U.S. DEPARTMENT *of* ENERGY

Office of Environmental Management

DOE Packaging Certification Program

SAFETY EVALUATION REPORT
Amendment of Certificate of Compliance No. 9979 for the Model 9979 Package

Docket No. 26-04-9979

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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 a supplement to Safety Analysis Report for Packaging (SARP) Revision 7, 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 9979, Revision 20, for the Model 9979 package design.

Summary

By email [1] dated December 1, 2025, the DOE CoC 9979 certificate holder, SR, requested an amendment of DOE CoC No 9979 to:

1. authorize use of a "MacroBag®" as dunnage to facilitate easier loading (or unloading) for Table 1.2 contents,
2. update A_2 activity limits for certain radioisotopes in Table 1.2
3. add three new shipping options and mass limits when a MacroBag® is used as dunnage,
4. increase the decay heat limit for Table 1.2 contents (to account for Co-60),
5. update certification drawings to clarify the Compact Augmented Permeation System (CAPS) and non-CAPS drum configuration options, and
6. to refine the SARP.

The safety basis document (application) submitted by SR in support of this amendment request is a supplement to Revision 7 of the Safety Analysis Report for Packaging (SARP) prepared by SRNL.[2] The supplement included a new nuclear criticality safety evaluation (NCSE) and a new gas generation calculation to authorize use of a MacroBag® as dunnage with SARP Table 1.2 contents (CoC Table 2). The supplement also included a revised gas generation calculation to evaluate the increased decay heat for Table 1.2 contents to account for Co-60.

DOE PCP staff reviewed the initial application and its supporting documentation and issued questions and comments (Q1s) to the applicant on January 22, 2026.[3] On March 5, 2026, SR submitted their Q1 responses with proposed implementation [4], which included a new gas generation calculation to evaluate use of a MacroBag®. Staff reviewed and found the Q1 responses acceptable [5] pending implementation in the final application. On April 13, 2026, SR submitted Revision 1 of the final application [6, 7], which staff reviewed and confirmed to be acceptable.

Based on the statements and representations in the SARP, as supplemented by this final application, and the conditions listed in this SER, DOE PCP staff independently confirmed by review and analysis that the proposed changes to the authorized package design have been adequately described and evaluated. Therefore, staff has reasonable assurance that the regulatory requirements of 10 CFR Part 71 have been met and recommends amendment of the CoC by the DOE Headquarters Certifying Official (HCO).

Evaluation

In addition to changes to the authorized package design addressed below, the application includes numerous non-safety refinements to grammar, punctuation, and other administrative changes that were reviewed by DOE PCP staff and found to be satisfactory. These changes are not addressed in detail in this SER.

Use of the term "SARP" is this SER means Revision 7 of the SARP and its three approved

supplements (Dockets 21-03-9979, 23-11-9979, & 21-16-9979), which are authorized in Revision 20 of the CoC.

Use of the term "application" or "supplement" in the SER means the final SARP supplement for this docket (26-04-9979). The application supplements SARP Chapters 1-4 and 6-9 - there were no changes to SARP Chapters 5 and 8 (Shielding and Acceptance Testing and Maintenance) for this docket.

1.0 General Information

Model 9979 is a Type A fissile package design composed of one 55-gallon drum overpack, and one 30-gallon inner drum as defined in Section 5(3) of the CoC. The purpose of the package is to transport a Type A quantity of normal form or special form solid fissile radioactive material by public highway. The package is used to ship DOE radioactive waste or product material.

1.1 Packaging

There were no significant safety changes to the authorized packaging design for this docket.

The applicant made clarifications in Sections 1.2.1, *Packaging,* and 1.2.1.1, *Drums and Closures*, of the supplement regarding authorized configurations for the 30-gallon drum lid. The drum lid may have one or two bung holes – one is required for the pressure-relieving plug/device (PRD) and the other is optional if the CAPS device or blind plug are used. The PRD is required in all 30-gallon drum lid configuration. The CAPS device is an engineered component that allows flammable gas (less than 5% by volume) to permeate rather than accumulate in 30-gallon drum. Drum lids without the CAPS device require administrative controls and a safe-shipping window to prevent a flammable mixture from accumulating in the 30-gallon drum.

The applicant made a clarification in Section 1.2.1.1 of the supplement regarding the requirement for the 1/8-in. diameter through-hole in the 55-gallon drum body to allow hydrogen gas to diffuse (exit) from the package to the environment when the CAPS device is used in the 30-gallon drum lid configuration.

DOE PCP staff acknowledges these drum configurations are necessary for users to continue use of packaging fabricated prior to CoC Revision 19 (July 2025), without required backfit for the CAPS device configuration, and flexibility for newly fabricated new drums the option to use the CAPS device configuration only if needed.

1.2 Contents

There were changes requested by the applicant to the existing authorized radioactive contents that required supporting nuclear criticality safety and gas calculations. The applicant established new fissile mass limits and non-radioactive material mass limits for three package configurations with a MacroBag®, based on a revised criticality evaluation in Chapter 6 of the application.

The applicant proposes to use a MacroBag® as dunnage to facilitate easier loading (or unloading) of Table 1.2 contents in the 30-gallon drum.

