



January 25, 2019

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SUBJECT: AOS RESPONSE TO NRC QUESTIONS (DATED 01-15-2019) TO
SUPPORT THE RESPONSE TO THE REQUEST FOR ADDITIONAL
INFORMATION ISSUED OCTOBER 9, 2018

USNRC Reference(s): Docket No. 71-9316
EPID-L-2018-LLA-0201

AOS Reference: FM9006.1-012019-001 and FM9006.1-1012019-002

Mr. Saverot:

Alpha-Omega Services, Inc. (AOS) hereby submits the responses NRC questions (dated 01-15-2019) in support of the response to the requests for additional information (RAIs) for Certificate of Compliance No. 9316 issued on October 9, 2018. Each of the responses are provided below on both the matrix and in blue text following each additional question; and brown text are questions for future consideration. Applicable portions of Chapters 1, 2, 3, 5, 7, and 8 of the Safety Analysis Report are resubmitted to incorporate clarifications as indicated in the RAI responses.

Clarifications to identified SAR requirements were addressed as follows:

- Correction of identified typographical errors [Chapter 1 - Section 1.2.2; Chapter 5 - Appendix 5.5.7, Appendix 5.5.8; Chapter 7 - Section 7.1.3.4, Section 7.3.4, Appendix 7.5.1]
- Deletion of the Shipping Cage Structural Analysis included in SAR FM9054 Rev. H-5 [Chapter 2 - Appendix 2.12.16]
- Deletion of Isotope Ho-166 [Chapter 1 - Table 1-2; Chapter 5 - Tables 5-6, 5-13, 5-14, 5-21, 5-22, 5-23, 5-30, 5-35a, 5-35b, 5-43, 5-49, 5-50, 5-51, 5-52, and 5-53, Section 5.5.8]
- Various corrections identified for document consistency [Chapter 1 - Table 1-2; Chapter 5 - Section 5.3.1.4, Table 5-15, Appendix 5.5.1, Appendix 5.5.4, Appendix 5.5.6, Appendix 5.5.7, Table 5-38, Appendix 5.5.8, Tables 5-43, 5-44, and 5-45; Chapter 7 - Section 7.1.3.4]

- Clarification on question of Co-60-C source values; and calculation with MCNP [Chapter 5 - Tables 5-39, 5-40a, and 5-41]
- Addition of contribution of low E beta/gamma emitters (and progeny) to decay heat calculations [Section 5 – Appendix 5.5.5, Appendix 5.5.6, Appendix 5.5.7; and Section 7 – Appendix 7.5.1]
- Addition of notes regarding accessibility of bottom surface of package [Chapter 7 - Section 7.1.1.2, d; Section 7.2.1, g]

The attachments listed below are being submitted separately through the EIE system. Please address any questions or comments to the undersigned.

Best Regards,

Troy Hedger, President
Alpha-Omega Services, Inc.

Attachments:

List of Changes to SAR AOS-FM9054 Rev. H-5, H-6, and H-7 Updates - January 25, 2019) (17 pages)

Safety Analysis Report AOS-FM9054 Revision H-7 (revised sections only of Chapter 1, Chapter 2, Chapter 3, Chapter 5, Chapter 7, and Chapter 8; including Revs. H-5 and H-6) (93 pages)

L.14. Section 1.2.2, 2nd Paragraph example for Ir-192 and 194 activity limits now has a wrong number for the 192 limit.

Response: (Page 1-10) Corrected to read, "1,009"

L.13. Why is the structural analysis of the initial submittal still in the SAR since the cage is not part of the package? It was not evaluated/accepted by the staff and should not be in the SAR. (i.e., Appendix 2.12.16)

Response: (Page 2-155; Pages 2-942aq through 2-942bn) Deleted Appendix 2.12.16 from SAR; (Pages 2-944 and 2-945) deleted associated references [2.36 through 2.41]

F.10. Section 5.2, 2nd paragraph: The conclusions in this paragraph need to be reconsidered for Ho-166. Item is also in previous list.

These conclusions are ok for the other nuclides in Table 5-6 based on either the Emax of their betas being low, or the intensity of the beta emissions being low, or a quick check using the Cember approximation showing that the gammas/sec from the bremsstrahlung would be a small fraction of the gammas/sec of the gammas emitted by the nuclide at equal or greater energies than the Emax of the betas. It is not clear that the conclusions in the paragraph hold for Ho-166 since the gamma intensities are quite small and the Emax and intensities of the betas are quite large.

