in the AOS-50 normal conditions of transport model does not match values in Table No. 3-12 of the application. Clarify which values are correct. Also consider tolerances in the licensing drawings as related to these gap sizes (see RAI 3-14).*

c. *AOS-25 and AOS-50 fire model polynomial coefficients for the total surface convection for surfaces 1 and 2 (see Figure No. 3.5 of the application) appear to be NCT-like rather than fire convection-coefficients shown in equation h, on page No. 3-46 of the application. Also in the AOS-25 and AOS-50 fire model, surfaces 1 and 2 (see Figure No. 3.5 of the application) have a boundary condition of 100°F; the boundary condition should be 1475°F due to the exposure of those surfaces to the fire. The packages should be fully engulfed in the fire.*

d. *During the post-fire cooldown for all AOS models, the impact limiter foam should be modeled as air because during the fire the impact limiter foam has exceeded its melting temperature (See RAI 3-23).*

e. *In the AOS-25 and AOS-50 NCT and post-fire models it appears that convection is considered on surfaces 1, 2, and 3; yet, it appears from the Licensing Drawing Nos. 166D8142 and 105E9718 that there is a base that the packages rest in and therefore there would not be convection on those surfaces (See RAI 3-19).*

f. *Provide justification for the total surface convection polynomial coefficients used in the LIBRA post-fire thermal models. In the AOS-25 post-fire model, the polynomial coefficients for the total surface convection for surfaces 1, 2, 3, 4, 9, 10, and 11 (see Figure No. 3.5 of the application) do not appear in the application. In the AOS-50, AOS-100A/A-S and AOS-100B post-fire models the polynomial coefficients for the total surface convection for surfaces 1 – 11 (see Figure No. 3.5 of the application) do not appear in the application.*

g. *Remove Section No. 3.5.10 from the application and reevaluate the NCT and fire thermal models using LAST-A-FOAM materials properties that appear in the General Plastics LAST-A-FOAM Design Guide. Update*

Table No. 3-8 of the application with the properties that appear in the General Plastics LAST-A-FOAM Design Guide. Section No. 3.5.10 shows that the "New" LAST-A-FOAM properties produce less conservative component temperatures compared to the "Old" LAST-A-FOAM properties used in the thermal model and therefore the thermal models should be reevaluated with the "New" LAST-A-FOAM properties that appear in the General Plastics LAST-A-FOAM Design Guide.

h. *In the AOS-100A/A-S and AOS-100B NCT models the polynomial coefficients for the total surface convection for surfaces 1 – 11 (see Figure No. 3.5 of the application) do not match the values in the application. Clarify which values are correct.*

i. *The AOS-100A "Ic111-t2-update.100" and "Ic112-t-update.100" input files are not producing the temperatures that have been provided in the application. For example, Table No. 3-35 of the application states the node 5001 has the temperature 262.8°F while the "Ic111-t2-update.100" input file produces the temperature 235°F for the same node. The output file, "tape6-111t2" also shows that node 5001 has the temperature 235°F. Provide the LIBRA thermal models that produce the temperatures in the application.*

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

Response:

The current LIBRA input and output files are provided in the application.

a) Done

b) Done

c) Models AOS-025 and AOS-050 have been modified to include a fire on all surfaces 1 through 11. This analysis is done in three parts; the steady state, restart for the fire transient, and a restart for the cool-down period. Boundaries for this event are, 100°F ambient temperature steady state, 1475°F for 30-minutes transient, and cool down transient at 100°F ambient until past maximum temperature conditions.

d) Done

e) Done

f) The surface convective polynomials for models AOS-100, AOS-050, and AOS-025 are given in Table 3-17. These values are for the steady state condition prior to the start of fire, and post fire transient analysis.

g) Done. See RAI 3.3 responses

h) Done

i) The solution for the thermal condition 3 requires the execution of three files. In this case, model AOS-100, the first file to be executed is LC111-t1-mf.100. This gives the steady state condition prior to the start of the fire. Next, is LC111-t2-mf.100. This is the fire transient solution that uses temperatures from the previous solution as a starting point. Boundary conditions are changed with fire environment and the 30-minute transient is solved. Temperature results given in Table 3-4 are the maximum values for those components listed at the end of the 30 minutes fire. The third execution is file LC112-t-mf.100. This is also a restart solution using temperatures at the end of the 30 minutes transient as the starting temperatures for a 7.5-hour cool down phase of the solution.

3.30 Provide, in section No. 3.5.7 "Insolation," the solar insolation values and the external surface identification figures used for the model Nos. AOS-25 and AOS-50 which are both oriented vertically rather than horizontally like the Model No. AOS-100. Also, modify the table heading "horizontal surface" because all surfaces in the figure are not horizontal. Finally, clarify if solar insolation values as reported in the application were applied continuously during NCT and the post-fire.

Although not explicitly labeled, it appears the cask assembly external surface identification and values in Section No. 3.5.7, "Insolation," are for the Model No. AOS-100 package. The applicant should include the solar insolation values and external surface identification figures that were used for the Model Nos. AOS-25 and AOS-50. The staff notes that the regulatory values in 10 CFR 71.71(c)(1) for solar insolation are total values for a 12 hour period.

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

Response:

Solar insolation loadings for all models and surfaces have been identified in Table 3-18 of the SAR. See Paragraph 3.3.3.7 for application of the solar load.

3.31 Address the thermal test results in relation to the temperature of the contents, basket, and shielding liners/plates that were not thermally modeled for the benchmark model described in Section No. 8.1.7 of the application or the AOS-25, AOS050, AOS-100A/A-S, or AOS-100B thermal models due to the assumption of uniform decay heat.