The contents changes are summarized below.

The applicant clarified their definition of "combustible materials" in Section 1.2.2.1 of the application

as "Combustible materials are those that are susceptible to thermal decomposition in the HAC temperature range of the contents (e.g., organic materials)."

The applicant updated Table 1.1 – *Content Categorization Examples* to add the MacroBag® to the list of combustible materials and moved the special form items [Vogan Assemblies, Plutonium Oxide Pod (POP) Assemblies, Am1.N02 Assemblies] to the Standards and Sources row.

The applicant updated Table 1.2 – *Envelope Limits including Highly Enriched Uranium (HEU) Content*, to:

- Marginally revise radioisotope mass limits based on Activity (A_2) for most radioisotopes in the table (the revised limits are still less than $1A_2$). The revised limits are based on an update to Appendix 4.1, *Content Description for the 9979*, *A_2 Calculation and Content Decay Heat for the 9979 Package Table 1.2 HEU Content Envelope Limits*.
- Add text "N/A | Not Fissile" to the non-fissile radioisotopes and added Table Note "c", in the Criticality column for the fissile uranium radioisotopes of all isotopes of plutonium. The note refers the user to two equations to confirm the fissile mass does not exceed $U\text{-}235_{(equivalent)}$ of 350 grams. Note "c" equations are a simplified version of the single equation in CoC 9979 Revision 20, Table Note 1.2 "f",
- Reformat and improve the "Non-Radioactive Material Mass Limits" section from four into six shipping configuration options,
- Add "MacroBags®" to the "Special Shipping Requirements" section of the table with new mass limits for Shipping Configuration Options 2, 5, and 6, and
- Update Table 1.2 Notes – the notes were reordered for changes in the table, and embellished with additional details for clarity, as needed. In addition, Note "j" was added to address the use of MacroBags®.

The calculated decay heat limit for Table 1.2 increased from 1.18E-02 to 1.63E-01 watts based on an update to Appendix 4.1.

The applicant updated Table notes to the following tables to add "Content envelope is not expected to exceed the external radiation limits in 10 CFR 71.47(a) and 49 CFR 173.441(a) for non-exclusive use shipments."

- Table 1-3 *Low Enriched Uranium (LEU) Content Envelope ≤ 19.9% U-235*,
- Table 1-4 *Low Enriched Uranium (LEU) Content Envelope ≤ 1.25% U-235*, and
- Table 1-5B *Radioactive Material Configuration B*.

The applicant revised Note "a" to Table 1-5A *Radioactive Material Configuration A*, to "Table 1.5.A contents have the potential to exceed the external radiation limits in 10 CFR 71.47(a) and 49 CFR 173.441(a) for non-exclusive use shipments. Table 1.5.A contents shall be shipped exclusive use in accordance with the requirements of 49 CFR 173.441, 10 CFR 71.47, and S-SARP-G-00006 Chapter 7 should the nonexclusive use external radiation limits be exceeded."

The applicant added text to Sections 1.2.2.3 *General Payload Configuration* and 1.2.2.4 *HEU Content Configuration – Table 1.2*, of the application to address the general and specific use of a MacroBag®.

DOE PCP staff confirmed by document review that the application describes the package in sufficient detail to provide an adequate basis for its evaluation.

1.3 Drawings

The applicant revised the following CoC drawings to clarify use of the packaging with and without the CAPS device. The revised drawings are included in Appendix 1.1 of the application.

Table 1 - Drawings Updated

Drawing No.	CoC Rev	New Rev	Title
R-R1-G-00028	8	9	9979 Type AF 30-Gallon Drum Assembly (U)
R-R2-G-00057	12	13	9979 Type AF 55-Gallon Drum Sub-Assembly and Weldment (U)
R-R2-G-00060	7	8	9979 Type AF 30-Gallon Drum Lid with Dual Bung Closures (U)
R-R4-G-00062	4	6	9979 Type AF 30-Gallon Drum Lid Gasket (U)

The applicant revised Drawing R-R1-G-00028 to add (back) the ¾-in. blind plug, which was previously approved in the CoC prior Rev 8 of the drawing.

The applicant revised Drawing R-R2-G-00057 to update Note 16 and Parts List Item 13 to clarify the "diffusion hole" and cover are only required when CAPS is used on the 30-gallon drum lid configuration.

The applicant revised Drawing R-R2-G-00060 to update Note 8 and Parts List Items 2 and 3 to clarify that the second bung flange is optional, that is, it is only needed if the CAPS device or ¾-in. blind plug is used.

The applicant revised Drawing R-R4-G-00062 Revision 4, Note 6, to clarify that the material specification in the table for Note 6, for the 30-gallon drum lid gaskets, is required. The applicant also updated the "Parker" part and drawings numbers for gasket R-R4-G-00062-A (Parker 4355|S, Dwg AR-09-004-3). The "Parker" part number for gasket R-R4-G-00062-B was to be issued for Parker Dwg AR-11-103-1 later. The applicant subsequently revised Drawing R-R4-G-00062 Revision 5, Note 6 to add "Parker" part number (Parker 42525S) and correct the drawing number for gasket R-R4-G-00062-B (Dwg AR-11-103-2). The applicant made marginal dimension changes to both gaskets, R-R4-G-00062-A and -B as shown in Detail B and Detail A of Drawing R-R4-G-00062, respectively.