Response: Deleted references to Ho-166, as follows: (Page 1-11) Table 1-2; (Page 5-6) Table 5-6; (Page 5-21) Table 5-13; (Page 5-22) Table 5-14; (Page 5-29) Table 5.21 and Table 5.22, (Page 30) Table 5.23, (Page 37) Table 5.30, (Page 5-44b) Table 5-35a, Table 5-35b; (Page 5-44t) Table 5-43; (Page 5-44ab) Table 5-49, Table 5-50; (Page 5-44ad) Table 5-51; (Page 5-44ae) Table 5-52; (Page 5-44ag) paragraph, 5th line and Table 5-53

L.1. Section 5.2, 2nd paragraph: The conclusions in this paragraph need to be reconsidered for Ho-166.

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Response: Deleted references to Ho-166; see F.10, above

L.2. Paragraph just preceding Table 5-9 should be removed/fixed for consistency with the other spots now added with respect to the impact limiter notches.

Response: (Page 5-14) Paragraph removed

L.3. Various places seem to be missing reference to Table 1-2b (e.g., Appendix 5.5.1, the 4th paragraph)

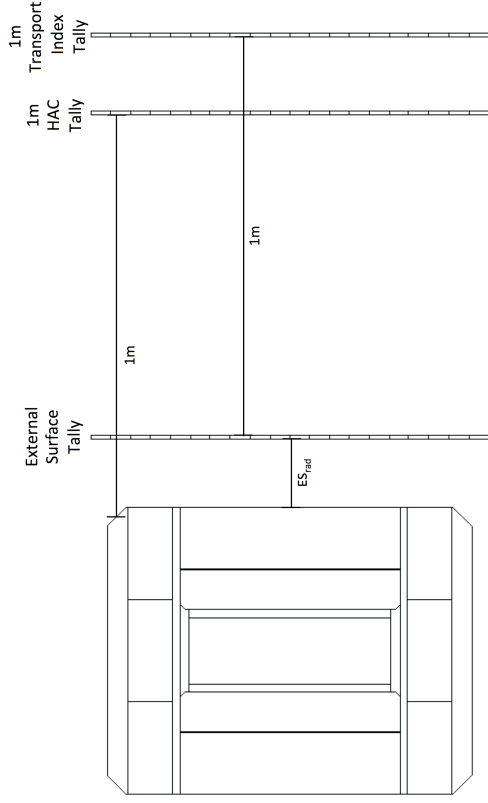
Response: Corrected (Page 5.28) Appendix 5.5.1 4th Para., 4th line to add reference to Table 1-2b

F.9. Need clarity on the response to the staff's question about the Co-60-C source being different from before and using a smaller volume for the calculations for that source (vs. previous calculations) based on the limit for specific activity. The response did not answer the staff's question and the meaning with regard to the information in the SAR as revised is also unclear. Appendix 5.5.4 used a source of a set volume size. Based on the specific activity set for the source, and the newer results having a Curie content that is smaller than was supposed for the basis of the Co-60-C source volume, the source volume used in the calculations should be reduced in volume vs. what was used in Appendix 5.5.4 or the specific activity limit should be changed. If a volume source was not used to calculate the new Co-60-C results, then the SAR needs to clearly describe what was used and ensure all discussion of it in Ch 5 are clear and consistent on that point. As needed, the specific activity limit for Co-60-C should also be changed in the relevant Ch 1 and Ch 5 tables.

Response: Dose rate/Curie values for Co-60-C under 10CFR71.47a are now based on a point source calculation, so the specific activity limit is no longer necessary. Notes stating activity limits for Co-60-C on (Page 1-11) Table 1-2 and (Page 5-23) Table 5-15 removed. For the exclusive use limits (10CFR71.47b) the activity limit is higher resulting in a larger volume than modeled. Text (Page 5-28) 5.5 APPENDIX, 4th Bullet, add to end of line, "Study", and (Pages 5-41 and 5-42) Section 5.5.4 revised to present the information in the appendix as a study. Appendix 5.5.4 was revised to include identification of the study considering a volume source for Co-60-C in the Model 100A/AOS-100A-S casks for a minimum activity of 19,000 Ci; and discussion of results of the study used as the basis for volume source geometry for Co-60-C dose rate calculations in Appendix 5.5.7.

C.2. Confirm that the new Co-60-C TI dose rate/curie value was determined by calculation with MCNP. It is not clear that is so, but it should have been calculated in that manner. Note that it is still not clear to the staff that a factor of safety of 1 for the TI is sufficient. However, given the margin to the TI limit for the new Curie limit for the Co-60-C source and that no other TI factors for the other nuclides and package models in Appendix 5.5.8.1 were less than 2, there is enough margin to address the staff's concern and compensate for it.

