Safety Evaluation Report for Certificate of Compliance No. 9516 Renewal and Amendment for the Model 9516 Package

Docket No. 19-12-9516

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This Safety Evaluation Report (SER) documents the U.S. Department of Energy (DOE) Packaging Certification Program (PCP) independent technical review of the application and supplements submitted for the DOE Idaho Operations Office (ID) for renewal of DOE Certificate of Compliance (CoC) Number 9516 for the Model 9516 package design. This package is needed to support the mission of the Idaho National Laboratory (INL), Space Nuclear Power & Isotope Technologies Division.

Summary

By email [1] dated July 31, 2019, as supplemented [2, 3] November 26, 2019 and January 7, 2020, the certificate holder, ID requested renewal of DOE CoC 9516 for the Model 9516 package design. The application and supplements in support of the ID requests were prepared for ID and INL by the Pacific Northwest National Laboratory (PNNL) and submitted for ID to PCP by INL. The initial application submitted to PCP consisted of:

- *Safety Analysis Report for Packaging (SARP) for the 9516 Package*, Rev 2a [4]
- *Safety Analysis Report for Packaging (SARP) for the 9516 Package*, *Addendum 1*, Rev 1a [5]

SARP Rev 2a consists of minor editorial changes to every SARP chapter, minor package design changes to Chapters 1, 2, 3, & 7 through 9, and changes to packaging Drawing No. 756179, 756180, 756181, 756182, and 756189. SARP Addendum 1, Rev 1a consists of minor changes to Chapters 1, 2, 5, 7, & 9 and packaging Drawing No. 796848 for two new shipping configurations of plutonium dioxide (PuO_2) produced by Oak Ridge National Laboratory (ORNL).

PCP staff reviewed the initial application and performed a confirmatory shielding analysis of the new shipping configurations. Based on staff's review, PCP issued nine regulatory comments/questions (Q1s) on November 1, 2019 to ID. [6]

PNNL revised the initial application to address the Q1s and implement their proposed responses. The revised application was submitted by INL, for ID, to PCP on November 26, 2019:

- *Safety Analysis Report for Packaging (SARP) for the 9516 Package*, Rev 2b [7]
- *Safety Analysis Report for Packaging (SARP) for the 9516 Package*, *Addendum 1*, Rev 1b [8]

The responses to Q2.1 and Q5.3 were revised by INL and resubmitted by ID to DOE on January 7, 2020 [3], with proposed page changes to implement the responses.

PCP staff reviewed and accepted all Q1 responses and proposed implementations. ID submitted a final application on February 20, 2020 consisting of SARP, Rev. 2 [9] and SARP Addendum 1, Rev. 1 [10] page changes dated January 2020. Staff verified all the agreed upon responses were accurately implemented in the final application.

Based on the statements and representations in the final application, and the conditions listed in the following SER chapters, PCP staff independently confirmed that the modifications to the design and authorized contents are not significant with respect to the design, operating characteristics, safe performance of the containment system, or the prevention of criticality when the package is subjected to the tests specified in §§71.71 and 71.73, and that the modifications to the package satisfy the requirements of 10 CFR Part 71, *Packaging and Transportation of Radioactive Material*. Therefore, staff has reasonable assurance that the regulatory requirements of Part 71 have been met and recommends renewal by the DOE certifying official of this previously approved Type B(U)F package design.

Evaluation

This SER documents the independent review and confirmatory analysis by PCP staff of the application to the requirements of 10 CFR Part 71.

1.0 General Information

1.1 Introduction

This Type B(U)F package design was initially certified on February 22, 1993, by DOE CoC 9516, Rev. 0, Package Identification Number *USA/9516/B(U)F (DOE),* and Model No. *Mound 1KW*. The CoC was renewed on February 28, 1998 by issuance of CoC 9516 Rev. 5. The package design was recertified by DOE on October 6, 1999 to the -85 regulatory standards by issuance of DOE CoC 9516 Rev. 6, and the Package Identification Number was changed to *USA/9516/B(U)F-85 (DOE)*. The CoC was renewed by DOE on February 28, 2006, by issuance of DOE CoC 9516, Rev. 11. The package design was recertified by DOE on January 25, 2010, to the -96 regulatory standards by issuance of DOE CoC 9516, Rev 0, and the Package Identification Number and Model No. changed to *USA/9516/B(U)F-96 (DOE)* and Model No. *9516*, respectively. The CoC was renewed again by DOE on October 24, 2014 by issuance of DOE CoC 9516, Rev. 1, which expired on January 31, 2020.

DOE Order 460.1D, *Hazardous Materials Packaging and Transportation Safety*, requires the certificate holder to request renewal of a DOE CoC at least 90 days prior to the certificate expiration date. The certificate holder, ID, requested renewal and amendment of the CoC on July 31, 2019, and therefore met the Order requirement for timely renewal.

The safety basis for the currently approved package design are SARP, Rev. 1 [11] and the supplements listed below from Section 5(e) of CoC 9516, Rev. 5:

(1) Supplement dated March 24, 2016, W. Yoon (DWG 756179, Rev 2 and 756180, Rev 1). (Basis for CoC Rev. 2 issued May 2, 2016)

(2) *Safety Analysis Report for Packaging (SARP) for the 9516 Package, Addendum No. 1*, R1033-0065-ES, Revision 0, May 2017. (Basis for CoC Rev. 3 issued June 26, 2017)

(3) *Technical Justification for Re-Use of 9516 Package Graphite Support Block and Graphite Filler Block Components*, G. Hula and G. Nelson, November 22, 2017. (Basis for CoC Rev. 4 issued January 18, 2018)

(4) *Technical Justification for Minor Modification to the 9516 Package Product Can Lid Design*, G. Hula, April 9, 2018 (Basis for CoC Rev. 5 issued August 6, 2018)

(5) *SARP-9516 Cylinder Product Can*, Drawing 756180, Rev. 2. (Basis for CoC Rev. 5 issued August 6, 2018)

SARP and Supplements 1 and 3 through 5 are the safety basis documents for CoC Rev. 5, Shipping Configurations 1 through 6. The SARP and Supplement 2 are the safety basis documents for CoC Rev. 5, Shipping Configurations 7 and 8. The application in support of this CoC renewal and amendment request includes modifications to the packaging design and authorized contents. In addition, CoC Rev. 5, Supplements 1 and 3 through 5 were consolidated in SARP Rev 2, and Supplement 2 updated in SARP Addendum Rev 1.

ID provided a thorough summary [12] of the initial changes to the SARP (Rev 1 to Rev 2a), SARP Addendum 1 (Rev 0 to Rev 1a), and drawings to assist PCP staff's review and confirmatory analysis.

PCP issued nine Q1 review questions/comments to ID on November 1, 2019 from staff's review and confirmatory analysis of initial application. INL submitted a response with SARP Rev 2b and SARP Addendum 1, Rev 1b page changes for ID on November 26, 2019, to address the Q1s. The responses to Q2.1 and Q5.3 were subsequently revised by INL and resubmitted by ID to PCP on January 8, 2020, with additional proposed page changes for implementation.

The final application, consisting of SARP Rev. 2 and SARP Addendum 1, Rev. 1 page changes dated January 2020, was submitted by ID on February 20, 2020, to incorporate all the responses and proposed page changes acceptable to PCP staff.

1.2 Package Description

There were no changes to the previously approved package description in the application.

The Model 9516 is a Type B(U)F package that is designed for transport of up to 500 watts of PuO_2 heat source material in any solid form (e.g., powder, pellets, granules, etc.). The package has a maximum gross weight of 900 lb. (408 kg) and consists of a cylindrical cask that is housed within a personnel shield (frame and skid). The package contents consist of various quantities of plutonium heat source material (mostly Pu-238) and fissile material that may exceed 3,000 A_2. CoC 9516, Rev. 5, Figure 1 shows the package as offered for consignment.

1.2.1 Packaging

The Model 9516 packaging consists of three basic components: a cask, a one-time use containment vessel (CV), and personnel shield. These components are classified in SARP Table 9.1 as Quality Level A items (Quality Category A), which are critical-to-safe operation of the package.

The current authorized packaging design drawings in CoC Rev. 5 and the drawings modified in the application are shown in Table 1 below.

