



Department of Energy

Washington, DC 20585

April 25, 2024

MEMORANDUM FOR MICHAEL D. BUDNEY
MANAGER

SAVANNAH RIVER OPERATIONS OFFICE

FROM:

JULIA C. SHENK

Julia C. Shenk

Digitally signed by Julia C. Shenk
Date: 2024.04.25 09:34:48 -04'00'

HEADQUARTERS CERTIFYING OFFICIAL
DIRECTOR

OFFICE OF PACKAGING AND TRANSPORTATION

SUBJECT:

Renewal of Department of Energy Certificate of Compliance Number
9978

In response to the January 29, 2024, email request from Luke Sobus, Savannah River Operations Office, Department of Energy (DOE) Certificate of the Compliance (CoC) Number 9978, Revision 6, for the Model 9978 package is issued for renewal with its Safety Evaluation Report. Changes to the CoC are indicated by vertical bars in the right page margin.

This CoC is issued by DOE under the authority of 49 CFR 173.7(d) and is conditional upon fulfilling the applicable Operational and Quality requirements of 49 CFR Parts 100-199 and 10 CFR Part 71, and the conditions specified in Item 5 of the CoC.

The expiration date of the certificate is April 30, 2029.

If you have any questions, please contact me or the Docket Manager at (803) 645-3490 or lawrence.gelder@em.doe.gov

Attachments

cc: Luke Sobus, SR
Matthew Howard, SRNL
Docket 24-14-9978



**CERTIFICATE OF COMPLIANCE
For Radioactive Materials Package**

1a. Certificate Number	1b. Revision No.	1c. Package Identification No.	1d. Page No.	1e. Total No. Pages
9978	6	USA/9978/B(M)F-96 (DOE)	1	17

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):

U.S. Department of Energy
Savannah River Operations
Office
P.O. Box A
Aiken, SC 29808

(2) Title and identification of report or application:

Safety Analysis Report for Packaging
Model 9978, S-SARP-G-00002, Revision 3, as
supplemented [see 5(e)]

(3) Date:

March 2023

4. CONDITIONS

This certificate is conditional upon 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 Number: 9978

(2) Description

The 9978 is designed to ship radioactive contents in DOE-STD-3013 containers, food-pack cans, Engineered Containers, and Isentropic Compression Experiment (ICE) Container Assemblies. The components of the package include the insulated drum, Containment Vessel (CV), Load Distribution Fixtures (LDFs), spacers, contents, and containers. The maximum weight of the packaging is 235.7 lb., with a maximum payload of 50 lb., and a maximum gross weight of 285 lb.

The nominal 35-gallon drum design meets the performance requirements of 49 CFR 178 for an open-head drum, but is modified with a bolted-flange closure. The closure does not incorporate a gasket. The drum body is a closed unit consisting of a shell, top plate, reinforcing rim (vertical flange), and a liner assembly, with the volume between the liner assembly and drum shell filled with shock-absorbing thermal-insulating materials. The drum shell and liner are fabricated of 18-gauge (0.048-inch) Type 304L stainless steel (SS). The drum shell incorporates a "sanitary" style drum bottom which incorporates a radiused edge, which is butt welded to the side wall. The drum bottom includes a rolled 16 gauge "wear ring," $\frac{3}{4}$ -inch inside diameter (ID), attached by welds that are external to the drum shell. The drum's top plate is fabricated of $\frac{3}{16}$ -inch thick Type

6a. Date of Issuance: April 25, 2024

6b. Expiration Date: April 30, 2029

FOR THE U.S. DEPARTMENT OF ENERGY

7a. Address (of DOE Issuing Office)

U.S. Department of Energy
Office of Packaging and Transportation (EM-4.24)
1000 Independence Avenue, SW
Washington, DC 20585

7b. Signature, Name, and Title (of DOE Approving Official)

Julia C. Shenk Digitally signed by Julia C. Shenk
Date: 2024.04.25 09:31:59 -04'00'
Julia C. Shenk
Headquarters Certifying Official
Director
Office of Packaging and Transportation

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304L SS plate. Welded to the top plate, the liner centers the package contents and isolates them from the insulation materials. The top portion of the drum incorporates a $\frac{3}{16}$ -inch thick reinforcing rim (vertical flange), which reinforces the drum head, and protects both the closure lid and the bolts during Hypothetical Accident Condition (HAC) events. The rim includes eight (8) 1-inch diameter drain holes that are qualified as package lifting and tie-down points. Drum construction details are shown on drawings R-R2-G-00044 and R-R2-G-00045. As applicable, the drum is designed, analyzed, and fabricated in accordance with Section III, Subsection NF of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME B&PVC), as listed in Table 9.6 of the Safety Analysis Report for Packaging (SARP).

Four (4) $\frac{3}{4}$ -inch diameter vent holes are drilled at locations around the drum, approximately 90 degrees apart and at each of three (3) elevations, for a total of twelve (12) vent holes along the drum sidewall. Five (5) additional holes, two (2) 1-inch diameter fill holes, and three (3) $\frac{1}{4}$ -inch diameter vent holes are drilled into the drum bottom. All of the holes are covered with appropriately sized Caplug® fusible plastic plugs. During an HAC fire event, the plugs combust or melt, allowing the drum to vent gases generated by intumescent foam insulation. The vent holes ensure that the drum cannot be ruptured by gas pressure.