Response: All dose rates are calculated using MCNP. The TI dose rate locations in the body of the calculation are at a distance of 1-meter from the deformed impact limiter surface, but the HAC dose rate locations are 1-meter from the cask surface itself, as shown in the image below (reference SAR Page 5-13) (SAR Figure 5-6, for a point source on the cask side wall). Because of this, the DR/Ci value calculated from the 1m HAC Tally location is used, as this is the appropriate distance from the exposed cask surface.



F.2. Last statement of Appendix 5.5.6 should point to Appendix 5.5.7 as well as 5.5.5. Appendix 5.5.7 should also address contribution of low E beta/gamma emitters (and progeny) to the mixture decay heat calculation. Appendix 5.5.5 and 5.5.6 should also add about these emitters' progeny contributing to decay heat calculations too.

Response: (Page 5-44e) Corrected to add reference to Appendix 5.5.7; (Page 5-44b, Page 5-44e, 5-44k) Added contribution of low E beta/gamma emitters (and their progeny) to the mixture decay heat calculation

L.4. Table 5-38 should be clear that 'External Surface' is the surface of the package and not the cage.

Response: (Page 5-44f) Corrected "External Surface" to clarify surface of package

L.5. Table 5-40a, 1st criterion (i.e., label for first equation) is not correct. The parenthetical says the package surface is the cage surface; this is not correct. The parenthetical text should be fixed. In actuality the cage surface is at some distance from the package surface, at least on the radial and top surfaces. Also, the cage is not part of the package.

Response: (Page 5-44k) Criterion revised, note added. Table 5-40a corrected Criteria – External Surface to read, "(Package or Enclosure Surface)^b"; Footnote b reads, "Enclosure surface for Co-60-C, Package surface for all others."

L.6. Table 5-40a, 2nd equation label: 'Side of Rear' should be 'Side or Rear'

Response: (Page 5-44k) Corrected to read, "Side or Rear"

AOS Response to NRC Questions (Email dated 01-15-2019) – 2 Documents Submitted to AOS
AOS items to fix now (identified as, F.x; C.x) / AOS items to look into and fix (identified as L.x)

F.3. Table 5-39 and 5-41 surface dose rate/curie value for Co-60-C does not come from the package surface like the others do. It should be the value given in Table 5-46 not 5-44. Making this change will limit the Co-60-C amount to the amount in Table 1-2 and will make the limit in Table 1-2b the same as the limit in Table 1-2 too. If want to do this nuclide different from the others, the table should call that out clearly and explain what the location for that # is (by the way, it is NOT on the cage).

Response: For Co-60-C the listed "External Surface" location is based on the external surface of a closed exclusive use transport vehicle, with the cage being the enclosure. With this being the case, using the distance to the deformed impact limiter is approximately appropriate, but still conservative for the 200 mrem/hr limit. The package surface dose rate limit for this case is 1000 mrem/hr which provides enough margin that it would never be the limiting location. Text above (Page 5-44h) Table 5-39 revised to clarify and note added to (Page 5-44m) Table 5-41. Corrected Page 5-44h, 1st paragraph, last line to read, "... requirements of 10CFR71.47(b)(1)(i) through (iii) apply ..."; corrected Page 5-44m, Table 5-41 Footnote e to read, "... 10CFR71.47(b)(1)(i) through (iii) apply."

F.7. Table 5-39 should also specify the Co-60-B and -C axial shielding and spacer plate requirements.

Response: (Page 5-44h) For Isotopes Co-60-B and Co-60-C added reference to Footnotes "d" and "e" as required; added to Footnotes – "d. Use of tungsten alloy axial shielding plates 183C8491 is required", and "e" Use of tungsten alloy axial shielding plated 183C8491 and stainless -or- aluminum cavity spacer plates 183C8518 is required"

L.7. Further clarity would be very helpful on text after Table 5-42 (2nd paragraph on page 5-44q) and the associated tables and figures. What numbers are used to do what is still a bit unclear; so, the description of what was done in that text does not appear to match with the numbers and values in Table 5-43 vs. Table 5-14. This question also applies to the text and associated tables in the rest of Appendix 5.5.8.1. I figured it out for this review, but it would be good for it to be made more clear.

Response: (Page 5-44q) Revised text of the paragraph in question.

L.8. Page 5-44y, last sentence: It seems this should give the reason for the conclusion being that the effect is a lower increase in dose rates, not a larger increase in dose rates as is currently written.

