U.S. DEPARTMENT OF ENERGY

NATIONAL NUCLEAR SECURITY ADMINSTRATION

# OFFSITE TRANSPORTATION CERTIFICATE

(CERTIFICATE OF COMPLIANCE)

For Radioactive Materials Packages

| 1.A CERTIFICATE NUMBER: | 1.B REVISION NUMBER: | 1.C PACKAGE IDENTIFICATION NUMBER: | 1.C PAGE | | PAGES |
|---|---|---|---|---|---|
| 9977 | 0 | USA/9977/B(M)F-96 (NNSA) | 1 | of | 37 |

2. **PREAMBLE:**

A This Certificate is issued to certify that the package (packaging and contents) described in Item 5 below meets the applicable safety standards set forth in Title 10, Code of Federal Regulations, Part 71, *Packaging and Transportation of Radioactive Material.*

B This Certificate does not relieve the consignor from compliance with applicable requirements 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**

| A PREPARED BY: | B. TITLE AND IDENTIFICATION OF REPORTS FOR APPLICATION: | C. DATE: |
|---|---|---|
| Savannah River National Laboratory<br>Aiken, SC 29808 | (1) Safety Analysis Report for Packaging Model 9977 B(M)F-96, S-SARP-G-00001 Revision 2;<br>(2) SARP Addendum 2, S-SARA-G-00005, Revision 1;<br>(3) SARP Addendum 3, S-SARA-G-00006, Revision 4;<br>(4) SARP Addendum 5, S-SARA-G-00009, Revision 2; and<br>(5) SARP Addendum 7, S-SARA-G-00012, Revision 3 | Various |

3.D. **REPORTING DEVIATIONS:**

The following shall be reported to the NNSA Certifying Official upon discovery:

(1) Instances in which there is a significant reduction in the effectiveness of the Model 9977 Packaging;

(2) Details of any packaging defects with safety significance; and/or

(3) Instances in which the shipment was not in consonance with this CERTIFICATE OF COMPLIANCE.

4. **CONDITIONS:**

This certificate is conditional upon fulfilling the requirements of 10 CFR Part 71, and the conditions specified below.

5. **DESCRIPTION OF PACKAGING, AUTHORIZED CONTENTS, ADDITIONAL CONDITIONS, AND REFERENCES:**

A. <u>PACKAGING</u> <u>MODEL NUMBER</u>: 9977

<u>DESCRIPTION</u>

The 9977 is designed to ship radioactive contents in assemblies of Radioisotope Thermoelectric Generators (RTGs), 3013 Containers, Engineered Containers, or arrangements of nested Food-Pack Cans. The components of the package include the drum, insulation, the Containment Vessel (CV), Load Distribution Fixtures (LDFs), and Contents containers. The maximum weight of the packaging is 250 lbs, with a maximum payload weight of 100 lbs, and a maximum gross weight of 350 lbs [Item 3.B.(1) of this certificate].

A three-dimensional (3D), cut away illustration of the Model 9977 Transportation Packaging is shown in Figure 1.

The 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 deck plate, reinforcing rim (vertical flange), and an inner 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-gage (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.

| 6.A Date of Issuance | 6.B Expiration Date |
|---|---|
| Date 10/19/2012 | Date 9/30/2017 |

| 7.A Address of NNSA Certifying Official | 7.B Signature, Name and Title (of DOE/NNSA Approving Official) |
|---|---|
| **U. S. Department of Energy**<br>**National Nuclear Security Administration,**<br>**Office of Packaging and Transportation**<br>**P. O. Box 5400**<br>**Albuquerque, New Mexico 87185-5400** | A.M. Al-Daouk<br>**Ahmad M. Al-Daouk**<br>**National Nuclear Security Administration Certifying Official (NNSA CO)** |

**5.A. Continued**

The drum bottom includes a rolled "wear ring," 0.060-inch thick by ¾-inch inside diameter (ID), attached by welds that are external to the drum shell. The drum's top deck plate is fabricated of 3/16-inch thick Type 304L SS plate. The top portion of the drum incorporates a 3/16-inch thick reinforcing rim (vertical flange) that reinforces the drum head and protects the closure lid and the bolts. The rim includes eight 1-inch diameter drain holes that are qualified as package lifting and tie-down points. Drum construction details are shown on SARP [Item 3.B.(1) of this certificate] Drawings R-R2-G-00017 and R-R2-G-00018. As applicable, the drum is designed, analyzed, and fabricated in accordance with Section III, Subsection NF of the American Society of Mechanical Engineers Boiler & Pressure Vessel Code (ASME B&PVC), as listed in Table 9.6 of the SARP [Item 3.B.(1) of this certificate].

Four ¾-inch diameter vent holes are located around the drum, approximately 90° apart and at each of three elevations, for a total of twelve vent holes along the drum sidewall. Five holes, two 1-inch diameter fill holes and three ¾-inch diameter vent holes are located on the drum bottom. All of the holes are covered with appropriately sized Caplug® fusible plastic plugs.

The drum closure lid is fabricated from ⅛-inch thick Type 304L SS plate. Eight ⅝-inch by 1¼-inch long heavy hex-head bolts with ⅝-inch plain, narrow Type B washers secure the lid to the top deck 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 (0.07-inch) Type 304L SS, respectively. The top of the Lid Top is approximately 0.275 inches below the top surface of the drumhead reinforcing rim. The Lid Bottom chamber reinforces the Lid Plate and the Lid Top chamber reinforces the Lid Plate and closure and both provide additional thermal protection and shock absorption for the containment vessel and its contents. The Lid Top chamber also reinforces the Lid Plate, adds thermal protection to the contents, and protects the closure lid.

Four ¼-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 ¼-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). The Caplug® fusible plastic plugs are designed to combust or melt during a fire event and thereby allow the drum to vent gases.

The threaded inserts that receive the drum-closure bolts are welded to the underside of the drum's top deck plate. During installation, the bolts are tightened to a torque value of 45 (±5) ft-lb. The bolt heads are drilled through with a ⅛-inch hole to receive Tamper-Indicating Devices (TIDs).

Two layers of insulation material fill the volume between the drum liner and shell. First, two ½-inch thick blankets of Fiberfrax® insulation are wrapped around and attached to the sides and bottom of the drum liner. The Fiberfrax® is backed on both sides with fiberglass cloth held in place by fiberglass thread stitched longitudinally at 4-inch intervals. The fiberglass cloth gives the Fiberfrax® composite both mechanical strength and wear resistance and helps retard gas flow during a 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®). The nominal densities of Fiberfrax® and FR-3716 foam are 7-to-10 $lb/ft^3$ and 16 $lb/ft^3$, respectively. The thermal-physical properties of Fiberfrax® and FR-3716 are listed in Tables 2.9, 2.10, and 3.8 of the SARP. The combined thickness of the two insulators is approximately 4.95 inches radially (i.e., between drum liner and shell) and approximately 4.52 inches axially (i.e., between the drum liner bottom and drum bottom). Details are shown on SARP Drawings R-R1-G-00020, R-R2-G-00017, and R-R2-G-00019.

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 chamber contains a rigid disk of Thermal Ceramics TR-19® Block insulation, 4.3-inch thick by 8-inch diameter. When installed, the TR-19® disk compresses two 8-inch diameter by ½-inch thick blankets of Fiberfrax® insulation to a total thickness of ½ inch. The total axial thickness of both the insulators is approximately 5.75 inches. Details are shown in SARP Drawing R-R2-G-00018.

The CV has a 6-inch nominal ID (i.e., the 6CV). The 6CV is designed, analyzed, and fabricated in accordance with Section III, Subsection NB of the ASME B&PVC, with design conditions of 800 psig at 300°F, as listed in Table 9.5 of the SARP. The 6CV is fabricated from 6-inch, Schedule 40, seamless, Type 304L SS pipe (0.280-inch nominal wall). A standard Schedule 40 Type 304L SS pipe cap (also 0.280-inch nominal wall) is welded to the pipe segment to form a blind end. A stayed head is machined from a 7½-inch diameter by 2¼-inch long Type 304L SS bar and is welded to the open end of the pipe segment, completing the vessel body weldment. The head is machined to include 6½-12UNS-2B internal threads and an internal cone-seal surface with a 32-micro-inch finish. Both vessel body joints are ASME Code Category B, full-penetration, complete-fusion, circumferential welds. A support skirt to stand the 6CV vertically is formed from a short segment of 5-inch, Schedule 40 Type 304L SS pipe welded to the convex side of the cap. Two rectangular notches milled into the bottom edge of the skirt (180° apart) can engage a rectangular key to prevent vessel rotation during removal and installation of the closure assembly.

The 6CV 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 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 matching diameters so that they mate with radial clearance of 0.0007 inches. To minimize the potential for thread galling, the Cone-Seal Nut and the Containment Vessel body are made from dissimilar materials. Two O-ring grooves (outer and inner) are machined in the face of the external Cone-Seal Plug. 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° 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 CV through the vent hole.

A leak-test port is built into the Cone-Seal Plug and connected by a drilled radial passage to the annular volume between the two O-ring grooves in the 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 weldment, the Cone-Seal Plug, the Leak Test Port Plug, and the Outer O-ring.

The internal volume of a closed 6CV is approximately 608 cubic inches. The nominal assembly weight is 52.3 lb, and the nominal overall length is 24.03 inches. The usable cavity of the 6CV is a minimum of 20.25 inches deep with a minimum diameter of 5.95 inches. Details are shown in SARP Drawing R-R2-G-00042.

The Top and Bottom LDFs are made from 6061-T6 aluminum round bar and fit within the Drum Liner cavity, above and below the 6CV. The LDFs center the 6CV in the liner, stiffen the package in the radial direction, and distribute loads away from the 6CV. The 6CV fits directly into the LDFs. Details are shown in SARP Drawing R-R4-G-00032.

