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DOE Packaging Certification Program

Safety Evaluation Report for Certificate of Compliance No. 9979 Amendment and 5-Year Renewal for the Model 9979 Package

Dockets No. 19-06-9979 & 19-77-9979

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This Safety Evaluation Report (SER) documents the U.S. Department of Energy (DOE) Packaging Certification Program (PCP) independent review and confirmatory analysis of the Safety Analysis Report for Packaging (SARP) submitted by the Savannah River National Laboratory (SRNL) on behalf of the DOE Savannah River Operations Office (SR) for amendment and renewal of DOE Certificate of Compliance (CoC) Number 9979 for the Model 9979 package design.

Summary

By email [1] dated October 30, 2018, the DOE CoC 9979 certificate holder, SR, requested an amendment of the DOE CoC to authorize use of the package for shipment of normal and special form (SF) radioactive materials, in support of the Los Alamos National Laboratory (LANL). The scope of the initial request was subsequently expanded to:

- renew the CoC,
- authorize delta-phase plutonium (Pu) with up to 4.5 percent gallium (Ga) in the Pu content description,
- add additional information on the method used to calculate free volume within the 30-gallon drum,
- revise Hypothetical Accident Condition (HAC) pressure calculation to correct an error in the moisture content calculated for the packaging,
- include all supplements listed in the CoC 9979, Revision 15, including those supporting Dockets 18-35-9979 (approved in CoC Rev.10) and Docket 19-50-9979 (approved in CoC Rev. 15),
- combine this request with Docket 19-77-9979, to add Cs-137, Eu-155, Sr-90, Th-228, Th-229, Th-230, and Cm-243 to SARP Table 1.2.

SRNL (hereinafter referred to in this SER as the applicant) developed and submitted SARP Revision 6a [2] as the safety basis document in support of the initial SRRO amendment request; Revisions 6b and 6c [3, 4] in response to DOE PCP staff comments/questions (Qs) [5]; and expanded scope for renewal of the CoC and to address Pu-Ga contents. The applicant submitted a final consolidated SARP Revision 6 [6] on September 11, 2020 for staff to verify all the agreed-upon changes in Revisions 6a, 6b, and 6c and responses to Qs were accurately implemented. However, during staff's review, they discovered the SARP omitted previous changes for Dockets 18-35-9979 and 19-50-9979 and inconsistencies between the Vogan and POP content mass limits in the SARP and their SF certification tests. In response, the applicant submitted SARP Revision 7a [7] to include the omissions, consolidate Docket 19-77-9979 in the SARP, and provide defensible mass limits for the Vogan and POP assemblies. On December 14, 2020, DOE PCP issued a list of corrections [8] to SARP Revision 7a. The applicant submitted SARP Revision 7b page changes [9] with the corrections noted. On December 21, 2020, DOE PCP accepted [10] all changes in SARP Rev 7b, pending submittal of a final SARP Revision 7. The applicant submitted the final SARP on December 28, 2020.[11]

Based on the statements and representations in SARP Revision 7 and conditions listed in this SER, DOE PCP staff independently confirmed by review and analysis that the package design

has been adequately described and evaluated in the SARP for the additional contents. Therefore, staff has reasonable assurance that the regulatory requirements of 10 CFR Part 71, have been met and recommends amendment and renewal of the CoC by the DOE Headquarters Certifying Official (HCO).

Evaluation

The applicant submitted SARP Revision 6a for review to DOE PCP on November 11, 2019 to incorporate previously approved SARP Rev 5, page changes and their supporting calculations (i.e., DOE CoC 9979 Revision 15 supplements), and authorize use of the Model 9979 for shipment of:

1. Pu-239, Pu-240, and Pu-241 in SF in either the Vogan or Plutonium Oxide Pod (POP) capsule designs,
2. Am-241 in SF in the Am1.N02 capsule design, and
3. Cs-137 and Th-232 in normal form.

DOE PCP staff generated ten Qs from their independent review and confirmatory analysis of SARP Revision 6a. These Qs were issued to SRRO by the DOE PCP Manager on April 13, 2020.

SARP Revision 6b was submitted by the applicant on June 4, 2020 to implement their responses to Qs. Staff reviewed the applicant's responses and SARP Revision 6b page changes, and found them acceptable, except the response to the Q3.1 regarding the 30-gallon drum void volume and corresponding Hypothetical Accident Condition (HAC) pressure calculations.

On July 14, 2020, the Pacific Northwest National Laboratory notified the HCO [12], that delta-phase Pu alloyed with Ga (Pu-Ga) was used by LANL for a similar SF capsule design and the same Pu-Ga material was intended for use in the Vogan and POP assemblies. The applicant assumed in SARP Revisions 6a and 6b that the Pu was in the alpha-phase, i.e., unalloyed.

SARP Revision 6c was submitted on August 4, 2020 to update SRNL's response to Q3.1 and to expand the scope of the submittal to evaluate Pu used in the Vogan and POP assemblies with up to 4.5 percent Ga as an alloying metal in the Pu. The applicant revised SARP Chapter 3 and Appendix 3.2 to demonstrate their method of calculating free volume within the 30-gallon drum and to update their HAC pressure calculations to close out Q3.1. The thermal, shielding, and nuclear criticality evaluations were updated to address Pu-Ga. Staff reviewed the revised response and implementation of Q 3.1 and the revised thermal, shielding, and nuclear criticality evaluations for the Pu-Ga in SARP Revision 6c and found them acceptable.

SARP Revision 6 was submitted on September 10, 2020 to consolidate Revisions 6a, 6b, and 6c. DOE PCP staff verified all the agreed-upon responses to Qs were accurately implemented in SARP Revision 6.

On September 18, 2020, DOE PCP staff requested the applicant to confirm Supplements 2 and 4 through 21 of CoC Revision 15 were incorporated in SARP Revision 6. The applicant informed staff on September 21, 2020 that all supplements were incorporated, except Supplements 11 and 20: Supplement 20 was superseded by Supplement 21, but Supplement 11 was omitted from incorporation in the SARP. Supplement 11 is the safety basis for authorizing use of the package for shipment of Tri-Structural Isotropic (TRISO) fuel and process materials.

Furthermore, on September 25, 2020, DOE PCP staff requested the applicant to provide information of the surrogate materials used in the SF capsule test specimens. This request led to the discovery that the masses of the surrogate content materials used for the certification tests of Vogan and POP SF capsule designs were less than the 25 grams limit proposed in the SARP for these SF assemblies.

The applicant submitted SARP Revision 7a to include TRISO fuel and process materials; correct the Vogan and POP content mass limits to 17.5 and 18 grams, respectively, for consistency with their SF certification tests; and to consolidate Docket 19-77-9979 into the SARP to authorize use of the package for shipment of Cs-137, Eu-155, Sr-90, Th-228, Th-229, Th-230, and Cm-243. Staff reviewed the SARP Revision 7a changes and had no additional technical questions or comments but generated and issued a list of document errors for correction.

The applicant submitted SARP Revision 7b page changes with the corrections noted and on December 21, 2020, DOE PCP formally accepted all changes in SARP Rev 7b, pending submittal of a final SARP Revision 7. The applicant submitted the final SARP on December 28, 2020.

The following sections in this SER document DOE PCP staff's chapter-by-chapter independent review and confirmatory analysis of SARP Revision 7 to confirm it contains a sufficient safety basis for HCO approval of the package design to the requirements of 10 CFR Part 71.

1.0 General Information

The Model 9979 is a Type A fissile package composed of one 55-gallon drum overpack and one 30-gallon inner drum. The purpose of the Model 9979 package is to transport a Type A quantity of solid fissile radioactive material by public highway.

1.1 Packaging

There were no important-to-safety changes to the packaging design currently authorized in CoC Revision 15. The 9979 packaging consists of a 30-gallon confinement drum nested inside an internally insulated 55-gallon protective overpack drum. The safety function of the 30-gallon is to prevent loss or dispersal of its radioactive contents under Normal Conditions of Transport (NCT) and ensuring that the fissile material contents remain subcritical under NCT and HAC.

1.2 Contents

The following contents were added in SARP Revision 7. In some cases, the contents were authorized in previous revisions of the CoC, based on supplements to the SARP and CoC, as noted in the descriptions below. A_1/A_2 calculations used in these tables and the maximum decay heat values are based on the tables in SARP Appendix 4.1, *Content Description for the 9979*.

SARP Table 1.1 - *Radioactive Content Description*: TRISO Fuel and process materials, Vogan Assemblies, Plutonium Oxide Pods (POP) Assemblies, Am1.N02 Assemblies, and Cesium & Thorium samples were added to the "non-combustible" payload category and "solid compounds and metal" material forms. The SARP was revised to incorporate CoC Supplements 10 and 11 and add new contents for Docket 19-06-9979. Note – TRISO Fuel and process materials were authorized contents in CoC Revision 10.

SARP Table 1.2 - *Envelope Limits including Highly Enriched Uranium (HEU) Content*: Cs-137, Eu-155, Sr-90, Th-228, Th-229, Th-230, and Cm-243 were added to the table and their respective mass limits. The general table note was updated to include these isotopes. Table Note "g" was added to include an additional condition to the gram limit that the sum of these mass fractions is limited to "≤ 1", to control dose rate. These contents were the scope of the CoC amendment request for Docket 19-77-9979 and subsequently consolidated in SARP Revision 7. SARP Section 1.2.2.4*, HEU Content Configuration – Table 1.2*, was revised to add the loading configuration for TRISO Fuel and process materials. The maximum decay heat calculated for the SARP Table 1.2 contents was updated in SARP Appendix 4.1, Table 1.2, to 4.49E-02 watts.