Table 1 – Model 9516 Drawings

Authorized Package Design Based on CoC 9516 Rev. 5 (SARP Rev. 1, SARP Addendum 1, Rev. 0)			Application	
Drawing No.	**Rev.**	**Title/Notes**	**SARP Rev. 2**	**SARP Addendum 1, Rev. 1**
756179	2	9516 Shipping Container (11 Sheets)	3	3
756180	2	Cylinder, Product Can (2 Sheets)	3	3
756181	1	Liner, 5.00 High (3 Sheets)	2	N/A
756182	1	Liner, 5.75 High (3 Sheets)	2	2
756183	0	Graphite Filler Block (1 Sheet)	0	0
756184	0	Graphite Support Block for GPHS Module (1 Sheet)	0	0
756185	0	Graphite Support Blocks for Product Cans (1 Sheet)	0	0
756186	0	PuO2 Powder Can Set (3 Sheets)	0	0
756187	0	Cylinder, Product Can (2 Sheets)	0	0
756188	0	Graphite Support Block for Product Cans (1 Sheet)	0	0
756189	1	Containment Vessel, 16.25 High (2 Sheets)	2	2
796848	0	Graphite Support Block for FSO (1 Sheet)	N/A	1
796849	0	Graphite Filler Block for FSO (1 Sheet)	N/A	0

Cask

A thorough description of the cask is provided in SARP Section 1.2.1.3 and summarized below.

The cask is a welded Type 304L stainless steel vessel 1.5 inches thick with an overall height of 19.5 inches and diameter of 9.5 inches. The cask cavity is 16.5 inches deep by 6.5 inches in diameter. The cask closure lid is 1.5 inches thick and is fastened to the cask body with eight ½-13 UNC, Grade B6 (AISI 410) bolts, 2 inches in length. The closure bolts have a hole drilled through the bolt head for the placement of a wire-type security seal. The cask lid is sealed to the cask body by a 0.13 inch cross-sectional-diameter, Helicoflex® metal O-ring seal with aluminum jacket. A ⅝ inch by 1 inch, stainless steel, shoulder-style eyebolt is installed in the cask lid to lift the cask and is removed prior to shipment of the package. The cask body is welded to a rectangular base plate 14 inches by 12 inches, 1.5-inches thick. The base plate has three 13/16 inch through-holes on each long side to fasten the cask to the personnel shield using ¾-10 UNC, Grade B6 (AISI 410) bolts that are 4 inches in length, stainless steel lock washers, and heavy hex nuts. The weight of the empty cask is approximately 285 lb.

The safety function of the cask is to provide confinement of the CV.

There were no changes in the application to the cask packaging description in Section 1.2.1.3 of SARP Rev. 1. The cask design is defined in Drawing 756179. This drawing was modified from Rev. 2 to Rev. 3 to change the closure torque range (Note 1, Sheet 8) from to 130-145 to 252-300 inch-lb. This design modification is evaluated in Chapters 2 and 7 of the application.

Containment Vessel

A thorough description of the CV is provided in Section 1.2.1.4 of the SARP and is summarized below.

The CV is a can weldment constructed of Type 304L stainless steel tubing for the wall, and stainless steel plate for the bottom and cover. The overall height and diameter of the CV is 16.25 inches and 6.435 inches (max.), respectively. The minimum wall CV thickness is 0.12 inch and the base and cover thickness are nominally 0.5 inch (each). The CV cavity is approximately 15.25 inches deep and 6 inches in diameter. The CV cover is securely closed by a full penetration fusion weld of the cover to the wall. A ⅜-16 threaded hole tapped into the center of the CV cover is used only for lifting hardware to load and remove the CV from the cask cavity. The CV design meets the "leaktight" definition in *American National Standard for Radioactive Materials—Leakage Tests on Packages for Shipment*, ANSI N14.5-1997. The maximum normal operating pressure for the CV is 37.6 psig. The estimated weight of a loaded CV is 70 lb. (31.75 kg). Since the CV design is for one-time use, a 0.03 inch (max.) deep cutting groove is machined around the circumference of the CV wall to assist in opening the CV with a pipe cutter or by other means to remove its contents. The location of the cutting grove may be changed at the user's discretion.

There was a minor editorial change in the application to clarify the description of the CV examination requirements described in SARP Rev. 1, Section 1.2.1.4, from "…However, because of the hazards of the content and requirement for remote assembly of the CV, strict compliance to Subsection NB cannot be achieved." to "… However, because of the hazards of the content, in addition to the top-end closure design and the examination requirements for the top-end closure weld of the CV, strict compliance to Subsection NB cannot be achieved." The modification is incorporated in Chapter 2, Appendices 2.12.10 and 2.12.12

The CV design is defined in Drawing 756189. This drawing was modified from Rev. 1 to Rev. 2 to:

- Change Note 8 to allow additional information marking on the CV,
- Change Note 12 to remove "Option Flux Shall Meet the Requirements of Paragraph 8.1.2.4 of R1033-0062-ES". Section 8.1.2.4 of SARP Rev. 1 addresses the optional *Use of Weld Flux,*
- Change the cutting groove detail and location (now shown approximately 8 inches from the base of the CV),

- Add Note 13 which allows the user to change the location of the cutting groove, for opening the CV,
- Add Note 14 statement that CVs fabricated to Rev. 0 and Rev. 1 of the drawing meet the requirements of Rev. 2, and
- Change tolerances and detail of CV body and lid step diameters for ease of fabrication.

The modification to Note 8 and addition of Notes 13 and 14 are not safety significant. The modification to Note 12 is not safety significant because weld flux is no longer used in CV fabrication, so this option is unnecessary (Note - Section 8.1.2.4 is deleted in SARP Rev. 2 to implement this change). The modification to the CV body and lid for fabrication is not safety significant.

Personnel Shield

A thorough description of the personnel shield is provided in Section 1.2.1.2 of the SARP and is summarized below.

The personnel shield consists of a welded, Type 304 stainless steel frame and wire mesh cage assembly mounted on a skid assembly fabricated from ASTM A-500 Grade B carbon steel. The wire mesh is welded to three sides of the frame. The remaining side and top of the frame are covered with removable wire mesh panel covers (i.e., weldments). These weldments are fastened to the frame with ¼-20 UNC oval head, 18-8 stainless steel, Phillips machine screws, and removed for cask loading and unloading operations. The skid assembly is designed for handling the personnel shield with a forklift.

The overall dimensions of the personnel shield are 30.75 square inches by 30.25 inches in height, and it weighs approximately 500 lb. The cask is fastened in the center of the personnel shield frame using six ¾-10 UNC, Grade B6 (AISI 410) bolts that are 4 inches in length, stainless steel lock washers, and heavy hex nuts.

The safety functions of the personnel shield are to:

- Isolate personnel from heat and radiation emitted from the cask,
- Limit impact to the cask during normal and accident conditions, and
- Secure the personnel shield within the transport vehicle using the tie-down brackets mounted on its frame.

There were no changes in the application to personnel shield description in Section 1.2.1.2 of the SARP Rev 1. The personnel shield design is defined in Drawing 756179. This drawing was modified from Rev. 2 to Rev. 3 to update the package identification plate information (Note 2, Sheet 11) from "MFR (insert manufacturer) to "Manufacturer (optional)." This modification is not safety significant.

1.2.2 Contents

A thorough description of the Contents is provided in Section 1.2.2 of the SARP and SARP Addendum No. 1 and summarized below.

The general contents authorized for shipment in the Model 9516 package consist of PuO_2 heat source material in solid form (e.g., powder, pellets, and granules) with a theoretical density of 11.46 grams/cm^3. The initial plutonium isotopic limits are shown in Table 1-1 of the SARP Rev. 1 and SARP Addendum No. 1, Rev 0, respectively. In addition to Pu-239 and Pu-241, the contents include fissile isotopes U-233 and U-235, but only in trace amounts.

The radioactivity in the mixtures of PuO_2 is primarily from alpha decay of Pu-238, which is the main decay heat source. The amount of Pu-238 is directly proportional to the decay heat; therefore, administrative controls are placed on the content shipping configurations to ensure that the maximum wattage of 500 watts for the package design is not exceeded.

There are eight (8) specific authorized shipping configurations for package contents. These configurations require the use of content liners, various material containers for the radioactive material, graphite support blocks, or graphic filler blocks.