Table 1 lists currently approved Model 9977 packaging drawings or fabrication specifications where no drawing applies, and identifies the content for which the packaging components apply:

(1) Inner Packaging, and Packing Material Limits for each Authorized Content Configuration

(a) Inner Packaging/Content Containers (i.e., Product Cans)

The 9977 is authorized for the shipment of contents in RTGs, Food-Pack Cans, SGQ Shielded Containers, SGQ Engineered Containers, Engineered Containers, 3013 Containers, and Training Sources Engineered Containers. These content containers are used to prevent the inadvertent contamination of the package by providing a level of confinement for the radioactive material contents, protecting the content, providing shielding as in the case of the Small Gram Quantity (SGQ) shielded containers, and performing criticality control function as is the case with the 3013 cans in the Dual 3013 Can configuration. None of the content containers are credited with any containment function.

(i) RTG Assembly Components
The RTGs can be inserted into the 6CV (i.e., 9977 containment vessel), along with the appropriate assembly components (i.e., spring assembly, union assembly, and finned cup assembly).

(ii) SGQ Shielded Containers
The SGQ-SC1 container uses lead as shielding material and provides gamma shielding. The SGQ-SC2 Container uses high density polyethylene (HDPE) as shielding material and provides neutron shielding. The SGQ-SC3 container uses tungsten as shielding material and provides gamma shielding.

(iii) SGQ Engineered Container(SGQ-EC1)
The SGQ-EC1 provides confinement. The SGQ-EC1s are loaded in the 6CV using suitable aluminum Foam Spacers.

(iv) Food-Pack Cans
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 — Voluntary Can Standards. Convenience containers are typically application-specific

designs that incorporate screw thread, crimp-sealed, or welded closures. These three types of cans are made typically from tin-plated mild steel or stainless steel. An elastomeric gasket material or polyvinyl chloride tape may be applied to the edge of the can lid. Figure 2 shows a typical configuration of a Food-Pack Can within the 6CV containment vessel. The description for Food-Pack Cans can be found in Section 1.2.2.1.2 of the SARP [Item 3.B.(1) of this certificate].

**Table 1**
**Model 9977 Packaging Component Drawings**

| Drawing Number | Revision | Title |
|---|---|---|
| R-R1-G-00020 | 2 | 9977 Assembly with Six Inch Diameter Containment Vessel (U) |
| R-R2-G-00017 | 1 | 9977 Drum and Liner Subassembly (U) |
| R-R2-G-00018 | 2 | 9977 Drum Lid Subassembly (U) |
| R-R2-G-00019 | 1 | 9977 Insulating Blanket Subassembly (U) |
| R-R2-G-00042 | 2 | 9977 Six Inch Diameter Containment Vessel Subassembly (U) |
| R-R4-G-00032 | 3 | 9977Load Distribution Fixtures Details (U) |
| 502-440-716-AAA2 | | Socket Head Cap Screw, alloy steel |
| 502-1420-1-AAA2 | | Socket Head Cap Screw, alloy steel |
| **Additional packaging components REQUIRED for Component Envelopes C.1, Sandia National Laboratories (SNL) Radiological Thermoelectric Generator (RTG) Assemblies** | | |
| **Additional Packaging Components for baseline RTG Assembly** | | |
| 1A6780-00 | | Spring Assembly (2) |
| 1A6781-00 | | Union Assembly |
| 1A6782 | | Finned Cup Assembly (4) |
| **Additional Packaging Components REQUIRED for the Alternative RTG shipping Assembly** | | |
| 2A0469 | | Spring Assembly (2) |
| 2A0742 | | Union |
| 2A0741 | | Fin Cup (4) |
| **Additional packaging components REQUIRED for Component Envelopes AC.1, AC.3, AC.4 and AC.5** | | |
| R-R4-G-00053 | 2 | 9977 Sleeve and Plug Details (U) |
| **Additional Inner Packagings REQUIRED for the various Source (Offsite Source Recovery Program [OSRP]) Content** | | |
| R-R1-G-00037 | 1 | Small Gram Quantity (SGQ) Shielded Container Type 1 (U); SGQ-SC1 |
| R-R1-G-00038 | 1 | Small Gram Quantity Shielded Container Type 2 (U) ; SGQ-SC2 |
| R-R1-G-00039 | 1 | Small Gram Quantity Shielded Container Type 3 (U) ; SGQ-SC3 |
| R-R1-G-00045 | 0 | Small Gram Quantity Engineered Container Type 1(U); SGQ-EC1 |
| R-R4-G-00073 | 1 | 9977 Small Gram Quantity Shielded Container Type 1 Spacers (U) |
| R-R4-G-00074 | 1 | 9977 Small Gram Quantity Shielded Container Type 3 Spacers (U) |
| **Additional Packaging components REQUIRED for ICE Assembly Content (LANL Drawings)** | | |
| R83700 | | Los Alamos National Laboratory (LANL) Transport Container Assembly |
| 1001-0269-0000 | | Platform, Pu Anode Inner |
| 1103-0355-0000 | | Panel, ICE, Floor |
| 1103-0388-0000 | | Panel, 17mm Spacer, ICE |
| 1103-0389-0000 | | Plug, Panel, 17mm Spacer |
| 1350-2333-0000 | | Fitting 1/8 to 1/8, Custom |
| 1350-2357-0000 | | 90° Adaptor Fitting |
| 1350-2495-0000 | | Probe Nut |
| 1350—2496-0000 | | Mount, Probe Body, 3-Point |
| R83710 | | Transport Container Handle |
| R83711 | | Transport Container Anode Mount |
| R83712 | | Transport Canister Body |
| R83722 | | Transport Container Strain Relief |
| **Additional packaging components REQUIRED for Dual 3013 Can Content** | | |
| R-R4-G-00032 | 3 | 9977 Load Distribution Fixtures Details |
| R-R4-G-00081 | 0 | 9977 3013 Spacer Details (U) |
| DCS01 ZMJ DS PLG M 61241 | | Convenience Can (Design Authority: MOX Services) |
| 90Y-219875 | | Inner 3013 Cans (DOE-STD-3013-2012) (Design Authority LANL) |
| M-PV-F-0017 | | Outer Can (Design Authority: British Nuclear Fuels, Ltd.) |

(v) Vollrath 88020 Slip-Lid Can

The Vollrath 88020 Slip-Lid Can is a stainless steel convenience container, used to hold the Neptunium sphere contents. Section 1.2.2.2.1 of the SARP Addendum 2 [Item 3.B.(2) of this certificate] provides figures and drawing numbers of Neptunium Metal Spheres and Storage Containers, and additional configuration details. The Vollrath Slip-Lid Can would also fall under the descriptions for Engineered Containers.

(vi) Engineered Containers

The term "Engineered Container" includes metal sample containers, "sealed sources" (i.e., encapsulated 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 containers are made typically from plated mild steel or stainless steel. In order to be certified as a "Sealed Source," the design must be performance tested either as "special form," per 49 CFR 173.469, or as "sealed sources" under ANSI N542. Since the 6CV provides containment for all contents, these containers are neither credited nor required to be sealed. A description of an Engineered Container is contained in Section 1.2.2.1.3 of SARP Addendum 2 [Item 3.B.(2) of this certificate].

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 in the package 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 requirements applicable to all packages are satisfied.

(vii) 3013 Containers

The 3013 configuration consists of a 3013 outer storage can, a 3013 inner storage can, and optional material container(s), and is designed to meet the requirements of DOE-STD-3013. Individual package users typically develop site-specific 3013 inner and product containers. A description of the 3013 Containers, and additional requirements for its use, are specified in Section 1.2.2.1.1 of SARP Addendum 2 [Item 3.B.(2) of this certificate].

(viii) Training Sources Engineered Containers

The Training Sources Engineered Containers confine the radioactive materials within circular or square cross-section thin inner and outer polycarbonate bottles, have multiple polyethylene foam discs providing suitable packing, and are vented through filters. The Training Sources Engineered Containers contain less than 2 kg of plastic or other organic packing material susceptible to out-gassing. Section 1.2.2.1.1 of SARP Addendum 5 [Item 3.B.(4) of this certificate] provides a description of the Training Sources Engineered Containers, and details of the Training Sources Engineered Containers are provided in Appendix A.1.1 of SARP Addendum 5 [Item 3.B.(4) of this certificate].

(b) Table 2 provides a summary of the Containers and the approved contents.

**Table 2**

**Approved Convenience Containers and Shielded Containers for the Various Content Envelopes**

| Content Envelope | Content Details | Contents Convenience Containers | | | | | | Unshielded Containers | | | Shielded Containers | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | RTG or ICE Assembly | Food-Pack Can(s) | Vollrath 88020 Slip-Lid Can(1) | Engineered Containers | 3013 Containers | Training Source Eng. Containers | Sleeve and Plug | 3013 Spacer & Heat Dissipation Sleeve | SGQ-EC1 (Unshielded Container) | SGQ-SC1 (Pb Shielded) | SGQ-SC2 (HPDE Shielded) | SGQ-SC3 (Tungsten Shielded) |
| **C.1 (RTGs, etc.)** | – | X | X | – | – | – | – | – | – | – | – | – | – |
| **ICE** | – | X | – | – | – | – | – | – | – | – | – | – | – |
| **AC.1, Np Metal** | **Sphere** | – | – | X | – | – | – | X | – | – | – | – | – |
| | **Pieces** | – | X | X | X | – | – | – | – | – | – | – | – |
| **AC.2, BeRP Ball** | – | – | – | X | – | – | – | – | – | – | – | – | – |
| **AC.3, Pu/U Metal** | – | – | X | X | X | X | – | X | – | – | – | – | – |
| **AC.4, Pu/U Metal** | **Total Rad. Contents < 450 g** | – | X | X | X | X | – | – | – | – | – | – | – |
| | **Total Rad. Contents > 450 g** | – | X | X | X | X | – | X | – | – | – | – | – |
| **AC.5, U Metal** | – | – | X | X | X | X | – | X | – | – | – | – | – |
| **AGR-1 Compact** | – | – | – | – | $X^{(2)}$ | – | – | – | – | – | – | – | X |
| **Type 4 Sources** | – | – | X | X | X | – | – | – | – | $X^{(3)}$ | $X^{(4)}$ | $X^{(5)}$ | $X^{(4)}$ |
| **Training Sources** | – | – | X | X | X | X | X | – | – | – | – | – | – |
| **Dual 3013 Contents** | – | – | – | – | – | X | – | – | X | – | – | – | – |