The applicant provided a drawing of the MacroBag® as a reference in Section 1.4 *REFERENCES*, Ref 17, of the application for review by DOE PCP staff. A MacroBag® consists of an inner, middle, and outer bag, with zippered closures, and support loops for lifting the MacroBag®. The outer bag is made from coated non-woven polypropylene (NWPP), the inner bag is made from NWPP, and the middle bag is made from PVC-coated nylon. A MacroBag® weighs approximately 7 lb.

DOE PCP staff reviewed the revised certificate drawings and MacroBag® drawing and found they contain sufficient detail to evaluate the safety performance of the package.

1.4 Operational Features

There were no significant changes in Section 1.2.4, *Operational Features*, in the application.

1.5 Conclusion

Based on a review of the statements and representations in the SARP, as supplemented by this application, DOE PCP staff confirmed that the package design changes in support of this CoC amendment 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, as supplemented by this application, includes 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.

The applicant revised Chapter 2 in the application to:

- Clarify that use of the CAPS device in the 30-gallon drum lid is optional (Sections 2.1.1, *Discussion*, and 2.3.1.3, *Thirty Gallon Drum*).
- Add (back) the ¾-in. blind plug (Bung Hole Blind Plug) in Table 2.4 – *Packaging Components and Material Specifications*, as on option in the 30-gallon drum lid, and
- Clarify use of the Bung Hole Blind Plug in the 30-gallon drum lid is optional (Section 2.3.1.3, *Thirty Gallon Drum*), and
- Acknowledge that thermal degradation of the 55-gallon drum lid gasket under hypothetical accident conditions [per § 71.73(c)(4)] is an additional factor that prevents over pressurization of the drum (Section 2.7.4.1, Summary of Pressures and Temperatures).

DOE PCP staff confirmed by document review that these changes do not affect the structural performance of the package. Staff notes the diffusion hole is required in the 55-gallon drum when the CAPS device is used in the 30-gallon drum configuration.

Based on review of the statements and representations in SARP, as supplemented by this application, 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 in the SARP, as supplemented, for the tests specified under NCT and HAC and that the package design satisfies the thermal requirements of 10 CFR Part 71.

The applicant revised Chapter 3 in the application to:

- Clarify use of the CAPS device and Bung Hole Blind Plug in the 30-gallon drum lid, and diffusion hole in the 55-gallon drum are optional (Sections 3.1 *DESCRIPTION OF THERMAL DESIGN,* 3.2.2.1*, 55-Gallon Overpack,* and 3.2.2.3, *30-Gallon Drum*).
- Increase the decay heat for Table 1.2 to 1.63E-01watts (Section 3.1.2, *Content's Decay Heat*)
- Clarify that the shipping window restrictions still apply if a CAPS device is not in use (Section 3.3.2, *Maximum Normal Operating Pressure*), and
- Update Reference 33, *Hydrogen Gas Generation Rates from the 9979 Shipping Package Contents during Normal Conditions of Transport (NCT)*, M-CLC-A-00734, Rev. 1. The applicant performed this calculation to more accurately quantify the amount of decay energy

from each radioisotope absorbed into hydrogenous material and, therefore, contributing to hydrogen generation.

DOE PCP staff confirmed by document review that these changes do not affect the thermal performance of the package. Staff notes that:

- 1/8-in. diffusion hole is required in the 55-gallon drum when the CAPS device is used in the 30-gallon drum configuration.
- increased decay heat for Table 1.2 contents to 1.63E-01watts is the sum of the decay heats for Co-60, U-235, and U-238. The applicant used this combination of radioisotopes to maximize decay heat without exceeding the package activity, fissile mass, and payload mass limits, and is still bounded by the package decay heat of 3.5 watts [per the CoC Section 5(b)(3)].
- Hydrogen gas generation in the package has been conservatively evaluated in M-CLC-A-00734, Rev. 1, based on the updated total decay heat of 1.63E-01watts for Table 1.2 contents. DOE PCP staff found the calculations and results appropriate. The calculated hydrogen generation rates and time to reach the lower flammability limit for hydrogen are used in Chapter 7 of the supplement for package users to calculate shipping windows.
- The applicant added Ref 18, *Evaluation of Hydrogen Gas Accumulation in PacTec Inc. MacroBag® for the 9979 Package*, M-CLC-A-00808, Revision 0, to Chapter 1 of the supplement, to evaluate hydrogen gas generation and accumulation rates in the MacroBag®, with the CAPS device 30-gallon drum configuration, for Table 1.2 contents at a decay heat of 1.63E-01watts. The results show that the bounding hydrogen concentration within the Macrobag® is approximately 2.3 volume %. This calculation sufficiently demonstrates the hydrogen concentration within the package will not exceed the lower flammability limit of 5% at any time during shipment for the CAPs device configuration - Macrobag® and CAPs device permeability are sufficient engineering controls to prevent a flammable mixture in the package.
- The existing thermal evaluation model produces upper-bound normal conditions of transport (NCT) and hypothetical accident condition (HAC) temperatures for the package. The calculated average NCT payload temperature of 154°F will not cause plastics to decompose; therefore, the Macrobag® should have no impact on the package Maximum Normal Operating Pressure (MNOP). The Macrobag® is expected to thermally decompose under HAC, like other plastics contents in the 30-gallon drum; however, the PRD in the 30-gallon drum lid is an engineering control that provides overpressure protection of the drum.