Shipping Configurations 1 through 6

SARP Rev.1, Section 1.2.2 defines the contents for Shipping Configurations 1 through 6 as PuO_2 in any solid form (e.g., powder, pellets, granules, etc.). The Pu-238 has an initial composition ranging from 74 to 90 weight percent (wt. %) of the total Pu in the PuO_2. The composition of Pu-239 plus Pu-241 of the total Pu depends on the initial composition of Pu-238. The initial concentration of Pu-239 plus Pu-241 ranges from 23.9 to 7.9 wt. % of the total Pu, and Pu-241 is less than 1 wt. % of the total Pu.

The maximum neutron emission rate for the package with fueled clad assemblies is 12,000 neutrons/second per gram of Pu-238 and 18,000 neutrons/second per gram of Pu-238 for powder. Some contents may exceed 18,000 neutrons/second per gram of Pu-238 due to impurities in the PuO_2; consequently, SARP Chapter 5, Section 5.4.4.4 and Figure 5-8 address mass limits on Pu-238 for neutron emission rates between 18,000 and 36,000 neutrons/second per gram of Pu-238.

Shipping Configurations 1 through 6 are briefly described below and detailed descriptions are in Section 1.2.2.1 of the SARP. Table 1.2 of the SARP lists the component, drawing(s), and part (item number/drawing page) required for each shipping configuration. All components within the CV are classified in SARP, Table 9.1, as Quality Level 3 (Quality Category C), which is minor to safety.

> **Shipping Configuration 1 – General Purpose Heat Source (GPHS) fueled clad assembly (FCA)**: one or two PuO_2 fuel pellets encased in an iridium alloy capsule, with one or two FCAs and associated graphite support blocks and a graphite filler block, as

necessary, per product can, and up to four product cans with threaded or welded lids are placed in a 5.75 inch tall liner. Two liners can be placed into the CV with a graphite filler block.

Shipping Configuration 2 – GPHS graphite impact shell (GIS): GPHSs placed within a GIS that is made of fine-weave pierced fabric (FWPF), with one GIS per product can, and a maximum of two product cans in a 5.75 inch tall liner. Two liners can be placed into the CV with a graphite filler block.

Shipping Configuration 3 – GPHS module: a base component in the assembly of a radioisotope thermoelectric generator (RTG), which is placed in 5 inch tall liners and is held in position by a graphite support block. Two liners can be placed into the CV with a graphite filler block.

Shipping Configuration 4 – Domestic PuO_2 powder: loose PuO_2 powder from domestic sources in a threaded product can, where the PuO_2 powder is placed in up to eight product cans, with a maximum of four product cans per 5.75 inch tall liner. Two liners can be placed into the CV with a graphite filler block.

Shipping Configuration 5 – Russian PuO_2 powder: loose PuO_2 powder from Russian sources in a threaded product can, where the Russian PuO_2 is placed in a threaded ampoule, surrounded by a welded capsule, and then placed on a grade WDF felt cushion inside a Russian (welded) product can and sealed. Up to four Russian product cans, with a graphite support block, may be placed in a 5.75 inch tall liner. Two liners can be placed into the CV with a graphite filler block.

Shipping Configuration 6 – Generic Contents: PuO_2 in any solid form (e.g., powder, pellets, granules) that meets the initial isotopic limits shown in Table 1-1 of the SARP and where the maximum neutron emission rate for a loaded CV does not exceed 1.587×10^7 neutrons/second. The total heat load of the contents must be limited to 500 watts, which equates to approximately 1,110 g of a combination of U-233, U-235, Pu-238, Pu-239, and Pu-241 isotopes. The generic contents are shipped in powder cans, product cans, or capsules, all of which are held in a liner with the appropriate graphite support block. One liner can be placed into the CV with a graphite filler block(s).

Content Modifications in the Application, SARP, Rev. 2

1. Table 1-1: Footnotes 1 and 3 were modified for clarity.

2. Shipping Configuration 1 was modified to increase the lower density range of the GPHS fuel pellet from 9.53 – 9.86 grams/cm^3 to 9.63 – 9.86 grams/cm^3. This change is not safety significant because the densities used for the current shielding and criticality evaluations bound this change.

3. Liner drawings 756181 and 756182 (Rev. 1) were redrawn and modified (Rev. 2) to incorporate changes for fabrication, marking, and to make corrections.

4. Cylinder Product Can drawing 756180 (Rev. 2) was modified (Rev. 3) to remove Notes 6 and 7 because the "Q" requirements are not applicable to Quality Category C items, and Note 12 was revised to add a statement that previous revisions of this drawing meet the requirements of 756180, Rev. 3.

Shipping Configurations 7 through 8

SARP Addendum No. 1, Rev.1, Section 1.2.2 defines the contents for Shipping Configuration 7 as PuO_2 powder produced at the ORNL and for Shipping Configuration 8 as PuO_2 pellets produced from ORNL powder. The Pu-238 has an initial composition ranging from 80 to 92 wt. % of the total Pu in the PuO_2. The composition of Pu-239 plus Pu-241 of the total Pu depends on the initial composition of Pu-238. The initial concentration of Pu-239 plus Pu-241 ranges from 20.0 to 5.9 wt. % of the total Pu, and Pu-241 is less than 1 wt. % of the total Pu.

The maximum neutron emission rate for the ORNL PuO_2 powder is 24,000 neutrons/second per gram of Pu-238 and for pellets is 18,000 neutrons/second per gram of Pu-238. The package decay heat limits are 140 watts for Shipping Configuration 7, based on 70 watts (150 grams of PuO_2) for each Fuel Storage Assembly Powder Overpack (FSO) Container, and 350 watts for Shipping Configuration 8, based on 1,000 grams of total Pu per CV.

Shipping Configurations 7 and 8 are briefly described below and detailed descriptions are in SARP Addendum 1, Section 1.2.2.1. Table 1.2 of the addendum lists the component, drawings, and part (item number/drawing page) required for each shipping configuration. All components within the CV are classified in SARP Addendum 1, Table 9.1, as Quality Level 3, which is minor to safety.

> **Shipping Configuration 7 – FSO Container**: Up to 150 g of ORNL PuO_2 powder will be placed in a powder can or capsule and one powder can or capsule will be placed in an FSO container. Each FSO container will have a maximum heat generation rate of 70 watts, for a total of 140 watts per package when the maximum of two FSO containers are shipped.
>
> **Shipping Configuration 8 – GPHS FCA with ORNL PuO_2**: The content container configuration for Shipping Configuration 8 is identical to Shipping Configuration 1; however, the maximum quantity of PuO_2 for Shipping Configuration 8 is based on GPHS fuel pellets produced from ORNL PuO_2 powder. The GPHS fuel pellet is a right circular cylinder with edges rounded to an aspect ratio of one. Its density is 9.63 – 9.86 g/cm^3 (84 to 86 percent of the theoretical density of PuO_2). The maximum amount of Pu in the CV is limited to 1,000 grams, which limits the number of GPHS FCAs with ORNL PuO_2 to five. The heat load of the GPHS FCA with ORNL PuO_2 is nominally 63 watts. The total heat load is limited to 255 watts per liner and 350 watts per package.

Content Modifications in the Application, SARP Addendum 1, Rev. 1

1. Table 1-1: Footnotes 1 and 3 were modified for clarity.

2. Table 1-1: A new column was added to include a limit for Zr-95 of 10^7 Becquerels/gram of PuO_2. Table NOTE was modified to state the Zr-95 limit applies to the time of shipment. This modification is evaluated in Chapter 5 of the application.

3. Section 1.2.2: The neutron emission rate limit for ORNL powder was increased from 18,000 neutrons/second per gram of Pu-238 to 24,000 neutrons/second per gram of Pu-238. This modification is evaluated in Chapter 5 of the application.

4. Graphite Support Block drawing 796848 (Rev. 1): The drawing was modified to increase the diameter of FSO bore from 2.95 to 3.125 inches. This modification is evaluated in Chapter 2 of the application.