Notes:

(1) The Vollrath 88020 Slip-Lid Can is a specific type of Engineered Container, as defined above

(2) AGR-1 Fuel Compact is placed in a threaded pipe prior to placement in the SGQ-SC3

(3) Unshielded container used for materials in Type 4 Source content envelope

(4) Shielded containers used for gamma-source materials in Type 4 Source content envelope

(5) Shielded containers used for neutron source materials in Type 4 Source content envelope

**Table 3**

**Summary of Additional Requirements by Content and Configuration for the C.1 and ICE Content Envelopes**

| Content Envelope | Container Configuration | | |
|---|---|---|---|
| | **Food-Pack Cans** | **SNL RTGs** | **ICE Assembly** |
| **C.1** | Maximum 100 g plastic (low density polyethylene, nylon, and/or polyvinyl Chloride tape) | Manufactured per drawing listed packing configuration control maximum 100 g polyurethane | - |
| **ICE** | - | - | Maximum 8 g radioactive material<br>Maximum 100 g plastic manufactured per drawings listed |
| **All** | • 19 Watts maximum radioactive decay heat<br>• Less than 1000 ppm (weight) other radionuclides, unless otherwise stated in Table 8<br>• Less than 100 ppm (weight) each other inorganic impurities with total mass less than 0.1 Wt%, unless otherwise stated in Table 8<br>• 100 lb maximum content weight (i.e., radioactive material content, convenience cans, contamination control devices packing material, spacers, etc.) | | |

## Table 4
## Summary of Additional Packaging Configuration Requirements for Content Envelopes AC.1, AC.2, AC.3, AC.4, and AC.5

| Content Envelope | Configuration | |
|---|---|---|
| | **Food-Pack Cans or Engineered Containers** | **3013** |
| **AC.1**<br>**Neptunium Metal Sphere Or Pieces** | • Aluminum Sleeve and Plug required for only the Neptunium sphere<br>• Maximum 100 g plastic<br>• Contents Container: Food-Pack Can(s)] or stainless steel cans (Vollrath) [Maximum 2000 g]<br>• Maximum 4500 g aluminum (heat-sink fixture and/or foil) | – |
| **AC.2**<br>**BeRP Ball** | • Maximum 100 g plastic<br>• Contents Container: Stainless steel cans (Vollrath) [Maximum 2000 g]<br>• Maximum 4500 g aluminum (heat-sink fixture and/or foil) | – |
| **AC.3**<br>**Pu Metal** | • Aluminum Sleeve and Plug required<br>• Contents Containers: Food-Pack Cans, or Engineered Containers<br>• Maximum 100 g plastic<br>• If ≥ 3kg per Food-Pack Can:<br>  ▪ Sum of can walls < 0.26 inches<br>  ▪ Sum of can tops & bottoms < 1.77 inches<br>  ▪ 400 x 400 can or bigger | • Aluminum Sleeve and Plug required<br>• If ≥ 3kg per inner/material can<br>  • Sum of can walls < 0.26 inches<br>  • Sum of can tops & bottoms < 1.77 inches<br>  • 400 x 400 can or bigger<br>• Other 3013 requirements* |
| **AC.4**<br>**Pu Metal** | • Aluminum Sleeve and Plug required (unless total radioactive contents mass is less than 450 g)<br>• Contents Containers: Food-Pack Cans, or Engineered Containers<br>• Maximum 100 g plastic | • Aluminum Sleeve and Plug required (unless total radioactive contents mass is less than 450 g)<br>• Other 3013 requirements* |
| **AC.5**<br>**U Metal** | • Aluminum Sleeve and Plug required<br>• Contents Containers: Food-Pack Cans, or Engineered Containers<br>• Maximum 100 g plastic<br>• If ≥ 3kg per Food-Pack Can:<br>  ▪ Sum of can walls < 0.26 inches<br>  ▪ Sum of can tops & bottoms < 1.77 inches<br>  ▪ 400 x 400 can or bigger | • Aluminum Sleeve and Plug required<br>• If ≥ 3kg per inner/material can:<br>  ▪ Sum of can walls < 0.26 inches<br>  ▪ Sum of can tops & bottoms < 1.77 inches<br>  ▪ 400 x 400 can or bigger<br>• Other 3013 requirements* |
| **All** | • 19 Watts maximum radioactive decay heat rate<br>• Less than 1000 ppm (weight) other radionuclides (unless otherwise stated)<br>• Less than 100 ppm (weight) each other inorganic impurities with total mass less than 0.1 weight percent (unless otherwise stated)<br>• Maximum 100 lb. content weight (radioactive contents, product cans, Sleeve and Plug, etc.) | |

*See DOE-STD-3013.

**Table 5**
**Shielded Containers for Type 4 Contents**

| Isotope | Appropriate Shielded Container(s) |
| --- | --- |
| Co-60 | SGQ-SC1 or SGQ-3 |
| Cs-137 | SGQ-SC1 or SGQ-3 |
| Ir-192 | SGQ-SC1 or SGQ-3 |
| Sr-90/Y-90 | SGQ-SC1 or SGQ-3 |
| Ra-226 | SGQ-SC1 or SGQ-3 |
| Am-241 with Be | SGQ-SC2 |
| Cf-252 | SGQ-SC2 |
| Cm-244 | SGQ-SC2 |
| Pu-238 with Be | SGQ-SC2 |
| Pu-239 with Be | SGQ-SC2 |

**Table 6**
**Summary of Configuration Requirements for Type 4 Contents**

| SGQ-EC1 (i.e., SGQ-SC4) [Engineered Container] | SGQ-SC1 [Lead-Shielded Container] | SGQ-SC2 [HPDE-Shielded Container] | SGQ-SC3 [Tungsten-Shielded Container] |
| --- | --- | --- | --- |
| • Maximum 100-g plastic<br>• Aluminum pellets, foil or gauze for packing<br>• 19-Watts decay heat<br>• Dose rate 180 mrem/hr at surface & 9 mrem/hr at 1-meter | • Maximum 100-g plastic<br>• Aluminum foam spacers<br>• 6-Watts decay heat | • Maximum 100-g plastic<br>• Perforated Food-Pack Can spacer<br>• 3-Watts decay heat | • Maximum 100-g plastic<br>• Aluminum foam spacers<br>• 19-Watts decay heat |
| Note: 100-lb maximum content weight (radioactive contents, product cans, spacers, shielded container, etc.) | | | |

**Table 7**
**Training Sources Container Loading Restrictions**

| Contents | Packaging Configurations |
| --- | --- |
| | **Engineered Containers** |
| **Training Sources** | • Maximum 2 kg plastic<br>• Maximum 10 kg as stainless steel container components or as aluminum foil for dunnage<br>• 3.5 Watts decay heat rate<br>• Less than 1000 ppm other radionuclides (unless otherwise stated)<br>• Less than 100 ppm other inorganic impurities with total mass less than 0.1 weight percent (unless otherwise stated)<br>• 100 lb maximum content weight (radioactive content, impurities, product cans, spacers, etc.)<br>• Solid form as metal or oxides<br>• no free liquids<br>• not generate gases (other than helium by alpha decay)<br>• shall not react chemically with the containment vessel or one another or cause corrosion |

(i) C.1/SNL RTG Content Configuration:
This content specific configuration must be packed as described and illustrated in SARP [Item 3.B.(1) of this certificate] Section 1.2.2.1, and as modified by replacement of the baseline Spring Assemblies, Union and Finned Cup Assembly with the Spring

Assemblies, Union Assembly and Fin Cups identified the *Model 9977 Packaging Components*:

- Content packed in Food-Pack Cans packed in 6CV Food-Pack Can configuration, then packed using up to a maximum of 100 g plastic (low-density polyethylene, nylon and/or polyvinyl chlorine tape), or
- RTGs manufactured per drawing listed packing configuration control are packed using up to maximum 100 g polyurethane.

Refer to Table 3 and Figure 3 of this certificate for additional details.

(ii) Domestic Nuclear Detection Office (DNDO) Contents AC.1 through AC.5 Configurations:

The content specific configuration requirements are discussed and illustrated in SARP Addendum 2 [Item 3.B.(2) of this certificate], Section 1.2.2.2.

<u>Envelope AC.1, Neptunium Metal</u>:
This content must be packed using the basic Model 9977 packaging plus:

- Neptunium sphere packed in a Vollrath convenience can. The loaded Vollrath can is placed in the 6CV in the Sleeve and Plug configuration, and the remaining space above the Vollrath can may be packed with an empty Food-Pack Can and/or aluminum foil as final dunnage. The Vollrath can is a stainless steel slip lid convenience can that can be sealed by wrapping of tape where the lid rests on the body.
- Neptunium metal pieces to a maximum mass of 188 g may be shipped under this content envelope. The neptunium metal pieces must be packed in Food-Pack Cans or Engineered Containers. See SARP Addendum 2 [Item 3.B.(2) of this certificate] for information on dunnage that may be used to minimize vibration and movement of the contents during shipment in an Engineered Container. The total weight of all materials in the 6CV does not exceed 100 lbs. The estimated maximum mass of aluminum is 4430 g.

<u>Envelope AC.2, BeRP Ball</u>:
This content must be packed in basic Model 9977 packaging plus:

- The BeRP Ball is packed in Vollrath can (maximum 2,000 g stainless steel) with an estimated 790 g aluminum foil dunnage inside the Vollrath can. Additional aluminum foil and an empty perforated Food-Pack Can or an empty unsealed slip-lid cans serve as dunnage inside the 6CV.
- Other packing materials: 100 g plastic maximum and aluminum foil dunnage (maximum of 4.5 kg aluminum total).