Based on review of the statements and representations in the SARP, as supplemented by this application, and DOE PCP staff's confirmatory evaluation, 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 for a Type A quantity of radioactive material under NCT, that is, no loss or dispersal of the radioactive material per § 71.43(f).

The applicant revised Chapter 4 in the application to:

- Clarify "mandatory" use of the PRD, and optional use of the CAPS device and Bung Hole Blind Plug in the 30-gallon drum lid (Section 4.1, *Description of the Containment System*),

- Update Figure 4.1, *9979 Containment Boundary (Dashed)* to show the PRD and CAPS device or blind plug, and
- Update *A_2 Calculation and Content Decay Heat for the 9979 Package Table 1.2 HEU Content Envelope Limits*, in Appendix 4.1. The increase in decay heat to 1.63E-02 watts is due to the assumption that the package contains one A_2 of Co-60 (1.60E-02 watts) plus U-235 (350 g at 2.14E-05 watts) and U-238 (90 kg at 7.75E-04 watts).

DOE PCP staff confirmed by document review that these changes do not affect the containment performance of the package. The package is limited by administrative controls to a Type A quantity of normal form or special form radioactive material per Section 1.2.2.1, *Contents of Packaging*, of the supplement.

Based on review of the statements and representations in the SARP, as supplemented by this application, DOE PCP 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) meets the external radiation requirements in 10 CFR Part 71.

For Type A fissile packages, shielding reviews are not necessary because, by the nature of the contents, radiation source terms and radiation levels for these packages are negligible (Ref. NUREG-2216, *Standard Review Plan for Transportation Packages for Spent Fuel and Radioactive Material*, Section 5.4).

The packaging design does not include engineered features specifically intended to provide radiation shielding of the contents.

Compliance with § 71.47 is confirmed by measurement for each package prior to shipment.

6.0 Criticality Evaluation

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

The applicant revised Chapter 6 of the SARP to:

- Implement the results of the new nuclear criticality safety evaluation (NCSE), *Nuclear Criticality Safety Evaluation: 9979 AF Shipping Package MacroBag® Analysis*, N-CLC-A-00049, Revision 0, (Supplement Section 6.10, Ref. 5) for inclusion of the Macrobag® as authorized dunnage for Table 1.2 contents. The results are summarized in Table 6.1 – *Criticality Safety Analysis Results (Content Table 1.2)* of the application,
- Create/insert Table 6.2 – *Criticality Safety Analysis Results (Content Table 1.3)*. This table was split out of SARP Table 6.1. Results are based on previous NCSE (Supplement Section 6.10, Ref. 6), which was previously reviewed and approved as a supplement to CoC Revision 10, subsequent tables in the application were renumbered,
- Condense the CSI text in Section 6.1.3 and consolidate the CSI for all contents in Table 6.5 – *Summary of CSI Calculations*,

- Update Section 6.2.1, *Table 1.2 Content Envelope*, to add describe the Macrobag®, elaborate the uranium content description, and delete SARP Table 6-8 (redundant with Table 1-2),
- Condense the fissile material descriptions in Sections 6.2.2 through 6.2.4 of the application (SARP Tables 6.9 through 6.11 deleted),
- Combine the NCSE model configurations, with dimensions, in a single description in Section 6.3.1 and single table, Table 6.6 – *Model Dimensions* (SARP Tables 6.12 through 6.19 deleted), and renumber subsequent sections in the application (for example, 6.3.1 is now 6.3.1.1, 6.3.2 is now 6.3.1.2, etc.),
- Revise Sections 6.3.1.1, 6.4.1.1, 6.5.1.1, 6.6.1.1, and 6.8.1.1 to *Table 1.2 Content Envelope without MacroBag®*, for model configuration, single package evaluation, arrays under NCT, arrays under HAC, and benchmark evaluations,
- Create/insert new Sections 6.3.1.2, 6.4.1.2, 6.5.1.2, 6.6.1.2, and 6.8.1.2 to *Table 1.2 Content Envelope with MacroBag®*, for model configuration, single package evaluation, arrays under NCT, arrays under HAC, and benchmark evaluations,
- Create new Section 6.3.2, *Material Properties*, with the descriptions from SARP Sections 6.3.4.3 through 6.3.4.6, for each content envelop, and update 6.3.2.2 Table 1.2 Content Envelope (previously Section 6.3.4.3) to clarify carbon and graphite impurities,
- Combine the computer codes and cross section libraries in a single table, Table 6.7 – *List of Computer Codes and Cross-Section Libraries*, condense the descriptions in Section 6.3.3 *Computer Codes and Cross-Section Libraries* (previously SARP Section 6.3.5), and add the code used for Table 1.2 Content Envelope with MacroBag®,
- Condense the results for single package evaluation, in Section 6.4.2 *Table 1.3 Content Envelope*, in Table 6.10 – *Four Plates Separated by Polyethylene (Content Table 1.3)* (SARP Tables 6-21 through 6-29 deleted),
- Condensed the results for HAC array in Section 6.6.4.1, *Results*, to show a finite array is subcritical, as shown in Table 6.27 *–HAC Results for a Finite Array of 12×14×8 Drums (Content Table 1.5)* (SARP Table 6.43 and Figures 6.26 and 6.26 deleted),
- Revised Section 6.8, *BENCHMARK EVALUATIONS*, to include Scale 6.1 and its validation,
- Update Section 6.10 *REFERENCES*, to insert Ref. 5, *Nuclear Criticality Safety Evaluation: 9979 Type AF Shipping Package Macrobag® Analysis*, N-NCS-A-00049, Revision 0, revise Ref. 6 (previously Ref. 5), *Nuclear Criticality Safety Evaluation: LEU Cube and Plates in 9979 AF Shipping Package*, N-NCS-A-00031, to Revision 1, insert Ref. 10, drawing for *30 GAL DRUM INNER MACROBAG*, reorganized and renumbered references, and deleted SARP Ref. 9 through 11.

