U.S. DEPARTMENT OF ENERGY

DOE Packaging Certification Program

CERTIFICATE OF COMPLIANCE
For Radioactive Materials Package

DOE F 5822.1
(5-85 Formerly EV-618)
Rev (9-2011)

1a. Certificate Number	1b. Revision No.	1c. Package Identification No.	1d. Page No.	e. Total No. Pages
9516	8	USA/9516/B(U)F-96 (DOE)	1	12

2. PREAMBLE

2a. This certificate is issued under the authority of 49 CFR Part 173.7(d).

2b. The packaging and contents described in item 5 below meet the safety standards set forth in subpart E, "Package Approval Standards" and subpart F, "Package, Special Form, and LSA-III Tests" Title 10, Code of Federal Regulations, Part 71.

2c. This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. This certificate is issued on the basis of a safety analysis report of the package design or application --

(1) Prepared by *(Name and address)*:	(2) Title and Identification of report or application:	(3) Date:
U.S. Department of Energy Idaho Operations Office 1955 Fremont Ave. Idaho Falls, ID 83415	Safety Analysis Report for Packaging (SARP) for the 9516 Package, R1033-0062-ES, Rev. 2, January 2020, as supplemented [See 5(e)]	January 2020

4. CONDITIONS

This certificate is conditional upon the fulfilling of the applicable Operational and Quality Assurance requirements of 49CFR parts 100-199 and 10CFR Part 71, and the conditions specified in item 5 below.

5. Description of Packaging and Authorized Contents, Model Number, Transport Index, Other Conditions, and References:

(a) Packaging

(1) Model: 9516 Package

(2) Description:

The 9516 Package has a maximum gross weight of 900 lb. and consists of a cylindrical cask that is housed in a mesh personnel shield. The 9516 Package is designed for transport of up to 500 Watts (W) of plutonium dioxide heat source material in any solid form (e.g., powder, pellets, granules, etc.). The Containment Vessel (CV) provides the containment boundary and is housed within the cask during transport. The cask is the package confinement boundary. Figure 1 shows the assembled package.

The 9516 Package is based on the previous Mound 1 kW Package. There were no changes made to either the personnel shield or the cask; however, the CV was changed in accordance with the most current NRC regulations, 10 CFR Part 71, and the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC) requirements.

6a. Date of Issuance: May 3, 2021	6b. Expiration Date: January 31, 2025

FOR THE U.S. DEPARTMENT OF ENERGY

7a. Address *(of DOE Issuing Office)*	7b. Signature, Name, and Title *(of DOE Approving Official)*
U.S. Department of Energy Office of Packaging and Transportation (EM-4.24) 1000 Independence Avenue, SW Washington, DC 20585	Julia C. Shenk Digitally signed by Julia C. Shenk Date: 2021.05.03 08:18:02 -04'00' Julia C. Shenk Headquarters Certifying Official Director Office of Packaging and Transportation

The personnel shield (cage) provides protection from heat and radiation (i.e., fixed distance) from the package contents and also serves as an impact limiter for the stainless steel cask. Tie-down brackets on the frame are used to secure the package or packaging within the transport vehicle. The personnel shield is of welded construction and weighs approximately 500 lb. The overall height is 35.25 inches including the personnel shield lid. The overall base is 30.75 by 30.75 inches.

The personnel shield is fabricated of Type 304 stainless steel except for the structural tubes at the base, which are constructed of ASTM A-500, Grade B carbon steel. The personnel shield provides access to the stainless steel cask through the top and side removable weldment panels.

The base of the personnel shield consists of two rectangular hollow structural tubes that are 8 inches wide, 4 inches high, and 0.5 inch thick and have a total length of 30 inches. Two 3 inches by 1½ inches by 30 inches bars are welded across the structural tubes and serve as attachment points for the base plate of the cask. Six 13/16 inch holes are drilled in the 3 inches by 1½ inches by 30 inches bars to provide attachment points for the base plate of the cask. The framework is fabricated of a 2 inches by 2 inches by ⅜ inch angle. Bracing of the framework is provided by a 1½ inches by 1½ inches by ¼ inch angle. Stainless steel wire mesh is welded to the framework. The wire mesh completely encloses the cask during shipment while permitting heat to escape. The top and side covers are made of 1½ inches by ⅜ inch stainless steel plate bolted to the frame with ¼ - 20 UNC oval head, 18-8 stainless steel, Phillips machine screws. The top and side cover weldments are removed during cask loading and unloading.

The cask is designed to provide confinement of the CV and contents during Normal Conditions of Transport (NCT) and Hypothetical Accident Conditions (HAC). The cask was designed, fabricated, and examined in accordance with the 1989 Edition of the ASME BPVC, Section VIII, Division 1. At the time of design (in the 1989 to 1991 time frame) and as permitted in NUREG/CR-3854, the cask lid, body, base and closure bolts were manufactured from materials conforming to the ASTM material specifications. However, if any new casks are to be constructed, these casks will be constructed in accordance with latest revision of ASME BPVC, Section VIII, Division 1, using the latest ASME material specifications. In the case of replacement components for existing casks, the materials shall be in compliance with the 1989 Edition of the ASME BPVC, Section VIII, Division 1. However, if materials for replacement components for existing casks, or for fabrication on new casks are purchased to a later edition of the ASME Code, a reconciliation analysis shall be performed for each material type to ensure the original ASME Code requirements are met or exceeded.