5. Section 1.2.2.1.1:

    a. 2nd paragraph: clarification that the FSO Container approximate weight of 3.9 lb. includes the handle

    b. 3rd paragraph: clarification from "… the ^{238}Pu inner shipping capsule, and the other is the fuel storage inner container." to "… the ORNL ^{238}Pu inner shipping capsule, and the other is the LANL fuel storage inner container."

    c. 3rd paragraph: modification of the inner shipping capsule weight from 1.8 lb. to 2.6 lb. and diameter from 1.9 inches to 2.2 inches. This modification is evaluated in Chapter 2 of the application.

1.3 Evaluation Findings

Based on a review of the statements and representations in the application, PCP staff concludes that the package design and operation modifications 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 structural evaluation in the SARP (Rev. 1) examined the design of the primary packaging components, including the cask and cask closure bolts, the personnel shield, and the CV with payload liners or FSO container in the package. The structural performance of the package is evaluated in the SARP by using both analyses and full-scale testing of prototype packages. The DYNA3D finite-element analysis code was used to determine the worst orientation for the 30 ft. free-drop tests under Hypothetical Accident Conditions (HAC). Full-scale prototype packages were subjected to the following HAC tests: free-drop in the bottom-down orientation, a dynamic crush test, and a puncture test. For the crush and puncture tests, the cask was removed from the

personnel shield (i.e., impact limiter) for maximum damage to the cask with CV. The design requirements for the primary packaging components are listed in SARP Table 2-1.

There are eight modifications in Chapter 2 of the application (excluding non-safety related editorial changes) to the previously approved package structural design or evaluation.

1. SARP Rev. 2: The preload torque range for the cask lid closure fasteners was increased from 130 to 145 inch-lb. to 252 to 300 inch-lb. This change was evaluated in Appendix 2.12.2, and implemented in Section 2.4.3, Drawing 756179 Rev. 3, Sheet 8, Note 1, and Section 7.5, Step 22.

   PCP staff confirmed by independent calculation and document review that this increase in the range of the preload torque remains adequate to confine the CV in the cask under the HAC 30 ft. free drop test.

2. SARP Rev. 2: The evaluation of vibration normally incident to transport [§71.71(c)(5)] was based on highway transport of the package in the Safe Secure Transport (SST) trailer. The SST trailer was replaced in the 1990s by the Safeguards Transporter (SGT) tractor-trailer system. This change was evaluated SARP Ref. 2.62 and Appendices 2.12.3 (tie-down) and 2.12.4 (normal vibration & cyclic loading), and implemented in Section 2.6.5 and Section 7.1.3, Step 9.

   PCP staff confirmed by document review that the tie-down loading and associated requirements and attenuated shock and vibration spectra to the package for the SGT are bounded by the SST evaluation.

3. SARP Rev. 2: Chapter 2 was updated to clarify the non-adherence of the CV top-end closure joint design to the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC), Section III, Division 1, Subsection NB-4233 design and examination requirements (i.e., inability to perform liquid penetrant or magnetic particle tests of the weld). This change was evaluated in Appendices 2.12.10 and 2.12.12 and implemented in Sections 2.1.2 (design), 2.3.1 (fabrication), 2.3.2 (examination), and Sections 8.1.2.3.1 and Appendix 8.3.4.

   PCP staff confirmed by document review that the evaluation and implementation in SARP Rev. 2 does clarify the description of the non-adherence of top-end closure joint design to Subsection NB-4233 requirements.

4. SARP Rev. 2: Cask eyebolt material specification was corrected in Table 2.4 from Type 316 to Type 304 stainless steel, for consistency with Drawing 756179.

   PCP staff confirmed by document review the McMaster-Carr part number, #33045T83, on Drawing 756179, Item 9, is Type 304 stainless steel (https://www.mcmaster.com/33045t83). This part has a vertical capacity of 4,000 lb.

Staff confirmed this vertical capacity is consistent with the eyebolt evaluation in Appendix 2.12.2.

5. SARP Rev. 2: Weld flux is no longer used in CV fabrication, so this option is unnecessary. The ASME BPVC, Section III, Division 1, Subsection NB, Article NB-2000 requirements related to welding flux material in Appendix 2.12.12, page 2.12.12-6 were deleted. These changes were implemented in Drawing 756189, Rev. 2, Note 12; Appendix 2.12.12, Table 2.12.12-1; and Section 8.1.2.4.

   PCP staff confirmed by document review concurs that this change is not a safety significant modification to the containment system.

6. SARP Rev. 2: The last paragraph in Section 2.3 was deleted to remove the requirements related to review and/or requalification of weld procedure specifications and welders, for consistency with ASME BPVC.

   PCP staff confirmed by document review concurs that this change is not a safety significant modification to the examination requirements in Section 2.3.2 for package welding operations. Qualification requirements for welders, weld procedures, and examination personnel are included in Chapter 8 and/or applicable drawing.

7. SARP Rev. 2: Hydrostatic test pressure for the CV shell to the bottom-end assembly component and weld increased from 57 to 100 psig in Appendix 2.12.12-12. This change is evaluated Appendix 2.12.12-12 and implemented in Appendix 8.3.4.

   PCP staff confirmed by document review and calculation this modification to the CV test and acceptance criteria is consistent with §71.85(b).

8. SARP Addendum No. 1, Rev. 1: For Shipping Configuration 7, the weight of the loaded CV is increased from 47.2 to 48.8 lb., due to a weight increase of the *Oak Ridge Inner Shipping Capsule* from to 1.8 to 2.6 lb. The change was implemented in Table 1-2; Section 1.3.1 Reference 1.4; Sections 2.1.1, 2.1.2, and 2.12.1, Reference 2.2; and Table 2-1.

   PCP staff confirmed by document review and calculation that this change is not a safety significant modification to the package because increasing the CV weight to 48.8 lb. is still bounded by the weight of 72.2 lb. evaluated in the SARP Table 2.3.

2.1 Evaluation Findings

Based on review of the statements and representations in the application, PCP staff has reasonable assurance that the modifications to the package structural design are not significant and meet the requirements of 10 CFR Part 71.

3.0 Thermal Evaluation

The package is designed for transport of up to 500 watts of PuO_2 heat source material in any solid form (e.g., powder, pellets, granules, etc.). Administrative controls are placed on the shipping configurations to ensure that the maximum package wattage is not exceeded. The source of decay heat from the PuO_2 payloads is from the alpha decay of Pu-238.

There are no modifications in Chapter 3 of the application (excluding non-safety related editorial changes) to the previously approved package thermal design, but there are two minor modifications to the previously approved package thermal evaluation.

1. SARP Rev. 2: Tables 3-1 and 3-15 were modified to increase the maximum allowable HAC temperature from 1192ºF to 1200ºF for the CV and 1393ºF to 1400ºF for the cask. Section 3.1.3 of the SARP (Rev. 1) states, "… acceptability of the peak HAC temperatures of 1393°F and 1192°F for the cask and the CV, respectively, are established in Chapter 2."

   PCP staff confirmed by document review that the material properties for the stress calculations are based on a temperature of 1200°F for the CV and 1400°F for the cask (SARP Rev. 1, Section 2.7.4.1).

2. SARP Rev. 2: Table 3-13 was modified to add a Table Note, "The maximum allowable fuel age for configurations not addressed in Table 3-13 shall be determined following the methodology in Chapter 3, Section 3.3.2.2." This table note was added to reference the methodology used for fuel age calculations for configurations not shown in the table.

   PCP staff confirmed by document review that this table note provides adequate clarification of fuel age calculations for configurations not shown in the table.

3.1 Evaluation Findings

Based on review of the statements and representations in the application, PCP staff has reasonable assurance that the modifications to the package thermal evaluation are not significant and meet the requirements of 10 CFR Part 71.

4.0 Containment

The package containment boundary is a one-time use CV, which is a welded stainless steel can. The CV provides a tested leaktight containment boundary for the contents of the package.

There are no modifications in Chapter 4 of the application (excluding non-safety related editorial changes) to the previously approved package containment design, but one minor modification to the previously approved package containment evaluation.

SARP Rev. 2: Section 4.5.2, last paragraph was modified to correct the reference for the maximum allowable fuel age from Table 2-38 to Table 3-13.

PCP staff confirmed by document review that the Table 3-13 is the correct reference.

4.1 Evaluation Findings

Based on review of the statements and representations in the application, PCP staff has reasonable assurance that the modification to the package containment evaluation is not significant and meet the requirements of 10 CFR Part 71.