It appears that the thermal test results in Section No. 8.1.7 of the application show that thermocouples 1 and 2 inside the cask cavity report significantly higher temperatures than thermocouple 7 on the cask cavity wall and the analytical *results predicted cask cavity temperature using the assumption of uniform decay heat (see Figure No. 8-13 of Section No. 8.1.7). The applicant needs to address the temperatures of the contents, basket, and shielding liners/plates that have not been modeled due to the assumption of uniform decay heat in Section No. 3.5.9 of the application.*

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

Response:

The information contained in Sub-section 8.1.7 is now in Appendix 3.5.7. In the test model, the decay heat is applied at the center of the cask cavity, causing thermocouples 1 and 2 to report higher temperatures than all other thermocouples. For the correlation, the decay heat is applied to match the cavity wall temperature TC 2, 4, 7, and 8, for a total of 7000 watts heat load. The resulting temperature distribution elsewhere is compared with the test distribution. This verifies that heat transfer mechanism across each boundary has been represented sufficiently in the analytical model, and that the assumed heat distribution at cask bottom, side and top, are adequate. In the analyses for NCT and HAC, the decay heat load is applied at the cavity walls with a distribution similar to the one identified during the test.

3.32 Clarify how the packaging weight shown in Table No. 3-1 of the application is calculated.

The staff notes that the definition of packaging in 10 CFR 71.4,"…consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, and devices for cooling or absorbing mechanical shocks." The definition of package includes the packing together with its contents. Ensure that the column label in Table No. 3-1 of the application is appropriate for the weight calculation that was performed.

This information is required by the staff to determine compliance with 10 CFR 33(a)(2).

Response:

The packaging weight is calculated using the Inventor computer program 3D model. The results are reported in the Certification drawings.

3.33 Clarify if the weight of the impact limiters shown in Table No. 3-1 of the application is for each impact limiter or the total for both impact limiters.

This information is required by the staff to determine compliance with 10 CFR 33(a)(2).

Response:

Notes have been placed in the Certification drawing and tables clarifying the weight values given.

3.34 Clarify the following inconsistency: assuming that the applicant calculated the packing weight by including the cask, the impact limiters (assuming that is the total for both impact limiters), and content, the staff calculated a packaging weight of 3,322 kg for the Model No. AOS-100B. This value is greater than the value the applicant provided (3,232 kg) in Table No. 3-1 of the application.

This information is required by the staff to determine compliance with 10 CFR 33(a)(2).

Response:

The packaging weight is recalculated using the Inventor computer program 3D model.

Chapter 4 – Containment

4.1 *Justify the use of the test data in Appendix No. 4.5.1 of the application to indicate the behavior of the lid seals used in the design. Provide justification for a -54ºC to 232ºC (-65ºF to 450ºF) operating temperature range for the ethylene propylene O-ring compound used in the Model No. AOS-100. Correct the notation on the drawings for the Parker compound.*

The testing described in Appendix No. 4.5.1 was conducted on Helicoflex H-309646 (metal) and H-309353 (elastomer). These are not the seals used in the AOS packages as indicated below from the drawings. The Helicoflex seals can be any combination of jacket and spring materials. Stainless steel jackets will behave differently than silver jackets. The staff was not able to find the applicant's Helicoflex designations in the Helicoflex literature. The Parker compound is given on the drawings as 51224-70. It should be S1224-70.

	AOS-025A	AOS-050A	AOS-100A(B)	AOS-100A-S
Lid Seal	None indicated-a	Helicoflex	Parker	Helicoflex
#		H-309852	E0740-75 - a	H-309850
Jacket	Silver	silver		
Spring	Alloy 90	Alloy 90		
material			EPDM	Stainless steel
Port seals	Parker	Parker		
	51224-70	51224-70	E0740-75	51224-70
material	Silicon	silicon	Ethylene propylene - a	

a- *indicated on drawings*

This information is required by the staff to determine compliance with 10 CFR 71.51(a)(1&2).

Response:

The licensing drawing(s) have been revised and references to "51227-70" and "silicon" have been replaced with "S1227-70" and "silicone", respectively. Further, all references to EPDM in the drawing(s) have been eliminated.

The following table summarizes the seals used in the AOS models as listed in the licensing drawings and supporting analyses to be submitted with the revised application.

	AOS-025A (Dwg. 166D8143)	AOS-050A (Dwg. 166D8137)	AOS-100A and -100B (Dwg. 105E9712)	AOS-100A-S (Dwg. 105E9719)
Lid Seal	Helicoflex	Helicoflex	Helicoflex	Helicoflex
#	H-309854	H-309852	H-309850	H-309850
Jacket	Silver	Silver	Silver	Silver
Spring	Alloy 90	Alloy 90	Alloy 90	Alloy 90
Port seals	Parker	Parker	Parker	Parker
	S1224-70	S1224-70	S1224-70	S1224-70
Material	Silicone	Silicone	Silicone	Silicone

The referenced Helicoflex lid seal part numbers are referenced in the revised application, as appropriate.

The leak tests described in Appendix No. 4.5.1 were performed to confirm the operating temperature range for the initially selected seal materials (Note that Appendix 4.5.1 may remain in the application as supplemental information, but will not be referred to in the application). The resultant leak test data was not used to qualify the seal joint. Rather, the seal joint qualification test will be performed with the actual joint using the cask, seal, lid, and bolting installed, as prescribed in the “Acceptance Test and Maintenance” procedures, found in Chapter 8 of the application.

4.2 Provide an appropriate illustration of the containment boundary, in Figure No. 4-1, for the AOS series of packages.

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

Response:

Figure 4-1, in the application has been revised to outline the containment boundary for the AOS Transport Packaging System models, as illustrated in the following figure.