The drum closure lid is fabricated from $\frac{1}{8}$ -inch thick Type 304L SS plate. Eight (8) $\frac{5}{8}$ -inch by $1\frac{1}{4}$ -inch long heavy hex-head bolts with $\frac{5}{8}$ -inch plain, narrow Type B washers secure the lid to the top plate of the drum body. The closure lid incorporates chambers, above and below the Lid Plate, filled with shock-absorbing, thermal-insulating materials. The Lid Top and Lid Bottom chambers are fabricated of 18-gage (0.048-inch) and 14-gage (0.075-inch) Type 304L SS, respectively. The top of the Lid Top is approximately 0.275 inches below the top surface of the drum-head reinforcing rim. The Lid Top and Bottom chambers reinforce the Lid Plate and provide additional thermal protection and shock absorption for the containment vessel. Four (4) $\frac{1}{4}$ -inch diameter holes through the Lid Plate allow the Lid Top and Lid Bottom volumes to exchange gases and equilibrate pressure. The Lid Top chamber is vented by four (4) $\frac{1}{4}$ -inch diameter holes also covered with Caplug® fusible plastic plugs. The Caplugs® prevent water from entering the lid through the vent holes under Normal Conditions of Transport (NCT). In an HAC fire event, the plugs combust or melt, allowing the lid to vent heated air from the Lid Top and Lid Bottom chambers.

To simplify drum-closure operations, the threaded inserts that receive the drum-closure bolts are welded to the underside of the drum's top plate. During installation, the bolts are tightened to a torque value of 45 (± 5) ft-lb. The bolt heads are drilled through with a 0.094-inch hole to receive tamper-indicating devices (TIDs). Details are shown in Drawing R-R1-G-00021.

Two (2) layers of insulation material fill the volume between the drum liner and shell. First, two (2) $\frac{1}{2}$ -inch thick blankets of Fiberfrax® insulation are wrapped around and attached to the sides and bottom of the liner. The Fiberfrax® is backed on both sides with fiberglass cloth held in place by fiberglass thread stitched longitudinally at four (4) inch intervals. The fiberglass cloth gives the Fiberfrax® composite both mechanical strength and wear resistance, and helps retard gas flow during an HAC fire event. The remaining volume between the Fiberfrax® and the drum wall is filled with General Plastics FR-3716 polyurethane foam (also known as Last A Foam®), poured through fill holes in the drum bottom and foamed in place. The nominal densities of Fiberfrax® and FR-3716 foam are 7-to-10 lb./ft³ and 16 lb./ft³, respectively. The thermal and physical properties of Last A Foam® and Fiberfrax® are listed in Tables 2.10, 2.11, and 3.8 of the SARP. The combined thickness of the two insulators is approximately 4.95 inches radially (i.e., between the liner and the drum shell), and approximately 4.52 inches axially (i.e., between the liner bottom and drum bottom). The insulation is illustrated in Figures 1.1 through 1.3, and the details are shown in Drawings R-R1-G-00021 and R-R2-G-00046.

The closure lid incorporates two chambers of insulation. The Lid Top chamber contains a 1-inch thick, 14-inch diameter disk of Thermal Ceramics Min K® 2000 insulation. The Lid Bottom

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chamber contains a rigid disk of Thermal Ceramics TR-19 Block insulation, 4.3-inches thick by 8-inches in diameter. When installed, this disk compresses two (2) 8-inch diameter by ½-inch thick blankets of Fiberfrax® insulation to a total thickness of ½ inch. The total axial thickness of the Lid Bottom chamber insulation is approximately 5.75 inches. Details are shown in Drawing R-R2-G-00045.

The 9978 is designed with a CV with a nominal ID of five (5) inches (5CV). The 5CV is a SS pressure vessel designed, analyzed, fabricated, and examined in accordance with Section III, Subsection NB of the ASME B&PV Code, with design conditions of 900 psig at 300°F, as listed in Table 9.5 of the SARP. The 5CV is fabricated from 5-inch, Schedule 40, seamless, Type 304L SS pipe (0.258-inch nominal wall), with a corresponding standard Schedule 40 Type 304L SS pipe cap (also 0.258-inch nominal wall) welded to the pipe to form a blind end. A stayed head is machined from a Type 304L SS bar and welded to the open end of the pipe segment, completing the vessel body weldment. The head is machined to include 5½-12UN-2B internal threads and an internal cone-seal surface with a 32-micro-inch finish. Both vessel body joints are Category B, with full penetration, complete fusion, circumferential welds. A support skirt to stand the 5CV vertically is formed from a short segment of 4-inch, Schedule 40, Type 304L SS pipe welded to the convex side of the cap. Two (2) rectangular notches milled into the bottom edge of the skirt (180 degree apart) can engage a rectangular key to prevent vessel rotation during removal and installation of the Cone-Seal Closure.

The 5CV Closure Assembly consists of a Type 304L SS Cone-Seal Plug, shaped in part like a truncated cone, and a threaded Cone-Seal Nut made from Nitronic 60 SS. The two (2) Closure Assembly components rotate freely relative to one another, and are coupled by a snap-ring that also ensures unseating of the closure seal during disassembly. As the Cone-Seal Nut is threaded into the stayed head of the vessel, the Cone-Seal Plug is thrust axially against the corresponding cone-seal surface of the vessel. Both internal and external sealing surfaces are machined to the same angles, surface finishes, and with matched diameters so that they mate with essentially zero clearance. To minimize the potential for thread galling, the Cone-Seal Nut and the containment vessel body are made from dissimilar materials. Two (2) O-ring grooves (Outer and Inner) are machined in the face of the external Cone-Seal Plug finish, as shown in Figure 1.4 of the SARP. Viton® GLT/GLT-S O-rings fit into these grooves to complete the leaktight closure assembly.

For operator safety, a 0.094-inch diameter vent hole is located in the stayed head between the threads and the internal sealing surface. The vent hole is clocked 90 degrees from the notches in the vessel support skirt. Unscrewing the Cone-Seal Nut a few turns will unseat the Cone-Seal Plug from the internal cone-seal surface and route any pressurized gases from the 5CV through the vent hole.