Response: (Page 5-44y) Text revised to read, "... would result in a smaller predicted dose rate ..."

L.18. Section 5.5.8.1, last paragraph, last sentence: 'can be used' should read 'are used'

Response: (Page 5-44r) Changed, "can be used" to read, "are used"

L.11. NCT tests and HAC tests were evaluated for impact on the impact limiter recess areas and the exposed cask surfaces correct? They should have been. Same question for exposed cask side for 50 and 100 models.

Response: The only NCT test that could affect the recessed area of the impact limiters is the penetration test, which is analyzed in SAR Section 2.6.10, and calculated a maximum displacement of ~0.00125 in. (see SAR Figure 2-29). The penetration test was not analyzed on the exposed cask side of the AOS-050 and AOS-100 casks. But, as this test resulted in no significant deformation to the softer foam, the same could be said for the steel cask body.

The HAC puncture test was analyzed in the recessed area of the impact limiters, as discussed in SAR Section 2.7.3, however from the perspective of the shielding analysis the impact limiter is assumed to be removed for HAC; therefore, the deformation of the impact limiters from this test does not apply. The HAC puncture test was not analyzed on the exposed surface of the AOS-050 and AOS-100, however, it would not be expected to result in significant damage to the cask body. This position was stated in Revision 0 of the 71-9316 Safety Evaluation Report dated February 28, 2012:

"The package is evaluated for accidental drops in Load case 311. The Model Nos. AOS-025A, AOS-050A, and AOS-100A packages are analyzed for 4-foot drop onto a 6-in diameter steel bar. The orientation for the event was vertically through the center of the impact limiter. Although a potentially more damaging configuration could exist for the Model No. AOS-050 through direct impact with the portion of the package which is not covered by the impact limiter, this portion of the package is away from the containment, and is unlikely to result in any significant damage to the package. The same applies to the Model No. AOS-100, which is even thicker and stronger, while the Model No. AOS-025 is completely covered by the impact limiters. Staff reviewed the analyses presented by the applicant and finds that the requirements of 10 CFR 71.73(c)(3) are met."

While it is recognized that there would be some deformation of the cask body from a puncture, the outer body of the AOS casks are composed of a thick layer of stainless steel (~2.8 in. for the AOS-050 and ~5.6 in. for the AOS-100). Thus, the maximum deformation from a HAC puncture event is expected to be small (<1/4 inch). As all HAC dose rates have large factor of safety to the regulatory limit (>2 in all cases), the addition of a small recess in the side of the cask body would not result in a large enough increase in dose rate to exceed the regulatory limit.

L.12. How is the curvature of the impact limiters' axial surface accounted for in the analyses? It should have been.

Response: The curvature of the impact limiters is not modeled, however, the offset for the impact limiters considers deformation from both a top and side drop together. The deformation from the top end drop flattens out a large portion of the curved impact limiter, and the deformation from a side drop crushes out the 'lowest' parts of the curved portion of the impact limiter. Together this leaves a very small portion of the curvature remaining. This is to be considered in a future revision to the SAR; and to review and determine corner drop analysis.

L.17. For acceptance tests for tungsten shield components; may need further clarity on what tests/standards are used to capture acceptable dimensional tolerances on these components. It is not all that clear now where/how those dimensional tolerances are specified and how big they are (including whether or not the margins in the analysis adequately offset the impact of a tungsten component being at the minimum dimensional tolerance).

Response: All dimensional tolerances are listed on the licensing drawings of the respective components on the first page or the drawing by the signature block. The tolerance on nearly all dimensions of the AOS-025A liner is 0.05 in. The tolerance on nearly all dimensions for the AOS-100A tungsten shield plates is 0.1 in.

L.19. Models in shielding analysis should be at minimum dimensional tolerances (vs. the nominal used in the current analysis in the SAR).

Response: The dimensional tolerances are relatively small compared to the overall thickness of the shielding (0.01 – 0.1 in. depending on the dimension). This possible reduction in shielding thickness is covered by a combination of the 10% margin to all regulatory limits and the neglecting of any other shielding materials of the packaging/contents that would aid in the shielding of the package. For example, in the AOS-100A, any surface covered by the impact limiters has at least an additional 0.2 inches of stainless-steel shielding from the inner and outer shells of the impact limiter. Additionally, some additional shielding will be provided by the contents themselves, even if it is from only the source material itself. This is to be considered in a future revision to the SAR; and to make a more quantitative assessment of the tolerances.

L.16. Should have an explicit statement in Section 7.1.2.1 to verify cleanliness/emptiness of the package/cask cavity. At this point, this step is implicit and not explicitly stated. Appropriate criteria should be discussed.

