July 12, 2016

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

SUBJECT: CERTIFICATE OF COMPLIANCE NO. 9316, REVISION NO. 6, FOR THE MODEL NOS. AOS-25A, AOS-50A, AOS-100A, AOS-100B, AND AOS-100A-S PACKAGES

Dear Mr. Hedger:

As requested by your application dated March 16, 2016, supplemented June 27, 2016, enclosed is Certificate of Compliance No. 9316, Revision No. 6, for the Model Nos. AOS-25A, AOS-50A, AOS-100A, AOS-100B, and AOS-100A-S packages. The staff's safety evaluation report is also enclosed.

The approval constitutes authority to use the package for shipment of radioactive material and for the package to be shipped in accordance with the provisions of Title 49 of the *Code of Federal Regulations* (49 CFR) 173.471. Those on the attached list have been registered as users of the package under the general license provisions of 10 CFR 71.17 or 49 CFR 173.471.

If you have any questions regarding this certificate, please contact Pierre Saverot of my staff at (301) 415-7505.

Sincerely,

/RA/

John McKirgan, Chief
Spent Fuel Licensing Branch
Division of Spent Fuel Management
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-9316
CAC No. L25099

Enclosures:
1. Certificate of Compliance No. 9316, Rev. No. 6
2. Safety Evaluation Report
3. Registered Users

Upon removal of Enclosure 3, this document is uncontrolled

cc w/encls. 1&2: R. Boyle, Department of Transportation
J. Shuler, Department of Energy, c/o L. Gelder
Registered Users

President
Alpha-Omega Services, Inc.
9156 Rose Street
P.O. Box 789
Bellflower, CA 90706

SUBJECT: CERTIFICATE OF COMPLIANCE NO. 9316, REVISION NO. 6, FOR THE MODEL NOS. AOS-25A, AOS-50A, AOS-100A, AOS-100B, AND AOS-100A-S PACKAGES

Dear Mr. Hedger:

As requested by your application dated March 16, 2016, supplemented June 27, 2016, enclosed is Certificate of Compliance No. 9316, Revision No. 6, for the Model Nos. AOS-25A, AOS-50A, AOS-100A, AOS-100B, and AOS-100A-S packages. The staff's safety evaluation report is also enclosed.

The approval constitutes authority to use the package for shipment of radioactive material and for the package to be shipped in accordance with the provisions of Title 49 of the *Code of Federal Regulations* (49 CFR) 173.471. Those on the attached list have been registered as users of the package under the general license provisions of 10 CFR 71.17 or 49 CFR 173.471.

If you have any questions regarding this certificate, please contact Pierre Saverot of my staff at (301) 415-7505.

Sincerely,

/RA/
John McKirgan, Chief
Spent Fuel Licensing Branch
Division of Spent Fuel Management
Office of Nuclear Material Safety
and Safeguards

Docket No. 71-9316
CAC No. L25099
Enclosures:
1. Certificate of Compliance No. 9316, Rev. No.6
2. Safety Evaluation Report
3. Registered Users

Upon removal of Enclosure 3, this document is uncontrolled

cc w/encls. 1&2: R. Boyle, Department of Transportation
J. Shuler, Department of Energy, c/o L. Gelder
Registered Users

(Closes CAC No. L25099)
Filename: G:/SFST/PART 71 CASEWORK/9316.R6.docx; 9316 R6 LETTER SER.docx

ADAMS PKG: ML16195A013 ADAMS Letter No.: ML16195A017 Encl. 1: ML16195A018 Encl. 3: ML16195A019

E=With attachment/enclosure N=No copy C=Without attachment/enclosure

OFC	SFM	E	SFM	E	SFM	E	SFM	E	SFM	E	SFM	SFM
NAME	PSaverot		YKim		VWilson		JPiotter		ABarto		SFigueroa	JMcKirgan
DATE	06/28/2016		07/06/2016		07/01/2016		07/08/2016		07/08/2016		06/30/2016	7/12/16

OFFICIAL RECORD COPY

SAFETY EVALUATION REPORT

Model Nos. AOS-025A, AOS-50A, AOS-100A, AOS-100B, and AOS-100A-S Packages
Certificate of Compliance No. 9316
Revision No. 6

SUMMARY

By application dated March 16, 2016, supplemented June 27, 2016, Alpha-Omega Services, Inc. (AOS) submitted an amendment request to revise the shielding evaluation, include Ir-192 and Ir-194 impurities as a new authorized content, add changes previously communicated to NRC in letters dated April 4, May 14, and September 26, 2013; May 6, June 5, and August 5, 2015, and include miscellaneous updates and corrections.

