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DOE Packaging Certification Program

Safety Evaluation Report

for

Certificate of Compliance No. 9979 Amendment for the Model 9979 Package

Docket No. 21-16-9979

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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 18, for the Model 9979 package design.

Summary

By email [1] dated February 14, 2024, the DOE CoC 9979 certificate holder, SR, requested an amendment of DOE CoC No 9979 to authorize three changes to the packaging design to mitigate hydrogen gas accumulation in the package from CoC Tables 2 and 4 contents, which currently requires payload void volume and shipping period restrictions per Section 5(d)(6) of CoC 9979 Rev 18.

The applicant modified the design of the 30-gallon drum lid by replacing the 2-in. pressure relieving plug with the Compact Augmented Permeation System (CAPS) device and replaced the 3/4-in. blind plug with a 3/4-inch or 2-inch diameter pressure relieving device (PRD). The CAPS device allows hydrogen gas to permeate from the 30-gallon drum into the 55-gallon drum volume while confining the radioactive material in the 30-gallon drum under normal and accident conditions. A 3/4-in. or 2-in. PRD replaces the blind plug and provides pressure protection for the 30-gallon drum during normal and accident (thermal) conditions. The final packaging design modification is the addition of a small through-hole (diffusion hole) in the 55-gallon drum wall. The hole is covered with a hydrophobic membrane (disc) to prevent water ingress into the drum while allowing hydrogen gas to diffuse from the drum to the environment under NCT.

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]

DOE PCP staff reviewed the initial application and its supporting documentation and issued questions and comments (Q1s) to the applicant on December 6, 2024.[3] On January 17, 2025, SR submitted their Q1 responses with proposed implementation [4], which staff reviewed and found acceptable [5] pending implementation in the final application. On February 4, 2025, SR submitted Revision 1 of the final application [6, 7], which staff reviewed and confirmed to be acceptable.

On June 9, 2025, SR submitted a revised, final approved technical specification [8] for the CAPS device to provide greater detail on the permeation performance.

DOE PCP staff confirmed that the application and its supporting documents demonstrate that hydrogen gas generated in a package fitted with the CAPS device, would not exceed 5% (by volume) of the free gas volume in any confined region of the package during a period of one year; consequently, the need for payload void volume and shipping period restrictions are not required when the package is configured with the CAPS device, PRD, and diffusion-hole/cover.

Based on the statements and representations in the SARP, as supplemented by this application, and the conditions listed in this SER, DOE PCP staff independently confirmed by review and analysis that the packaging design changes have been adequately described and evaluated, and are sufficient to remove payload void volume and shipping period restrictions for Tables 2 and 4 contents for

packages configured with the CAPS device, PRD, and diffusion-hole/cover. 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 the packaging design changes and clarifications addressed below, the application includes numerous non-safety changes to format, grammar, punctuation, and other administrative changes that were reviewed by DOE PCP staff and found to be satisfactory, but are not addressed in detail in this SER.

Use of "SARP" is this SER means the Revision 7 of the SARP, and its two supplements (Dockets 21-03-9979 and 23-11-9979) authorized in Revision 18 of the CoC. The application for this docket (Docket 21-16-9979) only supplements Chapters 1-4 and 7-9 of the SARP. There were no content changes, and the packaging design changes did not affect SARP Chapter 5 and 6 (Shielding and Criticality).

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 and special-form solid fissile radioactive material by public highway.

1.1 Packaging

The applicant designed two new configurations for the 30-gallon drum lid. The first configuration has a CAPS device installed in the flange previously occupied by the 2-in. pressure-relieving plug (Rieke® S-220-2), and a 3/4-in. PRD installed in the flange previously occupied by the blind plug. This configuration does not require a modification to the flanges. For the second configuration, the lid is fabricated or modified for two, 2-inch flanges with the CAPS device installed in one of the flanges and a 2-in. PRD installed the second flange. Both lid configurations require a CAPS device and PRD. The only significant difference between the smaller and larger PRD is their size –both PRDs must meet the same pressure protection performance acceptance criteria. The previously approved 2-in. Rieke® S-220-2, ViseGrip II Steel pressure relieving plug (Item 9, CoC Drawing R-R1-G-00028, Rev. 7) meets the PRD performance acceptance criteria and remains approved for use.

The CAPS device provides a pathway for hydrogen gas to permeate from the 30-gallon drum into the 55-gallon drum volume, while confining solid radioactive material in the 30-gallon drum under NCT and confining solid radioactive material under hypothetical accident conditions (HAC). Table 9.3 of the application defines the CAPS device as major-to-safety component (Quality Category B) whose safety function is to "increase rate of H_2 permeation" from the 30-gallon drum. The CAPS device is described in Sections 1.2.1 and 1.2.1.1 and shown in Figures 1.1 through 1.3 of the application.

