Safety Evaluation Report for Certificate of Compliance No. 9978 Content Amendment for the Model 9978 Package

Docket No. 22-13-9978

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This Safety Evaluation Report (SER) documents the U.S. Department of Energy (DOE) Packaging Certification Program (PCP) independent review of the Safety Analysis Report for Packaging (SARP) prepared by the Savannah River National Laboratory (SRNL) on behalf of the DOE Savannah River Operations Office (SR) for amendment of DOE Certificate of Compliance (CoC) Number 9978 to authorize use of the package for shipment of Pu/Am Standards (Pu/Am-S) from the New Brunswick Laboratory (NBL), clarify the Pu-Ga contents, and update the Quality Assurance Program (QAP) description. The package was previously authorized by a Letter Amendment to the CoC issued February 9, 2017, for shipment of Pu/Am-S, but NBL requested SR to include these standards as an authorized content in the CoC for future missions.

Summary

By application [1, 2] submitted March 2, 2022, as supplemented [3, 4, 5] July 12, October 13, 2022, and March 21, 2023 the certificate holder, SR, requested an amendment to CoC 9978 Revision 4 to authorize use of the Model 9978 for shipment of NBL Pu/Am-S clarify that gallium may be present in stabilized Pu oxide and metal contents up to the combined 3013 impurity limit, and to update SARP Chapter 9, Quality Assurance to harmonize it with the latest SRNL QAP approved by the DOE Headquarters Certifying Office (CO).

The safety basis document for the CoC amendment from Revision 4 to 5 is SARP Rev 3.[5] In addition, SRNL also made numerous SARP changes involving administrative improvements and clarifications, spelling corrections, and non-substantive changes to punctuation or editorial items. Many stand-alone documents in SARP Appendices were removed and are now listed as SARP Chapter References, to reduce the length of the SARP.

Based on the statements and representations in SARP Revision 3, DOE PCP staff independently confirmed that the package design has been adequately described and evaluated for use of the package to ship the Pu/Am-S and Pu, with minimal gallium impurities in Content Envelopes C.1, C.2, and C.6. Therefore, staff has reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met and recommends approval of an amendment to the CoC by the DOE CO.

Evaluation

This SER documents the independent technical review by DOE PCP staff of the final application, *Safety Analysis Report for Packaging Model 9978*, S-SARP-G-00002, Rev. 3 (final), March 2023, to the requirements of 10 CFR Part 71.

The current DOE CoC No. 9978, Revision 4, is based on SARP Revision 1.

Revision 2 of this application (SARP) was submitted by SR to DOE PCP on March 2, 2022, and supplemented July 13, 2022, with Revision 2a page changes to the SARP in response to comments and questions issued May 5, 2022, from DOE PCP staff's completeness review. Staff completed their initial technical review of the SARP on September 6, 2022, with no additional technical questions. SR submitted a draft Revision 3 of the SARP on October 13, 2022, with the Revision 2 and 2a pages changes incorporated in Revision 3. Staff noted that the draft Revision omitted an evaluation of Pu-Ga in the Pu contents and issued additional comment. SR submitted a revised draft Revision 3 on March 7, 2023, with responses to staff's comments. Staff completed their technical review of the SARP on March 14, 2023, with no additional technical questions. SRNL uploaded a Revision 3 (final) of the SARP on March 21, 2023, to implement the changes accepted by staff.

The Pu/Am-S were previously reviewed by DOE PCP staff and authorized by the DOE CO for shipment in the package by a Letter Amendment (LA) to the CoC with its SER issued February 9, 2017 (Docket 16-24-9978). DOE CO issuance of the LA was based on DOE PCP staff's independent review and confirmatory analysis of *Model 9978 Safety Analysis Report for Packaging, New Brunswick Laboratory Pu/Am Standards Content Letter Amendment for Model 9978 Packaging Type B(M)F-96*, SARA G 00020, Rev. 3, January 2017. These standards are bounded radiologically by CoC content envelope C.6, *Sources and Samples*; however, several of the Pu standards also include $(SO4)_2.4H_2O$ as an impurity and limited to 530,000 parts-per-million, per package. The applicant implemented these standards in the SARP Table 1.2 as contents S.1 through S.5. For this amendment to DOE CoC Revision 4, staff confirmed by document review that S-SARA-G-00020, Revision 3, and its supporting documentation were accurately incorporated in SARP Revision 3.