The cask is a 1.5-inches-thick welded Type 304L stainless steel vessel that has an overall height of 19.5 inches and an outside diameter of 9.5 inches. The interior of the container has been machined to produce a 16.5-inches-deep cavity with a diameter of 6.5 inches. A 1.5-inches-thick lid is attached to the cask body by eight ½-13 UNC by 2-inches-long Grade B6 (AISI 410) bolts. All eight closure bolts have a hole drilled through the bolt head for the placement of a wire-type security seal. The security seal is placed on any two bolts to prevent inadvertent opening of the cask. The lid is sealed with 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 used to lift the lid and place the cask into the personnel shield. The base plate of the cask is a 14 inches by 12 inches by 1.5 inches plate that is welded to the cask body. To provide attachment points to the personnel shield, six 13/16 inch holes are drilled in the base plate of the cask. Six ¾-10 UNC by 4-inches-long Grade B6 (AISI 410) bolts, heavy hex nuts, and stainless steel lock washers secure the cask to the personnel shield. The weight of the empty cask is approximately 285 lb.

During shipment, the contents will be contained inside a stainless steel CV that is designed to remain leaktight in accordance with ANSI N14.5-1997, American National Standard for Radioactive Materials—Leakage Tests on Packages for Shipment, during NCT and HAC. The stainless steel CV is designed in accordance with ASME BPVC, Section III, Division 1, Subsection NB. The CV is manufactured, examined, and tested to the maximum practical extent to the requirements of Subsection NB. 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. Equivalent compliance is provided for the cases where strict compliance cannot be achieved.

The CV materials are in compliance with ASME BPVC, Section III, Division 1, Subsection NB and the appropriate material specification specified in ASME BPVC, Section II. A reconciliation analysis shall be performed if the material is purchased to a later edition of the Code to ensure all of the original requirements are met or exceeded.

The CV is constructed of Type 304L stainless steel tubing that has a minimum wall thickness of 0.12 inch. The Type 304L stainless steel base plate and cover plate of the CV are 0.5 inch thick. The CV has an outside diameter of 6.38 inches and is 16.25 inches tall. The dimensions of the CV used in the package are shown in Figure 1-4 of the SARP. To assist in loading and unloading of a CV, a ⅜-16 threaded hole is tapped into the cover. A 0.06 inch groove is provided on the CV to assist in opening with a pipe cutter or by other means.

The CV is sealed with a full-penetration weld using Type ER 308L welding wire. Welding wire is added to prevent solidification cracking of the weld. All the CV welds are radiographed and helium leakage rate checked to determine their acceptability. Site-specific welding procedures shall be developed at the user's facility. These procedures shall meet or exceed the requirements of the ASME BPVC. Drawings detailing the safety features of the containment system, including welding and inspection requirements for all components, are included in Appendix 1.3.2 of the SARP. The maximum normal operating pressure for the CV is 37.6 psig.

All contents for Shipping Configurations 1 through 6 and 8 are packaged inside a cylindrical liner that functions as dunnage material for positioning the contents inside the CV. Depending on the content configuration, either one or two liners are shipped in the CV. The liners are constructed of Type 304L stainless steel tubing that has an outside diameter of 6 inches and a minimum wall thickness of 0.12 inch. Each liner has a 0.5 inch-thick Type 304L base plate and cover plate that are welded in place. Each liner also has a 0.25-inch-diameter hole through the sidewall to prevent any pressure buildup. The various lengths of liners are shown in Figure 1-5 of the SARP. A graphite support block fills the internal void volume of a liner and positions the payload. Excess end spacing in the CV is filled with graphite filler blocks. The graphite support block and graphite filler block material is GrafTech ATJ, Poco TM, Poco PLS-1, Poco DFP-1, or KK-8. The dimensions of the graphite filler blocks are shown in Figure 1-6 of the SARP.

Contents for Shipping Configuration 7 are packaged inside a welded cylindrical container (Fuel Storage Assembly Powder Over-Pack (FSO Container)) that functions as a convenience container for an additional nested content container (powder can or capsule) within the CV. The FSO is supported by graphite support and filler blocks that provide dunnage and position the contents within the CV. Either one or two FSOs are shipped in the CV. The internal component arrangements in the CV for Shipping Configuration 7 are shown in Figures 1-2 and 1-3 of SARP Addendum 1. The FSO container is constructed of austenitic standard grade stainless steel, Type 347H, with overall dimensions of approximately 2.9 inches in diameter by 6.7 inches long. The graphite support and filler block material is GrafTech ATJ, Poco TM, or Poco PLS-1. The dimensions of the graphite support and filler blocks for FSO are approximately 6.0 inches in diameter and 6.7 inches long and 5.75 inches in diameter and 0.75 inches long, respectively.