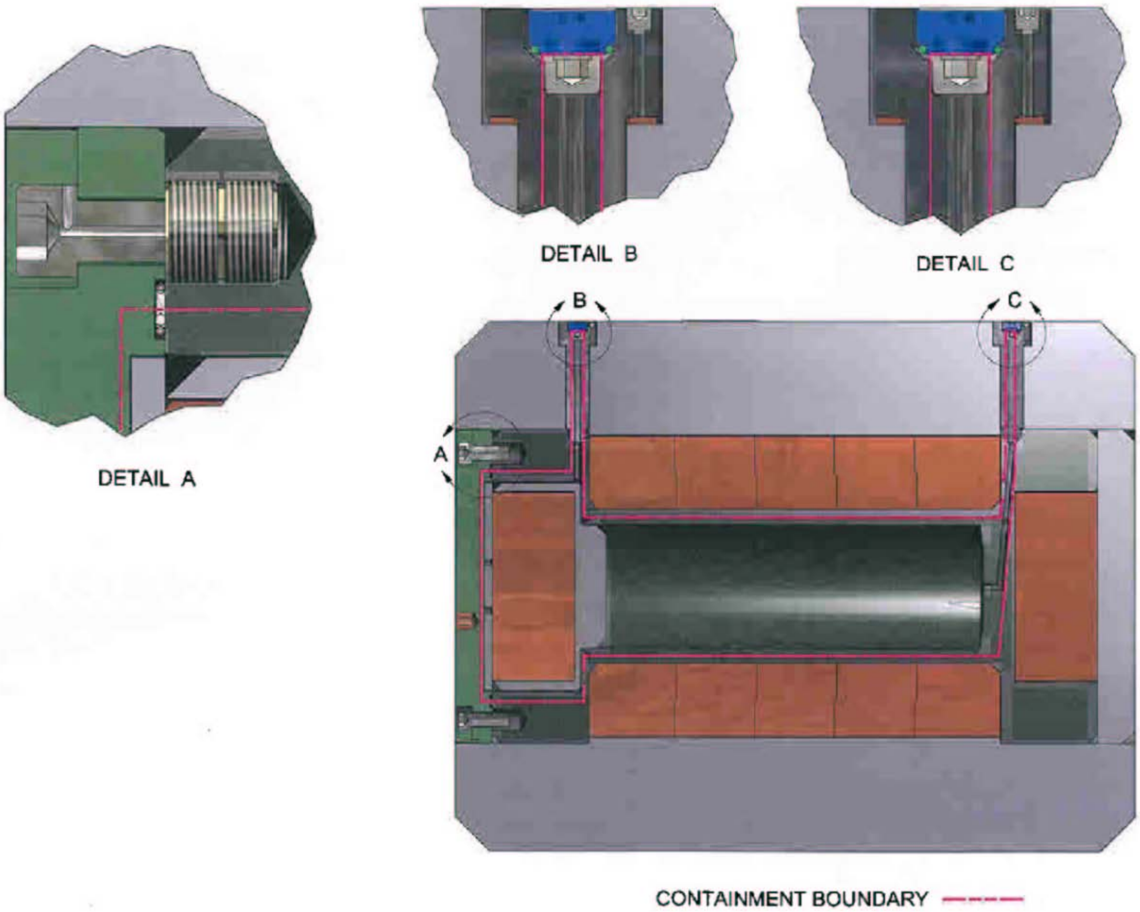


Illustration of transport package containment boundary

4.3 *Provide additional details on the leakage rate test described in Section No. 4.4 of the application, or clearly refer to a more detailed description of the leak test procedure within the application.*

The description of the leakage rate test done on the package does not provide any specific information or results. If any prototype of this series of packages was tested to demonstrate its leaktightness in accordance to ANSI N14.5, the staff needs a description of the test procedures and test results.

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

Response:

Details pertaining to the actual leakage rate test are provided in Chapter 7 of the application. Reference to leakage rate testing in Section No. 4.4 is for informational purpose only, and will be noted as such on the revised application, namely, refer to Chapter 7 for comprehensive leakage rate testing.

4.4 *Revise the application to delete all references to Appendix No. 4.5.*

The tests described in Appendix No. 4.5 of the application do not qualify any of the seals used in the Model Nos. AOS-025, AOS-050, and AOS-100 packages to temperatures higher than the manufacturer's rated maximum temperature. Any reference to, or use of, the results from the tests described in this Appendix should be removed from the application. The Appendix itself may remain as supplemental information.

This information is needed to confirm compliance with 10 CFR 71.31(b).

Response:

The application will be revised to delete references to Appendix No. 4.5.1, but said appendix may remain in the application as supplemental information. Appendix 4.5.2 will remain as it addresses the analysis in accordance with NUREG/CR-6007 for cask closure bolting.

Chapter 5 – Shielding Evaluation

5.1 *Resolve staff's concern that the gamma source term is non-conservative for certain nuclides or provide additional information demonstrating that the dose calculations are conservative given some possible non-conservative assumptions.*

The application contains the following statement: "Particles with a relative probability of emission less than 0.001 are not included in the shielding model. Particles with low relative probabilities are eliminated and the emission probabilities of the remaining particles are normalized, so that these probabilities sum to unity."

The staff notes that this method is not necessarily conservative. In some cases, photons with very high energy are omitted. Although they have a low probability of emission, since they have high energy, they have a much higher probability of contributing to the dose rate outside the package. Rather than omitting these gammas, and increasing the probability of emission of all of the other lower energy gammas, the applicant should have increased the probability of higher energy, and more bounding, gammas.

The staff requests that the applicant provides additional and detailed information justifying that their gamma source term is conservative given this possible non-conservatism. The staff specifically requests that the applicant provides additional information for the following nuclides:

a. *Ir-192 – It appears as though the decay chain to Os-192 has been neglected. This is a relatively low probability decay (~4.7%); however, it contains a high energy gamma (~884keV). Justify that neglecting the Os-192 decay chain is conservative*

b. *Ho-166 – Several high energy gammas (1.6-1.8 MeV) are neglected. The staff realizes that these are very low probability; however, the staff believes that they may be a notable contributor to the dose. Justify the exclusion of these gammas in the shielding calculations.*

c. *Sb-124 – Several high energy gammas (on the order of 1 MeV or greater) are neglected. Separately these gammas have a very low probability but together comprise of about 5% of emissions and 0.1 gammas per decay. Justify the exclusion of the high energy gammas in the shielding calculation.*

d. *Sm-153 – Several of the higher energy gammas (~500-600 KeV) are neglected. The staff realizes that these are very low probability; however, the staff believes that they may be a notable contributor to the dose especially since the applicant does not have any bounding high energy gammas for this calculation. Justify the exclusion of these gammas in the shielding calculation.*

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

Response:

The shielding analysis has been re-performed for all isotopes based on this RAI. All isotopes have been explicitly modeled in the cask system based on discrete gamma energy and emission probability source terms extracted from the ORIGEN-ARP gamma spectrum library. All available gamma energies from the library have been considered in the shielding calculations. Total photon/decay values are also be calculated and utilized based on the information contained in the ORIGEN-ARP library.

