Alpha-Omega Services, Inc.

AOS CASK SAR RAI's

January 18, 2011

AOS

Introduction

RAI Action Plan:

- NRC December 2010 RAI responses
- The projected completion Schedule to complete the RAI response/approach
- NRC to Discuss their Structural RAI's

AOS

Request for Additional Information

RAI 1:

Table 1-2:

- Clarify in Table 1-2 the Ci/Watt values for Co-60 and Sr/Y-90. Also clarify the activity values for Sr/Y-90, the activity values in Ci and TBq for that radioisotope do not appear to be equivalent. This RAI is a follow-up to the first round RAI 3-6 response.
- The Ci/Watt values for Co-60 and Sr/Y-90 have changed from Rev. C of the application. The activity values in Ci and TBq for Sr/Y-90 are not equivalent.

AOS RAI 1 Response:

- Question understood, no further explanation required.
- The values for Co-60 and Sr/Y-90 were rounded to 1 significant figure in Table 1-2. The SAR will be revised to have 3 significant figures to be consistent with the other isotopes.

AOS

Request for Additional Information

RAI 2:

Drawings:

- Correct the inconsistency in gross weight values on the nameplates and note 3 in Licensing Drawing No. 166D8142, sheet 2, and No. 166D8143, sheet 2. Similar inconsistencies also appear to exist for the Model Nos. AOS-50 and AOS-100 packages. This RAI is a follow-up to the first round RAI 1-12 response.
- The weight listed on any nameplate should be the package weight (packaging, contents, and impact limiters). It appears that Licensing Drawing number 166D8142, sheet 2 lists the AOS-25 package weight as 168 pounds (packaging, contents, and impact limiters) on the nameplate and note 3, while Licensing Drawing number 166D8143, sheet 2 lists the AOS-25 package weight as 140 pounds (packaging without impact limiters, and contents). While Licensing Drawing number 166D8143 does not show the impact limiters, the weight on the nameplate should include the impact limiters and note 3 should be consistent with the nameplate.

AOS RAI 2 Response:

- Question understood, no further explanation required.
- The name plate is to be used for information on the cask. It is not intended to meet marking requirements for the package. The weight is the proper weight for the cask and contents (excluding the impact limiter), and is intended to assure that personnel have proper values for lifting and rigging of a cask. The nameplates will be removed from the certification drawing.

AOS

Request for Additional Information

RAI 3:

Drawings / Section 3.2.2 / Tables 3-3 and 3-4 / Thermal Models / Chapter 4 :

- Ensure the quality category is correct for each of the containment boundary seals.
- Ensure temperatures are being provided for the correct containment boundary seals and all containment boundary seals.
- Ensure the locations in the thermal models for the containment boundary seals are correct.
- Ensure the above is in agreement with Chapter 4 of the application. Clarify if the copper alloy seals that are mentioned in Section 3.2.2 of the application are containment boundary seals.
- This RAI is a follow-up to the first round RAIs 1-1 and 4-2 responses. For example, in drawing 105E9712 for the AOS-100 item numbers 30 and 31 are Category A copper seals, while item numbers 19 and 29 are silicone and Category B. From the SAR Figure 4-1 it appears to the staff that the applicant is stating item numbers 19 and 29 are the containment boundary seals, which is in contrast to the Category B quality category given in drawing 105E9712. Looking further at the vent port in the thermal chapter, it appears that the applicant is pulling a temperature from detail X in the lid area of drawing 105E9712 sheet 3. This also doesn’t appear to be in agreement with SAR Figure 4-1.

AOS

Request for Additional Information

RAI 3 (continued):

Drawings / Section 3.2.2 / Tables 3-3 and 3-4 / Thermal Models / Chapter 4:

- As far as the staff can tell in the thermal chapter and on the licensing drawings the applicant has switched the labeling of the vent port and test port. This appears to be the case for all AOS models, not just the AOS-100. Finally, if the copper alloy seals are not part of the containment boundary, they should be removed from Section 3.2.2. If there are containment boundary seals that are not mentioned in Section 3.2.2, they should be mentioned in that section and their peak temperatures should be provided in Tables 3-3 and 3-4. The drawings quality category and seal location for the containment boundary seals, the seal temperatures provided in Chapter 3, the seal temperature locations from the thermal model, and the containment boundary seals in Chapter 4 of the SAR should all be in agreement. The applicant needs to present a clear understanding of the containment boundary location and its components throughout the entire application.

AOS RAI 3 Response:

- RAI understood, no further explanation is required.
- We will review the temperatures and assure they are properly used in Chapter 4.
- Items associated with the containment boundary will be Safety Category A.