5.0 Shielding Evaluation

The personnel shield is a cage-like engineering control that provides a physical barrier (i.e., fixed distance) from heat and radiation generated from the cask.

There are no modifications in Chapter 5 of the application (excluding non-safety related editorial changes) to the previously approved package shielding design, but two significant modifications to the previously approved package shielding evaluation in Addendum 1.

Modifications to the shielding evaluation in Addendum 1 are required to account for the limit of Zr-95 activity to 10^7 Becquerels/gram of PuO_2 at the time of shipment for Shipping Configurations 7 & 8 and to increase the maximum neutron emission rate for ORNL powder in Shipping Configuration 7 from 18,000 neutrons/second per gram of Pu-238 to 24,000 neutrons/second per gram of Pu-238.

All modifications (excluding non-safety related editorial changes) to the shielding evaluation in SARP and Addendum are evaluated below.

1. SARP Rev. 2: Footnote 1 to Tables 1-1 and 5-3 were modified to remove the statement, "…The photon maximum for 17.5 years is a requirement for fuel use and not a transportation limit."

   PCP staff concurs that this statement/information is not essential to the table or footnote.

2. SARP Addendum No. 1, Rev. 1: Section 5.1.2 text and Tables 5-1 and 5-2 were modified with new calculated maximum dose rates to account for Zr-95. The Table NOTE for both tables was revised from "Dose rate values are for the five GPHS FCA shipping configuration, which bounds all other shipping configurations." to "Dose rate values are for the five GPHS FCA shipping configuration for all dose rate locations except the outer surface of the vehicle, which is for the two FSO configuration."

   There are no changes to Addendum Sections 5.1.1, *Design Features*, or 5.3, *Shielding Model*, to implement these changes. The new calculated maximum dose rates in Tables 5-1 and 5-2 are based on the modifications to Section 5.2, *Source Specification*, for Zr-95, and modification to Section 5.2.2.2, *Neutron Source for Two FSO Containers*, to increase the maximum neutron emission rate of ORNL powder to 24,000 neutrons/second per gram of Pu-238 for Shipping Configuration 7.

PCP staff calculated the neutron and photon source terms using the ORIGEN module of the SCALE 6.2.3 code system and performed Monte Carlo analyses using Monte Carlo N-Particle code version MCNP6.2 to independently confirm the shielding calculations for both Normal Conditions of Transport (NCT) and HAC as well as the six-package exclusive use shipment configuration.

Table 5-1 below compares the Addendum with PCP staff's calculated maximum dose rates for a single package under NCT and HAC. The photon dose rate values include the secondary photons produced by neutron reactions. The dose rate values calculated by the staff include three times the standard deviation.

Table 5-1 Maximum Dose Rates for Exclusive Use Shipment of a Single 9516 Package

Normal Conditions of Transport – Exclusive Use Shipment								
	Package surface [a] (mrem/h)		Outer surface of vehicle [b] (mrem/h)		2m from vehicle external surface [c] (mrem/h)		Normally occupied position in vehicle (mrem/h)	
	Addendum	Staff	Addendum	Staff	Addendum	Staff	Addendum	Staff
Photon	75.9	75.8	37.9	36.7	1.00	1.05	1.42	1.46
Neutron	115.9	113.5	71.7	72.1	1.59	1.61	2.24	2.26
Total	191.8	189.2	109.7	108.9	2.59	2.66	3.66	3.72
§71.47(b) Limit [a]	1000		200		10		2.00	
Hypothetical Accident Conditions, 1m from package surface								
	Side (mrem/h)		Top (mrem/h)		Bottom (mrem/h)			
	Addendum	Staff	Addendum	Staff	Addendum		Staff	
Photon	9.87	9.93	11.91	11.82	8.10		8.17	
Neutron	15.57	15.59	17.85	18.57	16.85		16.73	
Total	25.44	25.62	29.76	30.40	24.95		27.90	
§71.51(a)(2) Limit	1000		1000		1000			

NOTE: Dose rate values are for the five GPHS FCA shipping configuration for all dose rate locations except the outer surface of the vehicle, which is for the two FSO configuration

[a.] For NCT, the package surface is the personnel shield (cage) exterior

[b.] Bottom of the trailer bed.

[c.] 2 m from the trailer sidewall.

Table 5-2 below compares the Addendum with PCP staff's calculated maximum dose rates for an exclusive use conveyance of six 9516 packages.

Table 5-2 Maximum Dose Rates for Exclusive Use Shipment of Six 9516 Packages

Normal Conditions of Transport – Exclusive Use Shipment						
	Outer surface of vehicle [a] (mrem/h)		2m from vehicle external surface [b] (mrem/h)		Normally occupied position in vehicle (mrem/h)	
	Addendum	Staff	Addendum	Staff	Addendum	Staff
Photon	39.6	38.42	3.45	4.06	1.44	1.46
Neutron	71.8	73.13	5.48	5.52	2.39	2.44
Total	111.5	111.6	8.94	9.58	3.83	3.90
§71.47(b) Limit [a]	200		10		2.0	

NOTE: Dose rate values are for the five GPHS FCA shipping configuration for all dose rate locations except the outer surface of the vehicle, which is for the two FSO configuration

[a.] Bottom of the trailer bed.

[b.] 2m from the trailer sidewall

Based on the Addendum and PCP staff's independent confirmatory analysis, the package continues to meet the external radiation requirements of §§71.47(b) and 71.51(a)(2), except for 71.47(b)(4). The calculated dose rate for the nearest normally occupied position (i.e. the truck cab) exceeds 2 mrem/hour [§71.47(b)(4)], so the exception to this limit must be included (i.e., retained) as a condition in the DOE CoC (Condition 7) retained.

3. SARP Addendum No. 1, Rev. 1: Section 5.2.1, text was modified (added) to this section to account for Zr-95. A new column was added to Table 5.3, consistent with Table 1-1, to include a limit for Zr-95 of 10^7 Becquerels/gram of PuO_2. The Table NOTE was also revised from "The isotopic limits in this table apply to the initial composition at date of conversion to oxide." to "The isotopic limits in this table apply to the initial composition at date of conversion to oxide for all isotopes except for ^{95}Zr where the limit applies to the time of shipment."

   PCP staff confirmed by document review and confirmatory analysis that Pu-238 is the largest contributor to the neutron source from α, n reactions (99.82%) and spontaneous fissions (99.70%). Staff conformed the calculated neutron source after 10 days and 17.5 years of decay were below the specific neutron emission rate of 18,000 neutrons/second per gram of Pu-238 and 24,000 neutrons/second per gram of Pu-238 for 5 GPHS FCAs (Shipping Configuration 8) and 2 FSO containers (Shipping Configuration 7), respectively. However, the dose rate values were calculated using the source strength (neutrons/second) based on the specific neutron emission rate values and the neutron spectra calculated after 10 days of decay.

   Staff confirmed that the highest photon dose rates are produced after 17.5 years of decay. The gamma source for 5 GPHS FCAs and 2 FSO containers was 3.87E+13 photons/second and 1.55E+13 photons/second, respectively, for both enrichment levels (80 and 92 wt.% of Pu-238 in the PuO_2).

4. SARP Addendum No. 1, Rev. 1: Section 5.2, Footnote 1 for Table 5-3 was modified to remove the statement, "…The photon maximum for 17.5 years is a requirement for fuel use and not a transportation limit."

   PCP staff concurs that this statement/information is not essential to the table or footnote and is consistent with the change implemented in Table 1-1.

5. SARP Addendum No. 1, Rev. 1: Section 5.2.1.1, Table 5.4, and Item 4 of the assumptions and parameters for the bounding hypothetical photon source strength, the density of PuO_2 (grams/cm^3) was corrected from 10.32 to 10.34 for consistency with the analysis. The correction was omitted from Section 5.2.2.2, 3rd paragraph, on Page 5-31 (INL notified on 2/18/2020 and will correct the omission in the next Addendum revision).

PCP staff confirmed by document review that 10.34 is the correct density value (i.e., was the value used in the previous shielding evaluation).