SARP Table 1.3 - *Low Enriched Uranium (LEU) Content Envelope ≤ 19.9% U-235*: U-235 and U-238 weight fraction and mass limits were revised to incorporate CoC Supplements 8 and 9. Note – This change was authorized in CoC Revision 10.

SARP Table 1.4 - *Low Enriched Uranium (LEU) Content Envelope ≤ 1.25% U-235*: Tc-99 mass limit was revised to incorporate CoC Supplement 12. Note – This change was authorized in CoC Revision 11. The maximum decay heat calculated for the SARP Table 1.4 contents was updated in SARP Appendix 4.1, Table 1.4, to 5.20E-03 watts.

SARP Table 1.5 - *Vogan/POP, Am1.N02, Cs-137, & Th-232 Content Envelope*: Table 1.5 and Table 1.5 Notes "a through f" added to the SARP for the special and normal form items of Docket 19-06-9979. SARP Section 1.2.2.7 *Special Form Pu, Special Form Am1.N02, & Normal Form Cs-137 & Th-232 Configuration – Table 1.5*, was added for the loading configuration of these contents. The maximum decay heat calculated for the SARP Table 1.5 contents was added in SARP Appendix 4.1, Table 1.5, and is 3.42E-01 watts. These contents and loading configuration are described below.

<u>Vogan Assembly</u>

The Vogan Assembly is a special form capsule design defined by LANL drawing 157Y701711-900, Revision B, and consists of two nested capsules that encapsulate a Pu metal disk and aluminum shim, i.e., spacer. The Pu mass limit is 17.5 grams, and the assembly mass limit is 79.5 grams. The outer capsule profile is approximately 1.30 inches in diameter and 0.50 inches thick and fabricated from titanium. The primary safety function of the outer capsule is structural protection of the inner capsule. The inner capsule is fabricated from tantalum and its primary safety function is containment of the Pu. These capsules are sealed by laser beam welding (LBW) or electron beam welding (EBW). The Vogan Assembly design was tested in accordance with 49 CFR 173.469 and certified by the Southwest Research Institute (SwRI), San Antonio, TX. The fabrication and certification drawings are included in SARP Section 1.3, Appendix 1.2, and the SF test and certification documentation in SARP Section 1.4, as References 9 and 10.

Plutonium Oxide Pod (POP) Assembly
The POP Assembly is a special form capsule design defined by LANL drawing 157Y701720-000, Revision A, and consists of two nested steel capsules that encapsulate Pu oxide. The Pu oxide mass limit is 18.0 grams, and the assembly mass limit is 53.4 grams. The outer capsule profile is approximately 1.30 inches in diameter and 0.48 inches thick and fabricated from 316 stainless steel. The primary safety function of the outer capsule is structural protection of the inner capsule. The inner capsule, also referred to as "SNAP" container, is fabricated from 1018 carbon steel and its primary safety function is containment of the Pu oxide. These capsules are sealed by LBW or EBW. The POP Assembly design was tested in accordance with 49 CFR 173.469 and certified by the Southwest Research Institute (SwRI), San Antonio, TX. The fabrication and certification drawings are included in SARP Section 1.3, Appendix 1.3, and the SF test and certification documentation are referenced in SARP Section 1.4, as References 11 and 12.

Am1.N02 Assembly
The Am1.N02 is a special form capsule design certified by competent authority of the Czech Republic, Certificate CZ/1009/S-96, Rev 2, and consists of two nested capsules that encapsulate 16 mg of Am-241 oxide with up to 20 milligrams of Be. The mass limit for the Am1.N02 assembly is 6.84 grams. The outer capsule profile is approximately 7.8 mm in diameter and 10 mm long, and its primary safety function is structural protection of the inner capsule. The primary safety function of the inner capsule is containment of the Am/Be source. Both capsules are fabricated from stainless steel and are sealed by tungsten inert gas (TIG) welds. The special from certificate is referenced in SARP Section 1.4, as Reference 14.

Cs-137 and Th-232
Normal form solids in disks or strips.

Table 1.5 Loading Configuration per package
The package may offered for shipment with up to eight (8) Vogan or POP assemblies, or any combination of the two, with up to ten (10) Am1.N02 assemblies, and Cs-137 and Th-232 in normal form up to 1.3 μg and 300 g, respectively, per SARP Table 1.5 and its table notes. These contents may be loaded in any orientation within the 30-gallon drum. SARP

> Figure 1.10, *Example Packing Configuration for Table 1.5*, illustrates one possible general packing configuration in a polyurethane foam structure. The estimated weight of the SARP Table 1.5 contents offered for shipment, excluding dunnage, is approximately 1.0 kg, based on eight Logan capsules, ten Am1.N02 capsules, and normal form Cs-137 and Th-232 solids at their maximum RAM masses. Since these contents are non-combustible, the thermal Insulation Bag (Drawing R-R4-G-00064) is optional. Void space in the 30-gallon drum may be filled with low-density polyurethane foam for dunnage. The total weight of the contents, including dunnage and thermal Insulation Bag, may not exceed 90 kg.

The applicant demonstrated in SARP Appendix 4.1, Table 1.5, that the maximum package activity for the mixture of radionuclides in special and normal form is less than one, in accordance with the formula in 10 CFR 71, Appendix A, Section IV, Item c. Therefore, SARP Table 1.5 is a Type A quantity of RAM.

Due to the presence of Pu-239 and Pu-241, SARP Table 1.5 contents are also fissile material, i.e., a Type A quantity of fissile RAM. The maximum fissile mass/per package is approximately 135 grams (Pu-239 + Pu-241), based on eight POP capsules as the bounding case. The Pu exceeds 0.74 TBq and is in solid form, as required by §71.63. For the criticality evaluation in Chapter 6 and Appendix 6.3 for the Vogan Assemblies, the applicant assumed all the Pu metal mass, 200 g, was Pu-239. The Criticality Safety Index (CSI) calculated in SARP Table 6-7 for the SARP Table 1.5 contents is 0.1.

1.3 Drawings

There were non-safety related changes to 30-gallon drum drawings R-R1-G-00028 and R-R2-G-00060. Assembly drawing R-R1-G-00028, Revision 6A, Note 7, was revised in Revision 7 to change the torque tolerances for the lid bung and pressure relief fittings from percentages to numerical values (e.g., 15 ft-lb. ± 10% to 15 ft-lb. ± 1.5 ft-lb). Lid drawing R-R2-G-00060, Revision 5A was revised in Revision 6 to add the bung torque requirements in Note 11 consistent with Note 7 of drawing R-R1-G-00028.

In addition, packaging drawings currently approved in CoC Revision 15 with a revision number letter combination (e.g., R-R1-G-00026, Revision 8A) were updated in the SARP to omit the letter, with no other changes to these drawing. The applicant made these administrative changes for compliance with their document control scheme.

The Vogan and POP Assembly drawings were added as SARP Appendices 1.2 and 1.3 and will be added to the CoC.

1.4 Conclusion

Based on a review of the statements and representations in the SARP, DOE PCP staff concludes that the content changes in support of the CoC amendment and renewal request have been described in sufficient detail to provide an adequate basis for the package evaluation under 10 CFR Part 71.

2.0 Structural Evaluation

The objective of this structural review is to determine that the information presented in the SARP, including the description of the packaging, design and fabrication criteria, structural material properties, and structural performance of the package design for the tests under NCT and HAC, is complete and meets the requirements of 10 CFR Part 71.

There were no changes to the structural design features of the packaging for this amendment and renewal request. The package contents including radioactive material, dunnage, packing, and thermal insulating bag (if used) is limited to 90 kg., based on evaluation of the structural design.

SARP Table 1.5 contents includes special form and normal radioactive materials. DOE PCP staff reviewed SARP Chapter 2 and Appendices 2.1 to 2.4 to confirm that the applicant included sufficient documentation to demonstrate that the Vogan and POP special form assembly designs were approved (by SwRI) in accordance with §173.476(a) for domestic use. Both assembly designs met the requirements of §173.469, with appropriate surrogate materials for Pu metal (tungsten metal) and oxide (bismuth oxide). The Am1.N02 special form assembly is certified by the competent authority of the Czech Republic and its certificate, CZ/1009/S-96, is sufficient documentation to meet to §173.476(a) for domestic use and §173.476(b) for import/export. SARP Section 2.10, *Special Form Contents*, was added to the SARP to describe the special form contents and summarize the test results and basis for the mass limits for the Vogan and POP Assemblies in SARP Table 2.14. *Tested Masses and Table 1.5 Mass Limits for the Vogan/POP Capsules*.

The mass of the Table 1.5 contents offered for shipment, excluding dunnage, is approximately one kilogram, and with dunnage will meet the maximum allowable content mass (90 kg) for the package. Therefore, a structural analysis of the SARP Table 1.5 content configuration is not required because its mass is bounded by the existing analysis.

The Table 1.5 contents are secured and positioned within the 30-gallon drum by a polyurethane form structure polyurethane dunnage. The drum is lined with an insulation bag to prevent direct contact between the between radioactive contents and the 30-gallon drum interior. The applicant added and evaluated material compatibility of the new materials (Titanium and Tantalum) used in the Vogan Assemblies to SARP Section 2.2.2, *Chemical, Galvanic, or Other Reactions*, and Table 2.8 – *Dissimilar Contacting Materials within the 30-Gallon Drum*, with the existing package materials. The outer shell of the Vogan Assembly is made from titanium alloy and the inner shell is made from tantalum with an aluminum shim. The POP Assembly outer shell is stainless steel, and the inner shell is carbon steel. The Am1.N02 Assembly shells are stainless steel. Galvanic corrosion between the titanium alloys and stainless steel assemblies is not likely when the materials are in incidental contact with each other. For the Vogan Assembly, the internal corrosion potential between the titanium outer shell, the inner tantalum, and the aluminum shim is essentially restricted by the anodized layer and the environmental condition (no internal moisture), which prevent galvanic corrosion from occurring. DOE PCP staff concurs with the applicant's evaluation that there is no material incompatibility issues between the SARP Table 1.5 contents, the form structure or dunnage, the insulation bag, and the 30-

gallon drum.