The PRD limits pressure in 30-gallon drum during NCT and thermal HAC. Table 9.3 of the application defines the PRD as a major-to-safety component (Quality Category B) whose safety function is to "limit pressure in 30-gallon drum." The PRD is described in Sections 1.2.1 and shown in Figures 1.1 through 1.3 of the application, with the smaller PRD shown in these figures.

The 55-gallon overpack was modified to add a 1/8-inch diameter through-hole in the 55-gallon drum

body to allow hydrogen gas to diffuse (exit) from the package to the environment. The through-hole (diffusion-hole) is covered with a hydrophobic membrane (disc) to prevent water leakage into the drum under NCT. Table 9.3 of the application defines the 55-gallon drum body as major-to-safety component (Quality Category B) whose safety function is to "Confine and Protect 30-gallon drum" and the hydrophobic membrane (diffusion-hole cover) as a minor-to-safety component (Quality Category C) whose safety function is "weather protection." This design change is described in Section 1.2.1.1 of the application with the diffusion-hole also credited as a diffusion path for flammable gases under HAC.

1.2 Contents

There were no changes requested by the applicant to the authorized contents. In Section 1.2.2.1 of the application, the title/caption references to Table 1.2 and 1.3 were revised to "Envelope Limits including Highly Enriched Uranium (HEU) Content" and "Low Enriched Uranium (LEU) Content Envelope ≤ 19.9% U-235", respectively, to match the actual table titles/captions, but there were no changes to the actual contents in these tables.

The applicant added a new note, Note "k", to Table 1.2 to clarify use of the calculation in Table Note "e" and its applicability with § 71.47(a). DOE PCP staff concurs with this clarification.

Section 1.2.2.2, *Payload Limits and Restrictions*, 3rd bullet was revised to add a 2 lb. limit for moisture, based on 1% of the maximum payload mass of 200 lb.

Section 1.2.2.3, *General Payload Configuration*, 5th bullet was revised to add further instruction on the requirement for venting handling conveniences to prevent flammable gas concentrations from developing within the convenience container. DOE PCP staff concur with this improved instruction.

1.3 Drawings

The following CoC drawings were revised to implement the packaging design changes for the CAPS device and PRD, the diffusion-hole/cover in the 55-gallon drum, and other non-safety significant changes – see Table 1 below. The revised drawings are included in Appendix 1.1 of the application. The CAPS device fabrication drawing [9] was provided to DOE PCP staff as a reference, and was not included in the text, references, or Appendix 1.1 of the application. The CAPS device is a part on drawing R-R1-G-00028 and is defined by its technical specification (M-DS-G-00124).

Table 1 - Drawings Updated

Drawing No.	CoC Rev	New Rev	Title
R-R1-G-00028	7	8	9979 Type AF 30-Gallon Drum Assembly (U)
R-R1-G-00029	5	6	9979 Type AF 55-Gallon Drum Assembly (U)
R-R1-G-00030	4	5	9979 Type AF Packaging Assembly (U)
R-R2-G-00057	11	12	9979 Type AF 55-Gallon Drum Sub-Assembly and Weldment (U)
R-R2-G-00058	6	7	9979 Type AF 30-Gallon Drum (U)
R-R2-G-00059	7	8	9979 Type AF 55-Gallon Drum Lid Sub-Assembly and Weldment (U)
R-R2-G-00060	6	7	9979 Type AF 30-Gallon Drum Lid with Dual Bung Closures (U)
R-R4-G-00064	3	5	9979 Type AF Insulation Bag (U)
R-R4-G-00065	3	5	9979 Type AF Insulation Cover Assembly for 30-Gallon Drum (U)

The safety-significant drawing changes are as follows:

- R-R1-G-00028, Rev. 8: the addition of CAPS and PRD in drawing Section A-A view, installation instructions in Note 7, and Parts List Descriptions as Items 9 (CAPS Device) and 8 (PRD) which include technical specifications M-DS-G-00124 (for CAPS) and M-DS-G-00150 (for the 3/4-in. or 2-in. PRD). The technical specifications are also referenced in Chapters 2, 3, and 8 of the application. These technical specifications were submitted as supporting documentation for the application and were reviewed by DOE PCP staff.
- R-R2-G-00057, Rev. 12: the addition of the 1/8-in. diffusion-hole and instructions to cover it per new Note 16, and diffusion-hole cover and its description as Parts List Item 13.

DOE PCP staff reviewed all the revised drawings and technical specification for the CAPS device and the PRD and found they contain sufficient detail to evaluate the safety performance of the package.

1.4 Operational Features

Section 1.2.4, *Drum Hoisting* text and Figure 1.11 were revised to reference a new lifting device drawing (*Models 9979 and 9981 Lifting Fixture Detail*, R-R4-G-00180) and updated illustration instead of a previous prototype device. Use of this specific device is not required for the safe operation (hoisting) of the package but is provided as an example of a certificate-holder approved lifting device.