Response: We're unsure of what specific requirement should be referenced here and would appreciate any clarification that could be provided. This is to be considered in a future revision to the SAR; to provide more information regarding contamination inside the cask, improve on vague wording.

F.5. Fix 7.1.3.4.b to state that contamination surveys on the cask surface will be done to ensure compliance with 71.87(i) (and appropriate TS-R-1 and DOT requirements); the current discussion appears to indicate that contamination swipes are done at some distance from the cask surface; this is not possible. Further, without contamination surveys on the cask surface to confirm compliance with the relevant regulatory requirements, it is not clear that the package surface contamination level checks in Section 7.1.3.4 are complete. As written, the section appears to only check the surfaces of the impact limiters, which does not address the exposed cask surface for the 50A and 100 (the 100A, 100A-S, and 100B) package models.

Response: (Page 7-11) 7.1.3.4.b is specific to dose rate surveys. 7.1.3.4.d revised to include cask surfaces. Corrected 71.87(i) to read, "&1.87(j)"

F.4. Confirm that Section 7.1.3.4.d is checking the inner and outer surfaces of the impact limiters. It should be. The text should be clear about this.

Response: (Page 7-11) Text added, "... levels on the outer cask surfaces and impact limiters (both inner and outer surfaces) are in compliance ..."

C.1. Section 7.1.3.4, Table 7-3: confirm the distances given are those to the outer surface of the impact limiter notch/recess for the axial column.

Response: (Page 7-11) Yes, all distances are based on the distance to the notch, rounded down to the nearest whole number.

L.9. Fix the Note at the top of page 7-12 to remove the words 'shipping cage' from the parenthetical text to ensure against confusion on the definition of the package surface – it is not the cage surface.

Response: (Page 7-12) Delete "shipping cage" from note

F.6. How can the 1m radiation levels be measured for the lower impact limiter area with all of the pallet hardware in the way that provides extra shielding that is not part of the package (Section 7.1.3.4, j)? The same question applies to Section 7.2.1.g for surface and 1m radiation levels and surface contamination levels and to Section 7.1.1.2.d for the relevant limits for that step too.

AOS Response to NRC Questions (Email dated 01-15-2019) – 2 Documents Submitted to AOS
AOS items to fix now (identified as, F.x; C.x) / AOS items to look into and fix (identified as L.x)

Response: It was our understanding that this is acceptable for pre-shipment dose rate measurements, as even though the cage is not a part of the package, this is how the package is "prepared for shipment" (per the wording of 10CFR17.47a). If measurements cannot be taken if there is any material that is not a part of the package in the way, how could one take 2-meter dose rate measurements for a closed transport (e.g. in an ISO container), trailer surface or 2-meter dose rates for an array of packages on a trailer, or driver cab measurements? Any clarification on this topic or any specific reference/guidance that could be provided, would be appreciated.

Added Note at 7.1.1.2, d and 7.2.1, g - The bottom surface of the package is not accessible until the package is removed from the pallet. As a result, when measurements are required, the radiation and external contamination levels on the bottom of the package are assessed after the cask is removed in step ... [(g) in 7.1.1.2, d; (j) in 7.2.1 (g)].

- F.8. Section 7.3.4 - decontamination should be done to the TS-R-1 Paragraph 508 limit (not the 520 limit). 508 is for the external surfaces of any package (per the words of that requirements). Requirements specific to leaking packages are only Paragraphs 510 and 511. So, the applicant's response to staff's question is incorrect. It is also inconsistent with the reference to 508 (which is correct) in other areas of the package operations in SAR chapter 7.

Response: (Page 7-17) Referenced sections of the regulations revised to read "508" and "49 CFR 173.443".

- F.1. Section 7.5.1 paragraph about low E beta/gamma emitters (and relevant spots in Ch 5): Progeny contribution to decay heat should also be included in the total package/contents decay heat calculation.

Response: (Page 7-19) Sentence revised to include progeny.

- L.15. Section 7.5.1, multiple isotope contents bullet, item B, 2nd sub-bullet: Should read more like "Compliance with external dose rate limits is calculated using the equations..." (Dose rate limits are not being calculated, compliance with dose rate limits is being verified/calculated.)

Response: (Page 7-19) Text revised to read, "Compliance with external dose rate limits ..."

- L.10. Page 7-19, last paragraph: the 2nd 0.3 is missing its units (MeV).

Response: (Page 7-19) Last paragraph, 4th line – add text to read, "0.3 MeV"