A leak-test port is incorporated into the Cone-Seal Plug and connected by a drilled radial passage to the annular volume between the two O-ring grooves in Cone-Seal Plug. The leak-test port provides a means of verifying proper assembly of the vessel closure, and is itself closed by the Leak-Test Port Plug. The vessel containment boundary is formed by the vessel body, the Cone-Seal Plug, the Leak-Test Port Plug, and the Outer O-ring.

The internal volume of a closed 5CV is approximately 313 cubic inches. The nominal assembly weight is 32.3 lb., and the nominal overall length is 18.64 inches. The usable cavity of the 5CV is a minimum of 15-inches deep with a minimum diameter of 5.02 inches. Details are shown in Drawing R-R2-G-00043.

The Top and Bottom LDFs are made from 6061 T6 aluminum round bar and fit within the Drum Liner cavity, above and below the 5CV. Aluminum honeycomb Spacers (discussed in Section 1.2.1.7 of the SARP) fill the volume between 5CV and the LDFs. The LDFs and honeycomb Spacers center the 5CV in the liner, stiffen the package in the radial direction, and

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distribute loads away from the 5CV. Details are shown in Drawings R-R4-G-00033 and R-R4-G-00034.

The 9978 is evaluated for shipment of radioactive contents as identified as Content Envelopes C.1 through C.6 and S.1 through S.5 defined in Table 1. The contents are in solid form as metal pieces or oxides. Contents in liquid form are not permitted. (Note: Content Envelope C.3 is currently reserved for future use.) The radionuclide mass limits are specified for Content Envelopes C.1 through C.5 as a weight percentage of the total mass of radioactive materials. For Content Envelopes C.6 and S.1 through S.5 the radionuclides are limited by mass. In every C.6 shipment, all the radioisotopes may be present and the Content is analyzed in the SARP as a sum of the masses listed. These contents are shipped in 3013 storage containers, food-pack cans, Engineered Containers, and ICE Container Assemblies.

Plutonium metal or oxide contents targeted for long-term storage must meet DOE-STD-3013. The 3013 configuration requires a series of nested containers designed specifically for long-term storage. These include a 3013 outer storage can, a 3013 inner storage can, and optional material container(s). The 3013 inner storage can and material containers are often site-specific designs. Various 3013 inner and material containers are acceptable, provided the general requirements listed in Section 1.2.2 of the SARP are satisfied, and the requirements below are fulfilled:

- The Reference 3013 outer storage can must be used;
- The 3013 inner and product containers meet the requirements of DOE-STD-3013, Section 6.2, Containers;
- The 3013 inner and material containers must not include organic liners; and
- A perforated food-pack can must be placed above the 3013 to consume the otherwise open axial space.

The term “food-pack” can includes metal cans with crimped-seal closures, “slip-lid” closures, or site-specific “convenience containers.” Crimp-sealed food-pack cans are typically fabricated in accordance with Federal Specification PPP-C-96E, or equivalent, and meet the size specification as defined by the Can Manufacturers Institute (CMI) Voluntary Can and End Dimension Reference Manual. Convenience containers are typically application-specific designs that incorporate screw thread, crimp sealed, or welded closures. These three types of cans are typically made from tin-plated mild steel or stainless steel.

Actinide metals, oxides, and other materials may be placed inside food-pack cans prior to placing items in the packaging. If not part of a 3013-qualified storage plan, an elastomeric gasket material or polyvinyl chloride tape may be applied to the edge of the can lid. The seal material may limit the spread of contamination, but is not credited for any measure of containment within the package.

The can containing the radioactive material is typically placed inside low-density polyethylene or nylon bagging for contamination control. Multiple bags may be present, up to the mass limit for plastics. The bagged inner can is typically then nested within one or more outer cans. The nested assemblies are then placed within the 5CV.

Nesting of food-pack cans is not required (i.e., a single food-pack can is allowed). Aluminum dunnage (peanuts, foil, or wool) may be used to minimize vibration and movement of the can during shipment. Food-pack cans may be arranged for handling convenience and contamination control into single, double, or triple-stacked configurations, provided the general requirements listed in Section 1.2.2 of the SARP are satisfied.

The term “engineered container” includes metal sample containers, “sealed” sources, and site-specific containers that are typically application-specific designs incorporating screw thread, “slip-lid”, crimp-sealed, or welded closures. These three types of cans are typically made from

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plated mild steel or stainless steel. In order to be certified as a "Sealed Sources," the design must be performance tested either as "special form" per 49 CFR 173.469, or as "sealed sources" under ANSI N43.6. Since the 5CV provides containment for all contents, these containers are neither credited nor required to be sealed.

The engineered container with its radioactive contents may be placed inside low-density polyethylene or nylon bagging for contamination control. Multiple bags may be present, up to the mass limit for plastics. The engineered container may be placed directly or may be placed into a food-pack can prior to placement in the packaging. An elastomeric gasket material or polyvinyl chloride tape may be applied to the edge of the can lid. The seal material may limit the spread of contamination, but is not credited for any measure of containment within the package.

Dunnage of aluminum peanuts, foil, or wool, or steel peanuts, foil, or wool may be used to minimize vibration and movement of the contents during shipment, provided the general requirements listed in Section 1.2.2 of the SARP are satisfied.

The Isentropic Compression Experiment (ICE) Special Nuclear Material (SNM) Target Container Assembly consists of an ICE Target in a Transport Container Assembly. The Transport Container Assembly consists of an assembled ICE Target, secured to a SS Platform, attached to a SS Canister Body, and topped with a SS Anode Mount. A lifting handle is mounted on top of the ICE Container. Armaflex SA foam (a nitrile-PVC blend) is used for cushioning and to center the ICE Container within the 5CV. The ICE Assembly components are defined in the drawings shown in Section 5(3), below.