1.5 Conclusion

Based on a review of the statements and representations in the SARP, as supplemented by this application, DOE PCP staff concludes that the packaging 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 deleted the reference to "HALEU" in the text of Section 2.2.2 *Chemical, Galvanic, or Other Reactions* and its reference to Section 2.14, Reference 45. Pyrophoricity of Uranium, WSRC-TR-92-106, H.B. Peacock, March 1992, since HALEU is not in the scope of this docket or authorized in the SARP or CoC.

2.1 Structural Design

There were several safety significant changes to the packaging design to add the CAPS device and PRD to the 30-gallon inner drum lid, and to add a 1/8-in. diffusion hole to the 55-gallon drum body. These changes do not affect the structural performance of the package.

The applicant added a description and function of the CAPS device to Sections 2.1.1 and 2.3.1.3 of the application, and updated Table 2.4 for the material specifications for the CAPS, PRD, and diffusion-hole cover. The applicant revised Section 2.7.4.1 to describe the safety function of the diffusion hole, that is, to "ensures that the internal volume between the 30-gallon drum and the 55-

gallon drum is incapable of sustaining pressure."

The applicant revised the summary data and notes in Table 2.13, *HAC Pressure and Temperature Inputs*, based on changes in Tables 3.2 and 3.5 of the application, for the 30-gallon drum as follows:

- Increase the maximum temperature of the drum body (from 523°F to 644°F) and contents (from 326°F to 458°F),
- Added a minimum pressure (-3.5 psig), and
- Revised the maximum pressure (from 12-14 psig to 21.7 psig) based on the PRD specifications and drum pressure rating.

The applicant revised Section 2.7.4.3 to credit the PRD as a pressure boundary safety feature under thermal HAC, that prevents the 30-gallon drum from exceeding its rated pressure; consequently, a stress calculation of the 30-gallon drum under thermal accident conditions is not required. Section 2.7.8 was revised to clarify the 55-gallon drum does not include a pressure boundary. The diffusion hole modification to the drum body supports this clarification.

DOE PCP staff reviewed these changes in the application and finds them appropriate.

2.1 Structural Design of CAPS and PRD

The design of CAPS device and its performance requirements are defined in its Technical Specification M-DS-G-00124. The CAPS device weighs approximately 0.8 lb. and consists of a thin, high surface area membrane, porous metal support structures, a housing subassembly (carbon or stainless steel), and an outer seal. Due to the introduction of stainless steel (SS) as a new packaging component, the applicant added it to list of packaging materials in Table 2.7 of the application and demonstrated in Section 2.2.2, that there is no chemical, galvanic, or other rection between the existing packaging components and SS or with package contents and SS, per § 71.43(d). The CAPS structural related performance requirements in the 30-gallon drum are pressure related: it must withstand an internal pressure of 21.7 psig and external pressure of 10 psig over a service temperature range of -40°F to 200°F, per M-DS-G-00124. The maximum calculated temperature of the 30-gallon drum under NCT is 149°F, per Table 3.2 of the application; consequently, the CAPS temperature range acceptance criteria in the technical specification is sufficient.

The PRD (3/4-in or 2-in.) is a commercial drum component but its performance requirements and acceptance for use in the 30-gallon drum are defined in Technical Specification M-DS-G-00150. All Model 9979 30-gallon drum lids fabricated prior to this application are configured with a 2-in. PRD and 3/4-in. blind plug. The larger PRD weighs approximately 0.4 lb. and may be constructed from carbon steel or SS. The PRD structural related performance requirements in the 30-gallon drum are pressure related: it must relieve an internal pressure between 12 psig and 21.7 psig or relieve pressure at a temperature range that would cause an internal pressure of 12 psig to 21.7 psig and withstand an external pressure of 10 psig. The PRD must perform these functions over a service temperature range of -40°F to 170°F, per M-DS-G-00150. The maximum calculated temperature of the 30-gallon drum under NCT is 149°F per Table 3.2 of the application; consequently, the PRD temperature range acceptance criteria in the technical specification is sufficient.

Based on Section 2.7.4.5 *Package Destructive Evaluation* of the application as shown in Figure 2.28, the lid of the 30-gallon drum showed no sign of damage from the sequential NCT and HAC impact

tests; consequently, it can be reasonably surmised that CAPS device and the PRD should not be damaged from NCT and the HAC impacts. Thermal performance of the CAPS device and PRD under NCT and HAC are addressed in the Thermal Evaluation section of this SER. DOE PCP staff concurs that the CAPS device and the PRD are sufficiently protected by the 55-gallon drum overpack to perform their intended safety functions and for the 30-gallon drum under NCT and maintain the confinement of the contents under HAC.

The additional weight of the packaging with the CAPS device and the larger PRD, with its larger flange, increases the total net weight by less than 1.0 lb. The weight of the diffusion hole cover is negligible. The applicant did not request a change to the maximum gross weight of a package, that is, 415 lb.; therefore, the current structural tests and evaluation remain valid.