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Request for Additional Information

RAI 4:

Table 2-6:

- Confirm that the correct temperatures per Regulatory Guide 7.8 for load case 111 in Table 2-4 of the application are being used. Also confirm that the temperatures from the latest thermal models as reported in the SAR have been used when required for all stress analysis load combinations.
- Because there are two thermal load cases with the designation number 111 for each AOS model (for example lc111-t1-mf.025 and lc111-t2-mf.025 for the AOS-025), confirmation that the temperatures from the lc111-t2-mf.XYZ thermal model at the end of the thirty minute fire are being used in the subsequent load combination 350 is needed. It appears that some of the thermal input files were created after the stress analysis was run. It seems that the AOS-25 thermal input files were created on 9/14/2010 and the AOS-50 thermal input files were created on 6/27/2010, while the stress analysis output files appear to have been created between 6/3/2010 and 6/6/2010. Confirmation is needed to determine if the latest thermal models have been used when required for the stress analysis. If confirmation cannot be provided, the stress analysis should be rerun with temperatures from the latest thermal models.

Request for Additional Information

AOS RAI 4 Response:

- Question understood, no further explanation required.
- The analyses were performed in the proper order. During review and verification some files had comments incorporated which changed the file creation date. Therefore, it appears that thermal files were created prior to the stress files. We will review and confirm that only comments, not data, were changed in the files that appear to be out of order.

AOS

Request for Additional Information

RAI 5:

Table 3-3 and 3-4:

- Provide a clear reference for the seal temperature limit of 572°F that appears in Tables 3-3 and 3-4 for the silver jacketed HELICOFLEX seal. This RAI is a follow-up to the first round RAI 3-8 response.
- The origin of the 572°F rated seal temperature should be clearly stated in the application.

AOS RAI 5 Response:

- Clarification requested. Are there particular items that the NRC would like to see in the reference? Is the NRC looking for a rational other than it was the temperature the vendor had data to support for an upper limit?
- Manufacturer data obtained to validate seal temperature limits and support the determination of 572°F as the control temperature.
- Thermal tests were performed to address the performance of the seal construction materials and can be provided

AOS

Request for Additional Information

RAI 6:

Section 3.2.1.5:

- Justify the validity of the simplified approximation of increasing the impact limiter foam density and thermal conductivity based on reduced impact limiter volume due to HAC deformation without actual foam crush data. This RAI is a follow-up to the first round RAI 3-24 response.
- The applicant made simplified assumptions on the density and thermal conductivity of the impact limiter foam based on the reduced volume of the impact limiter due to the HAC deformation. These assumptions must be justified with a demonstration that the approximation is bounding for the actual behavior of the foam when it is crushed.

AOS RAI 6 Response:

- Question understood, no further explanation required.
- When the material is crushed the density increases. Because information is not available at every density, interpolations are made between the available data points. This method was suggested by the manufacturer and appeared to be a reasonable engineering solution. To further analyze the result we will perform sensitivity calculations around the values used to assure the results do not challenge limits.

AOS

Request for Additional Information

RAI 7:

Table 3-12 :

- Editorial: Correct the heat flux shown in Table 3-12 for the AOS-25.
- In Table 3-12, the decay heat divided by the cavity area is not equal to the heat flux that is provided in Table 3-12 for the AOS-25.

AOS RAI 7 Response:

- Question understood, no further explanation required.
- Will check input data. Confusion may be due to use of mixed units such as Watts and in2. Will also provide a detailed example that shows full unit analysis.

AOS

Request for Additional Information

RAI 8:

Sections 3.3.3 and 3.4:

- Describe and justify how the current thermal models capture the thermal performance of the impact limiters, specifically with respect to the inside ribs that appear in the engineering drawings and their effect on peak temperatures of components such as containment boundary seals.
- The thermal models of the impact limiters for the AOS-25, AOS-50, and AOS-100 appear to only consist of the impact limiter foam and the stainless steel outer shell of the impact limiters. In the engineering drawings there is a significant number of stainless steel inside ribs that have not been thermally modeled. Describe the affect of the impact limiter ribs on peak temperatures of components such as containment boundary seals. This may be best addressed by determining the AOS model where the impact limiter ribs would have the largest effect on seal temperatures and then modifying that thermal model to include the inside ribs as part of a sensitivity study.

AOS RAI 8 Response:

- Question understood, no further explanation required.
- It was assumed that the ribs would add little conductivity through the foam, and therefore were not included in the analysis. We will perform additional analyses which model the ribs to better quantify our analysis.

AOS

Request for Additional Information

RAI 9:

Section 3.4.6:

- Provide an explanation for the decrease in temperature of the lid plug and the cavity shell peak temperatures during the first five to 20 minutes of the fire that can be seen in Figures 3-18, 3-45, 3-72, and 3-97 of the application.
- This is a phenomenon that is somewhat unexpected considering the boundary temperature has increased from 100°F to 1475°F. Noting that the air gaps within the package have been closed during the fire makes the phenomenon more realistic. Justification of the behavior should be provided in Section 3.4.6 of the SAR.