1.0 General Information

1.1 Introduction

The applicant submitted SARP Revision 3 with the following changes to:

- Incorporate the previously authorized NBL Pu/Am-S (S-SARA-G-00020), identified as contents S.1 through S.5, throughout the SARP,
- Address the presence of gallium in Pu metal and oxide,
- Update Drawing R-R4-G-00033, *9978-General Purpose Fissile Packaging Spacer Part Details for Five Inch Containment Vessel*, from Revision 4 to Revision 5 to reflect the as-built configuration of the spacer.

- Update organization information due to the new DOE management and operating contractor of SRNL, Battelle Savannah River Alliance (BSRA),
- Make administrative improvements and clarifications, spelling corrections, and non-substantive changes to punctuation or editorial items,
- Convert stand-alone documents from SARP Addendums (e.g., calculations, reports, etc.) to SARP Chapter References to reduce the size of the SARP, and
- Revise SARP Chapter 9, *Quality Assurance Requirements*, to harmonize this chapter with latest SRNL quality assurance program description approved by the DOE CO (https://rampac.energy.gov/docs/default-source/qa/approval_0035_r0.pdf).

There were no additional changes to the package design in Revision 3 of the SARP.

1.2 Package Description

The Model 9978 is a Type B(U)F-96 package certified by DOE for shipment of normal form Pu or U metal or oxide solids. The radioactive material (RAM) is first packaged in approved convenience or storage containers prior to loading in the package 5-inch internal diameter containment vessel (5CV). The 5CV loading configuration for each content type is described in Section 1.2.2.1 of the SARP. The 5CV loading configuration for Pu/Am-S is described in SARP Section 1.2.2.1.6 and illustrated in SARP Figure 1.9. Loading restrictions are described in SARP Section 1.2.2.2.

Gallium, which may be used as an alloying metal in Pu, was added as an approved non-radioactive constituent in Contents C.1, C.2, and C.6 in SARP Section 1.2.2 and Table 1-2, Table Note "q". There are no other changes to the package description for the contents authorized in CoC Rev. 4 (i.e., C.1, C.2, C.4, C.5, and C.6).

The package description in SARP Section 1.2 was updated to add Pu/Am-S.

The Pu/Am-S configuration increased the package maximum normal operating pressure (MNOP) from 56.3 psig to 177.7 psig and maximum pressure under HAC from 48.5 psig to 436.4 psig, but these increases are still well within the design pressure rating of the 5CV (i.e., 900 psig at 300ºF) authorized in CoC Section 5(a)(2).

The maximum decay heat for the Pu/Am-S contents is approximately 93 milliwatts, which is bounded by the package thermal design limit of 19 watts authorized in CoC Table 2.

The maximum estimated weight of the heaviest Pu/Am-S configuration, including convenience cans and dunnage is approximately 41 lb., which is bounded by the maximum content weight of 50 lb. authorized in CoC Table 2.

1.2.1 Packaging

There were no design changes to the packaging components described in the SARP and authorized in the CoC.

Convenience containers used for overpacking and handling radioactive contents for loading in the 5CV and steel or aluminum dunnage to fill void space in the 5CV are defined as not-important-to-safety items per SARP Table 9.3 *Safety Assessment of Packaging Features*.

Packaging Configuration for Pu/Am-S

Pu/Am-S are packaged in heat sealed in low-density polyethylene or nylon material (i.e., plastic) for contamination control.

Then the standards may be overpacked in a single or multiple handling containers prior to loading in the 5CV. The maximum mass of plastic for the Pu/Am standard content configuration is limited to 1,000 grams to minimize flammable gas generation from radiolysis of the plastic.

The first overpack may be a Food Pack can that is authorized in CoC Section 5(a)(2). This overpack is optional, and if used the can will also be packaged in a heat-sealed plastic bag for contamination control. If the can is not used, the standards will be overpacked directly in the final overpack.

The final overpack is a one- or two-quart SAVY ™ 4000 container. This container design was developed by the Los Alamos National Laboratory to meet the requirements of DOE M 441.1-1, *Nuclear Material Packaging* for interim storage of nuclear material in DOE facilities. These containers are commercially available items, are filter vented, and constructed of Type 316 stainless steel. These containers meet the definition of "Engineered Containers" authorized in CoC Section 5(a)(2).