The ICE Target is assembled at LANL into its final configuration with all SNM samples glued and double sealed inside counterbores machined into aluminum panels. The primary seal is a transparent material (typically LiF), approximately 3 to 6 mm thick, glued into place on top of the SNM sample with an epoxy. The secondary seal is a metallic diagnostic probe holder glued into place above the sample assembly. The flex lines connected to this volume are closed in transit.

ICE SNM experiments are limited to 8.0 grams of ^{239}Pu , or its dose equivalent. The dose equivalent content with the greatest decay heat rate is of 0.0283 grams of ^{238}Pu , with 16×10^{-3} Watts.

An assembled ICE Target (panels, diagnostic mounts, flexible vent lines, windows, and samples) weighs approximately 1,375 grams. The empty Transport canister weighs approximately 7,500 grams. The total Armaflex mass is approximately 75 grams. The total system mass is approximately 8,950 grams (20 lb.). The configuration and mass of spacers used may vary, provided the general requirements listed in Section 1.2.2 of the SARP are satisfied.

The New Brunswick Laboratory Pu/Am standards S.1 through S.5 are gram quantities of Pu metals, Am metals, Pu oxides or Pu sulfate tetrahydrates confined in glass tubes, vials, or and bottles. These standards must be packaged in a plastic bagging for contamination control, and then may be overpacked in an authorized food-pack can (optional) prior to loading in a one- or two-quart SAVY™ 4000 container (i.e., engineered container). The nested loading configurations for the standards are defined Sections 1.2.2.1.6 and 1.2.2.2.5 of the SARP.

Neither the 9978 materials nor the component geometry provides significant radiation shielding. Dose rate attenuation is provided primarily by the distance between the source and points external to the package.

The 9978 design does not incorporate materials specifically for the purpose of poisoning or moderating neutron radiation. Subcriticality is ensured by limiting package contents and by crediting the packaging as a means of maintaining a minimum distance between adjacent fissile material sources.

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Option to use the radiofrequency identification (RFID) system: The option to use the RFID system is justified by Supplement 5(e)(1) to be within the existing safety basis. The RFID guide Supplement 5(e)(2), provides procedures for installing the DOE MK-II RFID tag to the 9978 package. The DOE MK-II RFID tag is not considered a part of the package. DOE MK-II RFID tags are equipped with a suite of sensors: seal integrity, temperature, humidity, shock, and battery status. The seal sensor is a thin flexible membrane that sits under the flange bolts of the drum cover when installed. The DOE MK-II RFID tag has a robust plastic front cover and the SS backplate provides adequate protection of the tag against damage under normal handling and transport. The tag weighs approximately 2.4 lb. (with four batteries) and is approximately 8 inches wide x 7 inches high x 1.5 inches tall. Appendix B of the RFID guide provides documentation that the batteries used in the DOE MK-II RFID tag are not subject to the hazardous material regulations and also contains the Material/Product Safety Data Sheet for the batteries.