AOS RAI 9 Response:

- Question understood, no further explanation required.
- The phenomenon in question caused by increased conductivity due to gap closures for fire condition. The closed gap is a conservative assumption during the fire period to increase heat flow. There is a brief period following closure when conductivity is increased due to gap closure, and fire heat has not yet reached the plug component.

AOS

Request for Additional Information

RAI 10:

Sections 3.4, 3.5.4.2.3, and 3.5.4.2.5:

- Provide a single thermal analysis of the worst-case post-accident condition of the package. The post-fire orientation and boundary conditions should be realistic based on the drop event. In addition, clarify if the “Side crush” that appears in Figures 3-124 through 3-126 is referring to side drop damage of the package. The thermal analysis should also include any crush and puncture damage which has been requested to be addressed in RAIs 2-XX and 2-XX of this package. This RAI is a follow-up to the first round RAI 3-25 response.
- Figures 3-124 through 3-126 of the SAR show all drop effects modeled simultaneously. The applicant should justify the one HAC drop that results in highest component temperatures and only model the effects of that drop. The worst case orientations (post-fire) should also be justified (i.e. vertical or horizontal) and boundary conditions should be realistic based on the drop event. Section 3.5.4.2.5 provides a sensitivity study for 50% drop deformation versus 100% drop deformation. The consideration of 50% drop deformation is not consistent with providing a single thermal analysis of the worst-case post-accident condition of the package…

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Request for Additional Information

RAI 10 (continued):

Section 3.4, 3.5.4.2.3, and 3.5.4.2.5:

- …The staff recommends removing Section 3.5.4.2.5 and applying 100% deformation for the one HAC drop that results in the highest component temperatures and only model the effects of that drop. Crush and puncture damage, if present, should also be included in the thermal models which has been requested to be addressed in RAIs 2-XX and 2-XX of this package.

AOS RAI 10 Response:

- Clarification requested. We combined damage results from different drop configurations. Should we stick with one configuration which would have less overall damage? We had no punctures of the over pack with the three 30 foot drop cases.
- Additional analysis will be performed or additional explanation will be provided to address these concerns once fully understood.

AOS

Request for Additional Information

RAI 11:

Section Sections 3.5.4.4.1 and 3.5.4.4.2:

- Justify the use of the equation for equivalent convection due to radiation in Sections 3.5.4.4.1 and 3.5.4.4.2 of the application for air gap number 5 for all thermal models. This RAI is a follow-up to the first round RAI 3-16 response.
- The equation given in Sections 3.5.4.4.1 and 3.5.4.4.2 is hr = S*F*4*T3 which makes the approximation that the temperature on both sides of the air gap is the same. The air gap number 5 in all thermal models has a rather large temperature difference across the air gap, up to 242.2°F during the AOS-25 post-fire as is seen in Table 3-97. If the use of the equation cannot be justified, an alternative method for modeling the radiative heat transfer across the air gap should be provided and the thermal models, temperature plots, peak temperatures should be updated accordingly.

AOS RAI 11 Response:

- Question understood, no further explanation required.
- Additional calculations have been performed and will be provided that demonstrate the radiation approximation used in the SAR is appropriate even for large temperature differences.

Request for Additional Information

RAI 12:

Section Sections 3.5.4.6:

- Editorial: Correct the equation for Tf in Section 3.5.4.6 of the SAR.
- The equation in Section 3.5.4.6 of the SAR should be $T_f = (T_w – T_b) / 2 + T_b$. The staff notes that the values for Tf in Table 3-121 of the SAR are from this equation and the values are correct.

AOS RAI 12 Response:

- Question understood, no further explanation required.
- The Tb was inadvertently removed and will be replaced in an update to the SAR.

AOS

Request for Additional Information

RAI 13:

Section Sections 3.5.6:

- 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 3.5.6 of the application. This RAI is a follow-up to the first-round RAI 3-31 response.
- Regarding the response to RAI 3-31, the applicant has chosen to not perform a thermal analytical model containing the radioactive contents, basket, or removable shielding, but has instead chosen to continue to apply a uniform decay heat to the cavity walls. The applicant has therefore not predicted temperatures for the radioactive contents, basket, or removable shielding. The staff believes that the cask cavity predicted temperatures using an applied uniform decay heat, underestimates the temperature of the contents in the cask cavity (radioactive contents, basket, and removable shielding). This was demonstrated in the physical test where higher temperatures were observed in thermocouples 1 and 2 which were located inside the cask cavity during the physical test. The applicant stated in the RAI response that this was due to the fact that the heat was applied to the center of the cavity.
- All types of contents in each package need not be modeled; instead the applicant should evaluate the most bounding contents and determine that the performance of the package is acceptable with those contents. This should include an evaluation of predicted temperatures, MNOP, and HAC cavity pressures

AOS RAI 13 Response:

- Clarification/discussion requested.