Envelopes AC.3 and AC.4, Pu/U Metals:
This content must be packed using the basic Model 9977 packaging with the 9977 Sleeve and Plug plus:

- The content packed in 3013 cans, Food-Pack Cans or Engineered Containers, and
- Loaded material container is packed in 6CV.
- If Envelope AC.3 radionuclide content is greater than 3 kg per innermost material container, the following must be ensured:
  - The sum of the radial wall thickness of all nested cans shall not exceed 0.26 inch.
  - The sum of the thickness 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 400 x 400).
- Other packing materials: maximum 100 g plastic when content packed in Food-Pack Cans or Engineered Containers.
- For Content Envelope AC.4 material with a mass less than or equal to 450 g, the requirement to use the aluminum Sleeve and Plug does not apply. Contents meeting these conditions and packed in 3013 cans, Food-Pack Cans, or an Engineered Container are permitted to be loaded into the 6CV with on additional packaging requirements. Aluminum foil may be packed around the product container as dunnage to restrict its movement within the 6CV.
- If Envelope AC.4 radionuclide content is greater than 3 kg per innermost material container, the following must be ensured:
  - The sum of the radial wall thickness of all nested cans shall not exceed 0.26 inch.
  - The sum of the thickness 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 400 x 400)
- Other packing materials: maximum 100 g plastic when content packed in Food-Pack Cans or Engineered Containers.

Envelope AC.5, U Metal:
This content must be packed using the basic Model 9977 packaging with 9977 Sleeve and Plug plus:

- Highly Enriched uranium metal alloyed with up to 10% molybdenum content packed in 3013 cans, Food-Pack Cans or Engineered Containers, and
- The loaded convenience container, followed by an empty perforated Food-Pack Can, followed by aluminum foil dunnage are loaded into 6CV. Aluminum foil dunnage may be placed around the loaded convenience can as dunnage to restrict its movement within the 6CV. Loaded material container is packed in 6CV.
- Content Envelope AC.5 has two separate mass limits depending on its percent enrichment of U-235. Contents with less than 95% U-235 have a mass limit of 18 kg. Contents with and enrichment greater than 95% (to a MAXIMUM OF 100%) U-235 have a mass limit of 16 kg.

- For Content Envelope AC.5, if the radionuclide content is equal to or greater than 3 kg per innermost material container, the following additional restrictions also apply:
  - The sum of the radial wall thickness of all nested cans shall not exceed 0.26 inch.
  - The sum of the thickness 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 400 x 400).
- Other packing materials: maximum 100 g plastic when content packed in Food-Pack Cans or Engineered Containers.

Refer to Figure 2 and Figure 5, respectively, for details on Food-Pack Can packing configuration and Vollrath can.

(iii) Isentropic Compression Experiment (ICE) Engineered Container configuration:
This content must be packed using the basic Model 9977 packaging using a specialized Engineered Container configuration, the ICE test apparatus consists of a stainless steel assembly containing approximately 8 g of Pu-239 or its dose equivalent packed in the 6CV. The ICE apparatus contains no plastics other than Viton® O-rings. The packing system consists of two sets of Spring Mounts 6061-T6 aluminum springs (ASTM A 288 QQW-470 steel music wire), and 2¼-inch square by 3½-inch long Foam Bumper Blocks (General Plastics Last-A-Foam®, TF-5070-10). Refer to Figure 4 for details.

(iv) AGR-1 Fuel Compact:
This content must be packed as described and illustrated in Section 1.2.2.2 of SARP Addendum 3 [Item 3.B.(3) of this certificate]. The AGR-1 Compact is packed in a pipe Container and then placed in the Small Gram Quantity Shielded Container Type 3 (SGQ-SC3) container then loaded axially in the 6CV using aluminum foam spacers.

(v) Type 4 Content (i.e., Sources):
This content must be packed as described and illustrated in Section 1.2.2.2 of SARP Addendum 3 [Item 3.B.(3) of this certificate].

- Gamma-sources are packed in SGQ-SC1 (6 Watt limit) or SGQ-SC3 (19 Watt limit) containers and then packed in 6CV.
- Neutron-sources are packed in SGQ-SC2 (3 Watt limit) container.
- Engineered Container SGQ-EC1 can be used for shipments of unshielded sources and pieces that do not require shielding, provided that the administrative dose rate limits of 180 mrem/hr (on contact of the unshielded source or piece) and 9 mrem/hr (at a distance of 1 meter of the unshielded source or piece) are met following procedures in Section 7.1.1.2 of SARP Addendum 3 [Item 3.B.(3) of this certificate]. Shielded sources and pieces must be packed in the appropriate shielded SGQ container, because the shielding integrity of the sources cannot be assured during an accident event when packed in the SGQ-EC1 container, the loaded shielded SGQ container will then be packed into the 6CV in accordance with Table A.1.2 of SARP Addendum 3 [Item 3.B.(3) of this certificate].

(vi) Training Sources:
Training Sources must be packaged in accordance with the packing configuration requirements specified and illustrated in Section 1.2.2 of SARP Addendum 5 [Item 3.B.(4) of this certificate].

(VII) Dual 3013 Can Content:
This content must be packaged in accordance with the packing configuration requirements specified and illustrated in Section 1.2 of SARP Addendum 7 [Item 3.B.(5) of this certificate]. This content must be packed using the basic Model 9977 packaging with a Heat Dissipation Sleeve and 3013 Spacer surrounding the outside of the 6CV. If only one 3013 container is packed in the 6CV, aluminum foil or peanuts may be used as dunnage in place of the second 3013 container.

B. <u>AUTHORIZED CONTENTS</u>

(1) <u>Type and Form of Radioactive Material</u>

The following contents are approved for transport using the Model 9977:

(a) Content Envelope C.1, i.e., Heat Sources and RTGs, and the Isentropic Compression Experiment (ICE), are defined in Section 5.B.(3)(a), below, and in Sections 1.2.2.1 and 1.2.2.2 of the SARP [Item 3.B.(1) of this certificate];
(b) Content Envelopes AC.1 through AC.5, i.e., Neptunium Metal, BeRP Ball Metal, Plutonium/Uranium Metal, and Highly Enriched Uranium (HEU) Metal are defined in Section 5.B.(3)(b), below, and in Section 1.2.2.2 of SARP Addendum 2 [Item 3.B.(2) of this certificate];
(c) AGR-1 Spent Fuel Compacts are defined in Section 5.B.(3)(c) below, and in Section 1.2.2.2 of SARP Addendum 3 [Item 3.B.(3) of this certificate];
(d) Type 4 Contents includes the specific radionuclides defined in Section 5.B.(3)(d), below, i.e., Co-60, Cs-137, Ir-192, Sr-90/Y-90, Ra-226, Am-241, Cf-252, Cm-244, Pu-238, and Pu-239, and also in Section 1.2.2.2 of SARP Addendum 3 [Item 3.B.(3) of this certificate];
(e) Training Sources Contents include the specific radionuclides defined in Section 5.B.(3)(e), i.e., Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, Am-241, Am-243, Cf-252, Cm-248, Np-237, Th-232, U-234, U-235, U-236, and U-238, and also in Section 1.2.2 of SARP Addendum 5 [Item 3.B.(4) of this certificate];
(f) The Dual 3013 Content Envelope is defined in Section 5.B.(3)(f), below, and also in Sections 1.2.2.1 and 1.2.2.2 of SARP Addendum 7 [Item 3.B.(5) of this certificate];

For the contents outlined above in 5.B.(1)(a) through 5.B.(1)(f), the following requirements are also applicable:

- All contents must be dry; contents in liquid form are not permitted;
- Except for the contents noted above in 5.B.(1)(b), i.e., Content Envelopes AC.1 through AC.5, the chemical form for all content envelopes may be in the form of oxides; for Content envelopes AC.1 through AC.5 the chemical form of the radioactive materials is metal.

(2) Maximum Radioactive Decay Heat:

- Maximum 19 Watts for:
  - Contents C.1(i.e., RTGs & ICE),
  - Contents AC.1 through AC.5,
  - AGR-1 Fuel Compact, and
  - 3013 Contents (when using one 3013)
- Maximum 38 Watts for two 3013 Containers
- Maximum 3.5 Watts for Training Sources Contents
- Maximum 19 Watts for Type 4 Contents in SGQ-EC1 unshielded container, or tungsten-shielded SGQ-SC3
- Maximum 6 Watts for Type 4 Contents in SGQ-SC1 lead-shielded container
- Maximum 3 Watts for Type 4 Contents in SGQ-SC2 in HPDE-shielded container

The maximum weight of the payload (i.e., everything that goes into the 6CV, including radioactive contents, the (one-piece) aluminum Sleeve and Plug, convenience cans, contamination control devices, packing materials, spacers, dunnage, etc.) is not to exceed 100 lb.

(3) Maximum Quantity of Radioactive Material per Package

(a) Content Envelope C.1 (i.e., RTGs, etc.), and the Isentropic Compression Experiment (ICE)

The C.1 content (Content Envelope C.1) can be placed in Food-Pack Cans or SNL Radioisotope Thermoelectric Generators (RTGs). The ICE test apparatus assembly (Content Envelope ICE) is placed directly in the 6CV.

The isotopic mass limits and the mass limits on inorganic impurities for the C.1 and ICE content envelopes are listed in Table 8. The contents cannot exceed any individual or total mass limit for a given envelope. In addition to heat source materials, other radioactive materials meeting all the limits for content envelope C.1 can be shipped in the 9977. The total content mass listed in Table 8 excludes material containers and packing materials (i.e., Food-Pack Cans, RTG containers, springs, fin cups and union).

The chemical form of the radioisotopes in Table 8 includes oxides. Except as stated in Table 8, small concentrations (<1000 ppm weight-basis each) of other actinides, fission products, decay products, and neutron activation products are permitted. Assessment of these impurities may be based on process knowledge.

Except as stated in Table 8, inorganic material impurity quantities of less than 100 ppm each are permitted as long as the total mass of inorganic impurities is less than 0.1 weight percent of the total content mass. Assessment of these impurities may be based on process knowledge.