The NRC staff reviewed Revision H-1 of the application "Radioactive Material Transport Packaging System, Safety Analysis Report, for Model AOS-025, AOS-050, and AOS-100 Transport Packages," dated March 11, 2016, as supplemented by Revision H-2 dated June 27, 2016, using the guidance in NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material."

Based on the statements and representation in the application, as supplemented, and the conditions listed below, the staff concludes that the proposed changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

EVALUATION

1.0 GENERAL INFORMATION

The family of AOS transportation packages consists of the AOS-025A, AOS-050A, AOS-100A, AOS-100B, and AOS-100A-S. The "A" designation refers to a tungsten shield, and the "B" designation refers to a carbon steel shield. The "S" designation on the AOS-100A-S means that the cask is double ended and there is a lid on each end of the cask. All of the packages have the same geometric shape, with the AOS-025 and AOS-050 having all dimensions scaled down to 25% and 50% (respectively) of the dimensions of the AOS-100 package.

The general design of the packages was not modified. The applicant has added cavity spacer plates specified in drawing 183C8518 when shipping larger amounts of Co-60 in the AOS-100A and AOS-100A-S which are used in conjunction with the tungsten axial shielding plates specified in drawing 183C8491.

The changes to the package with this amendment focus on the potential to exceed regulatory dose rate limits, should a source relocate to the corner of the package where a streaming path exists. Due to this potential, the applicant has reanalyzed the normal conditions of transport (NCT) and hypothetical accident conditions (HAC) dose rates with the source in a location that exposes the streaming path, and adjusted its allowable shipping quantities accordingly. Thus, Table Nos. 1.2 and 1.2.a of the application were modified, as well as their corresponding tables 1 and 2 "Maximum Activity Limits" in the CoC.

The applicant has added Ir-194 as a content which will be allowed as an impurity when shipped with Ir-192. For this content, the applicant has also added axial shielding plates, as specified in drawing 183C8519, for shipment of Ir-192/194 in the Model No. AOS-050.

2.0 STRUCTURAL EVALUATION

The objective of the structural evaluation is to verify that the structural performance of the package is adequately demonstrated to meet the requirements of 10 CFR Part 71.

The applicant submitted a revised application including a new shielding analysis. The NRC staff previously reviewed the structural adequacy of the AOS transportation packages (Model Nos. AOS-25A, AOS-50A, AOS-100A, AOS-100B, and AOS-100A-S) using the guidance provided in NUREG-1609 "Standard Review Plan for Transportation Packages for Radioactive Material" during the review of the Revision F of the application. The staff issued a safety evaluation report (SER) and concluded that the applicant demonstrated that the packages provided adequate structural, thermal, containment, and shielding protection under normal and accident conditions, and that the packages met the requirements of 10 CFR Part 71.

In Revision No. H-1, as supplemented by H-2, the applicant proposed to use axial shielding plates and/or cavity spacer plates depending on the model to ship large quantities of Co-60. The detailed information regarding the axial shielding plates and cavity spacer plates of the AOS transport packaging system are provided in Table 1.5 of the application. The applicant noted that the Models AOS-25A and AOS-100B do not use axial shielding plates or cavity spacer plates.

2.1 Hypothetical Accident Conditions

2.1.1 Drop Analysis for Axial Shielding Plate

The applicant used the ANSYS computer program to evaluate the structural performance of the axial shielding plate of the AOS transportation packages (Model Nos. AOS-50A, AOS-100A, and AOS-100A-S) for the HAC free drops (end, side and corner), as required by 10 CFR 71.73.

The ANSYS solid elements (SOLID185/186/187) were used for the solid portion of the model and the compression and contact elements (CONTAC174 and TARGE170) were used to simulate the interactions between the axial shielding plate and the cask inner cavity. Forces were applied on a surface of the model that represented the total applied load for the drop orientation considered. ANSYS structural surface effect elements (SURF154) were used to apply the load to the solid portion of the model. Figures 2-121 and 2-122 of Rev. H-2 of the application show the contact elements and surface effect elements for each drop orientation, respectively. Material properties of the axial shielding plate were taken from Table 2-11 of Rev. H-2 of the application.

