December 24, 2009

Mr. Troy Hedger, CEO
Alpha-Omega Services, Inc.
9156 Rose Street
P.O. Box 789
Bellflower, CA 90706

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION FOR THE REVIEW OF THE MODEL NOS. AOS-025, AOS-050, AND AOS-100 PACKAGES

Dear Mr. Hedger:

By letter dated September 14, 2009, Alpha-Omega Services, Inc. (AOS) submitted an application for approval of the Model Nos. AOS-025, AOS-050, and AOS-100 packages, along with its responses to a Request for Supplemental Information dated July 31, 2009.

In connection with the staff's review of the application "AOS Radioactive Material Transport Packaging System Safety Analysis Report," Report No. AOS-FM9054, Revision No. C, dated September 2009, we need the information identified in the enclosure to this letter. We request that you provide this information by January 15, 2010. If you are unable to meet this deadline, you must notify us in writing no later than January 4, 2010, of your submittal date and the reasons for the delay. The staff will then assess the impact of the new submittal date and notify you of a revised schedule.

Please reference Docket No. 71-9316 and TAC No. L24353 in future correspondence related to this request. The staff is available to meet with you to discuss your proposed responses. If you have any questions regarding this matter, I may be contacted at (301) 492-3408.

Sincerely,

/RA/

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

Docket No. 71-9316
TAC No. L24353

Enclosure: Request for Additional Information

cc w/encl.: Everett Redmond, NEI

Mr. Troy Hedger, CEO
Alpha-Omega Services, Inc.
9156 Rose Street
P.O. Box 789
Bellflower, CA 90706

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION FOR THE REVIEW OF THE MODEL NOS. AOS-025, AOS-050, AND AOS-100 PACKAGES

Dear Mr. Hedger:

By letter dated September 14, 2009, Alpha-Omega Services, Inc. (AOS) submitted an application for approval of the Model Nos. AOS-025, AOS-050, and AOS-100 packages, along with its responses to a Request for Supplemental Information dated July 31, 2009.

In connection with the staff's review of the application "AOS Radioactive Material Transport Packaging System Safety Analysis Report," Report No. AOS-FM9054, Revision No. C, dated September 2009, we need the information identified in the enclosure to this letter. We request that you provide this information by January 15, 2010. If you are unable to meet this deadline, you must notify us in writing no later than January 4, 2010, of your submittal date and the reasons for the delay. The staff will then assess the impact of the new submittal date and notify you of a revised schedule.

Please reference Docket No. 71-9316 and TAC No. L24353 in future correspondence related to this request. The staff is available to meet with you to discuss your proposed responses. If you have any questions regarding this matter, I may be contacted at (301) 492-3408.

Sincerely,

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

Docket No. 71-9316
TAC No. L24353
Enclosure: Request for Additional Information
cc w/encl: Everett Redmond, NEI
G :\SFST\Saverot\71-9316 AOS\RAI letter.doc **ADAMS Accession No. : ML093580136**

OFC:	SFST	E	SFST	E	SFST	E	SFST	E	SFST	E	SFST	E
NAME:	PSaverot		VWilson		BTripathi		EEinziger		JIreland		CBajwa	
DATE:	12/16/09		12/17/09		12/22/09		12/22/09		12/22/09		12/22/09	
OFC:	SFST	E	SFST	C	SFST	C	SFST	C	SFST	E	SFST	C
NAME:	HLindsay		MWaters		CCook		MRahimi		MDeBose		JGoshen for EBenner	
DATE:	12/17/09		12/23/09		12/23/09		12/21/09		12/18/09		12/24/09	

OFFICIAL RECORD COPY

Request for Additional Information
for the
Model Nos. AOS-025, AOS-050, and AOS-100 Packages
Docket No. 71-9316

By application dated September 14, 2009, Alpha-Omega Services, Inc. (AOS) submitted an application for approval of the Model Nos. AOS-025, AOS-050, and AOS-100 packages.

This Request for Additional Information (RAI) identifies information needed by the staff in connection with its review of the "AOS Radioactive Material Transport Packaging System Safety Analysis Report for Model Nos. AOS-025, AOS-050, and AOS-100 Transport Packages," Report No. AOS-FM9054, Revision No. C, dated September 2009. The requested information is listed by chapter number and title in the applicant's Safety Analysis Report. The staff reviewed the application using the guidance in NUREG 1609, "Standard Review Plan for Transportation Packages for Radioactive Material."