DOE PCP staff confirmed by document review the revisions and updates to clarify, correct, and condense information in Chapter 6 as summarized above in this SER was correctly and sufficiently implemented by the applicant.

Staff reviewed Chapter 6 changes and its supporting NCSE (N-NCS-A-00049 Rev. 0) for the proposed shipment of SARP Table 1.2 contents using a MacroBag® as optional content dunnage. The applicant's previous analysis from N-NCS-A-00019, Rev. 2, is repeated with the MacroBag® insert modeled in several configurations. Staff reviewed the applicant's NCSE methodology, assumptions, and modeling approaches for single package (SP), NCT array, and HAC array, and performed independent confirmatory calculations using MCNP 6.3 to verify subcriticality of the package, with MacroBag®, under the most reactive conditions.

6.1 Package Description

The Model 9979 packaging consists of a 30-gallon drum nested within a 55-gallon drum overpack. There were no changes to the packaging design except to authorize use of a MacroBag® as optional dunnage for certain shipping configurations as listed in Table 1.2 of the application. The MacroBag® consists of multiple nested plastic bags with zippered closures and is designed to fit within a 30-gallon drum. The MacroBag® provides neutron moderating material and is modeled (conservatively) as polyethylene in the NCSE.

Table 1.2 fissile contents are administratively limited to maximum of 350 grams of equivalent ^{235}U. Uranium may be at any enrichment and in various chemical forms, including oxide, fluoride, hydroxide, metal, or aqueous solution. Small quantities of ^{233}U, and fissile plutonium may be present in the uranium. Radioactive contents are typically normal and special form solids; however, some contents in liquid form are authorized. Consequently, moderation of fissile material within the package is possible. Nonradioactive materials such as carbon, beryllium, and/or hydrocarbons may be present with radioactive contents and are authorized in limited quantities based on six specific shipping configurations. Certain combinations of these materials require a reduction in allowable fissile mass.

6.2 Summary of NCSE and Staff's Confirmatory Evaluation

The applicant evaluated package subcriticality for Table 1.2 contents, with a Macrobag®, for SP, NCT array, and HAC array configurations using the SCALE 6.1 code system with the 238-group ENDF/B-VII.0 library. The limiting condition was identified as the HAC configuration consisting of a 6×6×3 array of damaged packages with interstitial flooding and beryllium reflection. The acceptance criterion applied in the applicant's analysis is $k_{safe} = 0.926$. Staff notes acceptance criterion in the previous NCSE, without the Macrobag®, is $k_{safe} = 0.931$ (N-NCS-A-00019, Rev. 2).

The applicant performed parametric studies varying H/X to identify optimal moderation conditions. The results show that k_{eff} increases with moderation up to approximately H/X of 700 and decreases at higher moderation levels, which is consistent with expected neutron moderation behavior. DOE PCP staff finds that the H/X parametric analysis is technically sound and adequately identifies the condition of optimal moderation.

Single Package

The applicant's single package (SP) configurations (9 cases total) were evaluated with various reflector conditions, including water and graphite, and the results are summarized in Table 6.8 – *Results for SP Analysis with Reflection (Content Table 1.2)* of the application. The most reactive SP configurations exceeding k_{safe} involved dry or flooded conditions with graphite reflection, and 300-350 grams of U-235 (Cases 5, 6, & 8); however, when the U-235 mass is reduced to 250 grams for dry condition (Case 7), the k_{eff}+2*sigma (0.904), and for the flooded condition (Case 9), k_{eff} +2*sigma (0.912) are both below k_{safe} (0.926). The results for all configurations of 350 grams of U-235 and no graphite reflection (Cases 1 through 4) are less than k_{safe}. Therefore, the applicant demonstrates compliance with the SP requirements of § 71.55(b). These limits will be included in the CoC, Table 2.