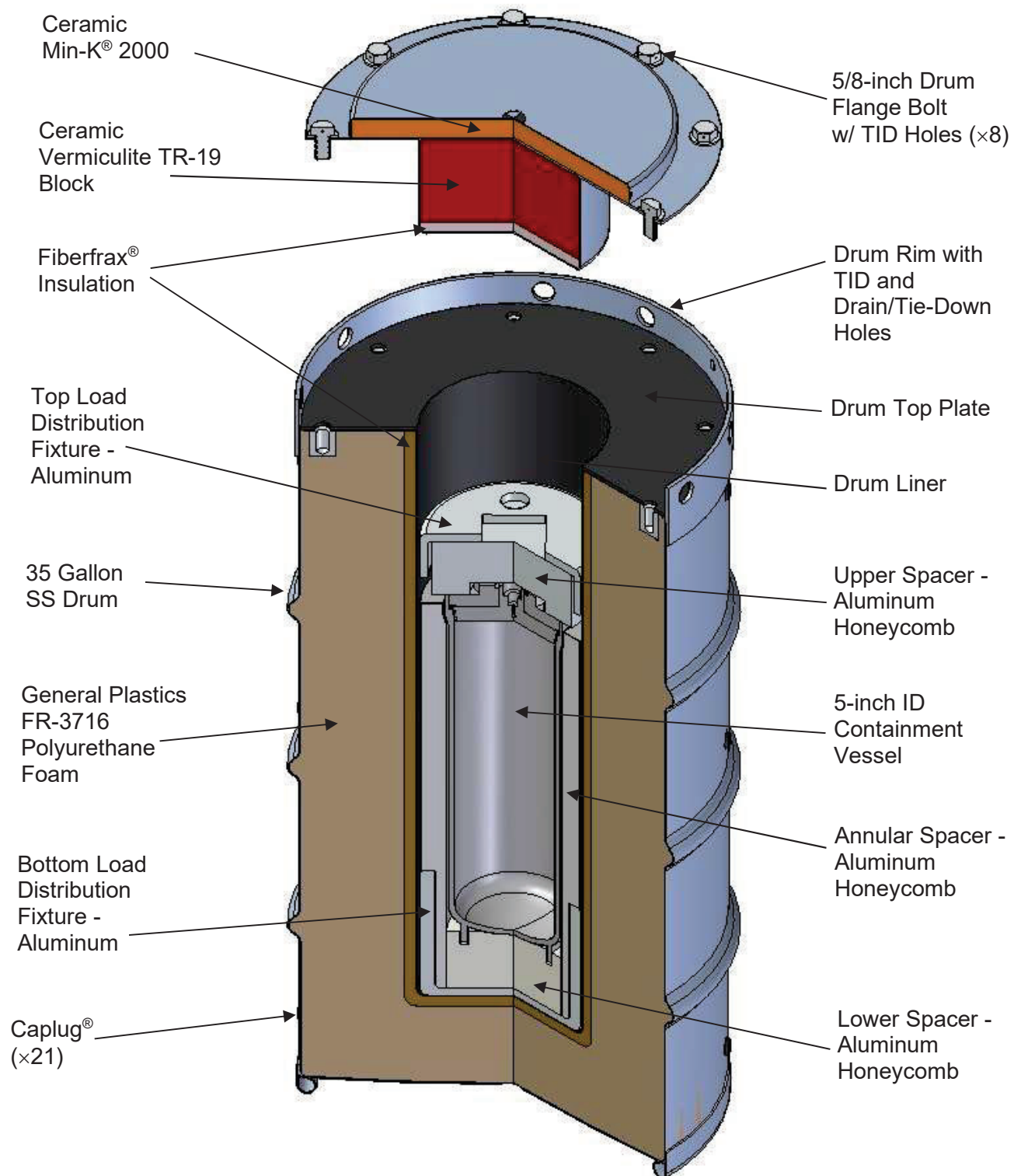


Figure 1 — Three-Dimensional Cut Away Illustration of the 9978

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(3) Drawings

The 9978 Packaging design is defined by the following Savannah River Site drawings:

Drawing Number	Revision Number	Title
R-R5-G-00003	0	9978-General Purpose Fissile Packaging Drawing Tree (U)
R-R1-G-00021	4	9978-General Purpose Fissile Packaging Assembly with 5-inch Diameter Containment Vessel (U)
R-R4-G-00033	5	9978-General Purpose Fissile Packaging Spacer Part Details for Five Inch Containment Vessel (U)
R-R4-G-00034	0	9978-General Purpose Fissile Packaging Load Distribution Fixture Details (U)
R-R2-G-00043	3	9978-General Purpose Fissile Packaging Five Inch Diameter Containment Vessel (CV) Subassembly (U)
R-R2-G-00044	1	9978-General Purpose Fissile Packaging Drum and Liner Subassembly (U)
R-R2-G-00045	0	9978-General Purpose Fissile Packaging Drum Lid Subassembly (U)
R-R2-G-00046	0	9978-General Purpose Fissile Packaging Insulation Blanket Subassembly (U)

The ICE Container Assembly is defined by the following Los Alamos drawings:

Number	Drawing or Part	Title
R83700	D	LANL Transport Container Assembly
1001-0269-0000	D	Platform, Pu Anode, Inner
1103-0355-0000	D	Panel, ICE, Floor
1103-0388-0000	D	Panel, 17mm Spacer, ICE
1103-0389-0000	D	Plug, Panel, 17mm Spacer
1350-2333-0000	D	Fitting, 1/8 to 1/8, Custom
1350-2357-0000	D	90° Adapter Fitting
1350-2495-0000	D	Probe Nut
1350-2496-0000	D	Mount, Probe Body, 3-Point
R83710	D	Transport Container Handle
R83711	D	Transport Container Anode Mount
R83712	D	Transport Canister Body
R83722	D	Transport Container Strain Relief
2-045	P	Viton® O-Ring
502-440-716-AAA2	P	Socket Head Cap Screw, alloy steel
502-1420-1-AAA2	P	Socket Head Cap Screw, alloy steel

(b) Contents:

(1) Type and Form of Radioactive Material

Package contents are identified as Content Envelope C.1 through C.6 and S.1 through S.5 and are defined in Table 1. Table 2 provides a summary of the requirements by content and configuration. All contents are in solid form, as metal pieces or oxides. Contents in liquid form are not permitted.

Table 1—Content Envelopes

(Note: Contents C.1 through C.5 radioisotope limits are specified by weight percent of total mass, C.6 in grams)

	Material ^{b, o}	C.1 ²³⁸ Pu Heat Sources (weight %)	C.2 ^c Pu/U Metal (weight %)	C.3 ^a (Reserved)	C.4 ^{e, f} U Metal or Alloy (weight %)	C.5 ^{g, h, i} U Compounds (weight %)	C.6 Samples & Sources (grams)
Radioisotope	²³⁸ Pu	100	2		-	-	3.5
	²³⁹ Pu ^k	40 ^q	100 ^q		-	-	190 ^q
	²⁴⁰ Pu ^l	13	25		-	-	25
	²⁴¹ Pu ^k	1	15		-	-	1
	²⁴² Pu	1.5	5		-	-	10
	²⁴¹ Am		15		-	-	3
	²⁴³ Am		-		-	-	6.63
	²⁵² Cf		-		-	-	2.6 × 10 ⁻⁷
	²⁴⁸ Cm		-		-	-	5.7 × 10 ⁻⁶
	²³⁷ Np	0.5	-		-	-	10
	²³² Th	10	-		-	-	10,000
	²³² U ^k	1.4 × 10 ⁻⁴	1 × 10 ⁻⁷		-	-	
	²³³ U ^k	0.2	0.5		-	-	
	²³⁴ U	40	100		-	-	1
	²³⁵ U ^k	40	100		100	100	500
	²³⁶ U	16	40		-	-	1
	²³⁸ U	40	100		-	-	2,000
Impurities	(unit) →	(gram)	(gram)	(gram)	(gram)	(gram)	(ppm)
	Be		-		-	-	1,500
	Al		-		-	-	150
	Mg		-		-	-	500
	Na		-		-	-	300
	F		-		-	-	200
	Ca	15	-		-	-	-
	Fe	5	-		-	-	-
	Cr	2	-		-	-	-
Total Mass (kg)	Radioactive Materials	0.1	4.4		13.5	4.4	12.75
	Impurities	0.02	3.08 ^{m, n}		-	-	0.034
	All Contents	0.1	4.4		13.5	4.4	12.78

Table 1—Content Envelopes (cont.)