Aluminum dunnage is placed in the bottom of the 5CV for the SAVY ™ 4000 container rest on. A perforated steel dunnage can is then placed above the one-quart SAVY ™ 4000 container or aluminum dunnage is placed above the two-quart SAVY ™ 4000 container to fill the void space in the 5CV.

SARP Figure 1.9 shows the Pu/Am-S content configuration for both with SAVY ™ 4000 containers and Food Pack cans included.

1.2.2 Contents

SARP Revision 3, adds the NBL Pu/Am-S contents to the SARP, including contents specified as S.1 through S.5. Contents S.1 through S.4 contain the isotopes Pu-239, Pu-240, Pu-241, and Pu-242. Content S.5 contains the isotopes Am-241 and Am-243. Contents S.1 through S.5 are bounded with respect to radionuclide content by content

C.6. Impurities in Contents S.1 through S.5 include less than 0.005 grams of Be, Al, Mg, Na, and F, and no more than 530,000 parts-per-million $(SO_4)_2.4H_2O$.

There were no changes to the radioactive material package contents evaluated in the SARP or authorized in the CoC, except for the addition of the Pu/Am-S.

The Pu/Am-S are solids consisting of five content envelops, listed as S1 through S5, and added to SARP Table 1-2, *Content Envelopes*:

- S.1 – Pu Sulfate Tetrahydrate & Pu Oxide (powder),
- S.2 – Pu Sulfate Tetrahydrate (powder),
- S.3 – Pu Sulfate Tetrahydrate (powder),
- S.4 – Pu metal, and
- S.5 – Am metal

The radioisotopes, other elements (impurities), and their respective mass limits for S1 through S5 are included in SARP Table 1-2. DOE PCP staff confirmed by document review that SARP Table 1-2 is consistent with S-SARA-G-00020, Rev. 3.

It should be noted that contents S.1 through S.5 are bounded with respect to the radioisotopic mass limits by C.6, *Sample & Source* in SARP Table 1-2. C.6 also bounds all chemical impurities of S.1 through S.5, except for Pu sulfate tetrahydrates $[(SO_4)_2.4H_2O]$ in S.1 through S.3, which is limited to 530,000 parts-per-million, per package.

Each standard is packaged in a sealed glass tube, glass vial, or glass bottle separately (i.e., not mixed or combined in the tube, vial, or bottle with other standards) and then heat sealed in a plastic bag. The applicant assumed the stopper in the vial, tube, or bottle was made of plastic and Teflon™ gasket material for their gas-generation evaluation. S1 through S3 are packaged in a glass vial or bottle, placed in a heat-sealed bag, and then may be loaded in a single or two, one-quart SAVY ™ 4000 containers or loaded a single two-quart SAVY ™ 4000 container, per 5CV. S4 and S5 are packaged in a sealed glass tube with the ends of each tube covered with butyl rubber bumper guards, placed in a heat-sealed bag, then loaded in a single 1- or 2-quart SAVY ™ 4000 container, per 5CV.

Loading Restrictions for Pu/Am-S

The following loading restrictions apply to the Pu/Am standard configuration, per 5CV.

- Total weight of the contents (i.e., everything in the 5CV) must be less than 50 lb.
- The total plastic (as low-density polyethylene, butyl rubber, Teflon™, nylon, and/or polyvinyl chloride tape) is limited to 1000 grams,
- Aluminum dunnage is limited to 200 grams,
- Steel dunnage is limited to 900 grams,

- Individual or multiple plastic bagged sources may be first placed into a food pack can or directly into a SAVY ™ 4000 container,
- Content Envelopes S.1 through S.3 may be overpacked into a 1-qt., a two-stacked 1-qt. SAVY ™ 4000 containers, or a 2-qt SAVY ™ 4000 container.
- Content Envelops S.4 and S.5 may only be overpacked in a single 1-qt. or 2-qt. SAVY ™ 4000 container.
- Due to flammable gas generation, Content Envelopes S.1, S.2 and S.3 are required to be loaded in the 5CV under an inert cover gas, and
- Due to flammable gas generation, a shipping window of 147 days is imposed for Content Envelope S.5.