2.2 Materials Change

The applicant revised Section 2.1.1, Tables 2.4 and 2.5, and Drawings R-R4-G-00064 and R-R4-G-00065, to add S-Glass fiberglass fabric as an option to E-Glass for the Kao-Tex Quilt Thermal Insulation Cover (R-R4-G-00065) and Thermal Insulation Bag (R-R4-G-00064) designs. S-Glass is a high-performance glass fiber and distinguished from E-glass primarily by its higher silica content, and mechanical properties (that is, greater tensile strength & elastic modulus, as well as about 10% greater stiffness (ref www.jpscm.com)). DOE PCP staff concurs that S-Glass fabric as an option to E-Glass would not affect the performance of the insulation cover or the insulation bag.

2.3 Conclusion

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 Section 3.16, *References*, to add the technical specifications and calculations in support of the design change for the CAPS and PRD:

13. *Compact Augmented Permeation System (CAPS) Technical Requirements Datasheet*, M-DS-G-00124, Revision 0, January 2024, (updated and approved June 4, 2025)
14. *Pressure Relief Device (PRD) Technical Requirements Datasheet*, M-DS-G-00150, Revision 0, January 2024,
33. *Hydrogen Gas Generation Rates from the 9979 Shipping Package Contents during Normal Conditions of Transport (NCT)*, M-CLC-A-00734, Rev. 0, August 2022, and
34. *Hydrogen Gas Permeation through Model CAPS-9979-01 for the 9979 Package*, M-CLC-A-00728, Rev. 0, August 2022.

Reference 33 (above) supersedes the applicant's previous gas generation calculation in SARP Section 3.16, Reference 31, *Hydrogen Gas Generated from the Contents in the 9979 Package*, M-CLC-A-00631, Rev. 4, June 2022. The applicant revised the decay heat limit used in the gas generation calculation for the SARP Table 1.2 contents from 9.12E-03 watts (M-CLC-A-00631) to 1.18E-02 watts

(M-CLC-A-00734). This change accounts for an increase of Eu-155 in the analysis from 4.46E-04 to 8.31E-03 grams. The increased Eu-155 mass is not a content change since this mass is still bounded by the CoC Rev 18 limit of 1.67E-01 grams based on its A_2 limit (see Table 2 of the CoC). In addition, for SARP Table 1.4 contents the applicant used a decay heat of 5.20E-03 watts in M-CLC-A-00734, based on SARP Appendix 4.1, instead of 5.18E-03 watts from M-CLC-A-00631, to calculate the gas generation rate for this content. The marginal difference in these decay heats is the references used by the applicant for the thermal power for Tc-99 (5.60E-06 vs. 1.02E-05 watts/gram). These new decay heat values support the new gas generation and permeation calculations will be updated in the CoC.

In Section 3.0, the applicant provided additional explanatory text to clarify how and why they adjusted the results from the baseline HAC thermal analysis to account for insolation as the initial condition at the start of HAC.

3.1 Thermal Design

There were no changes proposed to the package content limits. The applicant revised the description of the 55-gallon drum to include the diffusion hole (and cover) and its safety function and a description of the changes to the 30-gallon drum lid for the CAPS device and PRD options and their respective safety functions in Sections 3.1, 3.1.1.1 (55-gallon drum), and 3.1.1.2 (30-gallon drum). The diffusion-hole cover is for primarily weather protection and gas-diffusion from the 55-gallon drum to the environment under NCT. It does not serve any safety function for the thermal design of the package under HAC. DOE PCP staff concur that these descriptions are consistent with the descriptions of the packaging in Section 1.1 of the application and are sufficient to evaluate the package thermal design.

The applicant revised Table 3.1, *Packaging Thermal Design Limits for NCT and HAC*, to:

- Change the maximum pressure limit for the 55-gallon drum from 25 psig to N/A (not applicable) due to the diffusion hole in the drum wall,
- Change the maximum pressure for the 30-gallon drum from 22.5 psig to 21.7 psig to account for the new technical specifications for the CAPS device and PRG designs,
- Add the CAPS device and PRD with their respective temperature and pressure limits,
- Add the temperature limit for special form contents (Docket 21-03-9979), and
- Add table notes “j through o” to reference the basis for the limits.

DOE PCP staff confirmed by document review the table updates correctly implement the data from the source references.

3.2 CAPS Device and PRD - Temperature and Pressure under NCT and HAC

The temperature and pressure limits of the CAPS device and PRD were added to Table 3.1 of the application.