Ir-192 is an exception to the above methodology because the ORIGEN-ARP defined source term for Ir-192 was found to be missing several high-energy gamma rays when compared to those values listed in the Table of Nuclides. For this reason, the more conservative spectrum resulting from the use of all of the energies available in the Table of Nuclides from the decay of Ir-192 into either Os-192 or Pt-192 is used to calculate the limiting dose rates for Ir-192 in the cask system. The total photons/decay value is calculated based on the sum of the total absolute probability of emission per decay from all energies listed in the Table of Nuclides.

When performing these shielding runs, all three dose points relevant to 10 CFR 71.47(a) and 10 CFR 71.51(a)(2) have been explicitly considered for all isotopes to allow for more consistency between isotopes and casks in the shielding methodology.

Section 5.1.2, Section 5.2.1, and Section 5.4.4.2 of the SAR has been updated based on this response.

5.2 Justify transient equilibrium conditions for Zr/Nb-95.

In Section 5.5.1 of the application, the applicant provides information justifying the number of photons/decay assumed for Zr/Nb-95. The staff understands that these nuclides are assumed to be in transient equilibrium. Before the system reaches transient equilibrium, the total system activity reaches a maximum.

Specifically, provide information on how the Zr/Nb-95 is ensured to be in transient equilibrium (i.e., what controls on the Zr/Nb-95 are in place to ensure that the sample has decayed enough to reach transient equilibrium).

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

Response:

The curie limit determined for Zr/Nb-95 in Chapter 5 has been applied to a total allowable amount of Zr-95 in a shipment. The only source of Nb-95 in a shipment comes from the decay of Zr-95. As this is the case, the maximum amount of Nb-95 relative to Zr-95 will occur when the system is in equilibrium. By assuming Nb-95 exists in equilibrium with Zr-95 in any shipment, the analyzed total system activity is maximized, even if the true system composition may not yet have achieved its peak activity. Figure 1 below demonstrates the conservatism and validity of this assumption on a per curie basis.

Section 5.5.1 has been updated to clarify the meaning and applicability of the Zr/Nb-95 limit.

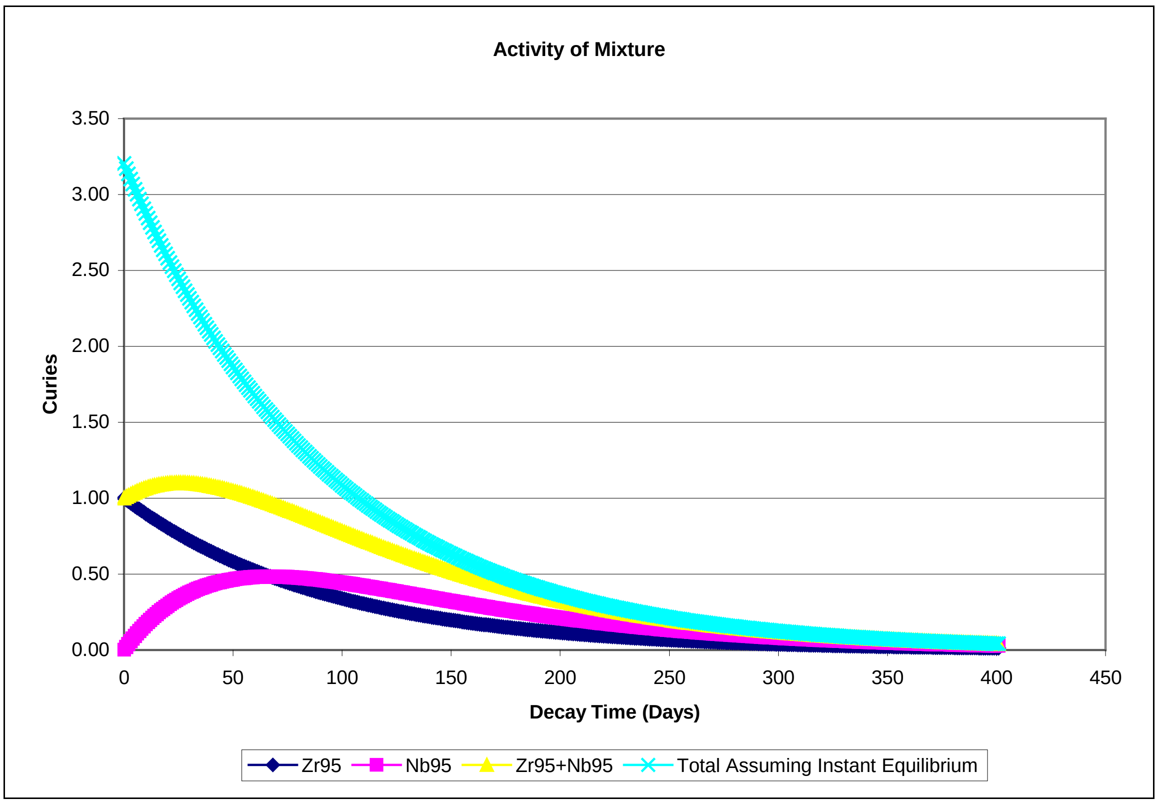


Figure 1 – Activity of Zr/Nb-95 Mixtures

5.3 Provide additional information to justify the use of the point source approximation.

A point source approximation is used to represent the geometry of the source material. The staff agrees that the point source can be limiting in that it eliminates self-shielding. Also, by placing it adjacent to the cavity wall, the distance to the detector is minimized and therefore the intensity of the emissions is maximized. However, the staff notes that, if the extent of the source is large with respect to the distance from the detector, then the point source approximation can be non-conservative. The angle at which the photons are emitted in a point source is isotropic. If the extent of source is large and a line source is used, it is possible for more photons to be seen by the detector (in comparison to a point source) via the angles at which they are emitted. It is generally accepted that the point source is a valid approximation as long as the distance to the detector is greater than three times the maximum source dimension.