Contents for Shipping Configurations 9 through 11 are packaged in welded cylindrical containers. There are three sizes of content containers (Small, Medium Overpack with Small Container, and Large). Each content container is overpacked in an unsealed can (small, medium and large) constructed of graphite and stainless steel that is used to identify CV contents via radiography. Various graphite support and filler blocks, and stainless steel spacers are used to position the contents within the CV. The internal component arrangements in the CV for Shipping Configurations 9 through 11 are shown in Figures 1-1 through 1-4 of SARP Addendum 2.

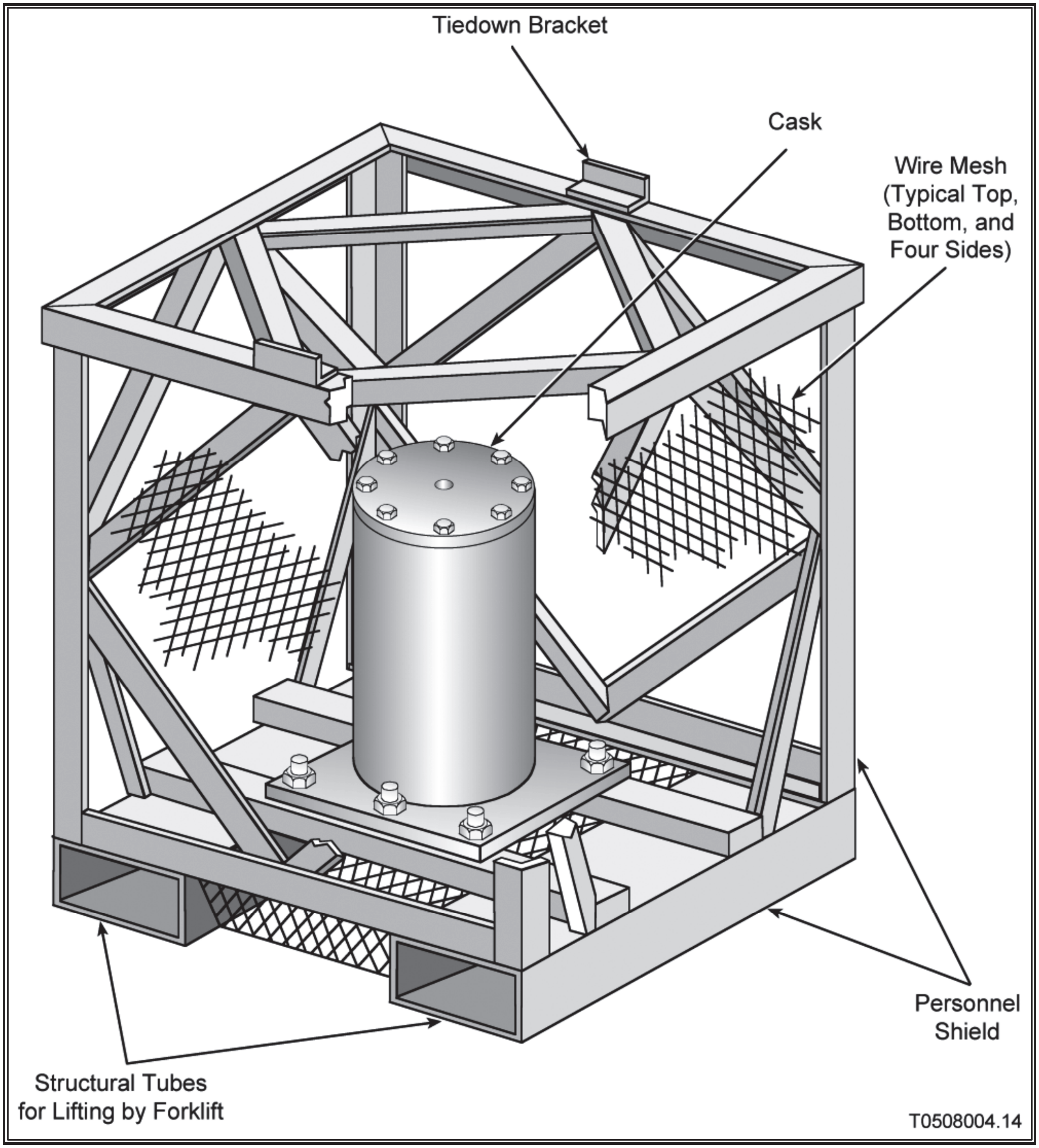

Figure 1. 9516 Package

(3) Drawings:

Drawing No.	Rev	Title/Notes
756179	5	9516 Shipping Container (11 Sheets)
756180	3	Cylinder, Product Can (2 Sheets)
756181	2	Liner, 5.00 High (2 Sheets)
756182	2	Liner, 5.75 High (2 Sheets)
756183	0	Graphite Filler Block (1Sheet)
756184	0	Graphite Support Block for GPHS Module (1 Sheet)
756185	0	Graphite Support Blocks for Product Cans (1 Sheet)
756186	0	PuO2 Powder Can Set (3 Sheets)
756187	0	Cylinder, Product Can (2 Sheets)
756188	0	Graphite Support Block for Product Cans (1Sheet)
756189	2	Containment Vessel, 16.25 High (2 Sheets)
796848	1	Graphite Support Block for FSO (1 Sheet)
796849	0	Graphite Filler Block for FSO (1 Sheet)
SKNEN2-5663	B	Stainless Steel Can, Large (2 Sheets)
SKNEN2-5664	B	Stainless Steel Can, Medium (2 Sheets)
SKNEN2-5665	B	Stainless Steel Can, Small (2 Sheets)
853326	0	Top Graphite Filler Block (1 Sheet)
853327	0	Stainless Filler Block Spacer (1 Sheet)
853328	1	Spacer Weldment (1 Sheet)
853329	0	Large Graphite Support Block (1 Sheet)
853330	0	Medium Graphite Support Block (1 Sheet)
853331	0	Small Graphite Support Block (1 Sheet)
853332	0	Tall Top Graphite Filler Block (1 Sheet)
853333	0	Spacer Plate (1 Sheet)

(b) Contents:

(1) Type and Form of Material:

For the contents described below, as the initial ^{238}Pu weight percent is increased in a mixture of plutonium dioxide, the ^{239}Pu and ^{241}Pu weight percentages are reduced. Almost all the activity in these mixtures of plutonium dioxide is from the alpha decay of ^{238}Pu; therefore, ^{238}Pu is the decay heat source and the curie content (amount of ^{238}Pu) is directly proportional to the decay heat. Because ^{234}U is an insignificant contributor to the neutron and gamma source, the neutron and gamma dose contribution associated with ^{238}Pu will decrease as the ^{238}Pu decays. Administrative controls shall be placed on the loading arrangements to ensure that the maximum wattage is not exceeded.

<u>Shipping Configurations 1 through 6</u>:

The contents for Shipping Configurations 1 through 6 consist of plutonium dioxide in any solid form; e.g., powder, pellets, granules, etc. The principal isotope in the plutonium dioxide is ^{238}Pu, which has an initial composition of 74 – 90 weight percent (wt.%) of the total plutonium in the mixture. The initial plutonium that is ^{239}Pu and ^{241}Pu could range from 23.9 - 7.9 wt.% for different mixtures. The plutonium that is ^{241}Pu shall be less than 1 wt.% for all mixtures. The fissile isotopes of uranium, ^{235}U and ^{233}U, will only be present in trace amounts. The theoretical density of the plutonium dioxide is 11.46 grams per cubic centimeter (g/cm^3).

Limiting the amount of decay heat in the package to 500 W establishes the activity limit, which is approximately 15,930 Ci. The composition of the plutonium shipped in the package for

Configuration 1 through 6 are shown in Table 1. The maximum neutron emission rate for the fueled clad assemblies is 12,000 neutron/second per gram of ^{238}Pu (n/s-g-^{238}Pu). The maximum neutron emission rate for the plutonium dioxide powder is 18,000 n/s-g-^{238}Pu. See Chapter 5, Section 5.4.4.4 of the SARP, for a reduction in the allowable payload per package when shipping plutonium dioxide with neutron emission rates between 18,000 and 36,000 n/s-g-^{238}Pu, particularly Figure 5-8 of the SARP. Administrative controls shall be placed on the loading arrangements to ensure that the maximum wattage is not exceeded.

Shipping Configurations 7 and 8:

The contents for Shipping Configuration 7 consist of plutonium dioxide powder produced by the Oak Ridge National Laboratory (ORNL) and for Shipping Configuration 8, plutonium dioxide pellets produced from the ORNL powder. The principal isotope in the plutonium dioxide is ^{238}Pu, which has an initial composition of 80 – 92 weight percent (wt.%) of the total plutonium in the mixture, with up to 6 parts per million ^{236}Pu, and up to 1E+07 Bq/g-PuO_2 of ^{95}Zr.

The initial plutonium that is ^{239}Pu and ^{241}Pu could range from 20.0 – 5.9 wt.% for different mixtures. The plutonium that is ^{241}Pu shall be less than 1 wt.% for all mixtures. The fissile isotopes of uranium, ^{235}U and ^{233}U, will only be present in trace amounts. The theoretic density of the plutonium dioxide is 11.46 g/cm^3. The total plutonium mass is less than 1000 g per package and the maximum concentration of the fissile isotopes ^{239}Pu + ^{241}Pu do not exceed 20.0 wt.%. Therefore, per 10 CFR 71.15(f), Shipping Configurations 7 and 8 are exempt from classification as fissile material and from the fissile material package standards of §§71.55 and 71.59.