CAPS Device

The CAPS device consists of a steel housing (carbon or stainless steel), a stainless steel, aluminum or ceramic porous support structure, a high temperature silicone membrane (McMaster Carr 74515A33 or equivalent), and a high temperature silicone gasket (McMaster Carr 1182N228 or equivalent). The safety function of the CAPS device under NCT is to prevent a flammable concentration of hydrogen from collecting within the 30-gallon drum by allowing gas to permeate through the CAPS silicone membrane into the 55-gallon drum space. The temperature limiting components of the CAPS device

design are the membrane and gasket material, that is, high temperature silicone. The service temperature range for the membrane is -85° to 500°F and for the gasket, -60° to 400°F. Both elastomeric materials are within the NCT environment temperature range of -40 to 100°F. The service temperature rating on the CAPS device, per its technical specification, is -40 to 200°F, and the calculated maximum temperature of the 30-gallon drum body under NCT with insolation is 149°F, per Table 3.3, *Calculated 9979 Package Component Temperatures under NCT*; therefore, the CAPS device with these elastomeric materials are acceptable for NCT.

According to the applicant's material thermal tests (Section 3.6, Ref. 11), the silicone gasket material used for the 30-gallon drum-lid gasket was heated to 690°F and, following the test, showed no signs of degradation, that is, no discernable visible change to its color, size, or flexibility, and it lost less than 0.3% of its initial weight; therefore, the drum lid closure is expected to perform its safety function of retaining the drum contents at the maximum temperature of the 30-gallon drum body under HAC (644°F), per Table 3.4, *Calculated 9979 Package Component Temperatures under HAC*. The elastomeric components of the CAPS device are most likely to degrade at the maximum HAC temperature of the drum body but not to an extent of allowing the contents to breach the drum through the drum lid flange threads or through the metallic components of the CAPS device. DOE PCP staff concurs with the applicant's reasoned argument and engineering judgement and given the conservation decay heat values used in the thermal evaluation staff has reasonable assurance that the contents would be sufficiently confined in the 30-gallon drum under thermal HAC.

The internal pressure rating of the CAPS device, per its technical specification, is 21.7 psig, and it relies on the PRD for pressure protection. This internal pressure rating of the CAPS device meets the Table 3.5 – *Calculated Maximum Pressures in the 30-gallon Drum* under NCT (6.46 psig) and HAC (21.7 psig). The elastomeric components of the CAPS device (and PRD gasket) are expected to degrade when approaching the maximum HAC temperature of the 30-gallon drum body (644°F) but at this temperature the drum is not likely to retain pressure due to degradation of these seals.

PRD

The PRD consists of a commercial carbon or stainless-steel pressure relief plug and EPDM gasket for sealing the plug to the drum lid flange. The metal components of the PRD are rated at 1800°F and the EPDM gasket service temperature ranges -40°F and 350°F. The temperature rating of the PRD, per its technical specification, is -40 to 170°F, and the calculated maximum temperature of the 30-gallon drum body under NCT with insolation is 149°F, per Table 3.3, *Calculated 9979 Package Component Temperatures under NCT*; therefore, the PRD and its gasket are acceptable for NCT.

According to the applicant's material thermal tests (Section 3.6, Ref. 11), EPDM material was heated to 600°F and, following the test, showed some degradation, that is, visible change to its color, minor shrinkage, and it lost approximately 2% of its initial weight; however, it remained essentially flexible. The gasket is required for the PRD to operate under normal service conditions by forming an annular seal between the drum lid-flange and the PRD flange. This seal allows the PRD to respond to pressure increases in the drum. Although the gasket may function for a short duration at the maximum temperature of the 30-gallon drum body under HAC (644°F), per Table 3.4, *Calculated 9979 Package Component Temperatures under HAC*, its degraded performance at this temperature would increase the likelihood that the 30-gallon drum would not retain pressure under thermal HAC due to air leakage at the gasket seal; however, the leak area through drum lid flange threads is not large enough to allow the contents to breach the drum. DOE PCP staff concurs with the applicant's

reasoned argument and engineering judgement and given the conservation decay heat values used in the applicant's thermal evaluation; staff has reasonable assurance that the contents would be sufficiently confined in the 30-gallon drum under thermal HAC.

The internal pressure rating of the PRD, per its technical specification, is 21.7 psig and meets Table 3.5 – *Calculated Maximum Pressures in the 30-gallon Drum* under NCT (6.46 psig) and HAC (21.7 psig). Section 1.2.1.1 of the application asserts that the PRD is designed to open between the maximum NCT pressure differential of 11.81 psig at the highest US elevation for ground transport (ref. Section 2.6.3 Reduced External Pressure) and the allowable 30-gallon drum assembly pressure (21.7 psig). The PRD prevents the drum from over pressurization at temperatures approaching thermal HAC. The PRD technical specification requires it to relieve pressure in the 30-gallon drum between 12 psig and 21.7 psig or relieve pressure at drum temperature range that would cause a pressure of 12 psig to 21.7 psig. If the gasket material of the PRD degrades under thermal HAC, the 30-gallon drum is not likely to retain pressure due to air leakage at the gasket seal; however, if the degraded gasket retains the seal, the PRD is expected to perform its safety function. DOE PCP staff concur with the applicant's reasoned argument and engineering judgement and given the conservation decay heat values used in the applicant's thermal evaluation; staff has reasonable assurance that the 30-gallon drum would not exceed its pressure rating under thermal HAC.