(Note: Contents S.1 through S.5 radioisotopes specified in grams)

	Material ^{b, p}	S.1 Pu Sulfate & Oxides	S.2 Pu Sulfate	S.3 Pu Sulfate	S.4 Pu Metal	S.5 Am Metal
Radioisotope	²³⁸ Pu	4.66×10 ⁻³	1.93×10 ⁻²	1.43×10 ⁻²	1.01×10 ⁻³	-
	²³⁹ Pu ^k	7.84	5.31	5.02	9.57	-
	²⁴⁰ Pu ^l	1.04	1.12	0.991	0.516	-
	²⁴¹ Pu ^k	8.37×10 ⁻²	0.327	0.244	1.23×10 ⁻²	-
	²⁴² Pu	1.63×10 ⁻²	6.83×10 ⁻²	5.68×10 ⁻²	2.95×10 ⁻³	-
	²⁴¹ Am	-	-	-	-	0.769
	²⁴³ Am	-	-	-	-	0.759
Impurities	(unit) →	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
	Be	1,500	1,500	1,500	1,500	1,500
	Al	150	150	150	150	150
	Mg	500	500	500	500	500
	Na	300	300	300	300	300
	F	200	200	200	200	200
	(SO ₄) ₂ ·4H ₂ O	530,000	530,000	530,000	-	-
Total Mass (grams)	Radioactive Materials	8.95	6.81	6.29	10.1	1.528
	Impurities	0.034	0.034	0.034	0.034	0.034
	All Contents	8.98	6.84	6.32	10.1	1.562

Table 1 Notes:

- a Reserved
- b All contents shall be dry
- c Pu/U content bulk density shall be no greater than 19.84 g/cc, and no less than 2.0 g/cc
- d Contents shall be stabilized in accordance with DOE-STD-3013, Section 6.1.1.
- e Reserved
- f H/X is the ratio of hydrogen to fissile atoms that can be mixed with the fissile material mass. For this Content H/X = 0.
- g Pieces shall have a specific surface area less than 100 mm²/g. This limit may be implemented by either restricting each piece mass to at least 50 g or by performing calculations and measurements.
- h H/X is the ratio of hydrogen to fissile atoms that can be mixed with the fissile material mass. For this Content H/X ≤ 0.15.
- i The moisture content of the compounds shall be less than 0.5 weight percent of the total content mass.
- j The only fissile compound permitted is uranium oxide. All other fissile compounds are excluded.
- k Nuclide classified as "fissile," per DOE Good Practices Guide, Criticality Safety Good Practices Program, Guide for DOE Nonreactor Nuclear Facilities, DOE G 421.1-1, 3.79 Fissile Nuclide, 8-25-99 (canceled by DOE N 251.93, 11-19-2010).
- l ²⁴⁰Pu shall be greater than ²⁴¹Pu.
- m Less than 0.005 g of (α, n) impurities {aluminum, beryllium, boron, fluorine, lithium, magnesium, and sodium} are permitted.
- n The impurity limit is based on the DOE-STD-3013 requirement that plutonium plus uranium mass shall not be less than 30 weight percent of the total content mass.
- o The maximum radioactive decay heat rate for Content Envelopes C.1 through C.6 is 19 watts.
- p The maximum radioactive decay heat rate for Content Envelopes S.1 through S.5 is 0.093 watts.

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- q Pu may include up to 4.5% gallium as an alloying metal. Pu metals and alloys containing gallium may only be shipped under Content Envelops C1, C2, and C6, where the gallium would be conservatively included with the Pu-239 content mass.

(2) Maximum Quantity of Radioactive Material per Package

- (a) *Envelope C.1, Plutonium 238 Oxide Heat Sources.* In addition to the general requirements listed in Section 1.2.2 of the SARP, and the isotopic and chemical content restrictions in Table 1, the following conditions apply.

A typical food-pack can packing within the 5CV is shown in Figure 1.6 of the SARP. The following conditions apply:

- A total of 100 grams of plastic (as low-density polyethylene, nylon, and/or polyvinyl chloride tape) may be present.
- For ease of handling, small heat sources are typically placed in a slip lid can and then surrounded by aluminum dunnage for packing and heat dissipation. The canned heat source is then loaded into the 5CV with aluminum dunnage to ensure heat transfer and to limit the movement of the can.

A typical Engineered Container configuration within the 5CV is shown in Figure 1.7 of the SARP. The following conditions apply:

- A total of 100 grams of plastic (as low-density polyethylene, nylon, and/or polyvinyl chloride tape) may be present.
- Small heat sources are loaded into the 5CV with aluminum or steel dunnage to ensure heat transfer and to limit the movement of the can content.

- (b) *Envelope C.2, Plutonium and Uranium Metal.* A typical 3013 packing configuration within the 5CV is shown in Figure 1.5 of the SARP. In addition to the general requirements listed in Section 1.2.2 of the SARP, the isotopic and chemical content restrictions in Table 1, and the configuration criteria listed in Section 1.2.2.1.1 of the SARP, a mass threshold applies. If the Pu or combined Pu/U content mass is greater than 3 kg per innermost material container, the following restrictions apply (no additional restrictions apply if the mass is less than 3 kg):

- The sum of the radial wall thicknesses of all cans (convenience can, 3013 inner can, and the 3013 outer can) constituting a 3013 configuration shall not exceed 0.26 inch.
- The sum of the thicknesses (tops and bottoms) of all cans constituting a 3013 configuration shall not exceed 1.77 inches.
- The innermost material container shall be at least 4 inches in diameter and at least 4 inches long (i.e., minimum can size 400 × 400).