AOS

Request for Additional Information

RAI 14:

Table 4-1:

- Clarify how the five rows of “Temperature change” values were arrived upon. Also address why an ambient temperature of 1475°F was not included in the table. If any changes to Table 4-1 of the application potentially results in changes to the lid attachment bolt analysis, the analysis and results should be updated.
- It is not clear how the five rows of temperature change values were arrived upon; the values do not appear to match up with thermal model temperature changes across surfaces or temperatures of surfaces. The staff also notes that if the values are temperature changes, a delta T of 80°C is not equal to a delta T of 176°F. It is also not clear to the staff why an ambient temperature of 1475°F was not included in the table.

AOS RAI 14 Response:

- Temperature values were derived from our analyses, selecting the appropriate nodes in the model. We can provide additional detail if necessary.
- Delta-T unit conversion will be corrected. These are deltas.
- Pre-load encompasses what is needed to survive the accident condition. Based on Regulation CR-6007 Section 4.5 Page 14, we don't account for the fire heat load (1475°F).

AOS

Request for Additional Information

RAI 15:

Section 7.1.3.4:

- Ensure every package for shipment undergoes a temperature survey to verify that limits specified in 71.43(g) are not exceeded. This RAI is a follow-up to the first round RAI 7-3 response.
- Based on NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material," Section 7.5.1.3, every package for shipment undergoes a temperature survey to verify the limits specified in 71.43(g) are not exceeded. Section 7.1.3.4 of the SAR states: "Note: Step k does not need to be performed for routine shipments of the same payload, after three (3) initial thermal surveys are conducted. From then on, step k should be conducted every 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." does not appear to follow the guidance provided in NUREG-1609.

AOS RAI 15 Response:

- Question understood, no further explanation required.
- Paragraph 7.1.3.4 of the SAR will be updated to reflect that every package for shipment undergoes a temperature survey to verify temperature limits are not exceeded.

AOS

Request for Additional Information

RAI 16:

Section Table 8.5 and Section 3.3.1:

- Justify how the thermal analysis parameters for the LAST-A-FOAM provide bounding peak temperatures when the material tests described in Table 8.5 allow for +/- 15% or 20% tolerance from thermal parameter nominal values. Table 8.5 also shows only one nominal value for LAST-A-FOAM density and thermal conductivity, clarify if the material test will be performed for each density and respective thermal conductivity of LAST-A-FOAM used.
- Table 8.5 shows that the material testing of LAST-A-FOAM allows for +/- 15% tolerance from the nominal density value, +/- 15% tolerance from the nominal thermal conductivity value, and +/- 20% from the nominal specific heat value. The LAST-A-FOAM density and thermal conductivity values used in the NCT analysis are nominal values or are based on nominal values for the HAC analysis which may not be providing the maximum temperatures based on the allowable tolerance for the LAST-A-FOAM material tests. This should be addressed in Section 3.3.1 of the application. If it cannot be justified, the NCT and HAC models should be rerun with the bounding LAST-A-FOAM parameters and peak temperatures should be updated. The staff also notes that only one nominal value for LAST-A-FOAM density and thermal conductivity was provided in Table 8-5. The staff needs clarification if the material test will be performed for each density and respective thermal conductivity of LAST-A-FOAM shown on the engineering drawings. This should be addressed in Table 8-5 of the application.

AOS

Request for Additional Information

AOS RAI 16 Response:

- Nominal values for materials properties and dimensions are typically used in thermal and structural analyses for Code applications, considering that safety margins included in the Code allowable values accounts for typical uncertainties. This was the approach utilize here.
- As noted in the first column in Table 8-5, properties are tested for either each batch or each pour, which is applicable to each cask size as well.

AOS

Request for Additional Information

RAI 17:

Section 8.1.7:

- Justify how the first fabricated packages used in the thermal test, as shown in Figure 8-1 of the application, will demonstrate the heat transfer capability of the packages as shown in the engineering drawings. Clarify if new thermal analytical models will be created to compare the predicted temperatures to the thermal test temperatures. This RAI is a follow-up to the first round RAI 8-3 response.
- The purpose of the thermal test is to demonstrate the heat transfer capability of the packaging and that the heat transfer performance determined in the evaluation is achieved in the fabrication process. There are clearly some differences between the AOS models shown in the engineering drawings and the thermal test model shown in Section 8.1.7 (no impact limiters or lid plug). The applicant should address that the majority of fabrication gaps have been captured by the thermal test model as shown in Figure 8-1 and in conjunction with the material tests for the impact limiter foam, the heat transfer performance of the packages will be demonstrated. Clarify in Section 8.1.7 if new thermal analytical models will be created to compare temperature predictions with the results of the thermal tests.