6. SARP Addendum No. 1, Rev. 1: Section 5.2.1.1, Item 4, *Thermal Power*, bounding hypothetical photon source strength assumptions and parameters, Items 5 and 7 were modified to address Zr-95, and Tables 5-5 through 5-7 were updated based on these changes (i.e., Zr-95).

   PCP staff confirmed by document review and confirmatory analysis these changes were accurately implemented to update Tables 5-5 through 5-7.

7. SARP Addendum No. 1, Rev. 1: Section 5.2.1.2, Tables 5-9 through 5-11 were modified to address Zr-95.

   PCP staff confirmed by document review and confirmatory analysis these changes were accurately implemented to update Tables 5-9 through 5-11.

8. SARP Addendum No. 1, Rev. 1: The addendum was modified to replace the representative ORIGEN-S and MNCP input files in Appendices 5.5.2 and 5.5.3 with a listing of the respective input files. The input files were provided to PCP staff on electronic media (CD). This change was implemented in the following sections of the addendum: 5.2.1.1, 5.2.1.2, 5.2.2.2, 5.3.1, 5.4.1, 5.4.2.1, 5.4.2.2, and Appendices 5.5.2 and 5.5.3.

   PCP staff verified that the shielding input files on the CD were used as the input data for the shielding calculations in the addendum.

9. SARP Addendum No. 1, Rev. 1: Section 5.2.2.2, and Tables 5-14 and 5-15 were modified to increase the maximum neutron emission rate for ORNL powder in two FSO cans from 18,000 neutrons/second per gram of Pu-238 to 24,000 neutrons/second per gram of Pu-238.

   PCP staff confirmed by document review and confirmatory analysis these changes were accurately implemented to update Tables 5-14 and 5-15.

10. SARP Addendum No. 1, Rev. 1: Section 5.4.4 text and tables were modified to update the external radiation levels for NCT and HAC, as follows:

    - Section 5.4.4.1 (Five GPHS FCAs), Tables 5-20 and 5-21,
    - Section 5.4.4.2 (Two FSO Containers), Tables 5-22 and 5-23,
    - Section 5.4.4.3.1 (Multiple Shipping Packages Containing Five GPHS FCAs), Table 5-24, and
    - Section 5.4.4.3.2 (Multiple Shipping Packages Containing Two FSO Containers). Table 5-25

PCP staff confirmed by document review and confirmatory analysis that the shielding evaluation results and external radiation levels were correctly implemented in Section 5.4.4 and Tables 5-20 through 5-25 and maximum external radiation levels are implemented in Tables 5-1 and 5-2.

5.1 Evaluation Findings

Based on review of the statements and representations in the application, PCP staff has reasonable assurance that the modifications to the package shielding evaluation meet the requirements of 10 CFR Part 71, subject to Condition 7 of the CoC.

6.0 Criticality Evaluation

The cask and CV are the only critical-to-safe operation packaging components (Quality Category A items) of the criticality control design. The cask keeps the fissile material confined during NCT and HAC. The seal-welded CV and liner maintain the geometry of the plutonium dioxide and prevent the plutonium from combining into a more reactive configuration. The liner(s), and graphite support and filler blocks are minor to safety packaging components (Quality Category C items) of the criticality control design for dunnage to restrict the movement on items within the CV.

There is one minor modification in Chapter 6 of the application to the previously approved package criticality design and no modifications to the previously approved package criticality evaluation.

SARP Rev. 2: Section 6.1.1, 1st paragraph was modified to account for Shipping Configuration 7 (FSO Container) without a liner, from "… All contents are shipped inside a cylindrical liner that functions as dunnage material for positioning the contents inside the CV." to "… Contents are typically shipped inside a cylindrical liner that functions as dunnage material for positioning the contents inside the CV."

PCP staff confirmed by document review that this minor modification to account for Shipping Configuration 7 (FSO Container) in the package criticality design description is necessary and acceptable for consistency. For Shipping Configurations 7 and 8, the maximum concentration of the fissile isotopes Pu-239 + Pu-241 is no more than 20 wt.%, and the total Pu mass is less than 1,000 grams; therefore, both shipping configurations are exempted from being classified as fissile material per §71.15(f) and no criticality evaluation for these configurations is required.

6.1 Evaluation Findings

Based on review of the statements and representations in the application, PCP staff has reasonable assurance that the modification to the package criticality design is not significant, with respect to the prevention of criticality, and meets the requirements of 10 CFR Part 71.

7.0 Operating Procedures

There are minor modifications in Chapter 7 of the application to the previously approved package operating procedures. These modifications are necessary to make improvements and corrections to the operating procedures

All modifications (excluding non-safety related editorial changes) to the package operating procedures in the SARP and Addendum are evaluated below:

1. SARP Rev 2: Section 7.1, 2nd paragraph was modified to implement the change in Table 3-13, Table Note, "The maximum allowable fuel age for configurations not addressed in Table 3-13 shall be determined following the methodology in Chapter 3, Section 3.3.2.2." to reference the methodology used for fuel age calculations for configurations not shown in the table.

   PCP staff confirmed by document review that this table note provides adequate clarification of fuel age calculations for configurations not shown in Table 3-13 and is correctly implemented in Section 7.1.

2. SARP Rev 2: Section 7.1, 3rd paragraph and was modified to account for Shipping Configuration 7 (FSO Container) without a liner, from "… All radioactive material shipped in the 9516 Package must be placed in a liner ..." to "Radioactive material shipped in the 9516 Package is typically placed in a liner ..."

   This modification was evaluated in Section 6.1 of this SER and is correctly implemented in Section 7.1 of the SARP.

3. SARP Rev. 2: Section 7.1.1, Step 8 was modified to remove "welding apparatus" from the step. The requirements for the "welding apparatus" were deleted in Section 2.3, last paragraph. The same modification was made in SARP Addendum 1 Rev. 1, Section 7.1.1, Step 7.

   PCP staff confirmed by document review these modifications correctly implement the change to SARP, Section 2.3.

4. SARP Rev. 2: Section 7.1.1, Step 9 was modified to add inspection and maintenance for reuse requirements for graphite components. The same modification was made in SARP Addendum 1 Rev. 1, Section 7.1.1, Step 8.

   CoC Rev. 5 authorized reuse of graphite components based on CoC Supplement 3, *Technical Justification for Re-Use of 9516 Package Graphite Support Block and Graphite Filler*. PCP staff confirmed by document review that requirements in the supplement were correctly implemented in the SARP and SARP Addendum in Chapters 7 and 8.

5. SARP Rev. 2: Section 7.1.2, 1st paragraph was modified to clarify the use of a liner, from "The procedure for loading the radioactive material into the 9516 Package for shipment is a three step process …" to "The procedure for loading the radioactive material into the 9516 Package for shipment using a liner is a three step process."

   PCP staff concurs with this clarification.

6. SARP Rev. 2: Section 7.1.2, Steps, 7, 10, and 19, Section 7.2.1, Step 15, Section 7.2.2, Step 3, were modified to authorize use of a Lifting Handle (a.k.a. T-handle) tool as another tool for lifting the Liner(s) or CV. The T-handle is threaded into the lid of the Liner or CV lid. A drawing of the tool is included Appendix 7.5.2. The same modifications were made in SARP Addendum 1 Rev. 1, Section 7.1.2.1, Steps 9 and 18, Section 7.1.2.2, Steps 7 and 10, Section 7.2.1, Step 15, and Section 7.2.2., Step 3.

   PCP staff confirmed by document review this change to the package operations is adequate to assure the package will be operated in a manner consist with the basis used for its safety evaluation.

7. SARP Rev. 2: Section 7.1.2, Step 17 was modified from "Section 8.1.1" to "Section 8.2.1" to correct the reference for routine inspection requirements. The same modification was made in SARP Addendum 1 Rev. 1, Section 7.1.2.1, Step 16, but omitted in Section 7.1.2.2, Step 17. INL was notified of the omission on March 3, 2020, and will correct in the next SARP revision.

   PCP staff confirmed by document review that this correction is valid and consistent with §71.87(b).

8. SARP Rev. 2: Section 7.1.2, Step 21, SARP Addendum 1 Rev. 1, Section 7.1.2.1, Step 20, and Section 7.1.2.2, Step 21 was modified to include use of lock washers to secure the cask lid. This detail was omitted from the operations steps.