Based on review of the statements and representations in the SARP, DOE PCP staff has reasonable assurance that the structural design of the package continues to meet the requirements of 10 CFR Part 71.

3.0 Thermal Evaluation

The objective of this thermal review is to verify that the thermal performance of the package has been adequately evaluated for the tests specified under NCT and HAC and that the package design satisfies the thermal requirements of 10 CFR Part 71.

There were no changes to the thermal design features of the packaging. The package thermal design is limited to a maximum of 3.5 watts of decay heat, based on SARP Appendix 3.1, *NCT and HAC Thermal Models for the 9979 Package*, M-CLC-A-00354.

The applicant revised SARP Section 3.1.2, *Content's Decay Heat*, to state the total decay heat of the package with contents from SARP Tables 1.2, 1.3, and 1.4 is less than 100 milliwatts, and for SARP Table 1.5 contents, approximately 500 milliwatts, based on the updates to SARP Appendix 4.1, Table 1.2, *HEU Content Envelope Limits* and Table 1.5, *Vogan/POP, Am1.N02, Cs-137, and Th-232 Content Envelope Limits*. The applicant also performed an NCT and HAC analysis of the SARP Table 1.5 contents and implemented it as SARP Appendix 3.2, *9979 Package NCT and HAC Thermal Analysis with Plutonium Special Form Capsules*, M-CLC-A-00664. This analysis included solar insolation under NCT and as the initial condition for the HAC thermal test. The results from this analysis are implemented throughout SARP Chapter 3 to update text and tables:

- Table 3.3 – *Calculated 9979 Package Component Temperatures under NCT*,
- Table 3.4 – *Calculated 9979 Package Component Temperatures under HAC*,
- Table 3.5 – *Calculated Maximum Pressures in the 30-gallon Drum*,
- Table 3.11 – *Thermal Model Content Configurations*,
- Table 3.12 – *Calculated 9979 Component Temperatures under NCT/Solar*,
- Table 3.15 – *Calculated Temperatures at End of 30-Minute HAC Fire*, and
- Table 3.18 – *Calculated Maximum Post-Fire Temperatures -- Special Form Capsules*.

The applicant added SARP Section 3.4.6, *Eutectic Reactions for Plutonium Special Form Contents,* to demonstrate that eutectic reactions are not likely in the Pu-Ga material because the temperatures of the special form assemblies under NCT and HAC are significantly below the melting temperature of Pu in a two-phase Pu-Pu_6Fe with small amounts of gallium.

The applicant updated SARP Section 3.6, *References*, to add or update the following references in support of the updated thermal and gas generation analysis:

- 24. *COMSOL Multiphysics version 5.2*, COMSOL, Inc., Burlington, MA, (2012) (added),

- 25. *Software Quality Assurance Plan for COMSOL Multiphysics (2012)*, B-SQP-A-00057 Rev. 0. (added),
- 36. *Hydrogen gas generated from the contents in the 9979 package*, M-CLC-A-00631, Rev. 3, Savannah River National Laboratory, (September 2020) (updated),
- 37. *Stabilization, Packaging, and Storage of Plutonium-bearing Materials,* DOE-STD-3013-2018, November 2018 (added), and
- 38. *Hydrogen Gas Concentration in Model 9979 Type AF Containers at Los Alamos National Laboratory,* LA-CP-18-20604, Revision 0, (September 2018) (added).

DOE PCP staff thermal review focused on decay heat load, accessible package surface temperature, peak temperatures of packaging components, maximum pressures under NCT and HAC, and hydrogen generation from the SARP Table 1.2 content addition and the new SARP Table 1.5 contents.

SARP Table 1.2 Content Addition

The sum of the decay heat of all isotopes listed in SARP Appendix 4.1, *Table 1.2 HEU Content Envelope Limits* (including the seven additional isotopes), at their maximum mass, is approximately 37 milliwatts. This assumption for the decay heat load would far exceed the activity limit for a Type A package but demonstrates that the decay heat for any combination of SARP Table 1.2 isotopes within their mass limits is bounded by the thermal design limit of 3.5 watts for the package.

The applicant evaluated gas generation from the additional seven isotopes added to the SARP 1.2 contents in SARP Reference 3.6.36 and revised the calculated maximum package decay heat load for the SARP Table 1.2 contents from of 8.8 milliwatts to 9.12 milliwatts, based on Tc-99, U-235, U-238, and Eu-155. The applicant's calculation uses a mixture of SARP Table 1.2 isotopes that have the highest potential decay heat, that meet the Type A package activity content limit ($A_2 \leq 1$), and the package payload mass limit of 90 kg. These results are shown in SARP Reference 3.6.36, Table 4, *9979 SARP – Table 1.2 Assumed* Contents.

The package thermal limit for SARP Table 1.2 contents is based on the gas generation analysis in SARP Reference 3.6.36. The updated hydrogen generation rate calculation for these contents, with the additional isotopes assumes a maximum package decay heat load increases from 8.8 to 9.12 milliwatts and results in a marginal change to the required minimum void volume fraction in the 30-gallon drum from 8.4% to 8.9%. This void volume control is required to keep the hydrogen gas concentration below 5% by volume during a 1-year shipping period (SARP Reference 3.6.36, Table 6, *Time to Reach 5% H_2 for 9979 Table 1.2*). The revised minimum void volume is bounded by the 9% minimum void volume in SARP Section 7.1.1.2 for SARP Table 1.2 contents.

DOE PCP staff reviewed the analysis and concurred with the results.

SARP Table 1.4 Contents
The hydrogen generation and collection rates for the SARP Table 1.4 contents were also revised in SARP Reference 3.6.36 (M-CLC-A-00631, Rev. 3) to account for the increase of the Tc-99 mass limit from 1.00E-06 to 4.00E+00 grams (CoC Revision 12, Docket #19-41-9979), and to correct errors in M-CLC-A-00631, Rev. 2, Table 11, *Time to Reach 5% H_2 for 9979 Table 1.4*. Consequently, the minimum void volume fraction in the 30-gallon drum was revised from 3.7% to 4.6% to demonstrate that the hydrogen gas concentration in the drum remains below 5% by volume during a 1-year shipping period. The applicant revised SARP Section 7.1.1.2, Step 4, c. *LEU Content Configuration – Table 1.4*, Item iii to implement this change by requiring a minimum of 5% void volume in the 30-gallon drum.

DOE PCP staff reviewed the analysis and notes that these changes increase the minimum void volume to 4.6% and decreases the shipping period from 360 to 180 days for SARP Table 1.4 contents [(i.e., CoC Rev. 15, Condition (9)].

SARP Table 1.5 Contents
The sum of the decay heat of all isotopes listed in SARP Appendix 4.1, Table 1.5, *Vogan/POP, Am1.N02, Cs-137, and Th-232 Content Envelope*, at their maximum mass per package, is approximately 468 milliwatts and is bounded by the thermal design limit of 3.5 watts for the package. Table 1.5 contents are the highest heat load contents for the package. DOE PCP staff confirmed the applicant's results by calculation. The decay heat limit is rounded to 500 milliwatts (or 0.5 watts) for SARP Table 1.5, Note "c" and in SARP Section 3.1.2 for the thermal evaluation.

The applicant used COMSOL software (SARP Reference 3.6.24) to analyze the SARP Table 1.5 contents under NCT and HAC. The applicant's software quality assurance plan for COMSOL is documented as SARP Reference 3.6.25. The results of the analysis are documented in SARP Appendix 3.2, *9979 Package NCT and HAC Thermal Analysis with Plutonium Special Form Capsules*, *M-CLC-A-00664*. DOE PCP staff reviewed the applicant's thermal analysis and the results and found them acceptable and properly implemented in SARP Chapter 3 text and tables.

DOE PCP staff confirmed by document review that the maximum calculated temperature of 101°F (SARP Appendix 3.2, Table 5) at the accessible surface of the package does not exceed the limits of §71.43(g) for non-exclusive use shipment (≤ 122°F) or exclusive-use shipment (≤ 185°F). Staff also reviewed and confirmed that the peak calculated temperatures of the packaging components and contents in SARP Tables 3.3 and 3.4 remain below their allowable temperature limits under NCT and HAC.

Staff reviewed SARP Appendix 3.2, Appendix D, *Free Volume Calculation* and concurred with the applicant's results of a free volume fraction of 90 % inside the 30-gallon drum. The free volume fraction and 500 milliwatts of decay heat were then used to calculate the maximum normal operating pressure (MNOP) and the maximum pressure under HAC for the containment boundary, i.e., the 30-gallon drum. The 30-gallon drum design includes a 2-inch pressure release plug that is designed to open between 12-15 psig to limit internal pressure in the drum during HAC. HAC Based on SARP Appendix 3.2, Sections 4.5.1 and 4.52, the MNOP and the maximum pressure under HAC are 24.75 psia (10.05 psig) and 68.1 psia (53.4 psig), respectively, at gas temperatures of 144°F for MNOP and 458°F for HAC. This MNOP for SARP Table 1.5 contents is less than the drum pressure rating of 22.5 psig listed in SARP Table 3.1, *Packaging Thermal Design Limits for NCT and HAC*. The HAC pressure exceeds 12-15 psig, so the pressure release plug is necessary for the SARP Table 1.5 contents. For both cases, the applicant assumed that all moisture in the 30-gallon drum, i.e., 1% of the packing material mass or 0.28 lb., is fully vaporized. For MNOP, this assumption is conservative because the equilibrium vapor pressure of water is 3.05 psia at 144 °F and is below the partial vapor pressure of 8.0 psia the applicant used in their MNOP calculation. For the HAC pressure calculation, this assumption is appropriate to calculate the pressure contribution of 42.6 psia from 0.28 lb. of water (7.07 moles). The total pressure of the system is 68.1 psia under HAC, based on the pressure of 25.5 psia from the temperature change from 70 °F to 458 °F and 42.6 psia from the moisture in the packing material. Staff confirmed the applicant's results by calculation.