AOS

Request for Additional Information

AOS RAI 17 Response:

- Question understood, no further explanation required.
- Post fabrication of each AOS Model, a thermal test will be conducted (reference Subsection 3.5.7). The test configuration of the packaging will be modeled using finite analysis techniques and results compared against the analytical results, documented in Appendix 3.5.7 of the SAR.

AOS

Request for Additional Information

RAI 18:

Section 4.1:

- Provide a revised description in Section 4.1.1 and a correct illustration of the containment boundary, in Figure No. 4-1, for the AOS series of packages.
- The description of the containment boundary is not clear, nor is the illustration in the current Figure 4.1 correct. The staff considers the containment boundary of the package to be the actual physical boundary including cavity walls, ports, and O-rings along (or against) which a particle might travel if attempting to escape from the package. This includes any boundaries that the particle might encounter preventing it from being released. Lid bolts which are used to attach the lid to the cask cavity are not generally considered part of the containment boundary. The actual boundary should be highlighted. An "outline" of the boundary is not acceptable.

AOS RAI 18 Response:

- Clarification requested. Are the concerns at the gaskets, the large surfaces (such as the surface of the cavity), and/or both?
- Application will be revised to provide additional information on the containment boundary and the associated illustration. To facilitate this discussion a 3-D rendering will be brought to the meeting. We will discuss with the NRC how to best show the boundary so that it is more apparent.

AOS

Request for Additional Information

RAI 19:

Section 4.2:

- Define the terms “Primary Vessel” and “Structural Shell” and revise Table 2-8 to clearly indicate the relation of the components listed in the table to the components and features of the AOS series of packages.
- In Table 2-8, the terms “Primary Vessel” and “Structural Shell” are used in the “Containment” and “Other Safety” categories, respectively. These terms appear nowhere else in the entire SAR. It is not clear what components of the AOS transportation packages these terms apply to. This must be clarified in order for the reviewers to determine what components the underlying codes mentioned in Table 2-8 apply to.

AOS RAI 19 Response:

- Question understood, no further explanation required.
- The terms here were directly copied from the regulation guide without changing the nomenclature to be consistent with the SAR. The table will be updated to be consistent with the rest of the SAR. (Ref. NUREG/CR-3854 Table 4.1, Fabrication Criteria Based on the ASME Code.)

AOS

Request for Additional Information

RAI 20:

Section 4.3:

- Provide clarification of Section 4.4, which states the section “describes the leakage test used to demonstrate that the AOS transport packages meet the containment requirements of 10 CFR 71.51” yet does not provide this description.

AOS RAI 20 Response:

- Question understood, no further explanation required.
- Application will be revised such that Section 4.4 properly referenced the corresponding subsection in Chapter 7 - Operating Procedures and Chapter 8 - Maintenance, which deal with leakage test.

AOS

Request for Additional Information

RAI 21:

Modify the following sections of SAR Chapter 7 “Package Operations” per the descriptions provided below:

- Section 7.1.1.1.d. (and following) – the term “Job Supervisor” is not a widely used nor understood term, and may not apply to all users of the AOS transport system. Provide a definition of this term, or use a more applicable generic term.

AOS RAI 21 Response:

- Question understood, no further explanation required. The Job Supervisor is the person responsible for direct oversight of people who are actually performing the work. This definition shall be incorporated into the SAR.

RAI 21 (Continued):

- Section 7.1.3 – the sequence of the placement and securing of the cask lid, especially when the cask is loaded underwater, is not clear. Specifically, it is not clear if the lid is placed on the unit and secured (lid bolts tightened) while it is still submerged or if this is done after the unit is removed from the water. It is also unclear what steps are taken to remove water from the threaded holes in the cask lid flange.

AOS RAI 21 Response:

- Clarification will be provided.

AOS

Request for Additional Information

RAI 21 (Continued):

Figure 7-4 – State whether this figure represents the actual vacuum drying system that is expected to be used for the AOS transportation system. It is not clear what a “Typical Vacuum Drying System” means in this case. In addition, this figure is of poor quality and difficult to read.

AOS RAI 21 Response:

- Figure 7-4 illustrates a typical vacuum drying system which draws vacuum and measures pressure conditions. The subject figure will be revised to improve legibility.

RAI 21 (Continued):

- 7.1.3.3 – This section is titled “Assembly Verification Leak Testing”; however, it describes a pre-shipment leak test. This does not coincide with the term used in Table 8-1 Acceptance Test Matrix, which lists a “Containment at assembly” verification test. Clarification of the terminology is requested. In addition, the section does not provide acceptance criteria for the pre-shipment leak test. This should be added.

AOS RAI 21 Response:

- The abovementioned terms will be reviewed and made to be consistent.

AOS

Request for Additional Information

RAI 21 (continued):

- 7.1.3.3.a. – Provide a justification for the use of a thermal conductivity sensing instrument for leak testing. Leak testing using a "thermal conductivity sensing instrument" is not a standard industry practice. It is not clear that this method is appropriate for the pre-shipment testing of the package to the required sensitivity.