   PCP staff confirmed by document review this change to the package operations is adequate to assure the package will be operated in a manner consistent with the basis used for its safety evaluation.

9. SARP Rev. 2: Section 7.1.2, Step 22 was modified to implement the change in the closure torque range for the cask lid bolts. The same modification was made in SARP Addendum 1 Rev. 1, Section 7.1.2.1, Step 21, and Section 7.1.2.2, Step 22.

   PCP staff confirmed by document review this change to the package operations is adequate to assure the package will be operated in a manner consist with the basis used for its safety evaluation. The change was evaluated in SARP Chapter 2.

10. SARP Rev. 2: Section 7.1.3, Step 5 was modified to correct the title of the DOT regulation cited: §173.443, *Contamination control*.

    PCP staff verified this title is correct per the Hazardous Material Regulations.

11. SARP Rev. 2: Section 7.1.3, Step 9 and SARP Addendum 1 Rev. 1, Section 7.1.3, Step 9 were modified to replace the SST with the SGT.

    PCP staff confirmed by document review this change to the package operations is adequate to assure the package will be operated in a manner consist with the basis used for its safety evaluation. The change from SST to SGT was evaluated in SARP Chapter 2.

12. SARP Addendum 1 Rev. 1: Section 7.2.2, Step 4 was modified to simplify this step by moving the tooling information to Step 3.

    PCP staff concurs with this simplification.

7.1 Evaluation Findings

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

8.0 Acceptance Tests and Maintenance Program

There are minor modifications in Chapter 8 of the application to the previously approved package acceptance testing and maintenance program.

All modifications (excluding non-safety related editorial changes) to the package acceptance testing and maintenance program in the SARP are evaluated below:

1. SARP Rev 2: Section 8.1.2.3, 1st paragraph modified to delete "overpressure test CVs" from the visual inspection requirements. The basis for deletion in included in the new Appendix 8.3.4, *CV Bottom Weld and CV Top Weld Hydrostatic Pressure Test Technical Basis and Historical Information*.

   PCP staff confirmed by document review of Appendix 8.3.4 and conclusion on page 8.3.4-4, a sufficient basis for deleting the requirement.

2. SARP Rev 2: Section 8.1.2.3, Step (i) added acceptance criteria that underfill/surface concavity shall not exceed 10% of the thickness of the thinnest joint member.

PCP staff confirmed by document review and confirmatory calculation that this modification confirms that the CV shell thickness is thicker than the maximum cutting groove depth that is already qualified as acceptable after the application of the §71.85(b) hydrostatic pressure test.

3. SARP Rev. 2: Section 8.1.2.3.1, *Changes to CV Top Lid Welding Apparatus* deleted, due to changes to the welding apparatus, and the sections following were renumbered.

   PCP staff concurs with this change.

4. SARP Rev. 2: Old Section 8.1.2.3.2, *CV Top Lid Qualification Welds*, and Steps 1 through 8 are now Section 8.1.2.3.1, Steps 1 through 7 – this section was modified to:

   - Clarify the requirements for consistency with ASME BPVC requirements and welding program terminology.
   - Delete in Step 3, the previous Step 4 (two places) requirement for metallographic exam, which in not required by ASME BPVC, Section V,
   - Delete in Step 3, the previous Step 4.d. requirement for hydrostatic overpressure proof test. The basis for deletion is included in the new Appendix 8.3.4, *CV Bottom Weld and CV Top Weld Hydrostatic Pressure Test Technical Basis and Historical Information*, and
   - Implement ASME BPVC requirements and welding program terminology in Steps 1 through 7.

   PCP staff confirmed by document review that these changes improve the clarity of the acceptance criteria and consistency with the ASME BPVC requirements and welding program terminology.

5. SARP Rev. 2: Older Section 8.1.2.3.3, *CV Top Lid Defective Welds*, and Steps 1 through 3, is now Section 8.1.2.3.2 - this section was modified to clarify the requirements for consistency with ASME BPVC weld repair requirements and welding program terminology. Previous Steps 1 through 3 were consolidated and clarified as text in the section.

   PCP staff confirmed by document review that these changes improve the clarity of the acceptance criteria and consistency with the ASME BPVC weld repair requirements and welding program terminology.

6. SARP Rev. 2: Section 8.1.2.4, *Use of Weld Flux* was deleted. Weld flux is no longer used, at the discretion of weld engineer, in the CV bottom and top lid welds.

   PCP staff concurs with this change.

7. SARP Rev. 2: Section 8.1.3.2 was modified to delete the hydrostatic overpressure test as part of the CV weld qualification. The basis for deletion is included in the new Appendix 8.3.4, *CV Bottom Weld and CV Top Weld Hydrostatic Pressure Test Technical Basis and Historical Information*.

   PCP staff confirmed by document review of Appendix 8.3.4 and conclusion on page 8.3.4-4, a sufficient basis for deleting the requirement.

8. SARP Rev. 2: Section 8.2.3 was modified to add Section 8.2.3.1, *Internal Components* to implement CoC Rev. 5, Supplement 3, *Technical Justification for Re-Use of 9516 Package Graphite Support Block and Graphite Filler*.

   PCP staff confirmed by document review that previously approved changes in Supplement 3 were correctly implemented in the SARP Chapter 8.

9. SARP Rev 2: Section 8.3.1, *References* was modified to delete previous Ref. 8.6 (Crocker, S., and R. C. King, *Piping Handbook*, Fifth Edition, McGraw-Hill, New York, New York, 1973) due to the Section 8.1.3.2 modification to delete the hydrostatic overpressure test as part of the CV weld qualification. References 8.7 through 8.9 were renumbered 8.6 through 8.8. References 8.9 (*2004 ASME Boiler and Pressure Vessel, Code*, Section III, Division 1, Appendices, New York, New York, 2004), and 8.10 [*Safety Analysis Report for Packaging (SARP) for the Mound 1 kW Package*, MLM-MU-91-64-001, CoC USA/9516/B(U)F-DOE] were added as references to the new Appendix 8.3.4. Updated References 8.6 through 8.8 were implemented in Sections 8.1.5, 8.1.5.2, 8.2, and 8.2.2, as applicable.

   PCP staff confirmed by document review that the reference changes are appropriate and correctly implemented in SARP Chapter 8.

10. SARP Rev 2: Appendix 8.3.3 and Table 8.3.3-1 modified to change the Quality Level nomenclature from Quality Level 1 and 3 items to Quality Level A and C in accordance with Chapter 9, Section 9.2.1.

    PCP staff concurs that these changes are more consistent with 10 CFR 71 Subpart H Quality Assurance Programs, based on Nuclear Regulatory Commission (NRC) Regulatory Guide 7.10, *Establishing Quality Assurance Programs for Packaging Used in Transport of Radioactive Material*, Rev. 3.

11. SARP Rev. 2: Appendix 8.3.4, *CV Bottom Weld and CV Top Weld Hydrostatic Pressure Test Technical Basis and Historical Information*, was added as the technical basis for deleting the hydrostatic overpressure test as part of the weld qualification program.

    PCP staff confirmed by document review that Appendix 8.3.4 provides a sufficient technical basis for eliminating the hydrostatic overpressure test from the CV weld

qualification process. The conservative ASME BPVC calculations in SARP Chapter 2, Appendix 2.12.10, Attachment 1, demonstrate that eliminating the hydrostatic overpressure test would not reduce the level of confidence in the ability of the CV to maintain its structural integrity.

8.1 Evaluation Findings

Based on review of the statements and representations in the application, PCP staff has reasonable assurance that the modifications to the packaging acceptance test 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 applicant's 10 CFR 71 Subpart H Quality Assurance Program (QAP) is approved by DOE (https://rampac.energy.gov/docs/default-source/qa/approval_0010_r1.pdf). There are numerous minor modifications in Chapter 9 of the application for consistency with their QAP, *Quality Assurance Program Description for Type B and Fissile Material Packaging*, PDD-199, Rev. 2. PCP staff confirmed by document review that most of the modifications in the application do not reduce the commitments to the QAP, as defined in §71.106(b).

All modifications in the SARP and Addendum that could reduce the commitments in the DOE approved QAP are evaluated below:

1. SARP Rev. 2: Section 9.2.1, 3rd paragraph was modified to remove "Fabrication, inspection, and testing are controlled through use of 10 CFR 71, Subpart H, and ASME NQA-1-2000 requirements in procurement specifications."