Limiting the amount of decay heat in the package to 140 W for Shipping Configuration 7 (70 W for each FSO Container) establishes the activity limit, which is approximately 4,460 Ci. The decay heat limit in the package for Shipping Configuration 8 is 350 W and corresponds to an activity limit of 11,151 Ci. The composition of the plutonium shipped in the package for Shipping Configurations 7 and 8 are shown in Table 1. The maximum neutron emission rate for the ORNL plutonium dioxide powder is 24,000 n/s-g-^{238}Pu and 18,000 n/s-g-^{238}Pu for General Purpose Heat Source (GPHS) pellets made from ORNL plutonium dioxide powder.

Shipping Configurations 9 through 11:

The contents for Shipping Configurations 9 through 11 consist of plutonium dioxide powder. The principal isotope in the plutonium dioxide is ^{238}Pu, which has an initial composition of 80 – 90 weight percent (wt.%) of the total plutonium in the mixture. The powder is pressed to a density of approximately 6 g/cm^3. The total plutonium mass is less than 1000 g per package and the maximum concentration of the fissile isotopes ^{239}Pu + ^{241}Pu do not exceed 20.0 wt.%. Therefore, per 10 CFR 71.15(f), Shipping Configurations 9 through 11 exempt from classification as fissile material and from the fissile material package standards of §§71.55 and 71.59.

Limiting the amount of decay heat in the package to 420 W establishes the activity limit, which is approximately 13,000 Ci. The composition of the plutonium shipped in the package for Configuration 9 through 11 are shown in Table 1. The maximum neutron emission rate for the plutonium dioxide powder is 18,000 n/s g ^{238}Pu.

Table 1. Plutonium Initial Isotopic Limits.

Source specification:	^{236}Pu (ppm)[1]	^{238}Pu (wt.%)[2]	^{239}Pu + ^{241}Pu (wt.%)[3]	Other ΣPu (wt.%)[3]	Individual actinide impurities (wt.%)[4]	^{95}Zr (Bq/g-PuO_2)
Shipping Configurations 1-6	≤ 2.0	74-90	23.9-7.9	≤ 4	≤ 1	N/A
Shipping Configurations 7-8 [5]	≤ 6.0	80-92	20.0-5.9	≤ 4	≤ 1	1E+7
Shipping Configurations 9-11[5]	≤ 2.0	80-90	20.0-7.9	≤ 4	≤ 1	N/A

NOTE: The isotopic limits in Table 5-3 of the SARP apply to the initial composition for Shipping Configurations 1-6 when back-decayed to the date of precipitation; the limits in Table 1-1 of Addendum 1 apply to the initial composition for 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, and the limits in Table 1-1 of Addendum 2 apply to the initial composition for Shipping Configurations 9-11 at date of conversion to oxide.

1. Defined source of ^{208}Tl; the photon maximum is at 17.5 years.
2. Defined source of almost all α, n activity. Refer to footnote No. 4 below for the definition of instantaneous ^{238}Pu content.
3. There is no contribution to the source term except for a few α decays from α, n reactions. Therefore, the source term is significantly less than ^{238}Pu by orders of magnitude. Additionally, because the total inventory is low, there is not a criticality concern.
4. The shielding evaluation was done with individual actinide impurities (^{241}Am, Np, U, and Th) at average concentrations based on historic assay data. However, sensitivity cases with all of the individual actinide impurities set to 1 wt.% resulted in very small (<1%) increases in the overall dose rates outside the package. 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). The relative amounts of U will vary depending on the age of the material. There is an approximate 0.7% per year growth of ^{234}U due to the decay of ^{238}Pu. The method for calculating instantaneous ^{234}U and ^{238}Pu is discussed in Section 1.2.2 of the SARP.
5. Shipping configurations 7 through 11 are exempt from classification as fissile material per §71.15(f)

(2) Maximum Quantity of Material per Package

The plutonium dioxide content is shipped in various types of content containers that can be arranged in various configurations inside the CV. Descriptions of the eleven shipping configurations from the SARP and SARP Addendums 1 and 2 are summarized below.

Shipping Configuration 1—GPHS FCA. The General Purpose Heat Source (GPHS) fueled clad assembly (FCA) is composed of a plutonium dioxide fuel pellet encased in an iridium alloy capsule. The cladding capsule is a two-part shell that, when assembled, completely encapsulates the fuel pellet. 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 – 86 percent of the theoretical density of PuO_2). The pellets are made from a process in which two types of plutonium dioxide powder, high-fired and low-fired, are mixed and pressed. This process yields a stable product with a homogeneous microstructure. The heat load of the FCA is nominally 63 W. The total heat load is limited to 255 W per liner and 500 W per package.