AOS RAI 21 Response:

- We are referring to the method used but will clarify the reference to the "low-vacuum" thermal conductivity helium leak test unit.

RAI 21 (continued):

- 7.2.2.a. – The "site's Safeguard organization" is not a widely used nor understood term, and may not apply to all users of the AOS transport system. Provide a definition of this term, or use a more applicable generic term.

AOS RAI 21 Response:

- Subsection 7.2.2.a will be amended to include a definition for Safeguards organization as the organization or person at the facility responsible for maintaining an inventory of radioactive material.

AOS

Request for Additional Information

RAI 22:

Containment:

- Clarify statements made in Section 8.1.4 “Leak Tests,” regarding AOS package leak test procedures meeting the ANSI N14.5-1997 standard
- The statement “The leak test procedure meets the ANSI N14.5-1997 standard” is made followed by a general description of the leak tests conducted before first use, after its third use, and every 12 months thereafter, on the AOS series of packages. The statement cannot be verified, given that detailed leak-test procedures are not provided nor is a description of the how the proposed “leak test procedure” specifically meets ANSI N14.5.

AOS RAI 22 Response:

- Clarification requested. Is the NRC looking for commitments to particular portions of the standard?
- The leak test procedure will be expanded to clarify the applicability to ANSI N14.5-1997 standard.

AOS

Request for Additional Information

RAI 23:

Containment:

- With regards to Section 8.2.2. “Leakage Tests,” define a “Routine” leak test and compare that to a “pre-shipment” leak test. Clearly state that this test is conducted prior to each shipment of an AOS package.
- It is not clear from the description provided in Section 8.2.2.a that the test described is conducted prior to each shipment of any of the AOS series of packages.

AOS RAI 23 Response:

- Question understood, no further explanation required.
- In the SAR, pre-shipment and routine are synonyms. The SAR will be updated to only use the term pre-shipment.

AOS

Request for Additional Information

RAI 24:

Drawings:

- Make the following corrections and changes to the certificate drawings (see tables below), and modify Table 2-17 to precisely match the information in the drawings.
- All components with safety classification A or B must have at least one material specified by a national consensus standard and the corresponding material grade or type. For example, ‘300 series stainless steel’ is not an acceptable material designation, but ASME SA-240/ASTM A240 Type 304 is acceptable.

AOS RAI 24 Response:

- Question understood, no further explanation required.
- The specification for all safety classification A and B materials will be provided.

AOS

Request for Additional Information

RAI 25:

Materials

- Provide the detailed chemical characteristics, physical characteristics, location, and configuration of the contents of the AOS Transport Packaging System, and indicate whether the contents will be Special form or normal form. This RAI is a follow up to the first round RAI 1.2 and 2.8 responses.
- The chemical and physical form shall include density and moisture content. The location and configuration of the contents within the packaging shall include secondary containers, wrapping, shoring, and other materials not defined as part of the packaging.
- The staff needs to know precisely what the content materials consist of (as listed above) in order to determine if the 1000°F temperature limit is bounding for all contents that will be transported in the AOS Transport Packaging System, and to determine if any materials will be subject to chemical, galvanic, or other reactions, including the generation of combustible gases.
- Section 2-10 indicates that Special form material does not apply for the AOS Transport Packaging System, but Table 1-3 indicates that Special form material is a possible content of the cask. If Special form is a content of the AOS Transport Packaging System, a note indicating: "current Certificate of Compliance, as Special form, required" must be added to Table 1-3.

AOS RAI 25 Response:

- Clarification/discussion requested.

AOS

Request for Additional Information

RAI 26:

Materials:

- Provide manufacturer data for the design operating range of the lid seals Helicoflex H-309854, H-309852, and H-309850. Provide a complete description of the silver and Alloy 90 materials used in the seals, and correct the AOS-100 cask certification drawings and part lists to accurately indicate the lid seal materials. This RAI is a follow up to the first round RAI 4.1 response.
- The lid seal references provided could not be found on the manufacturer's website, thus no information regarding the operating range of the seals was found. The materials composing the lid seal are not adequately defined: a complete description of the materials including composition and temperature dependent thermal and mechanical properties must be provided for the entire design temperature range.

AOS RAI 26 Response:

- Question understood, no further explanation required.
- The thermal and mechanical properties for the construction materials of the Helicoflex seals are not available for the entire packaging design temperature range; hence, thermal test were performed to address the performance of the seal construction materials.