Additional limits and approved container configurations for Content Envelopes C.1 and ICE are summarized in Table 3. These contents containers and content-specific configuration requirements are also listed in SARP Revision 2 [Item 3.B.(1) of this certificate] Sections 1.2.2.1 and 1.2.2.2.

Contents meeting the C.1 Content Envelope mass limits can be placed within Food-Pack Cans and then placed within the 6CV. The can(s) 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 6CV. Nesting of Food-Pack Cans is not required (i.e., a single Food-Pack Can is allowed). Food-Pack Cans may be arranged for handling convenience and contamination control into single, double, or triple-stacked configurations. Perforated Food-Pack Can(s), aluminum foil, and/or aluminum peanuts can be used as dunnage around the contents containers to fill void space and prevent shifting of the contents container(s). See Figure 2 for a diagram of a typical arrangement of food-pack cans within the 6CV.

**Table 8**
**Content Envelopes C.1 and ICE**

| | **Material**(a, b, c) | **C.1 Heat Source (grams)** | **ICE (grams)** |
|---|---|---|---|
| **Radioisotope**(e) | Pu-236 | 1 ppm | 1 ppm |
| | Pu-238 | 33.50(g) | 3.20E-03 |
| | Pu-239 | 40.00 | 8.00 |
| | Pu-240(d) | 13.00 | 2.20 |
| | Pu-241/Am-241(d) | 1.00 | 5.00E-03 |
| | Pu-242 | 1.50 | 8.00 |
| | Am-241 | - | 1.40E-01 |
| | U-232 | 1.40E-04 | - |
| | U-233 | 2.00E-01 | - |
| | U-234 | 40.00 | - |
| | U-235 | 40.00 | - |
| | U-236 | 16.00 | - |
| | U-238 | 40.00 | - |
| **Non-Radioactive Inorganic Impurities (grams)** | Ca | 15.00 | - |
| | Fe | 5.00 | - |
| | Cr | 2.00 | - |
| | Other Inorganic Impurities(f) | 1.00E-1 (total) | 8.00E-3 (total) |
| **Total Mass (grams)** | Radioactive Materials | 100.00 | 8.00 |
| | Inorganic Impurities | 20.00 | 8.00E-03 |
| | All Contents | 100.00 | 8.00 |
| | (α,n) Impurities | 0.005 | 0.005 |

Notes
(a) All contents shall be dry.
(b) Pu/U content bulk density shall be within the range of 2.0 to 19.84 g/cc.
(c) Chemical form of contents includes oxides.
(d) Mass of Pu-240 shall be greater than Pu-241.
(e) Small concentrations (<1000 ppm by weight each) of other actinides, fission products, decay products, and neutron activation products are permitted. Assessment of these impurities may be based on process knowledge. If small amounts of actinide impurities are known or suspected to be present, OTC Conditions 5.D.(9) and 5.D.(10) must be complied with.
(f) For Ca, Fe, and Cr, inorganic material impurity quantities of less than 100 ppm (weight) each are permitted as long as the total mass is less than 0.1 weight percent of the total content mass. Assessment of these impurities may be based on process knowledge.
(g) 33.5 grams Pu-238 = 19 Watts.

SNL RTGs meeting the C.1 Content Envelope mass limits can be placed into the 6CV along with the appropriate assembly components (i.e., spring assembly, union assembly, and finned cup assembly). Two different sizes of RTGs (the MC2730 and MC3500) can be shipped within a single 9977 configuration. The RTGs are placed within vibration limiting and thermal-conducting assemblies. One RTG Assembly holds a maximum of four RTGs. Either, or both, sizes of RTGs may be shipped in the same assembly. The RTG assembly configurations positioned in the 6CV are shown in Figure 3.

An Isentropic Compression Experiment (ICE) test apparatus meeting the Content Envelope mass limits for the ICE Content Envelope can be placed into the 6CV along with the appropriate assembly components. The ICE consists of a stainless steel assembly containing approximately 8 g of Pu-239 or its dose equivalent [Reference. 5.E.(1)]. The ICE apparatus contains no plastics other than Viton® O-rings. The apparatus weighs less than 3 lb. The packing system, designed to protect the ICE apparatus from normal transport vibrations, consists of two sets of spring mounts (6061-T6 aluminum), springs (ASTM A 288 QQW-470 steel music wire), and 2¼-inch square by 3½ inch long foam bumper blocks (General Plastics Last-A-Foam®, TF-5070-10). The ICE assembly configuration positioned in the 6CV is shown in Figure 4.

(b) DNDO Neptunium, Plutonium and Uranium Metal Contents: Content Envelopes AC.1, AC.2, AC.3, AC.4, and AC.5

Neptunium Metal (Content Envelope AC.1), BeRP Ball Metal (Content Envelope AC.2), Plutonium/Uranium Metal (Content Envelopes AC.3 and AC.4), and Highly Enriched Uranium (HEU) Metal (Content Envelope AC.5) are approved contents for the 9977 [Item 3.B.(2) of this certificate].

(i) Envelope AC.1, Neptunium Metal

Two possible neptunium metal content configurations are allowed: Neptunium Sphere or neptunium metal pieces. See Table 9 for content envelope mass limits, and Table 4 for specific configuration requirements for content envelope AC.1.

The Neptunium Sphere configuration consists of a solid sphere of neptunium metal with cladding and shielding around the sphere, aluminum foil as dunnage, and a Vollrath convenience can. Figure 5 shows a diagram of the Vollrath can. The Vollrath can serves as a handling convenience. The stainless steel can will be sealed by a wrapping of tape where the lid rests on the can body. The loaded Vollrath can will be placed into the 6CV in the Sleeve and Plug configuration. The remaining space above the Vollrath can may be packed with an empty Food-Pack Can and/or aluminum foil as final dunnage. The estimated maximum mass of aluminum, including fixture and foil, is 4430 g. Section 1.2.2.2.1 of the SARP Addendum 2 [Item 3.B.(2) of this certificate] provides figures and drawing numbers of Neptunium Metal Spheres and Storage Containers.

Neptunium metal pieces to a maximum mass of 188 g may be shipped under this content envelope. These pieces must be packaged in Food-Pack Cans or Engineered Containers. A typical Food-Pack Can configuration is shown in Figure 2, and a typical Engineered Container configuration is shown in Figure 6.

(ii) Envelope AC.2, BeRP Ball
The BeRP Ball is a Beryllium Reflected Plutonium Ball that contains 4,484 g of alpha phase plutonium. Radioactive decay heat from the plutonium sphere is initially 10.656 Watts, which is within the limit of 19 Watts. Added to the mass of plutonium is the mass of the stainless steel shell for a total assembly mass of 4.5 kg. Section 1.2.2.2.2 of SARP Addendum 2 [Item 3.B.(2) of this certificate] provides figures and drawing numbers for the Plutonium. The BeRP Ball content is placed into a Vollrath can prior to placement in the 6CV. The Vollrath can holding the contents is placed in the 6CV, followed by one empty perforated Food-Pack Can or empty unsealed slip-lid can to serve as dunnage. The space between the Vollrath can and the dunnage can and between the dunnage can and the top of the 6CV will be packed with aluminum foil as final dunnage. See Table 9 for content envelope mass limits, and Table 4 for specific configuration requirements for content envelope AC.2.

(iii) Envelopes AC.3 and AC.4, Pu/U Metals
Content Envelopes AC.3 and AC.4 contain plutonium and/or uranium metal. Contents AC.3 and AC.4 are packaged in 3013 Containers, Food-Pack Cans, or Engineered Containers, and the product container is loaded into the 6CV after the Sleeve and Plug has been installed (if applicable). The description of Food-Pack Cans and Engineered Containers is provided in Section 5.A.(1) of this certificate, and also in Section 1.2.2.1.2 of Revision 2 of the SARP [Item 3.B.(1) of this certificate], and refer to Section 1.2.2.1.3 of SARP Addendum 2 [Item 3.B.(2) of this certificate] for information on Engineered Containers.

Materials shipped under content envelops AC.3 and AC.4 must be loaded into the 6CV with the incorporation of an aluminum Sleeve and Plug (except for Content Envelope AC.4 material with a mass less than or equal to 450 g). The one-piece aluminum Sleeve and Plug component is necessary to ensure sub-criticality and to satisfy the Normal Conditions of Transport (NCT) dose rate limit requirements. Section 1.2.2.2.3 of SARP Addendum 2 [Item 3.B.(2) of this certificate] provides figures and more details for these content envelopes. See Table 9 for content envelope mass limits, and Table 4 for specific configuration requirements for content envelopes AC.3 and AC.4.

For Content Envelope AC.3, if the radionuclide content mass is equal to or greater than 3 kg per innermost material container, the following restrictions shall also apply:

- 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; and
- The innermost material container shall be at least 4 inches in diameter and at least 4 inches long (i.e., minimum can size 400 x 400).

For Content Envelope AC.4 material with a mass less than or equal to 450 g, the requirement to use the aluminum Sleeve and Plug does not apply. Contents meeting these conditions and packaged in 3013 Containers, Food-Pack Cans, or an Engineered Container are permitted to be loaded into the 6CV with no additional packaging requirements. Aluminum foil may be placed around the product container as dunnage to restrict movement within the 6CV.

(iv) Envelope AC.5, Uranium Metal

Content Envelope AC.5 is Highly Enriched uranium metal, alloyed with up to 10% molybdenum. This content must be packaged in a 3013 Container, a Food-Pack Can, or an Engineered Container. This convenience container must be placed within the 6CV with the aluminum Sleeve and Plug component installed followed by an empty, perforated Food-Pack Can, followed by aluminum foil dunnage. Aluminum foil may be placed around the product container as dunnage to restrict movement within the 6CV. Requirements applicable to all packages, as documented in Section 1.2.2 of SARP Addendum 2 [Item 3.B.(2) of this certificate] apply to this content envelope. Section 1.2.2.2.4 of SARP Addendum 2 provides figures and more details for this content envelope. See Table 9 for content envelope mass limits, and Table 4 for specific configuration requirements for content envelope AC.5.