Some examples of contents that may be shipped using the AOS packaging system are provided in response to a Request for Supplemental Information (RSI) from the staff, dated July 31, 2009. In the response to RSI 1-2, an example of a Co-60 source that has an extent of 16 inches is provided. With the dose points at the personnel barrier or closer, the length of this source would exceed the length that is thought to be acceptable for the point source approximation.

Further, the staff does not find that the explanation provided in response to RSI 5-2 adequately addresses these concerns.

Demonstrate that the point source approximation is always conservative as compared to any other source geometry for the AOS packaging system. Provide all calculations and sensitivity studies as needed.

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

Response:

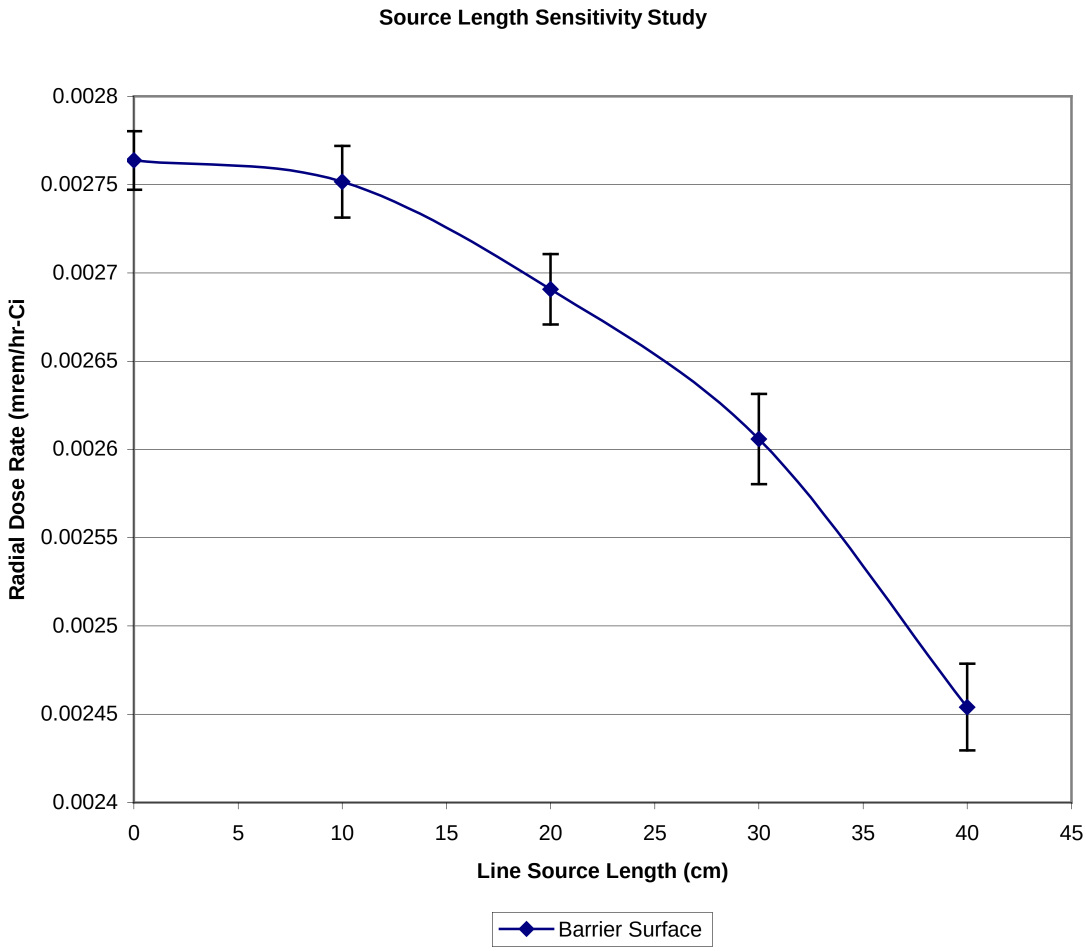
In cases where the true source geometry is long enough that it might be better represented by a line source, the error associated with the use of a point source may be large, but it will always be in the conservative direction. This general trend is demonstrated in the supplemental information provided by the review team, including the following websites:

http://www.radpro.com/JoeB.pdf

http://www.hps.org/publicinformation/ate/q4405.html

This was also found to be true in a sensitivity study with the AOS cask system. In this study, the AOS-100A cask with a point source emitting a cobalt spectrum was assumed as a baseline. This cask and isotope were selected as the base case to allow for the maximum source length to be studied in a system with tungsten shielding. The source length was modeled along the inner cavity wall such that it extended equidistant from the mid-plane of the cask while remaining as close to the radial dose points as allowable by the system. Variable lengths of the line source were assumed.

Results from the study are provided below:



This study demonstrates that the radial dose rate decreases at the personnel barrier surface, and thus allowable activity increases, as the length of an assumed line source increases in the AOS cask system. These results, in conjunction with the general trends presented in the provided references, demonstrate that the use of a point source in the AOS cask shielding analyses is conservative.

No change to the SAR has been made based on this RAI response.

5.4 Provide additional information to justify the use of the bounding energy approach.

The staff understands that the energy distribution of certain nuclides is used to bound the energy of other nuclides, as described in Section No. 5.4.4.1 of the application, "Maximum Source Strength Calculation." The staff agrees in principle with this approach, but requires additional information to justify this approach.