A typical food-pack can packing configuration within the 5CV is shown in Figure 1.6 of the SARP. In addition to the general requirements listed in Section 1.2.2 the SARP, the isotopic and chemical content restrictions in Table 1, and the configuration criteria listed in Section 1.2.2.1.2 of the SARP, the following conditions apply:

- A total of 100 grams of plastic (as low-density polyethylene, nylon, and/or polyvinyl chloride tape) may be present;
- Aluminum dunnage packing material is limited to 200 grams.

If the Pu or combined Pu/U content mass is equal to or greater than 3 kg per innermost material container, the following restrictions apply (no additional restrictions apply if the mass is less than 3 kg):

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- The sum of the radial wall thicknesses of all nested cans shall not exceed 0.26 inch.
 - The sum of the thicknesses of the tops and bottoms of all nested cans shall not exceed 1.77 inches.
 - The innermost material container shall be at least 4 inches in diameter and at least 4 inches long (i.e., minimum can size is 400 × 400).
- (c) Envelope C.4 and C.5, *Uranium Metal and Oxides*. The typical food-pack can packing configuration within the 5CV is shown in Figure 1.6 of the SARP. In addition to the general requirements listed in Section 1.2.2 of the SARP, the isotopic and chemical content restrictions in Table 1, and the configuration criteria listed in Section 1.2.2.1.2 of the SARP, the following conditions apply:
- A total of 100 grams of plastic (as low-density polyethylene, nylon, and/or polyvinyl chloride tape) may be present.
 - The aluminum dunnage packing material is limited to 200 grams.
 - The can material is limited to 900 grams.
- (d) Envelope C.6, *Samples and Sources*. The typical food-pack can packing configuration within the 5CV is shown in Figure 1.6 of the SARP. In addition to the general requirements listed in Section 1.2.2 of the SARP, the isotopic and chemical content restrictions in Table 1, and the configuration criteria listed in Section 1.2.2.1.2 of the SARP, the following conditions apply:
- A total of 100 grams of plastic (as low-density polyethylene, nylon, and/or polyvinyl chloride tape) may be present.
 - The aluminum dunnage packing material is limited to 200 grams.
 - The can material is limited to 900 grams.

The typical engineered container configuration within the 5CV is shown in Figure 1.7 of the SARP. In addition to the general requirements listed in Section 1.2.2 of the SARP, the isotopic and chemical content restrictions in Table 1, and the configuration criteria listed in Section 1.2.2.1.3 of the SARP, the following conditions apply:

- A total of 100 grams of plastic (as low-density polyethylene, nylon, and/or polyvinyl chloride tape) may be present.
- The aluminum or steel dunnage packing material is limited to 200 grams.
- The can material is limited to 900 grams.

The ICE Container configuration within the 5CV is shown in Figure 1.8 of the SARP. In addition to the general requirements listed in Section 1.2.2 of the SARP, the isotopic and chemical content restrictions in Table 1, and the configuration criteria listed in Section 1.2.2.1.4 of the SARP, the following conditions apply:

- A maximum of 8 grams of ²³⁹Pu or dose equivalent materials may be shipped.
- A total of 100 grams of plastic may be present as nitrile-PCV foam.

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- (e) Envelopes S.1 through S.5, *New Brunswick Lab (NBL) Pu/Am Standards*. Two of the three Pu/Am standard configurations loaded in a 5CV are shown in Figure 1.9 of the SARP. In addition to the general requirements listed in Section 1.2.2 of the SARP, the isotopic and chemical content restrictions in CoC Table 1 and the configuration criteria listed in Section 1.2.2.1.6 of the SARP, the following conditions apply:
- Co-mingling of standards types S.1 through S.5 is prohibited – only one standard type is authorized per 5CV/package.
 - The total plastic (as low-density polyethylene, butyl rubber, Teflon™, nylon, and/or polyvinyl chloride tape) is limited to 1000 grams.
 - Aluminum dunnage is limited to 200 grams.
 - Steel dunnage is limited to 900 grams.
 - Individual or multiple plastic bagged sources may be first packed into a food pack can or loaded directly into a SAVY™ 4000 container.
 - Content Envelopes S.1 through S.3 may be packaged in a single or two 1-qt SAVY™ 4000 containers, or a single 2-qt SAVY™ 4000 container, for loading in the 5CV.
 - Content Envelopes S.4 or S.5 may only be packaged in single 1-qt or single 2-qt SAVY™ 4000 container, for loading in the 5CV.

Table 2—Summary of Requirements by Content and Configuration

Container Configuration				
Content Envelope	3013	Food-Pack Can	Engineered Containers	ICE Container Assembly
C.1		maximum 100 g plastic	maximum 100 g plastic	
C.2	Ref. 3013 outer can Inner and material cans per DOE-STD-3013 No organic liners Top spacer can required if $\geq 3\text{kg}$ Pu or Pu/U per inner/material can * sum of can walls < 0.26 inches * sum of can tops & bottoms < 1.77 inches * 400 $\times$ 400 or bigger	maximum 100 g plastic maximum 200 g Al dunnage if $\geq 3\text{kg}$ Pu or Pu/U per inner/material can * sum of can walls < 0.26 inches * sum of can tops & bottoms < 1.77 inches * 400 $\times$ 400 or bigger		
C.3	RESERVED			
C.4 & C.5		perforated spacer can used in axial void space maximum 100 g plastic maximum 200 g Al dunnage maximum 900 g can mass		
C.6		perforated spacer can used in axial void space maximum 100 g plastic maximum 200 g Al dunnage maximum 900 g can mass	maximum 100 g plastic maximum 200 g Al or steel dunnage maximum 900 g can mass	maximum 8 g radioactive materials maximum 100 g plastic manufactured per drawings listed
All (C.1 – C.6)	• 19 watts maximum radioactive decay heat rate • less than 1000 ppm other radionuclides (unless otherwise stated) • less than 100 ppm other inorganic impurities with total mass less than 0.1 weight percent (unless otherwise stated) • 50 lb. maximum content weight (radioactive contents, convenience cans, contamination control devices, packing materials, spacers, etc.)			