NCT Array

The applicant's NCT array analysis considered 13 cases total of an 8×8×8 triangular-pitch array of packages with 2 meters of water reflection on all six sides. The results are summarized in Table 6.14 – *Results for NCT Cases with Reflection (Content Table 1.2)*, of the application. The most reactive configurations (Cases 8 and 9) exceeding k_{safe} included optimal moderation conditions - 350 grams of

U-235, H/X ratio of 600-700, and with compressed MacroBag® representation. The most reactive k_{eff}+2*sigma (0.948) was with H/X = 600; however, when the U-235 mass is reduced to 300 grams (Case 10), and flooded (Case 12), or with Be reflection (Case 13), the results are all less than k_{safe} for this finite array of packages. Therefore, the applicant demonstrates compliance with the requirements of §§ 71.55(d) and 71.59(a)(1). These limits will be included in the CoC, Table 2.

HAC Array

The applicant's HAC array analysis considered 15 cases total of 6×6×3 and 6×6×6 arrays of damaged packages with 2 meters of water reflection on all six sides, assuming: crushed drum geometry, clustered fissile contents, interstitial water flooding, and reflector conditions including beryllium. The results are summarized in Table 6.22 – *Results for HAC Analysis with Reflection and Flooding (Content Table 1.2)*, of the application. The most reactive 6×6×3 array (Case 5) had k_{eff}+2*sigma (0.930) and for 6×6×6 array (Case 4) had k_{eff}+2*sigma (0.929), with the H/X = 600 and 300 grams of U-235 for both cases. The applicant reduced U-235 mass to 280 grams for the 6×6×3 array (Case 6) to reduce k_{eff}+2*sigma (0.916) below k_{safe}. The applicant ran 23 additional cases of the 6×6×3 array, with the addition of 90 kg of graphite reflection and H/X ranging from 300-700. The results are summarized in Table 6.23 – *HAC Cases with Full Graphite (Content Table 1.2)*, of the application. Table 6-23, Cases 1 and 2, were the most reactive cases, exceeding k_{safe} by a significant margin. Case 1 analyzed H/X =700, with 300 grams of U-235, centered in the cylinder of graphite and resulted in k_{eff}+2*sigma (0.985). Case 2 analyzed H/X=700, with 300 grams of U-235 shifted to the edge of the graphite cylinder and resulted in k_{eff}+2*sigma (0.985). The applicant incrementally reduced the mass of U-235 to 120 grams, when the k_{eff}+2*sigma results were less than k_{safe}, as shown in Cases 15 through 23, for H/X = 400-600, with or without a Macrobag®, Be reflection, and flooding. Therefore, the applicant demonstrates compliance with the requirements of §§ 71.55(e) and 71.59(a)(2). These limits will be included in the CoC, Table 2.

Confirmatory Analysis

DOE PCP staff performed independent confirmatory calculations using MCNP 6.3 with ENDF/B-VIII.0 cross sections for representative cases in N-NCS-A-00049 Rev. 0, Tables 6-6 (SP), 6-8 (NCT array), and 6-10 (HAC array), which are implemented in Tables 6-8, 6-14, & 6-22 in the application. Staff verified:

- Package and MacroBag® dimensions,
- Fissile sphere radii corresponding to stated ^{235}U masses,
- Moderator composition consistent with specified H/X values,
- Reflector configurations (carbon and beryllium), and
- Array geometries and boundary conditions.

Representative results from the applicant's SARP Supplement/NCSE and DOE PCP staff's confirmatory calculations are provided in Table 6-1 below. Staff's confirmatory results were in good agreement with the applicant's reported results, within expected statistical uncertainty. The maximum allowable fissile mass is established by the highest evaluated mass that satisfies the acceptance criterion (k_{eff} +2*sigma < k_{safe} of 0.926), with higher mass cases exceeding the limit and confirming the bounding condition.

Table 6-1 SARP Supplement and Staff's Confirmatory Criticality Safety Calculations of Limiting Conditions

SARP Supplement Table	Desc.	Case #	Case	SARP $k_{eff} \pm \sigma$	Staff $k_{eff} \pm \sigma$
6-8	SP	6	single_graphite_fld.350	0.9774 ± 0.0003	0.9708 ± 0.0002
		9	single_graphite_fld.250	0.9090 ± 0.0003	0.9018 ± 0.0002
6-14	NCT array	8	2cnct_poly_pr.600	0.9470 ± 0.0003	0.9299 ± 0.0003
		10	2cnct_300U_poly_pr.600	0.9077 ± 0.0003	0.8898 ± 0.0003
6-22	HAC array	5	2chac_poly_be.600.x3.fld	0.9286 ± 0.0003	0.9311 ± 0.0003
		6	2chac_poly_be.280.600.x3.fld	0.9148 ± 0.0003	0.9106 ± 0.0003

Exceptions Noted

The SARP establishes a hydrocarbon mass limit and states, in the notes to SARP Table 6.1 – *Criticality Safety Analysis Results (Content Table 1.2)*, that optimal moderation occurs at hydrocarbon masses below the package limit. DOE PCP staff notes that the applicant's analysis demonstrates decreasing reactivity with increasing H/X beyond the optimum of 700; however, the analysis is presented as a function of H/X and not directly as a function of total hydrocarbon mass within the package. Therefore, the relationship between hydrocarbon mass and effective moderation (H/X) for realistic package configurations is not explicitly demonstrated.