DOE PCP staff reviewed the potential hydrogen generation and combustion in SARP Chapters 2, 3, and 4 for SARP Table 1.5 contents. Radiolysis of surface-absorbed moisture may lead to hydrogen generation and combustion. The special form radioactive materials are encapsulated in seal welded capsules and therefore are isolated from the moisture (water) outside of the special form capsules. The potential for hydrogen generation from the normal form contents, i.e., Cs-137 and Th-232, has a combined decay heat of 9.23E-07 watts, and is bounded by gas generation rates from SARP Tables 1.2, 1.3, and 1.4 contents.

Based on review of the statements and representations in the SARP, and DOE PCP staff's confirmatory calculations, staff has reasonable assurance that the package thermal design has been adequately described and evaluated and that the package continues to meet the thermal requirements of 10 CFR Part 71.

4.0 Containment Evaluation

The objective of this containment review is to verify that the package design satisfies the containment requirements of 10 CFR Part 71 under NCT and HAC.

There were no changes to the containment design features of the packaging. The package is limited to a Type A quantity of radioactive material, including fissile radioactive material.

The applicant added the following isotopes, in normal form, to the SARP Table 1.2 configuration: Cs-137, Eu-155, Sr-90, Th-228, Th-229, Th-230, and Cm-243, based on the activity and mass limits in SARP Appendix 4.1, *Table 1.2 HEU Content Envelope Limits*. This table also includes decay heat (watts/gram) for each isotope. The aggregate activity of the mixture of all seven of these isotopes at their mass limit is approximately is 1.93 and therefore exceeds the limit for Type A packaging. The total aggregate activity of the SARP Table 1.2 contents offered for shipment, per package, must be so limited that the A_2 value of the mixture is does not exceed 1 (A_2 mixture ≤ 1).

The applicant added the following isotopes in normal form and special form: Cs-137 and Th-232 in normal form and Pu-239, Pu-240, Pu-241, and Am-241 in special form, as SARP Table 1.5, based on activity and mass limits in SARP Appendix 4.1, *Table 1.5 Vogan/POP, Am1.N02, Cs-137, and Th-232 Content Envelope Limits*. This table also includes decay heat (watts/gram) for each isotope. The special form assemblies/capsules are approved in accordance with §173.476(a), i.e., meets the requirements of §173.469. The Pu, in metal form, is certified as special form the Vogan Assembly design; Pu in oxide form, is certified as special form in the POP Assembly design; and the Am-241, mixed with Be (Am-Be source), is certified as special form in the Am1.N02 capsule. The Cs-137 and Th-232 are normal form solids. The aggregate activity of the mixture of these of these isotopes at their mass limit is approximately is 0.11 and therefore meets the limit for Type A packaging.

DOE PCP staff confirmed by document review and calculation that the values used in SARP Appendix 4.1 are correct and are correctly implemented in SARP Tables 1.2 and 1.5.

The applicant added SARP Section 4.5 to address the addition and description of special form contents.

Based on review of the statements and representations in the SARP, and DOE PCP staff's confirmatory calculations, staff has reasonable assurance that the package containment design has been adequately described and evaluated and that the package continues to meet the containment requirements of 10 CFR Part 71.

5.0 Shielding Evaluation

The purpose of the shielding review is to confirm that the package (the packaging together with its contents) meet the external radiation requirements in 10 CFR Part 71.

There were no changes to the shielding safety design features of the packaging.

The applicant provided new shielding calculations to evaluate the seven isotopes added to SARP Table 1.2 content and to evaluate the new SARP Table 1.5 contents. DOE PCP staff reviewed the applicant's source specification, calculated the neutron and photon source terms using the ORIGEN module of the SCALE 6.2.3 package, and performed a confirmatory shielding analysis using the general-purpose Monte Carlo N-Particle code (MCNP) Version 6.2 to independently evaluate the shielding performance of the package under NCT and HAC. The applicant added new tables in SARP Chapter 5 for these contents, beginning with new Table 5.2, so subsequent existing tables were renumbered, and their references updated in the text.

The applicant updated SARP Section 5.1.2.1 *HEU/LEU (Cubes and Plates)* and SARP Table 5.1 *Summary Table of External Radiation Levels (Non-Exclusive Use)* to account for the increased estimated transport index (TI) value and the increased dose rate contribution under NCT and HAC from the additional Table 1.2 isotopes to demonstrate compliance with §§71.47(a) and 71.51(a)(2) limits, for non-exclusive use conveyance. The new TI and dose rates are based on SARP Appendix 5.4, *Shielding Analysis CNS Content in a 9979 Shipping Package (U)*.

SARP Section 5.1.2.3 *Los Alamos Source Devices* and SARP Table 5.2 *Summary Table of External Radiation Levels – Los Alamos Sources (Exclusive Use)* were added to demonstrate compliance with §§71.47(b) and 71.51(a)(2) of the package and conveyance dose rates with SARP Table 1.5 contents under NCT, HAC, and for the transport vehicle per the exclusive use conveyance requirements. Dose rates are based for the applicant's shielding evaluation in SARP Appendix 5.3 *Shielding Analysis for Pu, Am/Be, Cs, and Th Content Assortment in a 9979 Shipping Package (U)*.

5.1 Source Specification

SARP Section 5.2.1, *HEU/LEU (Cubes and Plates),* was updated to include the additional isotopes from SARP Table 1.2: Cs-137, Eu-155, Sr-90, Th-228, Th-229, Th-230, and Cm-243 for shielding evaluation. These isotopes were analyzed individually with their masses based on the A_2 values from §173.435, as shown in SARP Table 5.4, *A_2 Mass Limits for Additional Isotopes*. The applicant's source term analysis for these isotopes was completed in ORIGEN-ARP code in SCALE 6.1. Photon source spectra and strengths are listed in SARP Table 5.10, *Photon Spectra and Source Strength (Additional HEU Content)*, and the neutron source spectra and strengths are listed in SARP Table 5.11, *Neutron Spectra and Source Strength (Additional HEU Content)*. The photon and neutron spectra were calculated for 1 gram of each isotope. A uniform 1% by weight of beryllium was included in each source term generation to account for the (α, n) interactions. The analyses presented in SARP Appendix 5.1, *Shielding Analysis for the Model 9979 Shipping Package*, determined that the inclusion of UF_6 in the package content could potentially increase the intensity of neutrons, particularly at energies less than 1.5 MeV, beyond those generated for Be-9 (α, n) C-12 alone by as much as a factor of 2. Therefore, the neutron and secondary photon dose rates from non-fluoride source terms were multiplied by 2.0. The source strength used in the shielding calculations was the source strength calculated for 1 gram of each isotope multiplied by the isotope mass considered. The source terms were generated for up to 80 years of decay and the maximum was used for the shielding calculations.

SARP Section 5.2.3, *Los Alamos Source Devices,* and SARP Table 5.8, *Los Alamos Source Materials*, were added to include the SARP Table 1.5 contents for shielding evaluation. The applicant's source term analysis for these isotopes was completed in ORIGEN-S code. These contents were decayed from 0 to 300 days and then from 1 to 120 years in 15-year increments. The bounding source term used in the shielding calculations was organized in 47 energy groups using the largest value calculated for each energy throughout the decay. The contents were analyzed at the maximum proposed masses, excluding the Am/Be source. Separate analyses were conducted for 200 grams of Pu metal in Vogan Assemblies and Pu oxide in POP Assemblies. The Pu oxide results in a greater neutron source due to reactions with the oxygen. The Cs-137 source was modeled at 1.3 µg, and the Th-232 source at 300 grams. The Am/Be neutron and photon sources were based on a single capsule and the resulting spectra were multiplied by 10 to represent the total number of Am1.N02 capsules per package. The Pu in the Vogan and POP Assemblies may include up to 4.5 weight percent of gallium as an alloying agent. Inclusion of gallium has no impact on shielding since it does not produce neutrons or photons and therefore will not increase the bounding source terms. The resulting source spectra are shown in SARP Table 5.13, *Neutron Source Spectra for Los Alamos Source Devices*, and Table 5.14, *Photon Source Spectra for Los Alamos Source Devices*.

DOE PCP staff used the ORIGEN code SCALE 6.2.3 to calculate and confirm the applicant's photon and neutron bounding source terms.

5.2 Shielding Models

The applicant used MCNP 6.1 code for the models discussed below.

Package Model with Table 1.2 Additional Isotopes

SARP Section 5.3.1.1, *HEU/LEU (Cubes and Plates)*, was revised to account for the additional Table 1.2 isotopes. The package was modeled for the NCT analysis with the content represented as a 350 g sphere of U-235. The MCNP 6.1 model of the package consists of two concentric cylindrical vessels representing the 30-gallon and 55-gallon drums. Drum dimensions are listed in SARP Table 5.15, *Drum Dimensions for NCT Model with Los Alamos Sources & Additional HEU Content*. The volume between the drums is modeled as reduced density polyurethane foam. Only the uranium sphere is modeled for HAC dose rate calculations.