To determine the allowable stresses of the axial shielding plate under the HAC drop conditions, the applicant employed the analysis methods and stress criteria allowed by the ASME Code, Section III, Subsection NF for the accident conditions (Service Level D). Table 2-358 of Revision H-2 of the application presents the design limits used for the evaluations.

The applicant provided a summary of the results of the evaluations and corresponding margins of safety in Tables 2-360 and 2-362, where the smallest margin of safety of any of these evaluations was found to be +3.20. Based on the evaluations, the applicant concluded that the axial shielding plate has adequate strength and will perform its intended functions under the

HAC free drop conditions. The staff reviewed the analyses and verified the analyses results with the allowable stresses. The staff finds that the results are acceptable.

2.1.2 Drop Analysis for Cavity Spacer Plate

The applicant also used the ANSYS computer program to evaluate the structural performance of the cavity spacer plate of the AOS transportation packages (Model Nos. AOS-100A and AOS-100A-S) for the HAC of free drops (end, side and corner) as required by 10 CFR 71.73. The methodology used for the evaluations was the same methodology as discussed in Section 2.1.1 above.

The applicant provided a summary of the results of the evaluations and corresponding margins of safety in Table 2-364, where the smallest margin of safety of any of these evaluations was found to be +1.10. Based on the evaluations, the applicant concluded that the cavity spacer plate has adequate strength and will perform its intended functions under the HAC free drop conditions. The staff reviewed the analyses and verified the analyses results with the allowable stresses. The staff finds that the results are acceptable.

Based on the staff's reviews and verifications on the applicant's analyses and their results, the staff determines that the application meets the regulatory requirements of 10 CFR 71.73(c)(1).

2.2 Evaluation Findings

The staff reviewed the documentation provided by the applicant to verify that statements presented by the applicant are accurate and within acceptable engineering practices.

Based on the review of the statements, representations, supplemental calculations in the application, and the responses provided to the staff's Request for Additional Information, the staff concludes that the structural components of the axial shielding plates and cavity spacer plates have been adequately described and evaluated, and they have adequate structural integrity to meet the requirements of 10 CFR Part 71.

5.0 SHIELDING EVALUATION

The changes to the package, with this amendment request, focus on the potential to exceed regulatory dose rate limits, should a source relocate to the corner of the package where a streaming path exists. Due to this potential, the applicant has reanalyzed the NCT and HAC dose rates with the source in a location that exposes the streaming path, and adjusted its allowable shipping quantities accordingly.

The applicant has added Ir-194 as a content which will be allowed as an impurity when shipped with Ir-192. The applicant has also added cavity spacer plates specified in drawing 183C8518 when shipping larger amounts of Co-60 in the AOS-100A and AOS-100A-S which are used in conjunction with the tungsten axial shielding plates specified in drawing 183C8491. The applicant has also added axial shielding plates as specified in drawing 183C8519 for shipping Ir-192/194 in the AOS-050.

The applicant provided an evaluation demonstrating that the AOS family of packages meet external dose rate requirements of 10 CFR 71 in Section 5 of the application, Revision H-1. The staff reviewed the changes to the AOS application using the guidance in Section 5 of NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Material" (March, 1999).

5.1 Description of the Shielding Design

5.1.1 Design Features

The staff reviewed the General Information Chapter (Chapter 1) and the information in the Shielding Chapter (Chapter 5) of the application.

The staff verified that the applicant provided adequate information to describe the dimensions, tolerances and densities of the gamma shielding material as well as the additional spacer plates.

There is no specific arrangement of the contents required with respect to shielding performance since the analysis was done using a conservative source geometry.

5.1.2 Summary Table of Maximum Radiation Levels

The staff reviewed the summary Tables 5-4 and 5-5 of the application, as well as the calculated dose rates in Tables 5-13 through 5-18 of the application, and determined that the values are within the limits of 10 CFR 71.47 and 10 CFR 71.51 for both NCT and HAC.

5.2 Radiation Source

The package is designed to ship specific source material including Co-60, Cs-137, Hf-181, Ir-192/Ir-194, Zr/Nb-95, Ho-166, and Yb-169. The staff confirmed that the activity used in the shielding analysis is consistent or conservative with respect to that specified in Table 1-2 and 1-2a in the General Information section of the application.