3.3 Gas Generation

There were no changes to the contents described in Tables 1.2 through 1.5 of the application or authorized in the CoC. The hydrogen gas generation rates for these contents are documented in a new calculation in Section 3.6, Ref. 33 of the application. Table 1.2 contents yield the bounding hydrogen gas generation rate during NCT given the conservative assumptions in Section 2.2 of Ref 33. The hydrogen generation rate increases with increasing temperature, from approximately 2×10^{-5} cc/s at -40 °F to approximately 9.00×10^{-5} cc/s at 153°F. DOE PCP staff compared the new calculation with the applicant's previous calculation (*Hydrogen Gas Generated from the Contents in the 9979 Package*, M-CLC-A-00631, Revision 4, June 2022) of gas generation rate for the Table 1.2 contents of approximately 1.69×10^{-5} cc/s at -40 °F to approximately 6.92×10^{-5} cc/s at 153°F. The difference stems from, 1) a higher decay heat rate (1.18E-02 watts vs. 9.12E-03watts) used in the new calculation, and 2) a more conservative assumption is made and a higher gas generation constant (G value) from 4 °F to 153 °F is used in the new calculation. Staff conclude that the calculations of hydrogen gas generation rates in Section 3.6, Ref 33 are conservative and reasonable.

CAPS Device – Permeation

The hydrogen gas permeation rate through the CAPS device is documented in a new calculation in Section 3.6, Ref. 34, based on the design in the CAPS fabrication drawing (R-R1-G-00148). DOE PCP staff reviewed the drawing for the CAPS device and verified that the correct surface area of 7.522×10^{-3} m^2 (11.66 in^2) and thickness of 0.000254 m (0.01 in.) were used in the applicant's permeation rate calculations for the silicone membrane used in the CAPS device. The silicone membrane hardness used in the CAPS device has an estimated 26 Shore A durometer. Permeability of the membrane follows an Arrhenius relationship with temperature. The regressions, that is, the Arrhenius relationship between permeability and temperature for the 40 Shore A and 70 Shore A durometer silicone materials were determined from experimental data per CAPS test report.[10] This report uses linear extrapolation to obtain the permeability estimate for the 26 Shore A durometer silicone membrane material. Testing data in the report indicates that the permeability-durometer relationship is not strictly linear, and a linear extrapolation of permeability to lower durometer is a

conservative estimate. For this reason, linear extrapolation using experimental data for 40 and 70 Shore A durometer silicone will obtain a lower permeability than that of an actual 26 Shore A durometer silicone. The calculated steady-state hydrogen concentration in the 30-gallon drum for the Table 1.2 contents is shown in Figure 3 of Section 3.6, Ref. 34. This figure shows the hydrogen volume fraction decreases with increasing temperature, as the permeation rate is lower at lower temperatures. In the temperature range of interest from -40°F to 153°F (NCT temperature of the 30-gallon drum), the highest steady-state hydrogen concentration is approximately 1.22 vol.% at -40°F, and the lowest at 0.44 vol.% at 153°F, which are below the 5 vol.% limit per evaluation of the maximum normal operating pressure. DOE PCP staff performed confirmatory calculations of the steady-state hydrogen concentration and verified the applicant's results. The permeation rate performance criteria is defined in M-DS-G-00124 and may be demonstrated by the equation in the spec or by testing. Staff reviewed and concurred that the application's equation is valid and accounts for fabrication variation in the membrane thickness and area.

The 55-gallon drum assembly is not expected to retain internal pressure during NCT or HAC. The 1/8-in. diameter hole added to the 55-gallon drum body under the drum curl enables diffusion of hydrogen gas that may be generated within the 30-gallon drum. The diffusion hole is covered with a hydrophobic membrane (McMaster-Carr 4035N12 or equivalent) to prevent water ingress into the 55-gallon drum during NCT. The thermal design limit of the diffusion-hole cover is 250°F, which is greater than the NCT temperature of 55-gallon drum surface (157°F per Table 3.12). Airflow per unit surface area of the diffusion-hole cover is 0.28 cfm at one unit per square inch, which can be converted to 1.622 cc/s through the 1/8-in. diameter hole. This flow rate is more than four orders of magnitude higher than the calculated maximum hydrogen generation rate and is thus sufficiently high enough for hydrogen gas to escape through the hole and prevent hydrogen buildup in the 55-gallon drum cavity. The diffusion-hole cover is not expected to survive the HAC temperatures, so the drum would be continuously vented at temperatures above 250°F.

3.6 Conclusion

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).

There was no change to the authorized contents of the package in this application.

The CAPS device, PRD, and diffusion-hole cover are compliant with § 71.43(f), which prohibits "… a feature intended to allow continuous venting during transport", that is, under NCT.

A description of the CAPS was added to Section 4.1 and Figure 4.1 of the application. The CAPS device and diffusion-hole cover are used to accelerate permeation of the hydrogen gas from the 30-gallon drum into the 55-gallon drum and then from the 55-gallon drum to the ambient environment.