1.3 Drawings

Drawing R-R4-G-00033, *9978-General Purpose Fissile Packaging Spacer Part Details for Five Inch Containment Vessel*, was updated from Revision 4 to 5 in SARP Revision 3, Appendix 1.1, *Engineering Drawing List for the 9978 Package*. This drawing was revised in 2010 to incorporate the as-built configuration of the spacer parts.

1.4 Evaluation Findings

Based on review of the statements and representations in Chapter 1 of SARP Revision 3, DOE PCP staff concludes that the package in support of the CoC amendment request has been described in sufficient detail to provide an adequate basis for staff to evaluate it for compliance with 10 CFR Part 71.

2.0 Structural Evaluation

The objective of this structural evaluation is to determine that the information presented in the Addendum, including the description of the packaging, design and fabrication criteria, structural material properties, and structural performance of the package design for the tests under normal conditions of transport (NCT) and hypothetical accident conditions (HAC), is complete and meets the requirements of 10 CFR Part 71.

There are no changes to the 9978 structural design or analysis for the Pu/Am-S content configurations. The estimated maximum weight of this configuration is 41 lb. which is bounded by the maximum content weight of 50 lb. authorized in the CoC.

Although the MNOP is increased due to the Pu/Am-S contents, the MNOP of 177.7 psig is well within the 900-psig design pressure for the 5CV.

Minor changes to Chapter 2 of the SARP include editorial changes, reformatting of information, updating of references, and changing some appendices to references. Also, some new text was added to describe the allowable packing materials and containers for the Pu/Am-S, and the chemical and galvanic compatibility of the Standards with the packaging.

Note that the potential presence of gallium in the C.1, C2, and C.6 Content does not cause any deleterious chemical and/or galvanic reactions between the other constituents of the contents, or with any of the packaging materials, since no new corrosion mechanisms are introduced by the presence of gallium as an alloying element in plutonium metal.

2.1 Evaluation Findings

Based on review of the statements and representations in SARP Revision 3, DOE PCP staff has reasonable assurance that the package structural design continues to meet the requirements of 10 CFR Part 71.

3.0 Thermal Evaluation

The objective of this thermal evaluation 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.

The thermal evaluation of the NBL Pu/Am-S contents, designated S.1 through S.5, have been added to Chapter 3 of the SARP. The previously approved Content Envelopes C.1 through C.6, has a bounding thermal heat load of 19-watts, and were thermally modeled using the MSC PATRAN® Thermal software. The thermal modeling of the NBL Pu/Am-S added the SARP, has a bounding thermal heat load of 0.093 watts, and uses the COMSOL® Multiphysics software. The SARP includes details on the determination of the bounding thermal heat load for the Contents S.1 through S.5.

SARP Table 3.5 summarizes the maximum temperatures for NCT with exposure of the bounding C.1 to C.6 contents (i.e., 19 watts) to ambient air at 100°F, with and without insolation. Similarly, SARP Table 3.6 summarizes the bounding S.1 to S.5 contents (i.e., S.5 at 0.093 watts) but also for exposure to cold at -40°F. SARP Table 3.7 lists the summary of maximum NCT Package Temperatures vs Design Limits, and SARP Table 3.8 lists maximum temperatures for HAC for exposure to a 1475°F fire vs. design limit.

The MNOP is increased to 177.7 psig in Revision 3 of the SARP. This new MNOP is the bounding NCT pressure from the S.1 through S.5 Contents. The MNOP is calculated using the bounding NCT temperature, the plastic thermal off-gassing, the plastic radiolytic gas generation rate, alpha particle conversion to helium, and the adsorbed moisture available for evaporation. The free gas volume of the 5CV was determined as 313 in^3. Content Envelope S.1 under NCT developed the bounding pressure resulting in the MNOP. SARP Section 3.1.4 has a summary table of MNOP and maximum HAC pressures for NCT and HAC for the Content Envelopes S.1 through S.5. The maximum HAC pressure developed for the S.1 through S.5 contents was 436.4 psig, which is well below the 5CV design pressure limit of 900 psig.