The GPHS FCAs are shipped in 5.75-inches-tall liners. This shipping configuration contains one FCA per product can, and up to four product cans may be placed in a liner. Inside the product cans, a graphite support block is placed on the bottom and top of the FCA, and a graphite filler block is used to fill the excess space. Two graphite cushions are placed between the product can contents and the product can top lid. The product cans used for this shipping configuration have threaded or welded lids. The threaded or welded product can is constructed of Type 304 or 304L stainless steel. The can has a height of 4.25 inches or 4.339 inches and an outside diameter of 2.0 inches. The wall thickness is 0.061 inch. The base and lid of the can have thicknesses of 0.1 inch and 0.35 inch, respectively. The dimensions given are nominal values. When utilizing a product can with a welded lid, a full penetration weld seals the can. Up to four product cans are held in position by a graphite support block to provide spacing and prevent movement. The graphite support block is designed to snugly fit inside the liner to keep the contents in a fixed position during shipment. The graphite support block is machined to form recesses for the product cans. Once assembled, two of the 5.75-inches-tall liners can be placed into the CV with a graphite filler block in between as a spacer to limit movement.

An alternative method of packaging the GPHS FCAs for shipment is to place two FCAs in a product can. However, because the administrative limitation on maximum decay heat loading remains at 255 W or less per 5.75-inches-tall liner, the number of product cans shall be limited to two product cans per liner, and the two product cans shall be placed opposite one another in the graphite support block. Alternatively, one product can containing two FCAs can be shipped in the same liner with two product cans containing one FCA each. The product can decay heat load for two FCAs is nominally 125 W and is limited to 130 W. The configuration of the GPHS FCAs within the product can is similar whether one or two FCAs are loaded. The only difference is that the second FCA (together with its upper and lower graphite support blocks) is substituted for the graphite filler block used when only a single FCA is loaded per product can. A full penetration weld seals the CV.

Shipping Configuration 2—GPHS GIS. The graphite impact shell (GIS) is made of fine-weave pierced fabric (FWPF) and provides impact protection for two GPHS FCAs. The GIS consists of three pieces: a body, a cap, and a separator. The GPHS GISs are shipped in 5.75-inches-tall liners. Shipping configuration 2 contains one GIS per product can, and a maximum of two product cans are placed in a liner. A GIS containing two FCAs is placed in a single threaded or welded product can. An optional graphite felt pad may be placed on top of the GIS inside the product can to act as a spacer between the GIS and product can lid. The maximum decay heat load is limited to 130 W for the product can and 255 W for the liner. The product cans used for this shipping configuration have threaded or welded lids. The product can is constructed of Type 304 or 304L stainless steel. The can has a height of 4.25 inches or 4.339 inches and an outside diameter of 2.0 inches. The wall thickness is 0.061 inch. The base and lid of the can have thicknesses of 0.1 inch and 0.35 inch, respectively. The dimensions given are nominal values. When utilizing a product can with a welded lid, a full-penetration weld seals the can. The two product cans are held in position by a graphite support block. This provides spacing and limits movement. The two product cans are placed opposite one another in the graphite support block. The graphite support block is designed to snugly fit inside the liner to keep the contents in a fixed position during shipment. The graphite support block is machined to form recesses for the product cans. Once assembled, two of the 5.75-inches-tall liners can be placed into the CV with a graphite filler block in between as a spacer to limit movement. A full-penetration weld seals the CV.

Shipping Configuration 3—GPHS Module. The GPHS module is a component of the radioisotope thermoelectric generator (RTG). The overall dimensions of the module are 2.09 inches by 3.67 inches by 3.83 inches. The GPHS module is a 250 W (nominal) RTG component containing four FCAs. Each FCA is nominally 63 W at the time of pressing. Two of these FCAs are enclosed in a single GIS, which is then enclosed in a carbon-bonded-carbon-fiber (CBCF) insulator sleeve. Two of these GIS assemblies are held in the aeroshell. Lock members are used to locate the modules and to resist lateral loads on the module stack when assembled into the RTG. Layers of CBCF provide thermal insulation for the GPHS module. The GPHS module aeroshell is made of FWPF. The GPHS modules are shipped in 5-inches-tall liners. A GPHS module is held in position by a graphite support block. The graphite support block is designed to snugly fit inside the liner to keep the contents in a fixed position during shipment. The graphite support block is machined to form a recess for the GPHS module. Once assembled, two of the 5-inches-tall liners can be placed into the CV with a graphite filler block in between as a spacer. The maximum decay heat load for a liner is limited to 255 W. A full-penetration weld seals the CV.

Shipping Configuration 4—Domestic Powder. The radioisotopic makeup of the plutonium dioxide powder intended for shipment in the 9516 Package is provided in Table 1. Domestic powder is shipped in 5.75-inches-tall liners. Shipping configuration 4 contains plutonium dioxide powder in up to eight product cans with a maximum of four product cans per liner. The plutonium dioxide powder is first placed inside a threaded powder can, which is a 3.38-inches-tall stainless steel tube with a 1.75 inches outside diameter. The wall thickness of the powder can is 0.1875 inch. The lid and base are 0.1 inch and 0.2 inch thick, respectively. A 0.02-inch-thick copper gasket is used to seal the powder can. The maximum decay heat load is limited to 70 W per product can and 255 W per liner. The product cans used for this shipping configuration have threaded lids. The product can is constructed of Type 304 or 304L stainless steel. The can has a height of 4.25 inches and an outside diameter of 2.0 inches. The wall thickness is 0.061 inch. The base and lid of the can have thicknesses of 0.17 inch and 0.25 inch, respectively. A 0.02-inch-thick copper gasket is used to seal the product can. The dimensions given are nominal values. Up to four product cans are held in position by a graphite support block. This provides spacing and limits movement. The graphite support block is designed to snugly fit inside the liner to keep the contents in a fixed position during shipment. The graphite support block is machined to form recesses for the product cans. Once assembled, two of the 5.75-inches-tall liners can be placed into the CV with a graphite filler block in between as a spacer to limit movement. A full-penetration weld seals the CV.