Two of the nuclides listed in Table No. 5-13 of the application (Se-75 and Sm-153) have higher energy gamma emissions than the nuclide listed as bounding. The staff understands that the average energy of the bounding nuclides is higher; however, since higher energy gammas have a much higher probability of penetrating the shield, they should not be neglected.

Provide additional information explaining how these nuclides were determined to be bounding despite neglecting the higher energy gammas.

This information is required by the staff to determine compliance with the requirements in10 CFR 71.47 and 10 CFR 71.51.

Response:

The bounding energy approach methodology has been removed from the SAR. All isotopes that previously used this methodology to establish source strength limits will be explicitly modeled in the cask system based on discrete gamma energy and emission probability source terms extracted from the ORIGEN-ARP gamma spectrum library. Total photon/decay values are also calculated and utilized based on information contained in the ORIGEN-ARP library.

Section 5.4.4.1 and Section 5.4.42 of the SAR has been updated based on this RAI response.

5.5 Clarify the use of the additional shielding for the Model Nos. AOS-100A, AOS-100A-S, and AOS-100B packaging systems.

For Co-60 shipments in the Model Nos. AOS-100A, AOS-100A-S, and AOS-100B packaging systems, Table No. 1-6 of the application states that the use of the axial shielding plates "may" be used for "large-quantity" shipments. The analysis presented in the shielding section for Co-60 takes credit for the presence of the axial shielding plates.

With the current analysis, the staff will specify in the CoC that these plates are required when shipping any amount of Co-60 in the Model Nos. AOS-100A, AOS-100A-S, and AOS-100B packages. If the applicant wishes to make the use of these plates optional for lower amounts of Co-60, the applicant shall provide an analysis without the shielding plates to demonstrate that a lower amount of Co-60 meets the dose rate limits specified in 10 CFR 71.47 and 10 CRF 71.51 for both Normal Conditions of Transport (NCT) and hypothetical accident conditions.

Otherwise, please modify the text in Table No. 1-6 to state that the use of the axial shielding plates "shall" be used for "all" shipments of Co-60 for the Model Nos. AOS-100A, AOS-100A-S, and AOS-100B packaging systems.

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

Response:

Table 1-2 has been modified to provide Co-60 limits for transport with and without axial shielding plates in the model AOS-100 cask systems.

5.6 Provide additional information demonstrating that the minimum distance to the personnel barrier is preserved during NCT.

The dose point for NCT is calculated at the personnel barrier. It is not clear to the staff that normal conditions of transport provide no deformation to the impact limiter or personnel barrier such that the minimum distance from the cask to the personnel barrier is preserved.

The staff requests additional information justifying that there will be no damage to these structures during NCT as stated in Observation 3 submitted with the Request for Supplemental Information (RSI) dated July 31, 2009.

In response to Observation 3, the applicant said that it will submit an analysis demonstrating that the impact limiter and the personnel barrier remain intact during NCT. The staff did not locate this information in the revised application. Please provide this information.

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

Response:

An evaluation of the personnel barrier has been performed to demonstrate that the barrier remains in place during NCT of transport. The details are found in Paragraph 2.5.3.1 "Analyses of Personnel Barrier and Personnel Barrier Fasteners" in the application.

Chapter 7 – Package Operations

7.1 *Add a statement in Section No. 7.3.5.2b of the application to indicate that the vacuum pump will be isolated from the package cavity during the 30 minutes when the package must remain below 1 Torr.*

If the vacuum pump is not isolated, then it can not be determined if the pressure rise limit is actually met since the valve could be leaking thus keeping the pressure low.

This information is required by the staff to determine compliance with 10 CFR 71.43(d).

Response:

The information previously presented in "Section No. 7.3.5.2b is now contained in Paragraph 7.1.3.2 (b) to which the suggested words were added as demonstrated below:

b. The vacuum source must be isolated after the pressure is 1 torr or less. The pressure within the cask cavity must remain at or below 1 torr, for at least 30 minutes.

7.2 *Add specific procedures for the Model No. AOS-100B, as appropriate, in the operating procedures.*

For example, but not limited to either the following note, "Note: unless indicated otherwise, all information related to the Model No. AOS-100A is also applicable to the Model No. AOS-100A-S" or to the title of Figure No. 7.3.

This information is required by the staff to determine compliance with 10 CFR 71.87.

Response:

The maintenance and operation of the AOS-100B is the same as Model AOS-100A. The only difference among these packages is the quantity of radioactive material allowed as contents, because the shielding material is selected for each design. The AOS-100A shielding material is tungsten alloy, while the AOS-100B is carbon steel. Therefore, the text in the referenced Note has been changed as follows and relocated to the end of the chapter introduction prior to Figure 7-1.

Note: Unless indicated otherwise, all information related to the Model AOS-100A is also applicable to Models AOS-100B and AOS-100A-S.

7.3 *Describe the temperature survey to verify that limits specified in 71.43(g) are not exceeded.*

According to 10 CFR 71.43(g), "A package must be designed, constructed, and prepared for transport so that in still air at 38°C (100°F) and in the shade, no accessible surface of a package would have a temperature exceeding 50°C (122°F) in a nonexclusive use shipment, or 85°C (185°F) in an exclusive use shipment." A temperature survey to verify that these limits have not been exceeded has not been described in the operating procedures, e.g., in Section No. 7.3.5.5.

This information is required by the staff to determine compliance with 10 CFR 71.43(g) and 71.87(k).

Response:

The design of the package has been demonstrated to meet the requirements of 10 CFR 71.43(g) in Table 3-4. In addition, the operating procedure has been modified to include the following operational step (step k) in 7.1.3.4 to confirm that these conditions continue to be met.

Step k does not need to be performed for routine shipments of the same payload, or after three (3) initial thermal surveys are conducted. From then on, step k should be conducted every ten (10) shipments.