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Table 2—Summary of Requirements by Content and Configuration (continued)

Content Envelope	Container Configuration	
	Food-Pack Can	Engineered Containers
S.1 – S.3	Use of a Food-pack can is <u>optional</u> and if used, must be overpacked a SAVY™ 4000 container. Limits are:	SAVY™ 4000 container(s) Limits are: - Maximum plastic (as lowdensity polyethylene, butyl rubber, Teflon™, nylon, and/or polyvinyl chloride tape) is limited to 1000 grams with or without a Food-pack can. - Maximum 200 grams of aluminum dunnage - Maximum 900 gram can mass - One or two 1-qt SAVY™ 4000 containers, or one 2-qt. SAVY™ 4000 container per 5CV
S.4 – S.5	- Maximum plastic (as low-density polyethylene, butyl rubber, Teflon™, nylon, and/or polyvinyl chloride tape) is limited to 1000 grams. - Maximum 200 grams of aluminum dunnage - Maximum 900 gram can mass	SAVY™ 4000 container(s) Limits are: - Maximum plastic (as lowdensity polyethylene, butyl rubber, Teflon™, nylon, and/or polyvinyl chloride tape) is limited to 1000 grams with or without a Food-pack can. - Maximum 200 grams of aluminum dunnage - Maximum 900 gram can mass - Only a single 1-qt or 2-qt. SAVY™ 4000 container per 5CV
All (S.1 – S.5)	For loading in the 5CV (i.e., totals for all materials in the CV including secondary containers) • Co-mingling of standard types S.1 through S.5 is prohibited – only one standard type is authorized per 5CV/package. • The total plastic (as low-density polyethylene, butyl rubber, Teflon™, nylon, and/or polyvinyl chloride tape) is limited to 1000 grams. • Aluminum dunnage is limited to 200 grams • Steel dunnage is limited to 900 grams • The maximum radioactive decay heat rate is limited to 0.093 watts • 50 lb. maximum content weight (radioactive contents, engineered containers, contamination control devices, packing materials, spacers, etc.)	

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(c) Criticality Safety Index

The Criticality Safety Index (CSI) for the package with Content Envelope C.1 is 0.0 (zero) and 1.0 for Content Envelopes C.2, C.4, C.5, C.6, and S.1 through S.5.

(d) Conditions

- (1) The maximum allowable radioactive decay heat rate is 19 watts for C.1 through C.6 and 0.093 watts for S.1 through S.5.
- (2) The maximum weight of the payload (everything that goes into the 5CV, including radioactive contents, convenience cans, contamination control devices, packing materials, spacers, etc.) is not to exceed 50 lb.
- (3) The Model 9978 Package must be shipped in a closed conveyance.
- (4) Transport of fissile material by air is not authorized.
- (5) In addition to the requirements of Subparts G and H of 10 CFR Part 71, and except as specified in section 5(d) of this certificate, each package must 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.
- (6) If the option is chosen to attach a DOE MK-II RFID tag to the 9978 packaging, the operating procedures must follow the additional steps per Chapter 7 in Supplement 5(e)(1), and the guide to RFID monitoring system in Supplement 5(e)(2). The RFID guide contains a copy of the Material/Product Safety Data Sheet for the batteries used in the DOE MK-II RFID tag, which provides guidance on the safe use of the batteries.
- (7) Verification of the pre-shipment containment integrity of the containment system, on both the O-ring seal and the Leak Test Port Plug, shall be accomplished using either the pressure rise method, or the pressure drop method of testing as specified in ANSI N14.5-2014.
- (8) Only Departmental elements or persons working under contract to Departmental elements shall consign the package for domestic transport.
- (9) Nuclear Regulatory Commission (NRC) or Agreement State licensees shall not consign a DOE certified package for domestic transport but can transfer the material on-site to DOE elements or persons working under contract to DOE elements for consignment of the package.
- (10) The containment vessel must be inerted/diluted to a minimum 90% nitrogen, for Pu/Am S.1, S.2, and S.3 Standards in accordance with the procedure in SARP Appendix 7.2.
- (11) The shipping window for Pu/Am S.5 Standards is limited to 147 days. The shipping window starts (Day 1) when the Containment Vessel is closed. The shipment must be completed by Day 147 (i.e., package is no longer in transit).
- (11) Revision 4 of the certificate may be used until April 30, 2024. Revision 5 of this certificate may be used until April 30, 2025.

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(e) Supplements:

- (1) Justification for Use of the Radio Frequency Identification (RFID) System, Safety Analysis Report for Packaging Model 9978, Addendum, S-SAR-G-00011, Revision 0, February 2010.
- (2) Guide to the RFID Monitoring System (Models 9975, 9977, and 9978 Packages), Argonne National Laboratory, ANL/DIS-09-5, December 3, 2009.
- (3) 9978 & 9981 5-year CoC Renewal Request, email, Sobus, L. to Shenk, J., January 29, 2024.