Content Envelope AC.5 has two separate mass limits depending upon the percent enrichment of the U-235. Contents with enrichment less than 95% have a mass limit of 18 kg. Contents with enrichment greater than 95% (to a maximum of 100 %) have a mass limit of 16 kg. For Content Envelope AC.5, if the radionuclide content mass is equal to or greater than 3 kg, the following additional restrictions also apply:

- 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; and
- The innermost material container shall be at least 4 inches in diameter and at least 4 inches long (i.e. minimum can size 400 x 400).

## Table 9
## Content Envelopes for AC.1, AC.2, AC.3, AC.4, and AC.5: Neptunium, Uranium and Plutonium Metals

| | Material[a, b] | AC.1 Neptunium Metal (grams) | | AC.2 BeRP Ball (grams) | AC.3 Pu/U Metal (grams) | AC.4 Plutonium/Uranium Metal[c] (grams) | | AC.5 Uranium Metal (grams) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Sphere Configuration | Content Consists of Pieces | | | Sleeve and Plug Configuration | Content Placed Directly into the 6CV | Up to 100 wt% U-235 | Up to 95 wt% U-235 |
| Radionuclide[e] (grams) | Pu-238 | 9.71E-02 | 3.01E-03 | 8.96E-01 | 33.50[g] | 33.50[g] | 9.00 | - | - |
| | Pu-239 | 1.94 | 6.02E-02 | 4199.55 | 4400.00 | 2000.00 | 450.00 | - | - |
| | Pu-240 | 1.40E-01 | 4.32E-03 | 266.11 | 1100.00 | 1000.00 | 225.00 | - | - |
| | Pu-241 | 3.76E-03 | 1.17E-04 | 12.19 | 166.00 | 166.00 | 67.50 | - | - |
| | Pu-242 | 1.94E-02 | 6.02E-04 | 1.25 | 220.00 | 100.00 | 22.50 | - | - |
| | Am-241 + Pu-241[d] | 4.37E-02 | 1.35E-03 | 12.19 | 166.00 | 166.00 | 67.50 | - | - |
| | AM-243 | 10.93 | 3.38E-01 | - | - | - | - | - | - |
| | Np-237 | 5997.16 | 185.74 | - | - | - | - | - | - |
| | U-232 | - | - | - | 4.40E-06 | 2.00E-06 | 4.50E-07 | 1.60E-05 | 1.80E-05 |
| | U-233 | 2.12E-01 | 6.58E-03 | - | 22.00 | 10.00 | 2.25 | 80.00 | 90.00 |
| | U-234 | 3.46E-02 | 1.07E-03 | - | 4400.00 | 2000.00 | 450.00 | 16000.00 | 18000.00 |
| | U-235 | 1.70 | 5.26E-02 | - | 4400.00 | 2000.00 | 450.00 | 16000.00 | 17100.00 |
| | U-236 | 9.71E-03 | 3.01E-04 | - | 1760.00 | 800.00 | 180.00 | 6400.00 | 7200.00 |
| | U-238 | 1.88E-01 | 5.83E-03 | - | 4400.00 | 2000.00 | 450.00 | 16000.00 | 18000.00 |
| Non-Rad. Impurities[f] | Al, B, F, Li, Mg, Na, Be | 5.00E-03 | 5.00E-03 | 5.00E-03 | 5.00E-03 | 5.00E-03 | 5.00E-03 | 5.00E-03 | 5.00E-03 |
| | Mo | - | - | - | - | - | - | 1600.00 | 1800.00 |
| | C | - | - | - | - | - | - | - | - |
| Total Content Mass (grams) | Radioactive Materials | 6070.00 | 188.00 | 4480.00 | 4400.00 | 2000.00 | 450.00 | 16000.00 | 18000.00 |
| | Non-Radioactive Impurities | - | - | 21.50 | 3080.00[h] | - | - | - | - |
| | All Contents | 6070.00 | 188.00 | 4500.00 | 4400.00 | 2000.00 | 450.00 | 16000.00 | 18000.00 |

Notes:

(a) All Contents Shall Be Dry.

(b) Pu/U content bulk density shall be within the range of 2.0 to 19.84 g/cc.

(c) Contents shall be stabilized in accordance with DOE-STD-3013, Section 6.1.1.

(d) The mass of Pu-240 shall be greater than the mass of Pu-241.

(e) Less than 1000 ppm (weight each) of other actinides, fission products, decay products, and neutron activation products are permitted (unless otherwise stated). If small amounts of actinide impurities are known or suspected to be present, OTC Conditions 5.D.(9) and 5.D.(10) must be complied with.

(f) Less than 100 ppm (weight) other inorganic impurities with total mass less than 0.1 weight percent (unless otherwise stated).

(g) 33.50 grams Pu-238 = 19 Watts.

(h) 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.

(c) The Advanced Gas Reactor (AGR-1) Fuel Compacts

AGR-1 contents have less than 1 g of radioactive material, and contain no more than 1,000 ppm total of Cf-251, Cf-249, Am-242m, Cm-243, Cm-245, and Cm-247. The AGR-1 Fuel Compact has less than 6 g of total content mass (radioactive material plus impurities).

A typical AGR-1 Fuel Compact contains approximately 4,200 coated fuel particles that are slightly less than 1 mm in diameter. These particles are bound together with a thermosetting carbonaceous (i.e., graphite) matrix material. Each particle consists of a uranium oxycarbide (~75% $UO_2$, and the remainder UC and $UC_2$) fuel kernel surrounded by the following layers: Porous carbon buffer layer, Inner pyrolytic carbon (PyC) layer, Silicon Carbide (SiC) barrier coating, Outer PyC layer. The source isotopic distribution for the AGR-1 Fuel Compact is shown in Table A.5.2 of SARP Addendum 3 [Item 3.B.(3) of this certificate], and in Table A, App.1.2.1 of Appendix 1.2.

The AGR-1 Fuel Compact shall be placed in a pipe container (consisting of a threaded pipe section closed with pipe caps) with a minimum closed length of 2.8 inches. The AGR-1 Fuel Compact content in the pipe container is then placed inside the SCQ-SC3 container. The SGQ-SC3 container provides gamma shielding that consists of tungsten shielding material encapsulated in a stainless steel container with threaded closure. The SGQ-SC3 container is loaded axially within the 6CV and held in place by aluminum foam spacers. The typical packaging configuration is shown in Figure 7. SARP Addendum 3, Appendix 1.1 contains the drawings detailing the shielded container components.

The maximum allowable radioactive decay heat rate for the AGR-1 contents is 19 Watts.

(d) Type 4 Contents (i.e., Sources)

The Type 4 Content Envelope includes several isotopes: Pu-238, Pu-239, Am-241, Cm-244, Cf-252, Sr-90, Y-90, Ra-226, Cs-137, Co-60, and Ir-192. The content mass limits for Type 4 contents are shown in Table 10, and in Table A.1.1 of SARP Addendum 3 [Item 3.B.(3) of this certificate]. Type 4 contents can contain a total of 1,000 ppm (by weight each) of the Special Actinide Isotopes Am-242m, Cm-243, Cm-245, Cm-247, Cf-249 and Cf-251.

Type 4 contents can be placed in convenience containers (i.e., Engineered Containers or Food-Pack Cans) prior to placement in a shielded container (i.e., SGQ-SC1, SGQ-SC2, SGQ-SC3) or unshielded container (SGQ-EC1).

Type 4 contents that are gamma-sources will be placed in the lead-shielded containers (SGQ-SC1), which will then, in turn, be placed into the 6CV in accordance with the allowable content configuration, defined in Table A.1.2 of SARP Addendum 3 [Item 3.B.(3) of this certificate]. Gamma-sources can also be placed in the tungsten-shielded containers (SGQ-SC3), as the tungsten-shielded containers are an acceptable substitute for the lead-shielded containers. The SGQ-SC1 and SGQ-SC3 shielded containers are held in position within the 6CV with aluminum foam spacers. Typical packing configurations of the SGQ-SC3 and SGQ-SC1 within the 6CV are shown in Figures 7 and 8, respectively. The decay heat load for the SGQ-SC1 (i.e., lead-shielded) and SGQ-SC3 (i.e., tungsten-shielded) containers are limited to 6 Watts and 19 Watts, respectively.

**Table 10**
**Type 4 (Sources) Contents[b]**

| Radionuclides | Type 4 Contents (i.e., Offsite Source Recovery Program Sources) (grams) |
|---|---|
| Co-60 | 1.00E-04 |
| Cs-137[a] | 1.00E-01 |
| Ir-192 | 3.80E-03 |
| Sr-90/Y-90[a] | 1.00 |
| Ra-226 | 2.00E-01 |
| Am-241[a] | 1.00 |
| Cf-252[a] | 6.70E-06 |
| Cm-244 | 1.00 |
| Pu-238 | 2.00E-01 |
| Pu-239 | 66.00 |

Note:
(a) The mass limits established for some of these isotopes may result in dose rates exceeding 200 mrem/h on the surface of the package depending on the source decay time and the geometric configuration of the packaging materials and the content in the 6CV. Therefore, if the isotopic mass for the proposed content is close to the Table 10 limit, prospective shippers must either:
1) Perform payload-specific shielding calculations for the proposed content to demonstrate compliance with regulatory limits and to ensure ALARA practices are being followed; or
2) If dose rate information for the proposed content is available, it must be reviewed to determine if dose rates are ≤200 mrem/h on contact and ≤10 mrem/h at 1 m prior to loading the proposed content in the Model 9977 packaging for offsite shipment.

For shipments proposed for transport in the TSS, if the dose rates exceed these limits, the proposed content shall not be loaded in the Model 9977 packaging, and such package must not be scheduled for shipment in the TSS.