5.2.1 Gamma Source

With the exception of Zr/Nb-95, the applicant obtained the source spectra for each radionuclide using the discrete gamma energy and emission probability from the SCALE 6.1 ORIGEN gamma spectrum library. The staff found the spectra used by the applicant acceptable as the data are recent and considered standard.

The applicant treated Zr/Nb-95 differently as the activity limit for the parent/daughter system only applies to Zr-95. The only source of Nb-95 is from the decay of Zr-95 and to maximize activity the applicant assumed the two nuclides are in equilibrium.

The applicant modeled Ir-192 and Ir-194 using the same method as the other radionuclides however has different limits as shown in Table 1-2a of the application to account for different levels of Ir-194 impurity. The applicant evaluated each Ir-192/194 combination explicitly.

5.3 Shielding Model

The staff reviewed the information in the Structural Chapter of the application as it pertains to the shielding evaluation. The applicant used the impact limiter as the package surface and accounts for the deformation due to impacts under NCT.

The impact limiter is not continuous for the AOS-050 or AOS-100 packages which means there is a gap on the side of the cask around the cask centerline. Most all of the AOS contents are limited by the top and corner (streaming path) dose rates however there are a few configurations with axial shielding plates which cause the most limiting dose rate to be on the cask side where there is a gap in the impact limiter. There is a shipping cage present that will be attached around the package that should prevent a person from entering this space, but the

applicant did not submit any information demonstrating that this component would stay intact under NCT and prevent someone from accessing the cask surface inside the gap in the impact limiter. Therefore the applicant states that they will ship the sources requiring the axial shielding plates by exclusive use, in which case the regulatory dose rates increase to 1000 mrem/hour for the cask surface and 200 mrem/hour for the vehicle surface, and the package meets the requirements of 10 CFR 71.47. These allowable sources are: Ir-192/194 in the AOS-050, Co-60-B and Co-60-C in the AOS-100 package.

Any damage that occurs to the package as a result of HAC only happens to the impact limiter. The applicant referenced all HAC dose point locations from the cask surface, i.e. neglecting the impact limiter altogether. The staff found this conservative and acceptable.

The applicant uses nominal dimensions to model the package and shield inserts and spacers. Although this is a non-conservative assumption, the staff still finds it acceptable for this amendment of the AOS packages because the conservative assumptions used in the analysis would bound any potential reduction of shielding due to variations in manufacturing. One conservative assumption in the AOS analyses is point source representation for all contents except the Co-60-C in the AOS-100A and AOS-100A-S. This neglects the self-shielding which would be present for even small sources. For the Co-60-C, although the model of this content does take some credit for self-shielding of the material, it is still modeled in a conservative way as a single source on the side of the package interior coalesced into a conservative geometry. There are additional conservative assumptions that could also compensate for uncertainties related to manufacturing tolerances, such as neglecting the presence of any interior components, the spacer material (Aluminum or Stainless Steel) in the spacer and any impact limiter material under NCT. Although the impact limiter is made largely of polyurethane, it still has a stainless steel shell that is sufficient to compensate for dimensional tolerances of the shielding components. In addition to all the above mentioned conservative assumptions, the applicant's calculated dose rates all have 10% margin to the regulatory limits under NCT. Under HAC, there is a high margin to regulatory dose rate limits. The highest calculated external dose rate in any AOS package and content configuration is less than 40% of the HAC limit. Therefore dimensional tolerance uncertainties would not cause the package to exceed HAC external dose rate limits.

5.3.1 Configuration of Source and Shielding

For all AOS contents, packages and configurations except the Co-60-C content within the AOS-100A, the applicant assumed the radioactive material is a point source adjacent to the radial cavity wall for the side dose rate, the top lid for the top dose rate, and/or in the corner of the package for the corner dose rate which exposes the streaming path between the tungsten shields for "A" designated packages. The only package that does not have tungsten shields is the AOS-100B, which instead has carbon steel shield in place of the tungsten shield and therefore does not have a streaming path due to the similar attenuation properties of carbon steel and stainless steel. The applicant limits the package contents by the location that has the highest dose rate. The staff found this geometry configuration conservative. A point source concentrates the source and eliminates self-shielding and since the source was placed on the interior wall, this minimized the distance between the source and the detector.