Sections 2.0 and 3.0 of this SER evaluated the design changes for the CAPS device, PRD, and diffusion hole/cover and concluded that these changes would not result in loss or dispersal of the radioactive material under NCT or HAC.

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.

There were no changes to the contents or the packaging design affecting radiation shielding.

Compliance with § 71.47 is confirmed prior to each package 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).

There were no changes to the contents or the packaging design affecting nuclear criticality safety. Sections 2.0 and 3.0 of this SER evaluated the design changes for the CAPS device, PRD, and diffusion-hole/hole-cover and concluded that these changes would not result in loss or dispersal of the radioactive material under NCT or HAC; therefore, the nuclear criticality safety evaluation in the SARP remains valid, that is, the contents are confined in the 30-gallon drum.

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 operations procedures in the application to address inspection and installation of the CAPS device and PRD in lieu of the 2-in Pressure Relief Plug and ¾-in Plug, to add instructions to inspect/install the diffusion-hole cover in the 55-gallon drum body, and to remove the sections required for packaging in which the CAPS and PRD are not installed.

Section 7.1.1.1, *Packaging Preparation*, was revised in the application to add steps for inspecting and installing the diffusion hole cover on the 55-gallon drum body, and PRD and CAPS device in 30-gallon drum, including their torque requirements, which staff confirmed are consistent with the Drawing R-R1-G-00028. The CAPS device and PRD replaced the 2-in. Pressure Relief Plug and ¾-in. Plug locations in Figure 7.1 of the application.

Section 7.1.2, *Loading of Contents*, was revised in the application to remove void volume restrictions for Table 1.2 and 1.4 contents and to add requirements for installing the PRD and CAPS device in

case the contents are loaded into the 30-gallon drum through the 2-in. flange (for example – pellets or sand).

Section 7.2.2, *Removal of Contents*, was revised in the application for unsealing the PRD or CAPS device to relieve pressure prior to opening the 30-gallon drum closure.

Sections 7.4.3, *30-Gallon Drum Purging & Hydrogen Diffusion* and 7.4.4, *Hydrogen Gas Measurement and Sampling*, were also removed from the application because these operations are not necessary for packaging configured with the CAPS device, PRD, and diffusion-hole cover. However, these sections and conditions in the CoC are applicable to legacy packaging without CAPS device, PRD, and diffusion-hole cover.

Figure 7.3, *9979 30-Gallon Drum Lifting Device*, was revised in the application to show the new drum lifting device.

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

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 ensure packaging performance during its service life.

Section 8.1.3.1, *Pressure Tests*, was revised in the application from 22.5 to 21.7 psig for the 30-gallon drum.

Section 8.1.5, *Component and Material Tests*, was revised in the application to add a description and acceptance test requirements for the CAPS and PRD to replace the description and requirements for 2-in Pressure Relief Plug.

There are no packaging components, including the CAPS and PRD, that require periodic maintenance requirements, other than replacement for normal wear (for example seals and gaskets).

Based on review of the statements and representations in the SARP, as supplemented by this application, 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 CAPS device, PRD, and diffusion-hole cover were added to Table 9.3 in the application. There were no other changes in the application.

Table 9.3, *Safety Assessment of Packaging Features*, was revised in the application to replace the 2-in Pressure Relief Plug with PRD and add the CAPS device and diffusion-hole cover with their quality category (Q-Cat) and safety function. The Q-Cat and safety function of the PRD is the same as the 2-in Pressure Relief Plug, that is, a Q-Cat B item to limit pressure in the 30-gallon drum. The CAPS device is a Q-Cat B item to increase the rate of H_2 permeation (from the 30-gallon drum). The diffusion-hole cover is a Q-Cat C item for weather protection. Although not noted in the table, the diffusion-hole cover allows gas to diffuse from the 55-gallon drum to the environment under NCT. DOE PCP staff concurs with these component classifications with respect to their importance to safety and how they are credited for safety in the application.

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 18 are required to implement the amendment evaluated in this SER. In addition, several clarifications are included to implement user questions.[11]