Package and Conveyance Models for Table 1.5 Contents

SARP Section 5.3.1.3, *Los Alamos Source Device*, was added for the Table 1.5 contents. The shielding model of this configuration for NCT is simplified to consist of four concentric cylinders representing the 30-gallon and 55-gallon drums. Drum dimensions are listed in SARP Table 5.15. For the exclusive use conveyance, the two drums were modeled and separated by four feet center-to-center based on the pallet dimensions (4 ft. x 4 ft.). The walls of the vehicle cab were omitted and used as reference points for radiation detectors. The dimensions of the conveyance vehicle and pallet are shown in SARP Table 5.16, *Dimensions for Transport Vehicle and Pallet used in Exclusive-Use Analysis*, based on an industry standard 53 feet, air ride dry van and pallet. Only the sources are modeled for HAC.

Package Model for Vogan or POP Special Form Assemblies

The model for the Vogan Assembly and Pu metal disk is based on the dimensions in SARP Table 5.17, *Vogan Assembly Dimensions*. Eight Vogan Assemblies are modeled in the three configurations shown in SARP Figure 5.2, *Vogan and POP Special Form Assembly Modeled Configurations*, to identify the configuration that reduces the effect of self-shielding and spacing. The model for the POP Assembly and Pu oxide is based on the dimensions in SARP Table 5.18, *POP Assembly Dimension*. Eight POP Assemblies are modeled in the three configurations shown in SARP Figure 5.2, since they are very similar in size and shape as the Vogan Assemblies.

Package Model for Am1.N02 Special Form Capsules

The model for the Am1.N02 capsule is based on the outer capsule dimensions listed in special form certificate CZ/1009/S-96 (Rev. 2), which is a cylinder 10 mm (0.393 inch) long by 7.8 mm (0.310) diameter with the 0.2505 cm. in diameter and height solid Am-Be neutron source centered in the cylinder. The dimensions for the inner capsule and Am-Be source are not given in the certificate, but the applicant estimated the size of the source by calculation and analysis, based on its maximum activity of 7.4 GBq for Am-241 in oxide form, the maximum measured neutron emission rate of 1.2E+05 n/s for one Am1.N02 capsule (SARP Appendix 5.3, Appendix B), and densities of Am_2O_3 and Be. The applicant ran ORIGEN-S cases with increased masses of Be until the neutron output reached an emission rate of 1.22E+05 n/s, which occurred at 20 mg of Be. Case results are shown in SARP Appendix 5.3, Appendix B, in Table titled *Appendix B: Origen-S Beryllium Mass Calculation Results*. The overall dimensions of the Am-Be source, based on the applicant's calculations, is a solid cylinder 0.2505 cm. in diameter and height. SARP Table 5.19, *Americium and Beryllium Material Characteristics* lists the masses, densities, and volumes the applicant used to calculate the radius of the source. Ten Am1.N02 capsules are modeled in the three configurations shown in SARP Figure 5.5, *Configurations of Am/Be Capsules within 9979 Shipping Package*.

DOE PCP staff confirmed the applicant's Am-Be mass estimate using ORIGEN code of SCALE 6.2.3.

Package Model for Cs-137 and Th-232 in Normal Form

The Cs-137 and Th-232 sources were modeled as spheres with volumes based on their densities and maximum allowable mass. The Cs-137 sphere is modeled with a radius of 0.005 cm based on its mass limit of 1.3 μg and density of 1.89 g/cc. The Th-232 sphere is modeled with a radius of 1.828 cm based on its a mass limit of 300 g and density of 11.72 g/cc. These sources were modeled at the side of the 30-gallon drum centered vertically and at the top of the 30-gallon drum on the centerline. All the spherical sources were axially located on the z-axis in both cases.

5.3 Material Properties

The applicant added two new tables in SARP Section 5.3 to list material properties used in the shielding models, such as composition (wt.%) and density. The properties for the drum and insulation packaging components are listed in SARP Table 5.20, *9979 Shipping Package Material* Compositions, and the materials (radioactive and non-radioactive) for the SARP Table 1.5 configuration are listed in SARP Table 5.21, *Material Composition for Los Alamos Sources and Assembly Components*. DOE PCP staff confirmed the properties in these tables are consistent with material properties in SARP Chapters 1 and 2.

5.4 Shielding Analyses Results

The applicant used the MCNP code for the shielding calculations of the package model for the additional SARP Table 1.2 content configuration and new SARP Table 1.5 configuration. The applicant used MCNP6.1 and DOE PCP staff used MCNP6.2 of the code. Both the applicant and staff used ANSI/ANS-6.1.1-1977, *Neutron and Gamma-Ray Fluence-To-Dose Factors*, for flux-to-dose-rate conversion factors.

SARP Table 1.2 Content Addition

The maximum calculated NCT surface dose rate for the existing SARP Table 1.2 contents (i.e., HEU/LEU Cubes and Plates) is 172.9 mrem/hr., as shown in SARP Table 5.23, *Calculated Dose*

Rate from the Source Center (HEU/LEU Cubes and Plates). The applicant limited the mass of each additional isotope to keep its contribution to the package surface dose rate below 25 mrem/hr., in order that the maximum NCT package surface dose rate is less than 200 mrem/hr., and the transport index does not exceed 10 (i.e., 10 mrem/hr. at 1 meter), for non-exclusive use conveyance. The mass limit and its corresponding NCT dose rate at the surface of the packages are listed in SARP Table 5.24, *Dose Rate Outside of 9979 Package Under NCT (Additional HEU Content)* for each additional isotope. The mass limits are shown again in SARP Table 5.25, *Isotopic Limits for Additional HEU Content*. The NCT dose rates at the surface and at 1-meter from the package with the additional contents and the previously authorized contents are summed up in SARP Table 5.26, *NCT, TI, and HAC Results for HEU with Additional Contents*. The maximum NCT dose rates from this table were used to update SARP Table 5.1 and demonstrate compliance with §71.47(a).

DOE PCP staff's confirmatory analysis results were consistent with the applicant's results. Staff calculated the dose rates by adding the neutron and gamma dose rates shown in SARP Table 5.23 with the neutron and gamma dose rates calculated for the reduced activities of the additional isotopes that give 25 mrem/h. (dose rate plus three standard deviations). A comparison of the applicant's maximum package NCT dose rates, for the updated SARP Table 1.2 contents, and DOE PCP staff's results are shown in SER Table 5.1 below.

Table 5.1 – Maximum NCT Dose Rate Comparison

	SARP	Staff	10 CFR 71 Limit
	NCT Package Surface: mSv/h (mrem/h)		
Gamma	1.605 (160.5)	1.612 (161.2)	2 (200)
Neutron	0.383 (38.3)	0.367 (36.7)	
Total	1.988 (198.8)	1.979 (197.9)	
	NCT at 1 Meter from Package Surface: mSv/h (mrem/h)		
Gamma	0.0053 (0.53)	0.0053 (0.53)	0.1 (10)
Neutron	0.0011 (0.11)	0.0011 (0.11)	
Total	0.0064 (0.64)	0.0064 (0.64)	

The package dose rate (1 rem/hr. at 1 meter) under HAC per §71.51(a)(2) was not analyzed because it is bounded by the NCT surface dose rate in a shown in SER Table 5.1 and given that the 30-gallon drum survived the HAC test scenarios relatively undamaged and the applicant does not credit the insulated 55-gallon drum material for shielding.

<u>SARP Table 1.5 New Contents</u>
The applicant performed NCT and HAC shielding analysis of the SARP Table 1.5 contents in separate packages and summed the results. DOE PCP staff concurs that summing the results is conservative because dose rate reduction factors such as self-shielding and source displacement further from detectors are not considered. The applicant evaluated the following four radioactive contents in separate packages: ten Am1.N02 capsules, eight POP Assemblies, eight Vogan Assemblies, and Cs-137 and Th-232 in normal form. The special form capsules were evaluated as disks in three stacking configurations. The results are shown for each configuration under NCT and HAC in SARP Tables 5.28 through 5.31 and summed as a single configuration

in Table 5.32. The maximum calculated NCT surface dose rate for the SARP Table 1.5 contents is approximately 429 mrem/hr. at the side of the package and approximately 12 mrem/hr. at one meter, which requires exclusive use conveyance since this dose rate and TI exceed §71.47(a) limits. The applicant calculated regulatory dose rates for exclusive use conveyance in SARP Tables 5.33, *Dose Rate outside the Side and Rear of Transport Vehicle*, and 5.34, *Dose Rate at the Top and Bottom of Transport Vehicle*, to demonstrate compliance with §71.47(b). The maximum dose rates from SARP Tables 5.32, 5.33, and 5.34 were used as input to SARP Table 5.2 and demonstrate compliance with §§71.47(b) and 71.51(a)(2).