To address the potential for generation and accumulation of flammable gases, primarily hydrogen gas through the radiolysis of plastic, the SARP follows the guidance in NUREG-1609, *Standard Review Plan for Transportation Packages for Radioactive*

Material and the NRC Information Notice No. 84-72 (IN 84-72), *Clarification of Conditions for Waste Shipments Subject to Hydrogen Gas Generation*. IN 84-72 stipulates that the gas limits (i.e., 5% flammable gas or 5% oxygen) are to be met for time periods that are twice the expected shipping time. SARP Section 3.6 has a detailed analysis of the radiolytic gas production due to radiolysis. The contents S.1 through S.5 are analyzed as to their radiolytic hydrogen and gas production rates, and the corresponding NCT pressures. Due to the high radiolytic hydrogen production for contents S.1 through S.3, they are packaged in a 5CV that is inerted to prevent the accumulation of a flammable amount of oxygen (i.e., to maintain the oxygen concentration below 5%). The radiolytic flammable gas production rates for contents S.4 and S.5 are more modest and the applicant's approach to prevent flammability is to limit the hydrogen concentration to less than 5%. The determination of radiolytic gas production rates for the NBL Standards Contents, i.e., S.1 through S.5, included determining the fractions of contents decay energy as α, β, and γ radiation, the fraction of the various radiation fields reaching material that can undergo radiolysis, and the temperature dependence of the radiolytic G-values.

The 'Shipping Interval' is defined as the time for contents S.1 through S.3 to reach 5% oxygen, and for contents S.4 and S.5 to reach 5% hydrogen. After the 5CV is inerted with 90% inert gas with the contents S.1 through S.3, their remains about 2.1% oxygen, and the 'Shipping Interval' for these contents is the time it takes, after the 5CV is closed, for the oxygen to increase from 2.1% to 5%. The only source of oxygen in the 5CV is the radiolysis of the absorbed moisture. The 'Shipping Interval,' or time to reach 5% oxygen, for contents S.1, S.2, and S.3, are 11.86, 5.95, and 7.60 years, respectively. Since the 'Shipping Window' is one-half the 'Shipping Interval,' the 'Shipping Window' for contents S.1, S.2, and S.3, is 5.93, 2.98, and 3.80 years, respectively. For contents S.4 and S.5, the 'Shipping Interval,' or time to reach 5% hydrogen, was calculated as 6.06 years and 294.3 days, respectively. Therefore, the 'Shipping Window' for contents S.4 and S.5 is 3.03 years and 147.2 days, respectively.

Since the SARP periodic maintenance requires annual leakage testing of the entire 5CV, the package may be consigned for shipment with contents C.1, C.2, C.4, C.5, C.6, and contents S.1 through S.4, prior to expiration of the package maintenance, since these contents do not require any Shipping Window restrictions. However, for content S.5, the Shipping Window is only 147 days. Therefore, there must be a condition in the CoC that for shipment of S.5 contents the Shipping Window starts (day 1) when the 5CV is closed and the shipment must be completed by day 147 (i.e., no longer in transit).

In addition to adding all the pertinent details of the contents S.1 through S.5 to Chapter 3, including the details on the calculation of the MNOP, other changes SARP included an expanded description of the regulatory requirements, editorial changes, addition of references, and changing some appendices to references.

Note that the possible presence of gallium in the C1, C2, or C.6 contents is accounted for in the melting temperature limit for plutonium metal of 752°F discussed near the end of Section 2.2.2 of the SARP. This limit is from the investigation of the lowest melting point plutonium eutectic with iron and gallium from DOE-STD-3013-2018, *Stabilization, Packaging and Storage of Plutonium-Bearing Materials*). The actual peak temperature for contents under post-HAC fire conditions is derived for low density oxide but is still well under the maximum content limit temperature based on Pu metal. The maximum temperature for 19 watts of Pu metal contents from SARP Section 3.4.2.5 is 414°F under post HAC conditions with insolation. Thus, there is a significant temperature margin.

3.1 Evaluation Findings

Based on review of the statements and representations in SARP Revision 3, DOE PCP staff has reasonable assurance that the thermal design of the package continues to meet the requirements of 10 CFR Part 71, subject to the condition that the shipment of the S.5 contents that must be completed within 147 days from when the 5CV is sealed.

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.

Chapter 4 of the SARP was revised to address the NBL Pu/Am-S, designated as content envelopes S.1 through S.5.

SARP Section 4.2 addresses the MNOP increase from 56.3 to 177.7 psig and Section 4.3 to address the maximum HAC pressure increase from 48.5 to 436.4 psig, based on the results reported in SARP Table 3.3 from the updated pressure calculations in Chapter 3 of the SARP for the NBL Pu/Am-S. The increased MNOP and maximum HAC pressures are still well below the 5CV design pressure of 900 psig.