- Section 5(a)(2) Packaging Description
  - Add text after the 2nd paragraph, "The 30-gallon drum lid includes two safety components: a Compact Augmented Permeation System (CAPS) to prevent a flammable mixture within the drum and a Pressure Relief Device (PRD) to prevent over pressurization of the drum."
  - Revise Figure 1 for the CAPS device and ¾-in. or 2-in. PRD lid configuration for the 30-gallon drum (diffusion hole/cover not shown in the 55-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 3rd paragraph to add text after 1st sentence, "… Fissile materials must be normal form solids in two categories - fixed and non-fixed. The fixed category consists of fissile materials that are essentially indispersible, that is, the fissile material is not easily separated from the carbon/graphite due to chemical or physical bonding. The non-fixed category consists of fissile materials that may be easily separated from the carbon/graphite. If unknown or a mixture of fixed and non-fixed, the category is assumed to be non-fixed for determining the fissile mass limit per package." (clarification for users).
- Section 5(b)(2) Maximum quantity of material per package (changes for clarification/consistency):
  - Revise 1st paragraph and 4th paragraph, 4th item to "… shall not exceed to 90 kg." [package tested with 200 lb. of simulated content (90.7 kg) but some analysis done with 90 kg].
  - Revise description for Table 2, 3rd item, to: "U-235 fissile gram equivalent limit per package is …" (clarification for users).
  - Revise description for Table 2, 4th item: delete (redundant).
  - Add "h" to Table 2, "Radiation" column (clarification for users).
  - Revise Notes for Table 2, "c" to:
    - "Satisfying the formula below provides information to the Shipper that the radiation on the surface of the package will not likely exceed 200 mrem/h and therefore the contents

may be shipped non-exclusive use in accordance with 10 CFR 71.47(a):",
    - Replace "isotope" with "Radioisotope" for M_i, (consistency with the table)
    - Capitalize "mass" for L_i (consistency with the table)
  - Revise Note for Table 2, "d", item "ii." to change the decay heat from "9.12E-3 watts" to "1.18E-02 watts" (increase based on new gas generation and permeation calculations).
  - Add Note "h" for Table 2: "The Radiation Mass Values in Table 2 include the presence of daughter products generated from each isotope over an 80-year period (N-CLC-A-00108, Rev. 1); therefore, when evaluating the sum-of-the-fractions to assure the external dose does not exceed 200 millirem at the surface of the package, per Note "c." of Table 2 of the CoC, daughter products do not need to be included." (clarification to users)
- Section 5(b)(3) Maximum Decay Heat:
  - Revise Table 2 from "9.12E-3 watts" to "1.18E-02 watts" (based on new gas generation and permeation calculations).
  - Revise Table 4 from "5.18E-03 watts" to "5.20E-03 watts" (based on new gas generation and permeation calculations).
- Section 5(d) Conditions:
  - Replace (6), with "CAPS device must meet the technical requirements of 9979 TYPE A FISSILE PACKAGING COMPACT AUGMENTED PERMEATION SYSTEM (CAPS), Technical Requirements Datasheet, M-DS-G-00124, Revision 0, June 4, 2025."
  - Revise (10) to "Revision 18 of this certificate may be used until September 30, 2025."
- Section 5(e) Supplements"
  - Add (3), "Safety Analysis Report for Packaging Model 9979 Type AF Shipping Package, S-SARP-G-00006, Revision 7 (Supplement for Docket 21-16-9979), January 2025."
  - Add (4), "9979 TYPE A FISSILE PACKAGING COMPACT AUGMENTED PERMEATION SYSTEM (CAPS), Technical Requirements Datasheet, M-DS-G-00124, Revision 0, June 4, 2025."

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 9979 SARP Rev 7 Supplement for Docket 21-16-9979*, Email Sobus to Shenk, February 14, 2024.
[2] *Safety Analysis Report for Packagings Model 9979 Type AF Shipping Package, S-SARP-G-00006, Revision 7 (Supplement for Docket 21-16-9979)*, February 14, 2024.
[3] *Q1s issued for Docket 21-16-9979*, Memorandum Cable to Sobus, December 6, 2024.
[4] *RE: SRNL Responses to Q1s issued for Docket 21-16-9979 (SRNL-L2230-2024-00007, S-SARQ-A-00010),* Email Sobus to Gelder, January 17, 2025.
[5] *RE: SRNL Responses to Q1s issued for Docket 21-16-9979 (SRNL-L2230-2024-00007, S-SARQ-A-00010)*, Email Gelder to Sobus, January 17, 2025.
[6] *DOE-SR concurrence on transmittal of S-SARP-G-00006 Rev. 7 Supplement for Docket 21-16-9979*, Email Sobus to Cable, February 4, 2025
[7] *Safety Analysis Report for Packagings Model 9979 Type AF Shipping Package, S-SARP-G-*

00006, Revision 7 (Supplement for Docket 21-16-9979, Revision 1), January 2025.

[8] *Fissile Packaging Compact Augmented Permeation System (CAPS)*, Technical Requirements Datasheet, M-DS-G-00124, Revision 0, June 4, 2025.

[9] *Model 9979 Type AF 30-Gallon Drum Compact Augmented Permeation System (CAPS) Model: CAPS-9979-01*, Drawing, R-R1-G-00148, Revision 1.

[10] *Compact Augmented Permeation System (CAPS) Model CAPS-9979-01 Permeation Testing Report*, M-TRT-A-00042, Revision 0, August 2022.

[11] *Content Clarification of CoC Table 1 and Table 2 for 9979 Type AF*, SRNL-L2230-2024-00006, Rev. 2, Letter Eberl to Allen, December 18, 2024.