In the previously approved CoC, the staff found the use of point source approximation (versus that of a line source) for a cylindrical volume source acceptable based on information submitted by the applicant and therefore found it acceptable in this amendment.

The content that was not evaluated as a point source was the Co-60-C content for AOS-100A and 100A-S. This is a larger amount of Co-60 and this configuration requires both tungsten

axial shielding plates (Drawing 183C8491) and cavity spacer plates (Drawing 183C8518). Since the applicant credited self-shielding in this configuration, the content is limited by specific activity of 350 Ci/g to ensure an appropriate amount of self-shielding material is present. This is in addition to having a maximum Co-60 limit of 20,200 Ci (748 TBq). Based on the density of Cobalt, the applicant determined that with a specific activity of 350 Ci/g and a maximum Co-60 activity of 19,000 Ci, there would be a minimum mass of 52.29g Cobalt and this mass would occupy a volume of 6.1 cm^3. Since the density of Cobalt is considered a constant, this is bounding with respect to the allowable Co-60 limit because in conjunction with the specific activity limit, a larger activity would result in a larger source and greater self-shielding. The applicant submitted supplemental information showing that the choice of 350 Ci/g is a conservative specific activity based on information from source manufacturers that state that most Co-60 sources are produced within a range of 120-250 Ci/g with a realistic maximum at about 325 Ci/g as there are factors that generally prohibit a source from attaining a higher specific activity such as flux in the reactor, the absorption cross-section of the target nucleus, the irradiation time, and the half-life of the isotope being produced. In addition, the applicant provided an additional calculation which shows that the same Co-60 source concentrated to 700 Ci/g increases the dose rate at 1 meter from 9 mrem/hr to 9.4 mrem/hr. The staff found these justifications are sufficient for crediting the self-shielding of this source without any further restrictions on source uniformity within the CoC.

The applicant modeled several different geometries to determine the most conservative one. This included a cylinder of various dimensions as well as an arc segment of varying size. The applicant determined that the geometry that produced the highest dose rates was the arc segment with a radius of 6cm and angle of 80°. The staff found that this was conservative especially considering that actual source contents would not be in this geometry and will be distributed throughout the cask, especially during NCT.

Several of the AOS package configurations require additional inserts for shipment. Some of these inserts provide a shielding or spacing function, or both. The AOS-025A requires the use of a tungsten liner (Drawing 183C8485). The applicant assumed this liner was present in both NCT and HAC dose rate evaluations. The staff found this appropriate as the applicant demonstrated that this liner remains intact under these conditions per the analysis in Section 2.5.3.3.1 of the application. This assumption is the same as was used in the previously approved amendment of this CoC.

For Ir-192/194 shipments in the AOS-050, stainless steel axial shielding plates are required per Drawing 183C8519. The applicant assumes these plates are present for the dose rate evaluations under NCT but not HAC. The plates are not modeled in the dose rate evaluations for this configuration under HAC. The staff found these assumptions conservative and acceptable as the applicant demonstrated that the plates remain intact under NCT per the analysis in Appendix 2.12.15 of the application.

For Co-60-B quantities of material in the Models AOS-100A and 100A-S, tungsten axial shielding plates are required per drawing 183C8491. The applicant assumes these plates are present in both NCT and HAC dose rate evaluations. The staff found this appropriate as the applicant demonstrated that these plates remain intact under these conditions per the analysis in Section 2.5.3.3.2 of the application. This assumption is the same as was used in the previously approved amendment of this CoC.

For Co-60-C quantities of material in the Models AOS-100A and 100A-S, tungsten axial shielding plates are required per drawing 183C8491 as well as cavity spacer plates per drawing 183C8518. The cavity spacer plates are made of either aluminum or stainless steel. They are credited in the shielding analyses for the space these plates occupy, but the material within the

plate is neglected. This is a conservative assumption as the aluminum or stainless steel would also provide some radiation attenuation. The applicant assumes that both sets of plates are present in NCT but only the tungsten plates are present in the HAC dose rate evaluations. The stainless steel/aluminum plates are not credited in any way in the HAC evaluations. The staff found these assumptions appropriate and conservative as the applicant demonstrated that these plates remain intact under these conditions. The analysis for the tungsten shielding pate is in Section 2.5.3.3.2 of the SAR and the spacer plates are in Appendix 2.12.15 of the application.