The MacroBag® contributes approximately 3.4 kg of polyethylene, while the remaining allowable hydrocarbon mass is not explicitly tied to a modeled geometry or distribution. Although the trend of over-moderation is qualitatively supported in the application; DOE PCP staff did not identify explicit calculations demonstrating that increasing hydrocarbon mass from 80 kg to 90 kg remains subcritical. This limitation does not affect the identification of the limiting configuration or the adequacy of the evaluated margins to the acceptance criterion.

While the applicant's analysis qualitatively supports that increased hydrocarbon content beyond the optimal moderation condition results in reduced reactivity, DOE PCP staff did not identify explicit calculations directly relating total hydrocarbon mass in the package to reactivity for all configurations. This observation does not impact on the staff's conclusion regarding the adequacy of the NCS in the application.

6.3 Conclusion

DOE PCP staff finds that the criticality safety analysis methodology, modeling assumptions, and identification of limiting configurations in Chapter 6 of the application based on N-NCS-A-00049, Rev. 0, are acceptable, and that the applicant's evaluation of moderation behavior, including the use of H/X parametric studies, is consistent with established neutron moderation physics.

Based on review of the statements and representations in the SARP, as supplemented by this application, DOE PCP staff has reasonable assurance that the administrative controls of the package contents have been adequately described and evaluated and that the package continues to meet the NCS requirements of 10 CFR Part 71.

7.0 Operating Procedures

SARP Chapter 7, as supplemented by this application, 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 Chapter 7 of the SARP to:

- Clarify conditions in Section 7.1.1.1, *Packaging Preparation*, Steps 5, 6, and 9, regarding the CAPS device, diffusion hole, and ¾-in blind plug,
- Clarify conditions in Section 7.1.2, *Loading of Contents*, Step 6, regarding installation of the ¾-in blind plug,
- Add Step 13 to Section 7.1.3, *Preparation for Transport*, for users to calculate the "shipping window" for Table 1.2, 1.3, and 1.4 contents, if the CAPS device is not installed on the 30-gallon drum lid,
- Add the blind plug in the Note prior to Step 8 in Section 7.2.2 *Removal of Contents,* to the components backed out to relieve any internal pressure prior to opening the drum,
- Update the instructions in Section 7.4.3, *30-Gallon Drum Purging & Hydrogen Diffusion*, to clarify the purging process, simplify the purge time equation, and instructions for reinstalling the PRD and blind plug,
- Update the instructions in Section 7.4.4, *Hydrogen Gas Measurement and Sampling*, to clarify the instructions, use of the calculation in Section 7.1.3 to determine the "shipping window", and instructions for reinstalling the PRD, and
- Update Section 7.6, *References*, to add References 17, *Hydrogen Gas Generation Rates from the 9979 Shipping Package Contents during Normal Conditions of Transport (NCT)*, M-CLC-A-00734, Rev. 1, and 18, *Model 9979 Type AF Shipping Package: 30-Gallon Drum Purging Test Report*, M-TRT-G-00020, Revision 0.

DOE PCP confirmed by document review that the clarifications and changes to the package operating procedures are sufficiently clear to meet the applicable requirements of § 71.87.

Staff reviewed the updated gas generation calculation (Ref. 17) in Section 3 of this SER, and confirmed that the calculations from Ref. 17, Section 5.2, *Time to Lower Flammability Limit (LFL)*, of Ref. 17, were correctly implemented in Section 7.1.3, *Preparation for Transport*, of the application.

Staff notes that Section 7.6, Ref. 18 of the application was reviewed as part of Docket 19-29-9979 for CoC Revision 14.

Based on review of the statements and representations in the SARP, as supplemented by this application, 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 ensure the package will continue to be operated in a manner consistent with its evaluation for approval.

8.0 Acceptance Tests and Maintenance Program

DOE PCP staff confirmed there were no changes required to SARP Chapter 8, *Acceptance Tests and Maintenance Program,* to implement the proposed changes.

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 applicant revised Chapter 7 in the application to:

- Add the ¾-inch Blind Plug to Table 9.3, *Safety Assessment of Packaging Features*, and classified it as "major impact on safety" component, that is Q-Category B, for the package and credits the plug for providing containment of the contents at drum pressures.

DOE PCP staff reviewed this change and concurred that the plug is a Q-Category B item and works in conjunction with the PRD, another Q-Category B item, to prevent over pressurization of the 30-Gallon drum and release of radioactive material.

Based on review of the statements and representations in the SARP, as supplemented by this application, 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 ensure the package will be operated in a manner consistent with its evaluation for approval.

Conditions of Approval

The following changes to CoC Revision 20 are required to implement the changes evaluated in this SER.