Each individual RAI section describes information needed by the staff to complete its review of the application and to determine whether the applicant has demonstrated compliance with the regulatory requirements.

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 measures 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.

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.

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.

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).

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 No. 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 or 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.

Licensing Drawings and Bill of Materials

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.

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.

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).

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

All model components should have, on the Bill of Materials, the component 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).

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 list 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).

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 10 CFR 71.33(a)(2).

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).

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 compliance with 10 CFR 71.71.

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).

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.

Chapter 2 – Structural Evaluation

2.1 State the temperature at which the modulus of elasticity, given in Table No. 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).

2.2 Specify for which bolts the mechanical properties shown in Table No. 2.3.3 of the Appendix are applicable.

The materials listed for the bolts in Table No. 2.3.3 are neither those for the lid bolts nor the trunnion bolts, as indicated in Table Nos. 2-15 and 2-16 of the application, respectively.

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).

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 the staff to determine compliance with the requirements of 10 CFR 71.51(a)(1) and 71.51(a)(2).

2.4 Provide evidence to support the statement in Section No. 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 supporting 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).

2.5 Specify the elements of the testing series that constitute the acceptance testing of the stainless steel and foam listed in Table No. 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 71.51(a)(2).

2.6 Remove Table No. 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 currently stated in the application.

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

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.

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 with10 CFR 71.51.

2.9 Provide justification(s), validated by test data presented in Chapter 8 of the application, for reduction in the impact limiter's 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-25, AOS-50, and AOS-100 packages is not adequate, especially since the density of the foam material for the Model Nos. AOS-50 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 with10 CFR 71.35.

2.10 Provide documentation verifying that the Model No. AOS-50 package was subjected to a crush test. Provide the numerical value(s) of the deformation to the packaging due to the crush load applied to the Model Nos. AOS-25 and AOS-50 packages.

Section No. 2.7.2 of the application only describes the required crush test for the Model No. AOS-25 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 with10 CFR 71.73(c)(2).

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.

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 the 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.

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 buckling analysis.

The staff needs justification for using the formula from the reference titled, "Flügge, Wilhelm, Ed., *Handbook of Engineering Mechanics*, McGraw-Hill Higher Education, New York, 1962, pp. 44-40, 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.

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.

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 3/4" 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).

2.16 Specify the equation used for the definition of "Margins of Safety," as stated in Section No. 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).

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).

2.18 Provide the numerical 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-25, AOS-50, 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).

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).

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).

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 the 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).

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).

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).

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).

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 subsequent 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 leaktightness of the package.

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

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-cooling.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 nominal 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.

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).

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).

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).

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 limit.

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

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

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 in 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

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-fire 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 the cavity surface of the inner shell or 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 from fire and post-fire maximum temperatures and 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.

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

In the Licensing Drawings No. 166D8143 and No. 166D8137 for the Models No. AOS-25A and AOS-50A packages 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

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 provided 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.

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.

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.

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.

3.13 Justify the assumption that $\varepsilon_1 = \varepsilon_2 = 0.52$ 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.

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 cannot 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 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 10 CFR 71.73.

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 10 CFR 71.73.

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 equations 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.

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.

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.

3.19 Explain how the length and the 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.

3.20 Define the Rayleigh number and its component variables.

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

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 from the staff's reference "Incropera, Frank P., David P. DeWitt, Fundamentals of 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.

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.

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.

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 materials properties in the application.

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

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.

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.

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.

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.

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_t 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 "lc111-t2-update.100" and "lc112-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 "lc111-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 71.73.

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.

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, AOS-50, 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.

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 packaging 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).

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).

3.34 Clarify the following inconsistency: assuming that the applicant calculated the packaging 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).

Chapter 4 – Containment Evaluation

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 -54°C to 232°C (-65°F to 450°F) 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	E 0740-75 a	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).

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).

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).

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-25, AOS-50, 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).

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 71.51.

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

In Section No. 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 71.51.

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 71.51.

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 in 10 CFR 71.47 and 71.51.

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 for the Model Nos. AOS-100A, AOS-100A-S, and AOS-100B systems 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 CFR 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.

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.

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).

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.

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).

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 durably 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).

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.

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.

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.

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.

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.

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.

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.

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.

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).

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 materials 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).

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).

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).