The NBL Pu/Am-S are the bounding contents with respect to 5CV pressure as described in SARP Section 4.2.2 with its supporting calculation added as SARP Chapter 3, Reference 13.

Aside from the MNOP and maximum HAC pressure changes, the changes in SARP Chapter 4 include minor editorial changes, changes to clarify leakage test terminology, and updating references.

4.1 Evaluation Findings

Based on review of the statements and representations in SARP Revision 3, DOE PCP staff has reasonable assurance that the containment design of the package continues to meet the 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) meets the external radiation requirements in 10 CFR Part 71.

The NBL Pu/Am-S, designated as content envelopes S.1 through S.5, were added to SARP Chapter 5. The shielding performance of the package with content envelopes S.1 through S.5 were evaluated by comparison with content C.6. Since the Pu/Am-S contents are bounded by C.6 content, the dose rate from the Content Envelopes S.1 through S.5 are bounded by the dose rate from C.6. Also, since Content Envelopes C.1, C.2, C.3, C.5, and C.6 are bounded by the dose rate from C.2 (from previous shielding analysis), the dose rate from content C.2 is bounding for all other contents in SARP Table 1-2. There is a description and discussion of the packaging configuration and impurity levels for the contents S.1 through S.5 and the impacts of these items upon the external dose rate. SARP Table 5.1 summarizes the maximum calculated dose rates for NCT and HAC for Content Envelopes C.1 through S.5 and compares the results against the regulatory limits for shipment in commerce.

Other changes in the SARP include organizational name changes, updating of references, and some appendices were changed to references.

For Contents C.1, C.2, and C.6, gallium is a possible non-radioactive constituent. Gallium does not have a significant neutron yield when intimately mixed with alpha bearing materials. Therefore, including the gallium as part of the Pu-239 mass limit, as indicated in the SARP Table 1.2, Note “q”, ensures bounding results for the shielding analyses.

5.1 Evaluation Findings

Based on review of the statements and representations in SARP Revision 3, DOE PCP staff has reasonable assurance that the package shielding design continues to meet the 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).

The NBL Pu/Am-S Contents S.1 through S.5 were added to Chapter 6 in Revision 3. The contents for the package are specified in ten Content Envelopes, C.1, C.2, C.4, C.5, C.6, and S.1 through S.5. The SARP includes the criticality evaluation for contents C.1 (Heat Sources), C.2 (Pu/U Metals), C.4 (U Metals or Alloys), C.5 (U Compounds), and C.6 (Samples and Sources), as well as the criticality evaluations for S.1 through S.5 (Pu/Am-S), which are performed through analysis-by-comparison. Based on this analysis by comparison, the Criticality Safety Index for Content Envelopes S.1 through S.5 can conservatively be considered as 1.0. There is an added discussion on the effect of the

glass, plastic, and other polymeric materials in the packing configuration on the criticality evaluation for the S.1 through S.5 contents. The criticality analysis results for these contents (i.e., C.1, C.2, C.4, C.5, C.6, and S.1 through S.5) are summarized in the SARP Table 6.1. The analysis demonstrates that the package, loaded with any of Content Envelopes C.1, C.2, C.4, C.5, C.6, S.1, S.2, S.3, S.4, and S.5 is subcritical for all single package, and NCT and HAC array cases.

In addition to the changes noted above, Chapter 6 of SARP Revision 3 included: organizational name changes, updating of references, and appendices changed to references.

The addition of gallium to Content Envelopes C.1, C.2, and C.6 (i.e., alloying with gallium) will decrease the fissionable material density and therefore decrease k effective. Since the addition of gallium decreases the k effective, including gallium's mass as part of the Pu-239 mass limit, as indicated in SARP Table 1.2 *Content Envelopes*, is conservative. Based on evaluation-by-comparison with the 9975 package, 4.5 weight percent is acceptable in the Pu-239 mass.

6.1 Evaluation Findings

Based on review of the statements and representations in SARP Revision 3, DOE PCP staff has reasonable assurance that the package criticality design continues to meet the requirements of 10 CFR Part 71, subject to the condition that C.1, C.2, and C.6 may contain up to 4.5 weight percent of gallium in the Pu-239 mass.