For shipments proposed for transport by commercial carriers, the dose rate may exceed 200 mrem/h on contact or 10 mrem/h at 1 m; however, the shipment must be made exclusive use and must comply with OTC condition 5.D.(9), and must ensure that the proposed shipment complies with applicable security requirements.

(b) Contents can contain a total of 1,000 ppm (by weight) of the Special Actinide Isotopes Am-242m, Cm-243, Cm-245, Cm-247, Cf-249 and Cf-251. Less than 1000 ppm (weight each) of other actinides, fission products, decay products, and neutron activation products are permitted. If small amounts of actinide impurities are known or suspected to be present, OTC Conditions 5.D.(9) and 5.D.(10) must be complied with.

Type 4 contents that are neutron-sources will be placed in the HDPE shielded container (SGQ-SC2), which will then, in turn, be placed into the 6CV in accordance with the allowable content configuration, defined in Table A.1.2 of SARP Addendum 3 [Item 3.B.(3) of this certificate]. The SGQ-SC2 shielded container is held, for convenience, at the top of the 6CV using a perforated Food-Pack Can. A typical packing configuration for the SGQ-SC2 within the 6CV is shown in Figure 9. The decay heat load for the SGQ-SC2 (poly-shielded) container is limited to 3 Watts.

An Engineered Container (SGQ-EC1) can be used for shipments of contents that do not require shielding, provided that the administrative dose rate limits of 180 mrem/hr (on contact of the unshielded source or piece) and 9 mrem/hr (at a distance of 1 meter of the unshielded source or piece) are met following the procedures in Section 7.1.1.2 of SARP Addendum 3 [Item 3.B.(3) of this certificate]. A typical packing configuration for the SGQ-EC1 within the 6CV is shown in Figure 10. The decay heat load for the SGQ-EC1 is 19 Watts. Appendix 1.2 of SARP Addendum 3 contains the drawing details for the three shielded containers, Engineered Containers, and container components [Item 3.B.(3) of this certificate].

A listing of the appropriate shielded containers for various Type 4 isotopes is provided in Table 5. A summary of the approved configurations for the Type 4 Contents is provided in Table 6.

The Type 4 contents shall be in sold form (metal, oxide, or carbide). When shipped in a "sealed source" configuration, the Type 4 contents may contain carbonaceous matrix materials, halides, hydroxides, hydrides, oxycarbides, titanates, silicates, sulfates, or aluminosilicates [Item 3.B.(3) of this certificate].

(e) Training Source Contents

The Training Sources contents may include radioactive isotopes Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, Am-241, Am-243, Cf-252, Cm-248, Np-237, Th-232, U-234, U-235, U-236, and U-238, with impurities (such as Be, Al, Mg, Na, F). The maximum masses for the Training Sources Contents are limited to the masses noted in Table 11. Materials that comply with all the mass and configuration limits can be shipped under the training source content envelope, even if the materials are not to be used for training purposes. All bounding individual and total mass limits in Table 11 must be complied with. The following packaging configuration requirements listed below must be complied with (Table A.1.2 of SARP Addendum 5 [Item 3.B.(4) of this certificate], including, but not limited to:

- The material shall be in solid form (metal or oxide);
- Contents in liquid form are not permitted; the material shall contain no free liquids;
- The maximum allowable radioactive decay heat rate for the Training Source Contents is 3.5 Watts;
- Except as stated in Table 11, small concentrations (<1,000 ppm) of other actinides, fission products, decay products, and neutron activation products are permitted. Assessment of these impurities may be based on process knowledge;
- Except as stated in Table 11, inorganic material impurity quantities of less than 100 ppm each are permitted as long as the total mass is less than 0.1 weight percent of the total content mass. Assessment of these impurities may be based on process knowledge;
- The maximum weight of the payload (everything that goes into the 6CV, including radioactive contents, Engineered Containers, convenience cans, contamination control devices, packing materials, spacers, etc.) is not to exceed 100 lb (43.5 kg mass);
- The material shall not generate any gas (other than helium by alpha decay);
- The content containers, as described in SARP Addendum 5 [Item 3.B.(4) of this certificate] Section 1.2.2.1, may contain up to 2 kg of plastic materials (polycarbonate, polyethylene).

The packaging configuration requirements specified in SARP Addendum 5 [Item 3.B.(4) of this certificate] Section 1.2.2 must be complied with. In addition to Food-Pack Cans, DOE-Standard 3013 Containers and Engineered Containers, the Training Source contents can be placed in a Training Sources Engineered Container. The Training Sources Engineered Containers confine the radioactive materials within circular or square cross-section thin inner and outer polycarbonate bottles, have multiple polyethylene foam discs providing suitable packing, and are vented through filters. The Training Sources Engineered Containers contain less than 2 kg of plastic or other organic packing material susceptible to out-gassing. Details for the Training Sources Engineered Containers are provided in Appendix A.1.1 of SARP Addendum 5 [Item 3.B.(4) of this certificate]. The Engineered Containers are placed within the 6CV and held in place by aluminum foil. Typical packing configurations for the Training Sources Engineered Containers are shown in Figures 11 and 12.

**Table 11**
**Maximum Mass Limits for Training Sources Contents**

| | Material[a, b] | Training Sources (grams) |
|---|---|---|
| Radionuclide[g] | Pu-238 | 3.50 |
| | Pu-239 | 190.00 |
| | Pu-240[c] | 25.00 |
| | Pu-241[c] | 7.00 |
| | Pu-242 | 10.00 |
| | Pu-241 + Am-241 | 7.00 |
| | Am-243[d] | 6.63 |
| | Cf-252 | 2.60E-07 |
| | Cm-248 | 5.70E-06 |
| | Np-237 | 10.00 |
| | Th-232 | 10000.00 |
| | U-234 | 10.00 |
| | U-235 | 500.00/350.00[f] |
| | U-236 | 1.00 |
| | U-238 | 2000.00 |
| Non-Radioactive Inorganic Impurities[e] (ppm) | Be | 1500 |
| | Al | 150 |
| | Mg | 500 |
| | Na | 300 |
| | F | 200 |
| Total Mass (grams) | **Radioactive Materials** | **12750.00** |
| | **Non-Radioactive Inorganic** | **34.00** |
| | **All Contents** | **12780.00** |

Notes:

(a) All contents shall be dry,

(b) Pu/U content bulk density shall be no greater than 19.84 g/cc and no less than 2.0 g/cc.

(c) Pu-240 shall be greater than Pu-241.

(d) Care must be taken when handling the proposed content if Am-243 is known or suspected to be present to ensure worker doses are maintained ALARA because the photon dose rate can increase significantly during decay depending on the actual materials present and the geometric configuration. Available dose rate information for the proposed content must be reviewed to determine if dose rates are ≤200 mrem/h on contact and ≤10 mrem/h at 1 m prior to loading the proposed content in the Model 9977 for shipment.

(e) The Al, Mg, Na, and F limits may be increased on a ppm basis for an equal decrease in the Be content limit.

(f) The 350 g limit is imposed if the combined total Pu-239 mass plus Pu-241 mass equals or exceeds 10 g.

(g) Small concentrations (<1,000 ppm) of other actinides, fission products, decay products, and neutron activation products are permitted. If small amounts of actinide impurities are known or suspected to be present, OTC Conditions 5.D.(9) and 5.D.(10) must be complied with.

(f) Dual 3013 Container Contents

The allowable 3013 Container Content Envelope is defined in Table 12. The contents must be dry and in solid form. The radioactive material must be in the form as oxides. The total content mass listed in Table 12 applies to each 3013 Container. The 9977 package is approved for shipment of one or two 3013 container contents. The contents to be shipped in two 3013's package shall consist of not more than 10 kg (22.05 lb) of $PuO_2$. The $PuO_2$ is placed in one or Dual 3013 Container assemblies, with not more than 5 kg (11.02 lb) per 3013 Container assembly. The amount of radioactive material allowed in the 9977 package is 4.4 kg (9.7 lb) per 3013 Container assembly, for a total of 8.8 kg (19.4 lb) radioactive material in the 6CV. The total content mass listed in Table 12 does not include the associated packing materials discussed in Sections 1.2.2.1 and 1.2.2.2 of SARP Addendum 7 [Item 3.B.(5) of this certificate].

**Table 12**
**3013 Contents Envelope (per 3013 Container)**

| | **Material**[a, b, c] | **3013 Content (grams)** |
|---|---|---|
| **Radionuclides**[f] | Pu-236 | 4.40E-06 |
| | Pu-238 | 2.20 |
| | Pu-239 | 4.18E03 |
| | Pu-240[d] | 3.96E02 |
| | Pu-241[d] | 44.00 |
| | Pu-242 | 4.40 |
| | U[e] | 2.20E03 |
| | Pu-241 + Am-241 | 44.00 |
| | Np-237 | 2.20 |
| **Impurities** | Be | 4.40E-01 |
| | Al | 6.60E-01 |
| | Mg | 2.20 |
| | Na | 1.32 |
| | F | 1.10 |
| | B | 2.20 |
| | Li | 2.20 |
| **Total Mass** | Radioactive Materials | 4.40E03 |
| | Impurities | 82.00 |
| | All Contents | 5.00E03 |

Notes:

(a) All contents shall be dry and in solid form.

(b) Pu/U content bulk density shall be no greater than 7 g/cc and no less than 2.0 g/cc.

(c) Contents shall be stabilized in accordance with DOE-STD-3013, Section 6.1.1.

(d) The mass of Pu-240 shall be greater than the mass of Pu-241.

(e) All isotopes except U-232, which is limited to 1E-7 weight percent of the total mass of uranium.

(f) Small concentrations (<1,000 ppm) of other actinides, fission products, decay products, and neutron activation products are permitted. If small amounts of actinide impurities are known or suspected to be present, OTC Conditions 5.D.(9) and 5.D.(10) must be complied with.