- Section 5(a)(2) Packaging Description
  - Revise text after the 2nd paragraph, "The 30-gallon drum lid configuration includes two safety components: a Pressure Relief Device (PRD) is required on all lids to prevent over pressurization of the drum, and the option to use either a Compact Augmented Permeation System device (CAPS), which is used prevent the accumulation of a flammable gas mixture in the drum, or a ¾-in. Blind Plug, which is used for containment of the contents at drum pressures. The 55-gallon drum body must include a 1/8-in. diffusion hole (Drawing R-R2-G-0057, Note 16) when the CAPS device is used on the 30-gallon drum lid." (clarification)
  - Revise text 3rd paragraph, "… an insulation bag (optional for non-combustible contents) is installed in the 30-gallon drum." (clarification)
  - Replace Figure 1 with Figure 1.1 in the supplement , which shows the packaging configuration with CAPs and blind plug as lid options for the 30-gallon drum.
- Section 5(a)(3) Drawings – update the list of drawing per Table 1 of this SER.
- Section 5(b)(1) Type and Form of Radioactive Material
  - Revise 1st paragraph, "Contents (payload) include all radioactive (fissile and non-fissile) and non radioactive materials authorized in this certificate and must be loaded in the 30 gallon containment drum. The contents are grouped broadly into either non combustible and combustible payload categories according to their material form, as shown with their general descriptions in Table 1." (consistency and clarification with revised table caption in the supplement).
  - Revise Table 1 caption to "Content Categorization Examples" (see above)
  - Revise Table 1, row 2, General Description column to add "MacroBags" (per this SER)
  - Revise Table 1, to move special form capsules from "Solid Compounds and metal" to "Standards and Sources" (improvement)
- Section 5(b)(1) Type and Form of Radioactive Material – revise 3rd para to "… TRISO fuel and process materials may be placed in convenience containers …" (clarification)
- Section 5(b)(2) Maximum quantity of material per package:
  - Revise text 3rd paragraph to "… , 5a, and 5b." (improvement)

  - Replace text for Table 2, last subparagraph, with "U-235 fissile gram equivalent limit per package is based on the non-radioactive material mass limit, shipping configuration options, listed in the table (Limits from SARP, Section 6.10, Reference 4, N-NCS-A-00019 Rev 2, and SARP Supplement for Docket 26-04-9979, Rev 1, Section 6.10, Reference 5, N-NCS-A-00049, Rev 0.) (update per this SER for the Macrobag®)
  - Replace Table 2 with Table 1.2 of the SARP supplement (update per this SER for Macrobag® and consistency with Table 2 of the supplement).
  - Replace Notes for Table 2, (update per this SER for the Macrobag® and consistency with Table 2 of the supplement – with minor edits in the CoC for conciseness)
- Section 5(b)(3) Maximum Decay Heat:
  - Revise Table 2 to "1.63E-01 watts" (account for Co-60).
  - Revise Table 3 to "3.65E-04 watts" (corrected for consistency with the SARP Table 1.3).
- Section 5(d) Conditions:
  - Revise (10) to "Revision 20 of this certificate may be used until May 31, 2027."
  - Replace (14) with "Packaging without CAPS (Drawing R-R1-G-00028, Rev. 8, Items 8 and 9) and the 55 Gallon Drum diffusion hole (Drawing R-R2-G-00057, Rev. 12, Item 13) may continue to be used subject to the calculated shipping window restrictions in Section 7.1.3 of the SARP Revision Supplement for Docket 26-04-9979 for Tables 2 through 4 contents. The shipping window may be reset in accordance with Section 7.4.3 and Section 7.4.4 of the supplement. There are no restrictions on Table 5 contents.
  - Add (15) for Macrobag®, "If Macrobag® dunnage is used without the CAPS device in the 30-gallon drum lid and diffusion hole in the 55-gallon drum, the MacroBag® shall also be purged/sampled in accordance with Condition 14 to reset the shipping window."
- Section 5(e) Supplements"
  - Add (7), "Safety Analysis Report for Packaging Model 9979 Type AF Shipping Package, S-SARP-G-00006, Revision 7 (Supplement for Docket 26-04-9979, Rev. 1), April 2026."

Conclusion

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

References

[1] *Transmittal of SRNL-2230000-2025-00011 Rev 0 and S-SARP-G-00006 Rev. 7.4 for Docket 26-04-9979*, Email Sobus to Gelder, December 1, 2025.
[2] *Safety Analysis Report for Packagings Model 9979 Type AF Shipping Package, S-SARP-G-00006, Revision 7 (Supplement for Docket 26-04-9979)*, November 2025.
[3] *Q1s for Docket 26-04-9979*, Memorandum Cable to Sobus, January 22, 2026.
[4] *FW: Response to Q1s for Docket 26-04-9979,* Email Sobus to Gelder, March 5, 2026.
[5] *Accepted – Q1 Responses for Docket 26-04-9979*, Memorandum Cable to Sobus, April 6, 2026.
[6] *DOE-SR concurrence on transmittal of S-SARP-G-00006 Rev. 7 Supplement for Docket 26-04-9979*, Email Sobus to Cable, April 13, 2026
[7] *Safety Analysis Report for Packagings Model 9979 Type A Fissile Shipping Package, S-SARP-G-00006, Revision 7 (Supplement for Docket 26-04-9979 Rev. 1)*, April 2026.