Shipping Configuration 5—Russian Powder. The radioisotopic makeup of the plutonium dioxide powder intended for shipment in the 9516 Package is provided in Table 1. The values in Table 1 are estimates representing typical concentrations. The actual radioisotopic makeup of the powder is expected to vary somewhat from batch to batch.

Russian powder is shipped in 5.75-inches-tall liners. Shipping Configuration 5 contains Russian plutonium dioxide powder. The Russian plutonium dioxide powder is triple encapsulated before loading it into the liner. The plutonium dioxide powder is placed in a threaded ampule, surrounded by a welded capsule, and then placed on a grade WDF felt cushion inside a Russian (welded) product can and sealed as shown in Figure 1-17 of the SARP. The overall height of the assembly is 4.51 inches, and the outside diameter is 1.5 inches. The maximum decay heat load is limited to 70 W per product can and 255 W per liner. The Russian powder can also be shipped in the domestic powder shipping configuration.

Up to four Russian product cans are held in position by a graphite support block. This provides spacing and limits movement. The graphite support block is designed to snugly fit inside the 5.75-inches-tall liner to keep the contents in a fixed position during shipment. The graphite support block is machined to form recesses for the product cans. Once assembled, two of the 5.75-inches-tall liners can be placed into the CV with a graphite filler block in-between as a spacer to limit movement. A full-penetration weld seals the CV. Drawings detailing the safety features of the containment system, including welding and inspection requirements for all components, are included in Appendix 1.3.2 of the SARP.

Shipping Configuration 6 —Generic Contents. The generic content for the 9516 Package consists of plutonium dioxide in any solid form; e.g., powder, pellets, granules, etc. The plutonium dioxide shall meet the initial isotopic limits shown in Table 1, and the maximum neutron emission rate for a loaded CV shall not exceed 15.87 x 10^6 neutrons/s. The total heat load of the contents shall be limited to 500 W, which is approximately 1110 g of a combination of the ^{233}U, ^{235}U, ^{238}Pu, ^{239}Pu, and ^{241}Pu isotopes.

The plutonium dioxide 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. The liner(s) is contained in the CV and a graphite filler block(s) is used as a spacer to limit movement. The generic contents and dunnage configuration shall be designed to distribute the heat load in a uniform manner inside the package.

Shipping Configuration 7—FSO Container. Up to 175 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 W, for a total of 140 W per package when the maximum of two FSO containers are shipped.

Shipping Configuration 8—GPHS FCA with ORNL Plutonium Dioxide (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 – 86 percent of the theoretical density of PuO_2). The maximum amount of plutonium in the CV is limited to 1000 g, 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 W. The total heat load is limited to 255 W per liner and 350 W per package.

Shipping Configuration 9— Large Containers with PuO_2 Powder. PuO_2 powder for Shipping Configuration 9 is packaged in Large Containers that are constructed of a Hastelloy C-276 equivalent. Each Large Container has a maximum total plutonium mass of 453 g. The Large Container is a welded enclosure. Each Large Container is overpacked in an unsealed large can (Drawing SKNEN2-5663). Two Large Containers are loaded in each CV. Various graphite support and filler blocks, and stainless steel spacers are used to position the contents within the CV. The internal component arrangements in the CV is shown in Figure 1-1 of SARP Addendum 2. The maximum amount of plutonium in the CV is limited to 1000 g, which limits the number of Large Containers with PuO_2 Powder to two. The heat load of a Large Container with PuO_2 powder is nominally 205 W. The total heat load is limited to 210 W per Large Container and 420 W per package.

Shipping Configuration 10— Medium Overpack Containers and Small Containers with PuO_2 Powder. The PuO_2 powder for Shipping Configuration 10 is packaged in Small Containers that are constructed of a Hastelloy C-276 equivalent. Each Small Container has a maximum total plutonium mass of 194 g. A Small Container may also be overpacked in a Medium Overpack Container. The Small Container and Medium Overpack Container are welded enclosures. Each Small Container or Medium Overpack Container is overpacked in an unsealed can (Drawings SKNEN2-5665 or SKNEN2-5664, respectively). Two Small Cans and one <u>or</u> two Medium Overpack Containers are loaded in each CV. Various graphite support and filler blocks, and stainless steel spacers are used to position the contents within the CV. The internal component arrangements in the CV are shown in Figures 1-2 and 1-3 of SARP Addendum 2. The heat load of a Small Container or Medium Overpack Container with PuO_2 powder is nominally 86 W. The total heat load is limited to 90 W per container and 360 W per package.