Request for Additional Information

RAI 27:

Structural/Materials:

- Correct the cylinder radius and the calculated buckling critical force in Table 2-2, and correct the Young modulus values in note (b) to table 2-2. This RAI is a follow up to the first round RAI 2.1 response.
- The cylinder radii reported for AOS-050 and AOS-100 are erroneous, they should be 7.0 in. and 14.0 in., respectively. This correction results in a corrected critical buckling force of 2.184e6, which is lower than the 2.78e6 reported. Furthermore, there is a factor of 10 error in the Young modulus values provided in note (b) to Table 2-2. Assess the impact of these corrections on the analyses and calculations presented in the SAR, update the analyses and calculations of the SAR as required, and address any inconsistencies in the SAR as a result of these corrections.

AOS RAI 27 Response:

- Question understood, no further explanation required.
- For the AOS-025 the outside radius rather than the radius to the median surface was incorrectly listed on Table 2-2, 3.5" rather than 2.75". Using the correct radius would result in a buckling critical stress of 2.78E6 psi. Using the outside radius would produce a result of 2.18E6 psi. The lower result is still over 1 million psi, and therefore does not change the conclusion that buckling is not a factor.

AOS

Request for Additional Information

RAI 28:

Materials/Code and Standards:

- Clarify and justify which codes and standards are applicable for the design, fabrication and testing of the AOS Transport Packaging System, in Table 2-8.
- For components of the ‘other safety’ group, the referenced B&PV code section is Section III, Division 1, Subsection NG, but several NF code subsections are then referenced below in the same table. Clarify and justify the use of either NF or NG code subsections

AOS RAI 28 Response:

- Clarification/discussion requested.
- Designation of the ASME code sections to the system components were based on NUREG/CR-3854.

AOS

Request for Additional Information

RAI 29:

Justify the use of the mean coefficient of thermal expansion instead of the instantaneous coefficient of thermal expansion in Tables 2-9, 2-10, 2-12.

Table TE-1 in ASME Code Section II, Part D, provides three different values for the thermal expansion coefficient for each material group: instantaneous, mean, and linear (columns A, B, C respectively). Justify the use of the mean instead of the instantaneous coefficient of thermal expansion. If the thermal expansion coefficients are changed, assess the impact of these changes on the analyses and calculations presented in the SAR, update the analyses and calculations of the SAR as required, and address any inconsistencies in the SAR as a result of these changes.

AOS RAI 29 Response:

- Question understood, no further explanation required.
- Because our analysis is taken from room temperature, the change in temperature (delta T) should be multiplied by the mean coefficient of thermal expansion (α) to determine thermal strain. The instantaneous value represents the slope, and would be appropriate to use when determining incremental change over small temperature ranges.

AOS

Request for Additional Information

RAI 30:

Materials:

- Correct Table 2-10 to show the mechanical properties of the N07718 nickel alloy. This RAI is a follow up to the first round RAI 2.3 response.
- The Young modulus shown in Table 2-11 is that of the wrong material (Material Group B Nickel Steel). The Young modulus must be provided for N07718 Nickel alloy (Table TM-4 in Section II, Part D of the ASME code). The design stress intensity is also wrong by a factor of about 2, and should be corrected to show the correct design stress intensity for the N07718 Nickel alloy. Assess the impact of these corrections on the analyses and calculations presented in the SAR, update the analyses and calculations of the SAR as required, and address any inconsistencies in the SAR as a result of these corrections.

AOS RAI 30 Response:

- Question understood, no further explanation required.
- Table 2-11 will be corrected and we'll address any impact to specific analysis.

AOS

Request for Additional Information

RAI 31:

Materials/Structural:

- Provide temperature dependent properties for the tungsten alloy mechanical properties in Table 2-11. This RAI is a follow up to the first round RAI 3.1 response.
- Table 2-11 should resemble Tables 2-9, 2-10 and 2-12. Assess the impact of these changes on the analyses and calculations presented in the SAR, update the analyses and calculations of the SAR as required, and address any inconsistencies in the SAR as a result of these changes.

AOS RAI 31 Response:

- Question understood, no further explanation required.
- Tungsten properties do not enter into the stress calculations, as Tungsten material is not part of any containment boundary structure.

AOS

Request for Additional Information

RAI 32:

- Modify Table 2-14 so as to provide the mechanical properties of the different grades of LAST-A-FOAM FR-3700 foams used for the AOS Transport Packaging System as a function of temperature for temperatures ranging from -40°F to 279°F (the component temperature range specified in Table 3-3). For the AOS-050, justify the use of the FR-3710 foam at temperatures within 3°F of the glass transition temperature of 279°F. This RAI is a follow up to the first round RAI 2.21 response.
- Based on the manufacturer data found via the link provided below, the properties of FR-3710, FR-3712 and FR-3720 change by more than a factor of two between -75°F and 250°F. These changes in material properties as a function of temperature must be taken into account in the structural models of the impact limiters. For AOS-050, the maximum temperature of the foam for the impact limiter is 276°F, while the glass transition temperature of FR-3710 is 279°F (maximum operating temperature range). It is expected that the mechanical properties of FR-3700 series foams will decrease rapidly above the glass transition temperature. The 3°F temperature margin is very small, and should be justified.