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.

In addition to editorial changes and updating of references, the primary changes to the Chapter 7 in SARP Revision 3 relate to a limited Shipping Window for NBL Pu/Am-S content S.5, and the packaging configuration and inerting requirements for the NBL Pu/Am-S contents S.1 through S.5.

The introductory portion of Chapter 7 includes "…, once loaded into the containment vessel, the Content Envelopes S.1, S.2, and S.3 must be subjected to an inert gas atmosphere in order to lower the oxygen content to a sufficient level to preclude the formation of a flammable atmosphere within the 9978 package prior to completion of the shipment of the 9978." In SARP Section 7.1.2 there are details on the 5CV inerting and shipping window. If loading contents S.1, S.2, or S.3, dilute the atmosphere within the containment vessel to at least 90% Nitrogen in accordance with the procedure provided in SARP Appendix 7.2. If loading contents S.4 or S.5, utilize the one 1-quart SAVY ™

4000 or the one 2-quart SAVY ™ 4000 configuration (the two 1-quart SAVY ™ 4000 configuration is not allowed for contents S.4 and S.5). If loading content S.5, a shipping window of 147 days must be implemented. The shipping window is defined as the duration between the closure of the 5CV and the completion of the shipment. The date the 5CV was closed along with the date when the shipment must be completed must be identified on the associated shipping papers. DOE PCP staff has concluded that the operational controls on contents S.1 through S.5 to address flammable gas generation and accumulation, as presented in SARP Chapter 3, are properly documented in Chapter 7.

Also, SARP Chapter 7 describes the change in the closure of the cone-seal assembly from a process involving aligning scribe marks to achieve the proper torque to one with a torque requirement. The Cone-Seal Assembly is to be threaded into the 5CV body and tightened to a torque of 50 (+10/-0) ft-lb., and the scribe mark on the Cone-Seal Assembly should be aligned to within one-inch on either side of the scribe mark on the 5CV body. If the scribe marks do not align correctly, then verify the integrity of the 5CV Outer O ring seal by performing the O ring seal test in accordance with SARP Section 8.2.1. Install the Leak-Test Port Plug and Gland Nut, torquing the Gland Nut to 25 (±5) ft lb. DOE PCP staff has concluded that the change in the 5CV closure process is adequate to ensure proper closure and O-ring sealing.

7.1 Evaluation Findings

Based on review of the statements and representations in SARP Revision 3, DOE PCP staff concludes that the combination of the engineered safety features of the package and the operating procedures provide adequate measures and reasonable assurance for safe operation of the package in accordance with 10 CFR Part 71, subject to the 5CV inerting requirement for S.1 through S.3, and the shipping window restriction of 147-days for S.5.

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.

SARP Chapter 8 is essentially unchanged, with only minor editorial changes (e.g., renumbering pages in the table of contents, renumbering section numbers, grammar changes, and updated references).

8.1 Evaluation Findings

Based on the review of the statements and representations in SARP Revision 3, DOE PCP staff concludes 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.

9.0 Quality Assurance

The objective of this review is to verify that the Addendum 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 applicant's 10 CFR 71 Subpart H Quality Assurance Program (QAP) is approved by DOE (https://rampac.energy.gov/docs/default-source/qa/approval_0035_r0.pdf).

In general, the changes to Chapter 9, Quality Assurance, in SARP Revision 3 clarify the roles and responsibilities of the SRNL Quality Assurance Program Organization and the SRNL/SRNS QA organization and relationship. The changes to Chapter 9 included: organizational name changes, addition of a QA compliance statement with a listing of two SRNL QA documents and a SRNL Transportation Safety Document, a description of the SRNL Design Agency and Design Authority for the Model 9978, clarification of QA program compliance requirements for package users, added text on roles and responsibilities of the Design Agency and the SRNL QA Organization, rewording of Q-item descriptions, added use of Commercial Grade Dedication for level A and B, Q-items, expanded text on Software Control, added text on Internal Inspections, added text for nonconforming Q-items under Corrective Actions, and added details on Quality Assurance Records.

The SAVY ™4000 containers were added to the list of engineered containers in SARP Table 9.3 - *Safety Assessment of Packaging Features,* and the *Pu/Am Standards Nested Configuration* was also added to the table and classified as not-important-to-safety items as their function is convenience handling.