Step k must always be conducted for shipments in which the content decay heat value is equal to or greater than 80% of the maximum authorized decay heat value. For this case, wait to conduct step k until two (2) consecutive readings taken five (5) minutes apart show a temperature difference of less than three (3) degrees.

k. Using a hand-held infrared thermometer or equivalent device, conduct a thermal survey for maximum temperature upon:

- All reachable surfaces of the cask, if any
- Impact limiters
- Personnel barrier
- Pallet or cradle

This step verifies that the requirements of Paragraphs 652 and 71.43(g) (References **[7.1]** and **[7.2]**, respectively) are met.

7.4 Describe proper marking and labeling of the package or the visual inspection of proper marking and labeling in the operating procedures.

According to 10 CFR 71.85(c), "The licensee shall conspicuously and durable mark the packaging with its model number, serial number, gross weight, and a package identification number assigned by NRC. Before applying the model number, the licensee shall determine that the packaging has been fabricated in accordance with the design approved by the Commission." The proper marking and labeling or the visual inspection of the proper marking and labeling of the *package has not been described in the operating procedures, e.g., in Section Nos. 7.3.5.5 or 7.3.1*.

This information is required by the staff to determine compliance with 10 CFR 71.85(c).

Response:

The package labeling required in 10 CFR 71.85(c) is described on the package certification drawing for each of the models.

In addition, the information previously presented in Section No. 7.3.5.5 is now contained in Paragraph 7.1.3.4, which includes operational steps e and f:

e. Verify that the lettering on the cask and impact limiter identification nameplates is distinguishable and conforms to the Packaging Certification drawing requirement. Re-stamp the lettering or replace the nameplate(s), if necessary.

f. Remove old shipping labels and apply new ones, based upon the proposed payload, meeting the requirements of Paragraphs 541 through 545 and/or 172.403 (References [7.1] and [7.8], respectively).

7.5 Describe any special actions to be taken if the tamper indicating devices are not intact and verify that tampering has not occurred in Section 7.4.1 of the operating procedures.

This information is required by the staff to determine compliance with 10 CFR 71.87.

Response:

The information previously presented in "Section No. 7.4.1 is now contained in Paragraph 7.2.1 which includes the following operational step:

a. Verify the integrity of the transport package's security seals. If seals are broken, indicating package tampering, isolate the transport package and immediately notify the site's Safeguard organization, then wait for their instructions. Otherwise, remove the security seal, by cutting the wires, and properly dispose of them.

7.6 Describe, in Section No. 7.4.2.2 of the application, the removal of the tamper indicating device as well as the appropriate method to open the package.

This information is required by the staff to determine compliance with 10 CFR 71.

Response:

The information previously presented in “Section No. 7.4.2.2 is now contained in Subsection 7.2.2, which deals with the removal of the content from the cask unit, and includes the following operational step:

b. Break the anti-tamper seal(s), if applied. In the event that the seal is broken, indicating tampering, isolate the cask and immediately notify the site’s Safeguard organization, then wait for their instructions.

7.7 Add a verification process, after operation 7.5.1(a)., to certify that the package is empty.

This information is required by the staff to determine compliance with 10 CFR 71.87.

Response:

The information previously presented in Subsection. 7.5.1 is now contained in Subsection 7.3.1, which includes the following operational step:

b. Gather the necessary information, per site procedure, so that personnel can certify the transport package is “empty.”

7.8 Correct the references to 10 CFR 71.10(b)(1) and to 171.87(i). Add compliance to 49 CFR 173.443 to Section No. 7.5.4 of the application.

The staff could not find either 10 CFR 71.10(b)(1) or 171.87(i) in 10 CFR Part 71. While staff assumes that the applicant meant 10 CFR 71.87(i), staff needs a clarification for 10 CFR 71.10(b)(1). The applicant has not referenced 49 CFR 173.443 in Section No. 7.5.4 to ensure external contamination control levels meet the requirements of 49 CFR 173.443.

This information is required by the staff to determine compliance with 10 CFR 71.87.

Response:

The information previously presented in Subsection 7.5.4 is now contained in Subsection 7.3.4, which deals with shipments of empty packaging. The reference to 49 CFR 173.428 as used in Section 7.3.4 incorporates by reference 49 CFR 173.443. Therefore, AOS believes that the following operational step is correct:

Decontaminate the external surfaces of the empty cask, to a level consistent with Paragraphs 520 [7.1] and 49 CFR 173.428 [7.3].

7.9 *Provide clarification that the package's contents in the CoC must be verified and that the required maintenance must be performed.*

Section No. 7.3.3 of the application lacks a description that would ensure that the package's contents were authorized in the CoC. In addition, an explanation including the verification of the required maintenance being performed is not provided.

This information is required by the staff to determine compliance with 10 CFR 71.87.

Response:

Section 7.1 "Package Loading" discusses the requirement of performing a Pre-Shipment Engineering Evaluation. The purpose of this Engineering Evaluation is to assure that the package, with its proposed contents, satisfies the applicable requirement of the package's license or certificate. The following is the wording from this Section:

Part of the transport package loading preparation is to perform a Pre-Shipment Engineering Evaluation following Paragraphs 502, 71.87, and 173.475 (References [7.1], [7.2], and [7.3], respectively). The evaluation is used to ensure that the packaging, with its proposed contents, satisfies the applicable requirements of the transport package's license or certificate. This evaluation includes, but is not limited to, the review of the following:

- Proposed contents' isotopic composition, quantities, and decay heat;
- Proposed contents' form, weight, and geometry. If the content is defined as "Special form," verify its certification from the competent authorities;
- Shielding requirements (use of additional shielding devices may be required for shipment);
- Structural requirements;
- Thermal requirements;
- Pressure requirements;
- Shipping hardware (liners, racks, dividers, baskets, shoring devices, and so forth);
- Maintenance records.

7.10 *Place Table No. 7-8, the table of bolt size and pre-torques for all of the models, located in Section No. 7.3.5.2, into the Loading of Contents section, found in Section No. 7.3.4.*

On page No. 7-17 of the application, Table No. 7-8 displays the bolt size and pre-torques for all of the models, However, this table should be placed in the "Loading of Contents" section, instead of the "Preparing Transport" section, to be in line with NUREG-1609.