AOS RAI 32 Response:

- Clarification/discussion requested.
- We'll get with the manufacturer to get the additional materials data and address it in our analysis.

AOS

Request for Additional Information

RAI 33:

Materials/Drawings:

- Provide a complete description of the copper alloy used to fabricate the port plug seals and the conical seals on the AOS Transport Packaging System. Provide mechanical and thermal properties for the copper alloy used to make the seals. This RAI is a follow up to the first round RAI 2.4 response.
- The copper alloy C10100 is referenced in section 2.2.2. A national consensus standard should be provided for this material, as well as the corresponding material properties (mechanical and thermal). The material specification should be consistent with that specified in certification drawings.

AOS RAI 33 Response:

- Question understood, no further explanation required.
- The drawings and pertinent section(s) of the SAR shall be revised to include the standard application to the copper material used in the conical and flat seals.

AOS

Request for Additional Information

RAI 34:

Materials:

- Specify the exact type of foam used in the impact limiters for the AOS-165 cask drop tests.
- Provide the density, mechanical, and thermal properties of the foam used in the AOS-165 test cask and compare these properties with those of the foams used for the other cask sizes in the AOS Transport Packaging System SAR. The staff needs this information to assess the validity of the structural and thermal models and analyses described in the SAR.

AOS RAI 34 Response:

- Question understood, no further explanation required.
- The requested information shall be incorporated into the SAR, as an Appendix to Chapter 2.

AOS

Request for Additional Information

RAI 35:

Materials/Drawings:

- Justify the use of SA-193 Grade B8RA and SA-564 Type 630-H1100 as bolting materials (Table 8-3). If these materials are to be used, provide all corresponding temperature dependent mechanical and thermal material properties.
- SA-193 Grade B8RA and SA-564 Type 630-H1100 are not mentioned anywhere in the drawings or SAR, except in Table 8-3. Explain this discrepancy.

AOS RAI 35 Response:

- Question understood, no further explanation required.
- Reference to SA-193 and SA-564 bolting materials shall be deleted from Table 8-3 of the SAR; these materials are not used in the Package designs but were inadvertently left in the submittal.

AOS

Request for Additional Information

RAI 36:

Shielding: Make the following corrections in the Safety Analysis Report, and assess the impact of these changes on any analyses that may be affected, if any:

- Page 2-36: change “21mm” to “21 microns” to match the notes in the certificate drawings.
- Page 2-37: delete “per hour” in the statement “when subjected to a maximum cumulative dose of 2x108 rads per hour.”
- Page 2-39 in table 2-17: drawing number 105E9712G001 does not exist: replace with drawing number 105E9712.
- Section 2.6.2: “Low-temperature service does not affect the AOS Transport Packaging System, because all containment and non-containment structural components are fabricated of SS300, a material that does not undergo ductile-to-brittle transition in the temperature range of interest, down to -40°C (-40°F). Therefore, it is safe from brittle fracture.” Modify this statement to take into account (1) the lid attachment bolts made of nickel alloy N07718, and (2) the impact limiters containing FR-3700 series foam. Both the lid attachment bolts and the impact limiters are structural components.

AOS RAI 36 Response:

- Question understood, no further explanation required.
- All issues expressed in this RAI shall be addressed in the appropriate sections to clarify and address the concept or requirement identified therein.

Request for Additional Information

RAI 37:

Shielding:

- Provide dose rate evaluations for NCT at a location that is part of the structural design and analysis.
- Dose rate evaluations for NCT should be performed at a location that is part of the structural design and analysis, such as the deformed (due to NCT tests) impact limiter surface. The staff questions the adequacy of the information provided to support the personnel barrier as an appropriate location for dose rate analyses during NCT (See RAI 2.3 in this letter).
- The staff has previously asked for justification for the use of the personnel barrier as a dose point. This information was requested in Observation 3 submitted with the Request for Supplemental Information (RSI) dated July 31, 2009 and in 5.6 and 2.7 submitted with the request for additional information (RAI) dated December 24, 2009. Appropriate justification has not been submitted.
- Moving the dose point location closer to the source (without altering contents) will reduce the current safety margin for certain contents (as currently specified) within certain packages. For cases in which the margin is significantly reduced the staff expects that the analysis will include additional uncertainty evaluations with respect to package design tolerances, content definition and measurements, shielding code, etc.

AOS

Request for Additional Information

AOS RAI 37 Response:

- A complete response to the question will not be available until the structural questions are answered. However, we agree that dose limits should be considered at areas that are exposed in NCT expected values. Therefore, calculations will be reviewed and updated if necessary after the structural analysis is completed.

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AOS

Response Schedule

Complete analysis and verifications TBD

Update SAR 4 weeks later

Submit updated SAR to 1 week later

AOS