Shipping Configuration 11— Medium Overpack Containers with PuO_2 Powder. The PuO_2 powder for Shipping Configuration 11 is packaged in Small Containers that are constructed of a Hastelloy C-276 equivalent. Each Small Container has a maximum total plutonium mass of 194 g. Each Small Container is overpacked in a Medium Overpack Container. The Small Container and Medium Overpack Container are welded enclosures. Each Medium Overpack Container is overpacked in an unsealed can (Drawing SKNEN2-5664). Three Medium Overpack Containers are loaded in each CV. Various graphite support and filler blocks, and stainless steel spacers are used to position the contents within the CV. The internal component arrangement in the CV is shown in Figure 1-4 of SARP Addendum 2. The heat load of a Medium Overpack Container with PuO_2 powder is nominally 86 W. The total heat load is limited to 90 W per container and 270 W per package.

(c) Minimum Transport Index for Criticality Control (Criticality Safety Index): 0.0

(d) Conditions:

(1) Transport shall be by exclusive use.

(2) Due to the potential for helium off-gassing, the plutonium dioxide contents shall be shipped within a specified time period after the plutonium dioxide is processed to ensure the NCT CV pressure limit is not exceeded. Depending on the content for Shipping Configurations 1 through 6 and 8, the maximum age the processed plutonium dioxide can be at the end of a shipment ranges from 61 to 405 months as shown in Table 3-13 of the SARP. The maximum allowable age at the end of the shipping period for the FSO container (Shipping Configuration 7) with ORNL PuO_2 is 405 months (SARP Addendum 1). The maximum allowable age of PuO_2 powder at the end of the shipping period for Shipping Configurations 9 - 11 is 23.15, 25.00, and 32.91 years, respectively (SARP Addendum 2).

The maximum allowable fuel age for configurations not addressed in SARP Table 3-13 shall be determined following the methodology in Chapter 3, Section 3.3.2.2 of the SARP.

(3) Except for shipments made under the auspices of the Office of Secure Transportation, under the conditions provided in Chapter 7 of the SARP and Addendums 1 or 2, or except as provided in Condition 5.(d)(5), the 9516 Package shall not be shipped in an enclosed space that impedes natural convection heat transfer with the atmosphere.

(4) The 9516 Package shall not be covered with a tarpaulin or other material that impedes natural convection heat transfer with the atmosphere.

(5) Cargo containers 8 feet x 8 feet x 20 feet in size, made of metal (except for the flooring) single wall construction, uninsulated, and with at least 1.5 inches flooring, may transport up to three 9516 packages containing no more than 500 W of plutonium oxide powder each. The packages must be spaced apart by a distance of at least 68 inches from the centerline of one package to the next package and the external surface of the cargo container must be 96 inches or more from the normally occupied space. Each package shall be positioned on the centerline of the cargo container floor as shown in Figure 5-7 of the SARP. In land transport, all surfaces of the cargo container (except its bottom) must be fully exposed to the ambient air. In sea transport, the cargo container must be in the top layer of the on-deck stacks with at least 2 foot clearance on both long sides of the container from other cargo containers and ship structure.

(6) The 9516 Package shall not be used to transport plutonium by air.

(7) In accordance with 49 CFR 173.441(b)(4), the land transport crew shall wear radiation dosimetry devices and operate under provisions of a regulated radiation protection program. In sea transport the external surface of the cargo container shall be 8 feet or more from normally occupied positions.

(8) In addition to the requirements of Subparts G and H of 10 CFR Part 71, each packaging shall be fabricated, acceptance tested, operated, and maintained in accordance with the Operating Procedures requirements of Chapter 7, Acceptance Tests and Maintenance Program requirements of Chapter 8, and packaging-specific Quality Assurance requirements of Chapter 9 of the SARP, as supplemented by Addendums 1 and 2.

(9) Shipments made under the auspices of the Office of Secure Transportation shall be made in accordance with the requirements specified in the latest revision to the Technical Manual DOE SNL TYPEBARG REV2 CHNG 0, “Tiedown Procedure for Type-A, Type-B, ARG and

Miscellaneous Containers Transported in Safeguards Transporter (SGT)," March 2012.

(10) Revisions 6 and 7 of this certificate may be used until April 30, 2022.

(11) Only DOE elements or persons working under contract to DOE elements shall consign the package for shipment.

(12) Nuclear Regulatory Commission (NRC) or Agreement State licensees shall not consign a DOE certified package for shipment but can transfer the material on-site to DOE elements or persons working under contract to DOE elements for consignment of the package.

(e) Supplements

(1) Safety Analysis Report for Packaging (SARP) for the 9516 Package, Addendum No. 1, R1033-0065-ES, Revision 1, January 2020.

(2) Safety Analysis Report for Packaging (SARP) for the 9516 Package, R1033-0062-ES, Revision 3, April 2021.

(3) Safety Analysis Report for Packaging (SARP) for the 9516 Package, Addendum No. 2, R1033-0067-ES, Revision 0, April 2021.