DOE PCP staff's confirmatory analysis results were consistent with the applicant's results. A comparison of the applicant's maximum package and conveyance vehicle dose rates, for the SARP Table 1.5 contents, and DOE PCP staff's results are shown in SER Table 5.2 below

Table 5.2 – Maximum Dose Rate Comparison (Exclusive Use)

	SARP	Staff	10 CFR 71 Limit
	NCT Package Side Surface: mSv/h (mrem/h)		
Gamma	1.139 (113.932)	1.170 (116.963)	10 (1000)
Neutron	3.152 (315.181)	3.145 (314.485)	
Total	4.291 (429.114)	4.315 (431.448)	
	NCT/HAC at 1 Meter from Package Top or Bottom: mSv/h (mrem/h)		
Gamma	0.107 (10.658)	0.105 (10.484)	10 (1000)
Neutron	0.015 (1.421)	0.014 (1.371)	
Total	0.121 (12.079)	0.119 (11.855)	
	Vehicle Bottom Surface: mSv/h (mrem/h)		
Gamma	0.024 (2.368)	0.023 (2.330)	2 (200)
Neutron	0.121 (12.075)	0.121 (12.052)	
Total	0.144 (14.443)	0.144 (14.382)	
	2-meters from Vehicle Side Surface: mSv/h (mrem/h)		
Gamma	1.05e-3 (0.105)	1.15e-3 (0.115)	0.1 (10)
Neutron	3.14e-3 (0.314)	3.13e-3 (0.313)	
Total	4.19e-3 (0.419)	4.28e-3 (0.428)	
	Vehicle Normally Occupied Space: mSv/h (mrem/h)		
Gamma	1.2e-4 (0.012)	-	0.02 (2)
Neutron	4.3e-4 (0.043)		
Total	5.4e-4 (0.054)		

5.5 Conclusion

Based on review of the statements and representations in the SARP and DOE PCP staff's confirmatory analysis, staff has reasonable assurance that the package shielding design has been adequately described and evaluated and that the package meets the external radiation requirements of 10 CFR Part 71.

6.0 Criticality Evaluation

The purpose of the criticality review is to confirm that the package together with its contents meet the requirements in 10 CFR Part 71 for nuclear criticality safety (NCS).

There were no changes to the NCS safety design features of the packaging.

The addition of seven non-fissile radioisotopes to SARP Table 1.2 does not affect the existing NCS evaluation in SARP Chapter 6.

For the new SARP Table 1-5 contents, DOE PCP staff performed Monte Carlo analyses using MCNP6 (Version 6.2) to independently confirm NCS for the most reactive conditions under NCT and HAC. The applicant added new tables in SARP Chapter 6 for these contents, beginning with new Table 6-3, so subsequent tables were renumbered, and their references updated in the text.

The applicant updated SARP Section 6.1.2 *Summary Table of Criticality Evaluations* to note that the TRISO fuel contents are evaluated for NCS in SARP Appendix 6.5. Use of the package for shipment of these contents was authorized in CoC Revision 10.

SARP Section 6.1.2.4 *Special Form Plutonium Configuration* was added to describe the content loading configuration for the applicant's NCS evaluation in SARP Appendix 6.4. The fissile mass loading used in the NCS evaluation is greater than the fissile mass limits in SARP Table 1.5 and is therefore bounding. SARP Table 6.3 *Summary of Criticality Safety Analysis Results (Vogan/POP Assemblies)* lists the results of the NCS evaluation.

6.1 Content Configuration for NCS Evaluation

The SARP Table 1.5 content configuration consists of plutonium metal and oxide in special form, Am-Be in special form, and Cs-137 and Th-232 in normal form, with up to 4.5 wt.% gallium in the plutonium metal (Pu-Ga alloy). The maximum fissile mass (Pu-239 and Pu-241) for SARP Table 1.5 contents is 135.4 grams per package, based on eight POP Assemblies at 16.92 fissile grams per assembly as the bounding case. The NCS evaluation in SARP Chapter 6 is based on 200 FGE (Fissile Gram Equivalent) Pu-239 per package, based on 25 FGE Pu-239 per assembly. The NCS evaluation ignores Cs and Th because they a non-fissile and ignores gallium since it would absorb neutrons and lower the k-effective value (k_{eff}) of the system. The Pu masses and weight percent used in the applicant's NCS evaluation are listed in SARP Table 6.11.

The criticality safety index (CSI) for SARP Table 1.5 contents is added to the SARP Section 6.1.3.4 *Criticality Safety Index for Vogan and POP Assemblies* and CSI calculations for NCT and HAC array are shown in SARP Table 6-7 *Calculation of CSI for the LEU Metal Waste* (sic) (Note – the caption in Table 6-7 is incorrect, it should be *Calculation of CSI for Vogan and POP* Assemblies and will be corrected in the next SARP Revision). CSI is 0.1 based on HAC array for the DOE PCP staff confirmed the CSI was calculated correctly to be 0.1 in accordance with §71.59(b).

6.2 Package Model Configuration for NCS Evaluation

The model for applicant's NCS evaluation is described in SARP Section 6.3.4 *Model Configurations Vogan and POP Special Form Assemblies*. Each assembly was modeled as a disk, with eight disks per package. Each disk was modeled as 25 grams of Pu-239 in metal or oxide form. The Vogan disk dimensions are approximately 0.12 inch thick by 0.92 inch diameter. The POP disk dimensions are approximately 0.14 inch thick by 1.17 inches diameter. The applicant evaluated six different geometric configurations of the disks in the package, as shown in SARP Figure 6-13 *Different Arrangements of Assemblies Modeled* to determine the most reactive configuration for criticality. The assembly material of construction (a.k.a., casing) was not modeled for the NCS evaluation under NCT, but was included in some cases under HAC, for sensitivity analysis. The presence of this material reduces interaction and increases total neutron absorption. Spacing between fissile material disks shown in the SARP Figure 6-13 arrangements was still determined by the overall dimensions of the assembly.

The packaging model dimensions are shown in SARP Table 6-15 *Drum Dimensions for NCT and HAC Models (Vogan/POP Special Form)* and are consistent with the applicable drawings. The 55-gallon drum is not included in the NCS model for HAC.

6.3 Summary of SARP NCS Evaluation and Staff's Confirmatory Analysis

Single Package Evaluation

The applicant stated in SARP Section 6.4.4 *Vogan and POP Special Form Assemblies* they did not perform a single package evaluation for NCS because the maximum mass of 200 grams of Pu-239 is less than the minimum subcritical mass limit of 450 g of Pu-239, based on ANS/ANSI-8.1-2014, *Nuclear Criticality Safety in Operations with Fissile Material Outside Reactors*. DOE PCP staff concurs that a single package evaluation is not required.

NCT Array

The applicant added SARP Section 6.5.4 *Vogan and POP Special Form Assemblies* to describe the NCT array model configurations used with the 30-gallon drum empty (dry), filled with water (water in-leakage), or filled with polyethylene dunnage. In all cases, the 30-gallon drum was overpacked in the insulated 55-gallon drum. The NCS evaluation results for NCT Array are shown in SARP Table 6-31 *Eight Vogan Assemblies in Normal 9979 Container, Without Casings* (i.e., disks), and Table 6-32 *Eight POP Assemblies in Normal 9979 Container, Without Casings*. The most reactive configuration for NCT is summarized in SARP Table 6-3 and consists of an infinite, triangular pitched, array of undamaged packages, each with eight Vogan disks arranged in three vertical stacks (arrangement "C" of SARP Figure 6-13) at the side of the 30-gallon drum. In this case, the 30-gallon drum is drum filled with polyethylene dunnage and overpacked in the insulated 55-gallon drum. SER Table 6.1 below shows a comparison of the applicant's NCS evaluation results with DOE PCP staff's confirmatory analysis. The $k_{eff} + 2\sigma$ results are consistent with staff's and well below the k_{safe} value of 0.902, per SARP Table 6-46 *Validation k_{safe} Values (Vogan and POP Special Form Assemblies)*.

Table 6.1 NCT Infinite Array Comparision

NCT Array	$k_{eff} + 2\sigma$	
	SARP	Staff
Infinite Number of Undamaged Packages with eight Vogan Disks, 200 g of Pu-239 total, per package	0.307	0.293

DOE PCP staff confirmed by document review and Monte Carlo analyses using MCNP6 (Version 6.2) that the SARP demonstrates compliance with §§71.55(d) and 71.59(a)(1) of packages with SARP Table 1.5 contents, under NCT.

<u>HAC Array</u>
The applicant added SARP Section *6.6.4 Vogan and POP Special Form* to describe the HAC Array model configurations used with the 30-gallon drum empty (dry), filled with water (water in-leakage), or filled with polyethylene dunnage. The 30-gallon drums are arranged in an infinite, triangular pitched, array of damaged drums and a finite 12x14x8 array of damaged drums reflected by water. In all cases, the insulated 55-gallon drum was omitted from the model, which results in greater interaction of the fissile masses.

The NCS evaluation results for the infinite HAC Array are shown in SARP Table 6-39 *Eight Vogan Assemblies in HAC 9979 Container, Without Casings*, and Table 6-40 *Eight POP Assemblies in HAC 9979 Container, Without Casings*. The $k_{eff} + 2\sigma$ results for the Vogan and POP disks exceed k_{safe} for all cases where the 30-gallon drum is dry (not flooded), for all disk arrangements in SARP Figure 6-13. For these dry cases, the applicant surmised that reactivity is greater than k_{safe} due to the low absorption of the drum material, and for infinite arrays, leakage does not occur, so absorption or capture leading to fission are the expected neutron interactions. Once a neutron reaches the boundary for the system, it is either reflected or reemerges from the opposite boundary. In the dry HAC cases, POP oxides were slightly more reactive than the Vogan metal by about 4%. Although metals are often more reactive than oxides given, they are denser and do not have oxygen atoms acting as a slight poison, in this case leakage is not an inhibiting factor for the oxide, and the larger volume of the POP disks increases interactions in fissile material between drums.

The NCS evaluation proceeded for an infinite HAC Array configuration, of dry 30-gallon drums, and the special form materials of construction included. The results are shown in Table 6-41 *Assemblies under Dry Conditions with Casing Materials*. For the Vogan Assemblies, the $k_{eff} + 2\sigma$ results were below k_{safe} for all assembly arrangements as shown in SARP Figure 6-13; however, the $k_{eff} + 2\sigma$ results for the POP Assemblies exceed k_{safe} for all assembly arrangements.