This information is required by the staff to determine compliance with 10 CFR 71.87.

Response:

Former Table 7-8 is now Table 7-2 and is located in Paragraph 7.1.3.2 Securing the Cask Lid.

7.11 Provide clarification that an empty package would comply with 49 CFR 173.428, 49 CFR 173.443, and properly describe the closure requirements.

Section No. 7.5 of the application does not include a description of the package's closure requirements. In addition, an explanation demonstrating compliance with 49 CFR 173.428 and 49 CFR 173.443 is not provided.

This information is required by the staff to determine compliance with 10 CFR 71.87, 49 CFR 173.428, and 173.443.

Response:

The information previously presented in Section 7.5 is now contained in Section 7.3. Subsection 7.3.2 provides information on how to install and secure the cask closure lid. Subsection 7.3.4 addresses the compliance with 10 CFR 71.87, 49 CFR 173.428 and 49 CFR 173.443 (Also see RAI 7.8).

Chapter 8 – Acceptance Tests and Maintenance Program

8.1 Provide a physical comparison between the analytical model and the package used in the physical test (i.e., materials and gaps).

Section No. 8.1.7 of the application says that a thermal test was performed to evaluate the thermal analytical model. Yet there was no descriptive comparison between the analytical model and the package used in the physical test.

This information is required by the staff to determine compliance with 10 CFR 71.33 and 71.51.

Response:

The thermal test and reports are moved to Appendix 3.5.8, to be more consistent with Regulatory Guide 7.9. As requested, the introductory text is expanded to include a direct comparison of the analytical and test prototype models.

8.2 Justify the inconsistency between the maximum normal operating pressure in Table No. 3-3 and Section Nos. 7.3.5.3, 8.2.1.1 and 8.2.2 of the application. Describe steps, in Chapter 8 of the application, to monitor the cask internal pressure during leakage testing to ensure the design pressure for the Model No. AOS-25 has not been exceeded. Discuss the structural and containment effects over the life of the package and during HAC due to performing leakage testing at a pressure within 1% of the design pressure.

Table No. 3-3 states that the maximum normal operating pressure (MNOP) for the Model No. AOS-25 is 18 psia, while the MNOP for the Model Nos. AOS-50, AOS-100A/A-S, and AOS-100B, is 20 psia. Section No. 7.3.5.3 states that the cask cavity will be pressurized to 15 psia. Section No. 8.2.1.1 states that, as part of the leak test, the package is pressurized to 1 atmosphere above the background pressure of the cavity (that is equivalent to 29.4 psia), and Section No. 8.2.2 states that the cask cavity is pressurized to 15 psig (that is equivalent to 29.7 psia). The application should consistently report the maximum normal operating pressure throughout the application. If the maximum normal operating pressure is close to the design pressure as the case may be for the Model No. AOS-25, the applicant needs to describe steps to monitor the cask cavity pressure during leakage rate testing, and discuss the structural and containment effects over the life of the package and during HAC due to performing leakage testing.

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

Response:

Tables 4-6 and 4-7 present the resulting pressure in the cask cavity under NCT and HAC for each model of the AOS Transport Packaging System. They also provide the design pressure for each of the AOS Models. The information in these Tables has been reviewed and updated.

The Design Pressure column incorrectly showed values in psig, but was labeled as psia. With the data corrected in units of psia, the margins are increased for all models. For the AOS-025, the margin is now approximately 40%. Therefore, the concern is no longer considered an issue.

8.3 *Provide justification for not performing thermal acceptance and/or maintenance tests to verify the heat transfer characteristics and predicted temperature profiles of fabricated Model Nos. AOS-25, AOS-50, AOS-100A, AOS-100A-S, and AOS-100B packages.*

In Section No. 8.1.7 of the application, the applicant should justify not performing thermal acceptance testing on the Model Nos. AOS-25, AOS-50, AOS-100A, AOS-100A-S, and AOS-100B packages. The thermal acceptance test of a package can provide an indication of the quality and accuracy of manufacturing and the thermal evaluation of the package.

In Section No. 8.2.5 of the application, the applicant should justify not performing thermal maintenance testing on the Model Nos. AOS-25, AOS-50, AOS-100A, AOS-100A-S, and AOS-100B packages. The thermal maintenance test of a package can provide an indication of package aging during the service life of the package. The staff recognizes that the applicant stated the packages are constructed of material that will not degrade over normal conditions of transport.

An adequate justification should be provided for not performing thermal acceptance and maintenance tests. The justification should consider uncertainties in calculations, fabrication, accuracy, and the influence of gaps in heat transfer performances, thermal margins, and package aging.

This information is required by the staff to determine compliance with 10 CFR 71.85(a) and 71.87(b).

Response:

The test is conducted upon the first model produced of each of the AOS Transport Packaging System. The thermal test results are then compared with the results of the analytical procedure. Temperature variations are acceptable, as long as the test results are within 15% of the values predicted by the analytical model. Refer to Subsection 8.1.7 Thermal Test of the SAR for additional details. Ongoing temperature monitoring is conducted as described in Section 7.1.3.4, Step k, therefore any degradation of the temperature profile of the package will be detected.

8.4 *Provide a more detailed description of the fabrication leakage test performed for the package body, conducted separately from the acceptance test for the package seals.*

Section No. 8.1.4 does not provide a clear description of the fabrication leakage test (done in addition to the hydrodynamic pressure test) for the AOS package body. Additional details, including the test criteria, should be provided.

This information is required to show compliance with 10 CFR 71.51(a).

Response:

Subsections 8.1.3 and 8.1.4 are revised to provide a clear and concise description of the leak test procedure performed during fabrication. The leak test is performed first to determine that there are no leaks present. Subsequently, the hydrostatic pressure test is performed to verify the integrity of the containment boundary.

Editorial

E-1 Move “Weight” values from Table 3-1 to a more appropriate section of the application (i.e., Chapter 1 or Chapter 2).

Response:

The weight values from Table 3-1 will be incorporated into more appropriate section(s) of the revised application, as suggested.