5.3.2 Material Properties

The staff verified the material properties used in the shielding model are appropriate. In comparison to the material properties used in the previously approved CoC amendment, most all material properties are the same and the basis for their acceptance has not changed. The differences are in the modeling of tungsten and stainless steel components. The applicant reduced the density of tungsten in the model from 17.8 g/cm^3 to 17.75 g/cm^3. The staff finds this to be conservative as the reduced density will attenuate less radiation and cause calculated external dose rates to increase, which is conservative. For the stainless steel components, the applicant increased the density of the stainless steel from 7.8 g/cm^3 to 8.0 g/cm^3. The staff verified the density of Type 304 and 316 stainless steel from the ASM Handbook Volume 1: Properties and Selection: Irons, Steels, and High-Performance Alloys. It lists the density of stainless steel 304 as 7.9 g/cm^3 and 316 as 8.0 g/cm^3**.** Although assuming a density of 8.0 g/cm^3 may be non-conservative, the staff still found this acceptable. This is due to the analysis conservatisms identified in Section 5.3 of this SER.

The staff verified that the applicant decreased the allowable activity limits for all of the package configurations that are affected by the streaming path from that of the previous amendment. However there are package configurations that are not affected by the streaming path, these are the AOS-025A, due to the required tungsten liner (Drawing 183C8485) and the AOS-100B, because it has a carbon steel shield plates which have relatively equivalent radiation attenuation characteristics as the surrounding stainless steel. For these two packages, the allowable activity limits increased slightly and the staff found that this is due to the increase in density of the stainless steel. Although the AOS-025A also relies on tungsten for its gamma shielding, since the decrease in modeled density is much smaller than that of the increase in stainless steel, the allowable activity limits for this package saw a net increase.

5.4 Shielding Evaluation

5.4.1 Methods

The applicant used the MCNP6 computer code with continuous energy ENDF/B-VI.8 photon cross sections to calculate the external dose rate. This code and cross section set has been widely used in shielding evaluations and the staff found it acceptable for use in this application.

This code normalizes the dose rate response output to a single source particle with a given energy spectrum and therefore it must be multiplied by the activity and number of photons/decay to get the scaled external dose rate. The staff verified that the number of photons/decay were appropriate as determined by the ORIGEN gamma spectrum library.

To reduce run time for the MCNP code, the applicant used variance reduction techniques. The applicant employed mesh-based weight windows, source biasing and exponential transform. These techniques are described in Section 5.4.1 of the application. These techniques are standard techniques used for biasing MCNP problems of this nature. Care needs to be taken

when using biasing techniques so that non-physical results are not obtained. The staff performed independent calculations of the AOS-100A and 100B discussed in Section 5.5 of this application that give the staff confidence that the applicant's biasing techniques are not producing non-physical results and therefore the staff finds their use acceptable.

5.4.2 Input and Output Data

The applicant provided representative input and output files. The staff reviewed several of these files and determined that the information from the shielding models was appropriately input to the code.

5.4.3 Flux-to-Dose-Rate Conversion

The applicant stated that they used the flux-to-dose-rate conversion factors from American National Standards Institute/American Nuclear Society (ANSI/ANS) 6.1.1-1977. The staff finds this acceptable per the review guidance in NUREG-1609. The staff sampled the MCNP input files and verified that the conversion are consistent with ANSI/ANS 6.1.1-1977.

5.4.4 External Radiation Levels

In this amendment, as with previous CoC issuances, the applicant defines the external surface of the package as the impact limiter. The staff finds this appropriate for most contents and conservative considering this package will have a personnel barrier (shipping cage) installed but as they did not submit any information demonstrating it meets the NCT tests in 10 CFR 71.71, it is appropriate to neglect. The applicant takes into account the deformation of the impact limiter due to NCT when establishing the distance to the external surface. For contents utilizing axial shielding and spacer plates, the dose rate is limited in the radial direction and this assumption may not be conservative and therefore these contents are required to be shipped by exclusive use. The radial and axial distances established by the applicant are slightly different than that used in the previous amendment, however the staff verified that they are more consistent with the deformations reported in Table 2-35 of the application and are therefore acceptable. The applicant does not discuss if the corner deformations are used to establish the dose rate surfaces in the corner, however, the staff finds that since the applicant uses deformed radial and axial surfaces to establish this distance that the difference in dose rates would be very slight and are compensated for by conservative analysis assumptions as discussed in Section 5.3 of this SER.