The applicant continued the NCS evaluation to account for the POP cases above k_{safe} by modeling a 12x14x8 finite array configuration of 30-gallon drums for all POP disk arrangements shown in SARP Figure 6-13. The finite array was surrounded by 30 cm of water. The results are shown in SARP Table 6-42 *Assemblies in HAC 9979 Packages in a Finite Array of 12x14x8 Drums, Without Casings*. For the POP disks, the $k_{eff} + 2\sigma$ results were below k_{safe} for all assembly arrangements as shown in SARP Figure 6-13. The most reactive configuration occurs when the POP disk arrangement is in arrangement C of SARP Figure 6-13. SER Table 6.2 below shows a comparison of the applicant's final NCS evaluation results with DOE PCP staff's confirmatory analysis. The $k_{eff} + 2\sigma$ results are consistent with staff's and well below the k_{safe} value of 0.902, per SARP Table 6-46.

Table 6.2 HAC Finite Array Comparision

HAC Array	$k_{eff} + 2\sigma$	
	SARP	Staff
1344 damaged packages in a 12×14×8 array with eight Vogan Disks, 200 g of Pu-239 total, per package	0.152	0.153

The CSI calculation in SARP Table 6-7 is based on the 12×14×8 array for HAC.

DOE PCP staff confirmed by document review and Monte Carlo analyses using MCNP6 (Version 6.2) that the SARP demonstrates compliance with §§71.55(e) and 71.59(a)(2) of packages with SARP Table 1.5 contents, under HAC.

6.4 Benchmark Evaluations

The applicant added SARP Section 6.8.4 *Vogan and POP Special Form Assemblies* and SARP Table 6-46 to address and summarize the benchmark evaluation for the Vogan and POP configurations, based on SARP Appendix 6.4, Section 4.0 for the computer code - SCALE 6.1 (Section 4.1), code validation and bias (Section 4.2), material compositions (Section 4.3), and assumptions used in the analysis (Section 4.4). DOE PCP staff verified the applicant used the same codes and computational method in the NCS evaluation as was used in the validation study (SCALE 6.1) and accounted for bias and uncertainty. The Vogan model was within all parameters of the validation reference so its k_{safe} value was only reduced by the 0.05 minimum subcritical margin (final $k_{safe} = 0.938$). The POP model differed from its validation reference due to the lack of moderating material, difference in reflecting material, and a difference in geometry. Its k_{safe} value was therefore reduced by 0.03 for these areas of applicability (AOA) areas and by 0.05 minimum subcritical margin (final $k_{safe} = 0.902$). Staff verified that the material compositions used for Vogan and POP models in the NCS evaluation are reasonable and consistent with the actual materials, and the assumption to omit the insulated 55-gallon drum from the HAC model and analysis is conservative, that is, the 30-gallon drums are more tightly packed in the HAC array(s).

6.5 Conclusion

Based on review of the statements and representations in the SARP and DOE PCP staff's confirmatory analysis, staff has reasonable assurance that the package nuclear criticality safety design has been adequately described and evaluated and that the package meets the sub-criticality requirements of 10 CFR Part 71.

7.0 Operating Procedures

The SARP provides a description of package operations, including package loading and unloading operations, and the preparation of an empty package for shipment. Loading and unloading procedures show a general approach to perform operational activities because site-specific conditions may require the use of different equipment and loading or unloading steps.

The applicant revised the operating procedures in SARP Chapter 7 for use of the ARG-US radio-frequency identification (RFID), the torque requirements for the pressure relief and blind plug on the 30-gallon drum, minimum void volumes within the 30-gallon drum after content loading and loading instructions for SARP Table 1.5 contents.

The use of ARG-US RFID tags on the package was initially approved by the HCO in Revision 5 of the CoC, based on CoC Supplement 1, *Guide to the RFID Monitoring System (Models 9975, 9977, and 9978*, ANL/DIS-09-5, December 3, 2009. The applicant incorporated the requirements for use of the tags in SARP Section 7.0.3 *Equipment* and incorporated the supplement as Reference 16 in SARP Section 7.6.

7.1 Package Loading

The applicant combined Steps 1 and 2 of Section 7.1.1.1, *Packaging Preparation*, renumbered the steps in the section, and made the following changes to Steps 5, 7, and 8.

The applicant revised Steps 5 and 7 to update the torque tolerances from percentages to actual values for the pressure relief and blind plugs on the 30-gallon drum lid. These changes were also incorporated in Drawings R-R1-G-00028 Revision 7, Note 7, and R-R2-G-00060, Revision 6, Note 11.

Step 8 was revised to add a requirement that the 30-gallon and 55-gallon closure bolts shall remain with the split-ring closure devices during loading and unloading operations.

SARP Section 7.1.1.2 *Contents/Payload Preparation* was revised to incorporate minimum void volume restrictions in the 30-gallon drum due to flammable gas generation restrictions for specific content configurations: SARP Table 1.2 contents require a minimum void volume of 9%, and SARP Table 1.4 contents require a minimum void volume of 5%. There are no minimum void volume restrictions for Table 1.3 and 1.5 contents related to gas generation. Step 4.d. was added to SARP Section 7.1.1.1.2 to add preparation instructions for loading the SARP Table 1.5 configuration.

There were no changes to SARP Section 7.2, *Package Unloading*.

DOE PCP staff confirmed by document review that the package loading and unloading procedures are adequate for safe operation of the package.

7.2 Preparation of Empty Package for Transport

The applicant updated references in Step 3 of SARP Section 7.3.1 *Shipping an Empty Packaging*, to §173.421. The paragraphs in §173.421 were renumbered in 2014. DOE PCP staff verified the references in Step 3 are consistent with current edition of §173.421.

7.3 Other Operations

The applicant added an item in SARP 7.4.1 *Packaging Storage*, to ensure the drum fill and vent holes were covered with waterproof tape while packaging is in storage.

In addition, the applicant added SARP Sections 7.4.3, *30-Gallon Drum Purging & Hydrogen Diffusion* and 7.4.4 *Hydrogen Gas Measurement and Sampling* to implement changes authorized in CoC Revisions 14 and 15 respectively and added References 13 through 15 in SARP Section 7.6 to include the technical references for these new sections.

DOE PCP staff confirmed by document review that these changes were correctly implemented in SARP Section 7.4.

7.4 Conclusion

Based on review of the statements and representations in the SARP, DOE PCP staff has reasonable assurance that the package operating procedures meet the requirements of 10 CFR Part 71 and that these procedures are adequate to assure the package will continue to be operated in a manner consistent with its evaluation for approval.

8.0 Acceptance Tests and Maintenance Program

The objective of this review is to verify that the acceptance tests for the packaging meet the requirements of 10 CFR Part 71 and that the maintenance program is adequate to assure packaging performance during its service life.

The content amendment to SARP Table 1.2 and addition of the new contents in SARP Table 1.5 does not affect the existing Acceptance Tests and Maintenance Program for the packaging.

The acceptance tests and maintenance requirements for the SF capsules are not included in SARP Chapter 8. DOE PCP staff confirmed by document review of SARP Addendices 2.1 through 2.5 that Vogan and POP Assemblies meet the test and acceptance requirements of §173.469, and the Am1.N02 Assembly certificate, CZ/1009/S-96, is sufficient evidence to meet §173.469 in accordance with §173.476(a).

The Vogan and POP Assembly designs were independently tested and certified by SwRI to the requirements of §173.469. For approval for domestic use (within the US), the offeror must meet the documentation and records retention requirements in accordance with §173.476(a).

The Am1.N02 Assembly design was certified by competent authority of the Czech Republic to the IAEA *Regulations for the Safe Transport of Radioactive Material*, TS-R-1, 2009 Edition. For approval for domestic use (within the US), the offeror must meet the documentation and records retention requirements in accordance with §173.476(a). This assembly is authorized for export from the US in accordance with §173.476(b), based on its IAEA certificate, CZ/1009/S-96.

Based on review of the statements and representations in the SARP, DOE PCP staff has reasonable assurance that the packaging acceptance tests and maintenance program meet the requirements of 10 CFR Part 71 and are adequate to assure packaging performance during its service life.

9.0 QUALITY ASSURANCE

The objective of this review is to verify that the SARP demonstrates that the applicant's Quality

Assurance (QA) program description and package specific QA requirements comply with the requirements of 10 CFR Part 71, Subpart H, Quality Assurance.

The content amendment to SARP Table 1.2 and addition of the new contents in SARP Table 1.5 does not affect the existing QA requirements for the 9979 packaging regarding packaging design, purchasing, fabrication, handling, shipping, storage, cleaning, assembly, inspection, testing, operation, maintenance, repair, and component modification, etc.

The QA requirements for the SF capsule designs are described as follows.

Vogan and POP Assemblies

The design, manufacturing, and certification testing of the Vogan and POP SF assemblies were performed in accordance with LANL *Quality Assurance Program SD330*, which is the implementation of DOE Order 414.1D Admin. Chg. 1 and 10 CFR 830, as well as the ASME NQA-1 *Requirements and Work Practices*. Manufacture and inspection of the capsules was done by qualified personnel trained to facility approved procedures. The specific QA processes for manufacture of the Vogan capsules are documented in *Vogan Metal Activities*, PA-AP-01177, R1, 7/30/19, and *Application of the Graded Approach for Vogan Oxide Activities*, PA-AP-01164, R0, 8/30/18 (*Vogan Special Form Capsule Certification & Quality Assurance*, GS-NSD-20-004, Los Alamos Memorandum to Paul Blanton, April 21, 2020). Weld inspection of Pu oxide capsules was performed per PA-DOP-01825, *Plutonium Oxide POP Packaging System*, and welding of the Pu metal capsules was performed per PA-SPI-01166, R1, *Laser Welding Operations – Assembly Coupon Containment Can*. Dimensional tolerances were verified with a go/no-go gauge. All capsules were helium (He) leak tested and verified to have a leak rate better than 5×10^{-8} cc/sec. He, which meet the special form certification requirement of 10^{-7} cc/sec. He or less.