9.1 Evaluation Findings

Based on review of the statements and representations in SARP Revision 3, DOE PCP staff has reasonable assurance that the package-specific requirements are consistent with their DOE approved QAP, 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 are required to amend the CoC based on this SER.

1. General – change “lbs” to “lb.” throughout the CoC.
2. 5(a)(2) Description:
    a. Add S.1 through S.5 to the content descriptions on CoC page 4 (2 places) and correct grammar in the last paragraph on page 4.
    b. Add new paragraph on CoC page 5 for the New Brunswick Laboratory Pu/Am standards.
3. 5(a)(3) Drawings – Update R-R4-G-00033 from Revision 4 to Revision 5
4. 5(b)(1) Type and Form of Radioactive Material:
    a. Add S.1 through S.5 to the content definition in the first paragraph of CoC page 9.
    b. Add NBL Pu/Am Standards S.1. through S.5 to Tables 1 and 2.
    c. Add a bullet in Table 2 "Co-mingling of standard types S.1 through S.5 is prohibited - only one standard type is authorized per 5CV/package."
    d. Renumber/edit Table 1 notes for consistency with the SARP.
    e. Add a Note to Table 1, note k, “DOE G 421.1-1, 3.79 Fissile Nuclide, 8-25-99 (canceled by DOE N 251.93, 11-19-2010).”
    f. Add new Table 1 notes, “n, o, p, and q” to address S.1 through S.5 contents and gallium at 4.5 weight percent of Pu-239).
5. 5(b)(2) Maximum Quantity of Radioactive Material per Package – Add paragraph (e) Envelopes S.1 through S.5, New Brunswick Lab (NBL) Pu/Am Standards.
6. 5(c) Criticality Safety Index:
    a. Revise the CSI for C.1 to 0.0 (per Chapter 6 of the SARP).
    b. Add S.1 though S.5 with a CSI of 1.0.
7. 5(d) Conditions:
    a. Add decay heat limit (0.093 watts) for S.1 through S.5 to Condition (1).
    b. Update ANSI N14.5 to 2014 edition in Condition (7).
    c. Add Conditions (8) and (9) to clarify restricted use of the package (common to all DOE CoCs).
    d. Add Condition (10) for inerting requirement for S.1 through S.3.
    e. Add Condition (11) for the 147-day shipping window for S.5.
    f. Add Condition (12) to authorize use of the package under CoC Revision 4 until April 30, 2024.
8. 5(e) Supplements – Add Supplement (5) *Safety Analysis Report for Packaging Model 9978*, S-SARP-G-00002, Revision 3, March 2023.

Conclusion

Based on the statements and representations contained in SARP Revision 3and the conditions listed above, DOE PCP staff concludes that the package design has been adequately described and evaluated, and the Model 9978 package continues to meet the requirements of 10 CFR Part 71. Staff recommends approval of DOE CoC 9978 Revision 5 to authorize use of the package for shipment of the NBL Pu/Am-S Contents S.1 through S.5 and gallium as a non-radioactive component of Contents C.1, C2, and C.6.

References

[1] Email, *Docket 22-13-9978 SARP submittal*, Luke Sobus (DOE-SR) to Lawrence Gelder (DOE PCP Docket Manager), March 2, 2022.

[2] *Safety Analysis Report for Packaging, Model 9978*, S-SARP-G-00002 Rev. 2, (received March 2, 2022) dated May 2022.

[3] Email, *RE: Completeness Review (Docket 22-13-9978)*, Luke Sobus (DOE-SR) to Lawrence Gelder (DOE PCP Docket Manager), July 12, 2022, for *Safety Analysis Report for Packaging, Model 9978*, S-SARP-G-00002 Rev. 2a pages changes.

[4] Email, *Submittal of S-SARP-G-0002 Rev. 3 (Docket 22-13-9978)*, Luke Sobus (DOE-SR) to James Shuler (DOE PCP Docket Manager), October 13, 2022, for *Safety Analysis Report for Packaging, Model* 9978, S-SARP-G-00002 Rev. 3 (draft), dated October 2022.

[5] *Safety Analysis Report for Packaging, Model* 9978, S-SARP-G-00002 Rev. 3 (final), dated March 2023, uploaded March 21, 2023, to DOE secure server.