The applicant models the dose point locations as cell tallies that span the top, side and corner areas at the appropriate distances from the package representing either the deformed impact limiter as the package surface, 1 meter from this surface for evaluating the TI, and 1 meter from the cask surface for HAC (neglecting the impact limiter all together). This information is presented in Section 5.3.1.4 of the application. The staff reviewed this information and found that the cell sizes are sufficiently small enough to calculate a localized dose rate and encompass an area large enough to capture the location of the highest dose rate which is especially important for the corner source where streaming is a concern. The staff found that the cell tally size and locations are sufficient to evaluate the highest external dose rate, and are appropriate for determining compliance with the requirements in 10 CFR 71.47(a) and 71.51(a)(2).

The staff verified that the maximum calculated external radiation levels for all nuclides and packages in Tables 5-13 through 5-20 of the SAR are within the regulatory limits prescribed in 10 CFR 71.47(a) for non-exclusive use packages and 10 CFR 71.51(a)(2). The applicant added

an additional conservatism of 2σ and all calculated results show a margin of at least 10% to the regulatory limits.

5.5 Independent Calculations

The staff independently calculated the dose rates for a few of the AOS package configurations. The staff verified the surface external dose rates and the maximum TI for Co-60-B and Co-60-C quantities with the added axial shielding plates and spacers within the AOS-100A meet regulatory limits. The staff used the MONACO/MAVRIC from the SCALE 6.2 code package. The staff used ENDF/B-VII.0 cross section library, and the 1977 ANS flux-to-dose-rate conversion factors. The results of the staff's calculations using an independent code provide the staff with confidence in the applicant's modeling assumptions and use of biasing techniques are appropriate.

5.6 Evaluation Findings

Based on its review of the statements and representations in the application and independent calculations, the staff found reasonable assurance that the shielding design has been adequately described and evaluated and that the package meets the external radiation requirements of 10 CFR Part 71.

The staff reviewed the changes requested by the applicant, and finds that they do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

CONDITIONS

The conditions specified in the Certificate of Compliance No. 9316 have been revised as indicated below:

Item No. 3(b) was revised to include Revision H1, as supplemented by H-2, of the application.

Condition No. 5(a)(2) was revised to include (i) the use of a liner, axial shielding plates, and/or cavity spacer plates, depending on the model, for shipment of some contents; the use of an optional lifting bar on the Model Nos. AOS-050 and -100, (ii) new width and height dimensions for the package in transport configurations, along with a new footnote with respect to the optional lifting bar.

Condition No. 5.(a)(3) was revised to update the licensing drawings to their current revisions.

Condition No. 5(b)(2) was revised to update the activity limits of the isotopes previously authorized (Table 3), and include a new Table 4 for the activity limits of the newly authorized isotope Ir-194 when shipped with Ir-192.

Condition No. 14 was revised to remove the requirement for comprehensive radiation surveys to be performed at every location on the surface, and at 1 meter from the package surface, with a particular attention to the areas around the corners of the package. This requirement had been included in Revision No. 5 of the certificate to allow continuing use of the package until approval of this amendment request.

Condition No. 15 was revised. The condition requiring that no prior revision of the certificate could be used was deleted as being obsolete, and replaced by a condition requiring shipments by exclusive use for contents needing axial shielding and spacer plate configurations. The staff identified that the impact limiters do not cover the entire axial length of the AOS-050 and AOS-

100 models. For some contents, the dose rate on the surface of the exposed package surface may exceed 2 mSv/h (200 mrem/h). Although the shipping cage prevents access to the package surface, the shipping cage has not been shown to withstand the NCT tests and therefore cannot be credited for the purpose of an access barrier. With this exclusive use shipment condition, the external radiation levels will be governed by the limits in 10 CFR 71.47 (b).

Condition No. 16 was revised to include the new expiration date of the certificate to July 31, 2021.

The References section of the certificate was updated to include Revision H-1, supplemented by H-2, of the application.

CONCLUSION

Based on the statements and representations contained in the application, as supplemented, and the conditions listed above, the staff concludes that the design of the Model Nos. AOS-25A, AOS-50A, AOS-100A, AOS-100B, and AOS-100A-S packages has been adequately described and evaluated.

The staff concludes that the changes indicated do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 9316, Revision No. 6,
on July 12, 2016