These designs were independently tested and certified by SwRI to the requirements of §173.469. For domestic use within the US, the offeror must meet the documentation and records retention requirements in accordance with §173.476(a). These assemblies are not authorized for export from the US, since they haven't been certified by the US Competent Authority (i.e., DOT).

Am1.N02 Assembly

The QA requirements for Am1.N02 assembly are described in Section 3 of Certificate CZ/1009/S-96 issued by the competent authority of the Czech Republic. The certificate is included in SARP Appendix 2.5. The Am1.N02 assembly must be manufactured in accordance with the specified technical drawing, in accordance with the approved procedures and with the document titled *Quality Assurance Programme Q940-001* in the valid version, to meet the requirements of ISO 9001, ISO 13485, and Decree no. 132/2008 Sb of the Czech Republic.

This design was certified by competent authority of the Czech Republic to the IAEA

Regulations for the Safe Transport of Radioactive Material, TS-R-1, 2009 Edition. For approval for domestic use (within the US), the offeror must meet the documentation and records retention requirements in accordance with §173.476(a). This assembly is authorized for export from the US in accordance with §173.476(b), based on its IAEA certificate, CZ/1009/S-96.

The applicant revised SARP Section 9.9 *Control of Special Process* and added References 10 through 14 in SARP Section 9.20 *References*, to implement changes to the welding requirements for the 30-gallon and the 55-gallon drums, which were reviewed and authorized in Revision 13 of the CoC. DOE PCP staff reviewed and confirmed these changes have been correctly implemented in the SARP.

Based on review of the statements and representations in the SARP, DOE PCP staff has reasonable assurance that the package-specific requirements are consistent with their DOE approved Quality Assurance Program Document (QAPD), meet the requirements of 10 CFR 71 Subpart H, and are therefore adequate to assure the package will be operated in a manner consistent with its evaluation for approval.

Conditions of Approval

The following changes to the CoC are required to implement the modifications evaluated in this SER.

- Section 3, Block (2) – The safety basis document is the SARP: *Safety Analysis Report for Packagings Model 9979 Type AF Shipping Package*, S-SARP-G-00006, Rev. 7, December 2020.
- Section 5(a)(2), Packaging – simplified packaging description to remove excessive detail (clarification and simplification).
- Section 5(a)(3), Drawings:
    - Update revisions with SARP Appendix 1.1, 9979 *Engineering Drawings,*
    - Add the following text and table: "Special Form capsule designs authorized for transport in the package are defined by the following drawings or certificate."

Drawing Number	Revision Number	Title
157Y701711-900	B	Vogan Assembly with Tungsten
157Y701720-000	A	Plutonium Oxide Pod (P.O.P.) Assembly
CZ/1009/S-96	2	Am1.N02 Special Form Radioactive Material

- Section 5(b)(1), Type and form of material:
    - Revise 3rd paragraph to "… defined in Tables 2-1 through 2-6 of N NCS-G-00174, Revision 1 (SARP Appendix 6.5)." (CoC supplement added to SARP)
    - Add the following text and update Table 1, *Solid Compounds and Metal*: "Special Form Pu metal or oxide in Vogan or Plutonium Oxide Pods (POP) Assemblies, Special Form Am-241 with Beryllium (Am-Be) in the Am1.N02

Assemblies, and Normal Form Cesium-137 & Thorium-232 solid samples. The Pu may contain up to 4.5% Gallium as an alloying metal. The Am-241 is Am_2O_3 mixed with a maximum of 20 mg of Beryllium." (new contents)

- Section 5(b)(2), Maximum quantity of material per package –
    - Revise 1st paragraph to "… exceed to 200 lb. (90 kg)." (add mass in kg).
    - Add new 2nd paragraph "Type A quantity of radioactive material, per package." (clarification)
    - Revise the text for Table 2, to "Table 2 defines the limits for Highly Enriched Uranium (HEU) including TRISO fuel and process materials." (consistency with SARP)
    - Add the following text "Table 5 defines the limits for Pu and Am-241 in Special Form and Cesium-137 & Thorium-232 samples in Normal Form. One package may be used to ship eight Vogan or POP Assemblies, or combination of eight thereof, with ten Am1.N02 Assemblies, and Cs-137 and Th-232 samples in accordance with Table 5."
    - Update Table 2 – *Content Envelope Limits*:
        - Revise Table 2 title to "Content Envelope Limits for HEU, TRISO Fuel and Process Materials" (consistency with SARP)
        - With mass limits for: Cs-137, Eu 155, Sr-90, Th-228, Th-229, Th-230, and Cm-243, from SARP Table 1.2 –*Envelope Limits including Highly Enriched Uranium (HEU) Content*. (new contents)
        - Revise Table "Note" to "Note: Except for Sr-90, Cs-137, Eu-155, Th-228, Th-229, T-230, U-232, U-235, Cm-243, the mass limit for each isotope listed is based on a single A_2 or 90,000 grams." (new contents)
        - Add Table Note "g", "In addition to the requirements of note a) above, the sum of mass fractions for Sr-90, Cs-137, Eu-155, Th 228, Th-229, Th-230, & Cm-243 are limited to ≤ 1, to control dose rate. Mass fraction is m_x/M_x, where "m_x" = mass of isotope x from Table 2 offered for shipment and "M_x" = mass limit of isotope x from Table 2." (new contents)
    - Add Table 5 – *Content Envelope Limits for Vogan/POP, Am1.N02, Cs-137, & Th-232,* and Table Notes <u>based</u> on SARP Table 1.5. (new contents).

- Section 5(b)(3) - Add new section for *Maximum Decay Heat*: for package design (3.5 w), and maximum calculated decay heat for CoC content Tables 2 (9.12E-03 w), 3 (3.64E-04 w), 4 (5.18E-03 w), and 5 (3.42E-01). (limits for Tables 2, 3, & 4 based on decay heat used in applicant's gas-generation calculation, M-CLC-A-00631, Rev. 3, limit for Table 5 based on SARP Appendix 4.1.)

- Section 5(b)(4) – Add new section for *Maximum Moisture Content*: The contents shall not exceed one weight percent moisture. (clarification)

- Section 5(c), CSI – Update with "CSI = 0.1 for Table 3 and Table 5 contents." (add Table 5 CSI)

- Section 5(d), Conditions (1), (2), and (5) moved into Section 5(b) Contents. Condition (11) was deleted because the requirements for use of RFID tags and its references were added to the SARP. The condition numbers in Section 5(d) were renumbered.

    - Condition (6, formerly 9) revised to "… Tables 2 and 4 - shipping period is 180 days, with a minimum void volume of 8.9% for Table 2 contents and 4.6% for Table 4 contents. Tables 3 and 5 - shipping period is unlimited and with no minimum void volume. The shipping period for packages loaded with Tables 2 and 4 contents may be reset to 180 days by: …" (add Table 5 and revised Table 4 void volume, shipping window, and shipping window reset)
    - Condition (8, new) added "The calculated external radiation for the package with Table 5 contents exceeds the limits in §71.47(a), so the package with Table 5 contents must be transported by exclusive use shipment only, in accordance with §71.47(b)." (add for Table 5)
    - Condition (10, formerly 14) revised to "Revision 15 of this CoC may be used until September 30, 2021" (allow users time to implement CoC Rev. 16)

- Section 5(e), Supplements – Replace all supplements with "None."

Conclusion

Based on the statements and representations contained in the SARP and the conditions listed above, DOE PCP staff concludes that the package design has been adequately described and evaluated and the Model 9979 continues to meet the requirements of 10 CFR Part 71.

References

[1] *FW: New Docket Request - 9979 Package*, Email Maxcine Maxted to Shuler, October 30, 2018.
[2] *Safety Analysis Report for Packagings Model 9979 Type AF Shipping Package*, S-SARP-G-00006, Revision 6a, November 2019.
[3] *Safety Analysis Report for Packagings Model 9979 Type AF Shipping Package*, S-SARP-G-00006, Revision 6b page changes, June 4, 2020.
[4] *Safety Analysis Report for Packagings Model 9979 Type AF Shipping Package*, S-SARP-G-00006, Revision 6c page changes, August 5, 2020.
[5] *Q1 Comments from Department of Energy Packaging Certification Program Independent Review of Content Amendment Request*, Memorandum, Shuler to Maxted, April 13, 2020.
[6] *Safety Analysis Report for Packagings Model 9979 Type AF Shipping Package*, S-SARP-G-00006, Revision 6, September 10, 2020.
[7] *Safety Analysis Report for Packagings Model 9979 Type AF Shipping Package*, S-SARP-G-00006, Revision 7a, November 25, 2020.
[8] *Safety Analysis Report for Packaging Review Comments*, Memorandum, Shuler to Maxted, December 14, 2020.

[9] *Safety Analysis Report for Packagings Model 9979 Type AF Shipping Package*, S-SARP-G-00006, Revision 7b page changes, December 18, 2020.
[10] *Safety Analysis Report for Packaging Rev 7b Changes Accepted*, Memorandum, Shuler to Maxted, December 21, 2020.
[11] *Safety Analysis Report for Packagings Model 9979 Type AF Shipping Package*, S-SARP-G-00006, Revision 7, December 28, 2020.
[12] *Notification of Noncompliance with Conditions of Approval in 9980 Certificate of Compliance*, 20-PNSO-0189, Memorandum, Roger Snyder to Julia Shenk (Docket 20-45-9980), July 14, 2020.