   PCP staff confirmed by document review Section 9.2.1, 1st paragraph, and Table 9-3 contain sufficient detail required by §71.105 and does not reduce the commitments in the DOE approved QAP.

2. SARP Rev. 2: Section 9.2.1, 1st paragraph, page 9-5 was modified to change the nomenclature of "Quality Levels 1, 2, and 3" to "Quality Levels A – Nuclear Use, B – Commercial Use, and C – General Use." This change was implemented Tables 9-1 through 9-3, Sections 9.4.1, 9.7.2, and 9.9.

   PCP staff confirmed by document review that these changes are consistent with 10 CFR 71 Subpart H Quality Assurance Programs, based on NRC Regulatory Guide 7.10, *Establishing Quality Assurance Programs for Packaging Used in Transport of Radioactive Material*, Rev. 3 (RG 7.10).

3. SARP Rev. 2: Section 9.3.2, Step 1 through 3 was modified for the INL process for revisions to the package.

PCP staff confirmed by document review that these changes do not reduce the commitments in the DOE approved QAP or compliance with §71.107.

4. SARP Rev.2: Section 9.4.3, was modified to delete "… Copies of all procurement documents are filed by the procurement department as quality records."

   PCP staff confirmed by document review that this change does not reduce the commitments in the DOE approved QAP. Record requirements for procurement are addressed in other sections of the SARP: Sections 9.7.7 and 9.17.

5. SARP Rev. 2: Section 9.5.1, last paragraph was modified to delete software quality assurance requirements.

   PCP staff confirmed by document review that this change does not reduce the commitments in the DOE approved QAP. The verbatim text is included in Section 9.3.1, 3rd paragraph.

6. SARP Rev. 2: Section 9.10.1, Table 9-6, Step 6 was modified to remove the cask lid bolt torque values from the table and incorporate them by reference to Drawing 756179, Sheet 8.

   PCP staff confirmed by document review that the correct cask lid bolt torque values are in Note 1 of the referenced drawing/sheet.

7. SARP Rev. 2: Section 9.11.3 was modified to remove the inspection for shielding integrity prior to delivery.

   PCP staff concurs with this change because package shielding design does not include materials or components specifically intended for biological shielding.

8. SARP Rev. 2: Section 9.14, 1st paragraph was modified to remove "…A listing of each INL RPS Program-managed 9516 packaging and its operating status is maintained by the CMPM."

   PCP staff concurs with this change because §71.129 does not require this level of specificity.

9. SARP Rev. 2: Section 9.18 was modified by combining and consolidating subsections into the main section. The new section departs from the numbered subsection format of RG 7.10.

   PCP staff confirmed by document review that these modifications minimally meet the requirements of §71.137 but did not improve the quality and clarity of Section 9.18.

10. SARP Addendum 1 Rev. 1: Chapter 9, Page 9-1 and Table 9-1 were modified to change the Quality Level nomenclature from Quality Level 1 and 3 items to Quality Level A and C, respectively.

    PCP staff concurs that these changes are more consistent with 10 CFR 71 Subpart H Quality Assurance Programs, based on RG 7.10, and does not reduce the commitments in the DOE approved QAP.

9.1 Evaluation Findings

Based on review of the statements and representations in the application, PCP staff has reasonable assurance that the modifications are consistent with their DOE approved QAP, meet the requirements of 10 CFR 71 Subpart H, and are therefore adequate to assure the package will be operated in a manner consistent with its evaluation for approval.

Conditions of Approval

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

- Drawings 5.(a)(3) revised:
  - 756179 (Rev 2 to Rev 3)
  - 756180 (Rev 2 to Rev 3)
  - 756181 (Rev 1 to Rev 2)
  - 756182 (Rev 1 to Rev 2)
  - 756189 (Rev 1 to Rev 2)
  - 796848 (Rev 0 to Rev 1)

- Contents 5.(b)(1), Shipping Configurations 7 and 8 revised:
  - 1st paragraph added "…and up to 1E+07 Bq/g-PuO_2 of ^{95}Zr" to account for ^{95}Zr.
  - 4th paragraph revised to increase the maximum neutron emission rate for the ORNL plutonium dioxide powder from 18,000 to 24,000 n/s-g ^{238}Pu.

- Contents 5.(b)(1), Table 1 Plutonium Initial Isotopic Limits revised:
  - Add column for the ^{95}Zr limit for Shipping Configurations 7 and 8
  - NOTE revised to "…Shipping Configurations 7-8 when back-decayed to the date of conversion to oxide for all isotopes except for ^{95}Zr where the limit applies to the time of shipment."
  - Item 1, deleted "The photon maximum for 17.5 years is a requirement for fuel use and not a transportation limit."
  - Item 4, revised to "… Therefore, the shielding evaluation allows individual actinide impurities up to 1 wt.% of the total plutonium content when back-decayed to the date of precipitation (for Shipping Configurations 1-6) or conversion to oxide (for Shipping Configurations 7-8)."

- Conditions 5.(d) revised:
  - (2) Added "…The maximum allowable fuel age for configurations not addressed in Table 3-13 shall be determined following the methodology in Chapter 3, Section 3.3.2.2 of the SARP."
  - (8) 2nd paragraph deleted (now included in Addendum 1)
  - (9) - (11) conditions deleted (requirements are in SARP Chapters 7-8)
  - (12) - (15) renumbered (9) - (12): new (10) revised to "Revision 5 of this certificate may be used until December 31, 2020."

- Supplements 5.(e) revised:
  - (1) - (5) deleted (supplements consolidated in SARP and Addendum): new (1) "Safety Analysis Report for Packaging (SARP) for the 9516 Package, Addendum No. 1, R1033-0065-ES, Revision 1, January 2020."

Conclusion

Based on the statements and representations contained in the application and the conditions listed above, PCP staff concludes that the package design has been adequately described and evaluated, and the Model 9516 package meets the requirements of 10 CFR Part 71.

References

[1] *FW: 9516 SARP Renewal*, Email Carl Friesen to Shuler, July 31, 2019, with attachment.

[2] *Contract No. DE-AC07-05ID 14517 - Safety Analysis Report for Packaging for the 9516 Package, USA/9516/B(U)F-96 (DOE), 5-Year Certificate Renewal, Docket 19-12-9516*, Letter# CCN 245999, Letter to Carl Friesen, November 26, 2019, with enclosures.

[3] *FW: Docket 19-12-9516 - 9516 Comments 2.1 and 5.3 - Updated Response matrix*, Email Carl Friesen to Shuler, January 7, 2020, with attachments

[4] *Safety Analysis Report for Packaging (SARP) for the 9516 Package,* R1033-0062-ES, Revision 2a, Idaho National Laboratory, July 2019

[5] *Safety Analysis Report for Packaging (SARP) for the 9516 Package, Addendum No. 1,* R1033-0065-ES, Revision 1a, Idaho National Laboratory, July 2019

[6] *Comment/Questions from Review of Renewal and Amendment Request for Certificate Number 9516*, Memorandum Shuler to Carl Friesen, November 1, 2019, with attachment.

[7] *Safety Analysis Report for Packaging (SARP) for the 9516 Package,* R1033-0062-ES, Revision 2b, Idaho National Laboratory, November 2019

[8] *Safety Analysis Report for Packaging (SARP) for the 9516 Package, Addendum No. 1,* R1033-0065-ES, Revision 1b, Idaho National Laboratory, November 2019

[9] *Safety Analysis Report for Packaging (SARP) for the 9516 Package,* R1033-0062-ES, Revision 2, Idaho National Laboratory, January 2020

[10] *Safety Analysis Report for Packaging (SARP) for the 9516 Package, Addendum No. 1,* R1033-0065-ES, Revision 1, Idaho National Laboratory, January 2020

[11] *Safety Analysis Report for Packaging (SARP) for the 9516 Package,* R1033-0062-ES, Revision 1, Idaho National Laboratory, October 2009

[12] *Summary of Changes 9516 Package SARP, R1033-0062-ES (Revision 2a) 9516 Package SARP Addendum 1, R1033-0065-ES (Revision 1a) Docket 19-12-9516*, July 25, 2019