Requirements for the Dual 3013 Configuration contents and payload configuration are the following:

- The maximum allowable radioactive decay heat rate is 19 Watts per 3013 Container and 38 Watts total per Package;
- Small concentrations (<1,000 ppm) of other actinides, fission products, decay products, and neutron activation products are permitted. Assessment of these impurities may be based on process knowledge;
- Inorganic material impurity quantities of less than 100 ppm each are permitted, as long as the total mass is less than 0.1 weight percent of the total content mass. Assessment of these impurities may be based on process knowledge;
- The maximum weight of the payload (everything that goes into the 6CV, including radioactive contents, the 3013 Spacer, convenience cans, contamination control devices, packing materials, spacers, etc.) is not to exceed 77.7 lb.

A typical Dual 3013 packing configuration within the 6CV is shown in Figure 13. In addition to the isotopic and chemical content restrictions listed in Table 12 and the configuration criteria listed in Section 1.2.2.1.1 of SARP Addendum 7 [Item 3.B.(5) of this certificate], the following conditions apply:

- The 3013 Spacer must be used;
- The Heat Dissipation Sleeve must be used;
- The atmosphere within the 6CV shall be diluted to least 75% $CO_2$ per Section 7.1.2 of Addendum 7 [Item 3.B.(5) of this certificate];
- The 3013 Container (consisting of the outer can, the inner can, and the convenience can), shall be inerted with helium or nitrogen such that oxygen content in all void spaces is no greater than 5% by volume at the time the outer 3013 Container is sealed (i.e., welded closed).

C. CRITICALITY SAFETY INDEX (CSI)

(1) The CSI for package with Content Envelope C.1 or ICE is zero (CSI=0).
(2) The CSI for the package with Content Envelope AC.1 through AC.5 is 1.0 (CSI=1.0).
(3) The CSI for package with AGR-1 Fuel Compact is zero (CSI=0).
(4) The CSI for package with Type 4 (Sources) contents is zero (CSI=0).
(5) The CSI for package with Training Sources contents is 1 (CSI=1.0).
(6) The CSI for package with Dual 3013 contents is 1.0 (CSI=1.0).

D. ADDITIONAL CONDITIONS

(1) The contents shall have a maximum decay heat generation rate of 19 Watts, unless otherwise noted below:
- 19 Watts per 3013 Container and 38 Watts total per Package in the Dual 3013 configuration;
- 6 Watts in the SGQ-SC1 configuration;
- 3 Watts in the SGQ-SC2 configuration; and
- 3.5 Watts in Training Sources Engineered Container configuration.

(2) The maximum weight of the payload (everything that goes into the 6CV, including radioactive material contents, convenience cans, contamination control devices, packing materials, spacers, etc.) is not to exceed 100 lb, except for the Dual 3013 Can configuration where the maximum weight of the payload shall not exceed 77.7 lbs. The maximum allowable gross shipping weight of the 9977 package is 350 lb.

(3) The Model 9977 Package must be shipped in a closed conveyance.

(4) Transport of fissile material by air is not authorized. In addition, for Dual 3013 configuration shipments, shipment by water is not authorized.

(5) In addition to the requirements of 10 CFR Part 71 Subparts G and H, and except as specified each package must be fabricated, acceptance tested, operated and maintained in accordance with the Operating Procedures requirements of Chapter 7, the Acceptance Tests and Maintenance Program requirements of Chapter 8, and the packaging-specific Quality Assurance requirements of Chapter 9 of the SARP [Item 3.B(1) of this certificate], as supplemented by the

SARP Addenda [Items 3.B.(2), 3.B.(3), 3.B.(4), and 3.B.(5) of this certificate], and Applications [References 5.E.(1), 5.E.(2), 5.E.(3), 5.E.(4) and 5.E.(5)].

(6) For the AGR-1 fuel compacts, the requirements specified in Section 1.2.2.2.2, and in Table A.1.2 of SARP Addendum 3 [Item 3.B.(3) of this certificate], must be followed, along with the specific procedures outlined in Steps 1, 2, 6, 8, and 12 of Section 7.1.1.2 of the SARP Addendum 3.

(7) The documentation packages for the Quality Category components numbered as 17–20, in Table A, App. 8.2.1 of SARP Addendum 3, Dimensions/Materials Requiring Independent Verification Records, must be supplied by the Site directing fabrication to Savannah River National Laboratory as the Design Authority/Design Agency.

(8) For the Type 4 (Sources) contents, the requirements specified in Section 1.2.2.2.1, and in Table A.1.2, of the SARP Addendum 3, must be followed, along with the specific procedures of Section 7.1.1.2 of the SARP Addendum 3. The documentation packages for the Quality Category components, numbered as 17–30, in Table A, App.8.2.1 of the SARP Addendum 3, Dimensions/Materials Requiring Independent Verification Records must be supplied by the Site directing fabrication to Savannah River National Laboratory as the Design Authority/Design Agency.

(9) For shipments proposed for transport in the NNSA operated Transportation Safeguards System, if the estimated dose rate is >200 mrem/h at any point on the external surface of the package or >10 mrem/h at 1 m from the surface of the package, the proposed content shall not be loaded in the Model 9977 packaging. Packages whose dose rate is >200 mrem/h at any point on the external surface of the package or >10 mrem/h at 1 m from the surface of the package must not be scheduled for shipment in the TSS.

For shipments proposed for transport by commercial carrier, if the dose rate is >200 mrem/h at any point on the external surface of the package or >10 mrem/h at 1 m from the surface of the package for the proposed content, the package must be shipped exclusive use in accordance with 10 CFR 71.47(b) through (d), and the shipper must pre-notify the carrier with sufficient lead time for the carrier to take the appropriate actions and make the necessary plans. If the estimated dose rate on the surface of the package exceeds 1000 mrem/h, the proposed content shall not be shipped in the 9977 package.

(10) If small amounts of actinide impurities are known or suspected to be present, either:

a) payload-specific shielding calculations must be performed for the proposed content to demonstrate compliance with regulatory limits and to ensure ALARA practices are being followed.; or,

b) available dose rate information for the proposed content must be reviewed to determine if the dose rates are ≤200 mrem/h on contact and ≤10 mrem/h at 1 meter prior to loading the proposed content in the Model 9977 for shipment.

(11) 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 N14.5-1997.

(12) Package users must:

(a) Have and operate under a 10 CFR 71 Subpart H compliant Quality Assurance Program approved by the NNSA CO for NNSA users and by the DOE CO for DOE non-NNSA users;

(b) Have a current copy of this certificate and the appropriate documents listed in Item 3.B. of this certificate;
(c) Comply with the terms and conditions specified in this certificate; and
(d) Be registered as a user of this package with the NNSA CO.

(13) A radiological survey must be conducted on each package; validation that the survey was performed must be communicated to the package destination and retained by the shipper as part of the shipment records. Surface contamination on any part of the package must not exceed limits established in 49 CFR 173.443, Table 9. Emanations must not exceed limits established in 49 CFR 173.441. Measuring equipment must be calibrated and of sufficient accuracy.

(14) Package exterior marking and labeling must be legible and visible and in conformance with 49 CFR 172, Sections D and E (49 CFR 172.310, 172.400, and 172.403) except that classified information shall not be revealed.

(15) The following conditions apply for Dual 3013 shipments in the 9977 packaging:
(a) The 3013 Container (consisting of the outer can, the inner can, and the convenience can) shall be inerted with helium or nitrogen such that oxygen content in all void spaces is no greater than 5% by volume at the time the outer 3013 Container is sealed (welded closed);
(b) In addition to the radioactive material and impurity mass loading limits per 3013 Container assembly (Table 12), the $PuO_2$ in the 9977 package shall be limited to a total of 10 kg (22.05 lb) and the maximum amount of fissile material allowed in the package shall be 8.8 kg (19.4 lb);
(c) The Heat Dissipation Sleeve and the 3013 Spacer must be used for the 9977 package with Dual 3013 Containers. Verify that the Heat Dissipation Sleeve and the 3013 Spacer have been properly installed;
(d) The bulk density of the $PuO_2$ shall be >2g/cc and <7g/cc;
(e) Seal time must be 12 months or less, where seal time is defined as the length of time that the shipment must be complete after the 9977 CV is sealed;
(f) The void space within the CV shall be backfilled with ≥75% by volume carbon dioxide gas prior to shipment; and
(g) If the measured Transport Index is greater than 10, the package must be transported by "Exclusive Use" shipment, and/or additional 3013 Container mass loading restrictions or impurity control measures may be used to reduce the dose rates. Early notification of organization that will be transporting these packages must be notified of shipments with TIs of 10 or greater early in the scheduling process.

E. <u>REFERENCES</u>

(1) *ACTION: Application for Contents Amendment for Shipping Isentropic Compression Experiment (ICE) Apparatus in 9977 Packaging*, National Nuclear Security Administration (NNSA) memorandum from Paul T. Mann, Defense Programs Packaging Manager (NA-172.1), to James M. Shuler, Manager Packaging Certification Program (EM-63), dated February 20, 2009.

(2) *ACTION: Application for Amendment for Shipping Revised Sleeve and Plug Design in the 9977 Packaging*, NNSA memorandum from Paul T. Mann, Defense Programs Packaging Manager (NA-172.1), to James M. Shuler, Manager Packaging Certification Program (EM-63), dated June 29, 2010.

(3) *ACTION: Application for Contents Amendment for Shipping Alternate Radioisotopic Thermoelectric Generator (RTG) Assembly Configurations in 9977 Packaging*, NNSA memorandum from Paul T. Mann, Defense Programs Packaging Manager (NA-172), to James M. Shuler, Manager Packaging Certification Program (EM-63), dated November 22, 2010.

(4) *ACTION: Application for Contents Amendment for Shipping Training Source Contents in 9977 Packaging*, NNSA memorandum from Paul T. Mann, Defense Programs Packaging Manager (NA-172), to James M. Shuler, Manager Packaging Certification Program (EM-63), dated November 22, 2010.

(5) Letter Amendment Request for the 9975-85, 9975-96, 9977, and 9978, COR-OM-11/15/2010-301010, submitted to Dr. Jim Shuler, Environmental Management, by the National Nuclear Security Administration (NNSA), Livermore Site Office (November 17, 2010).

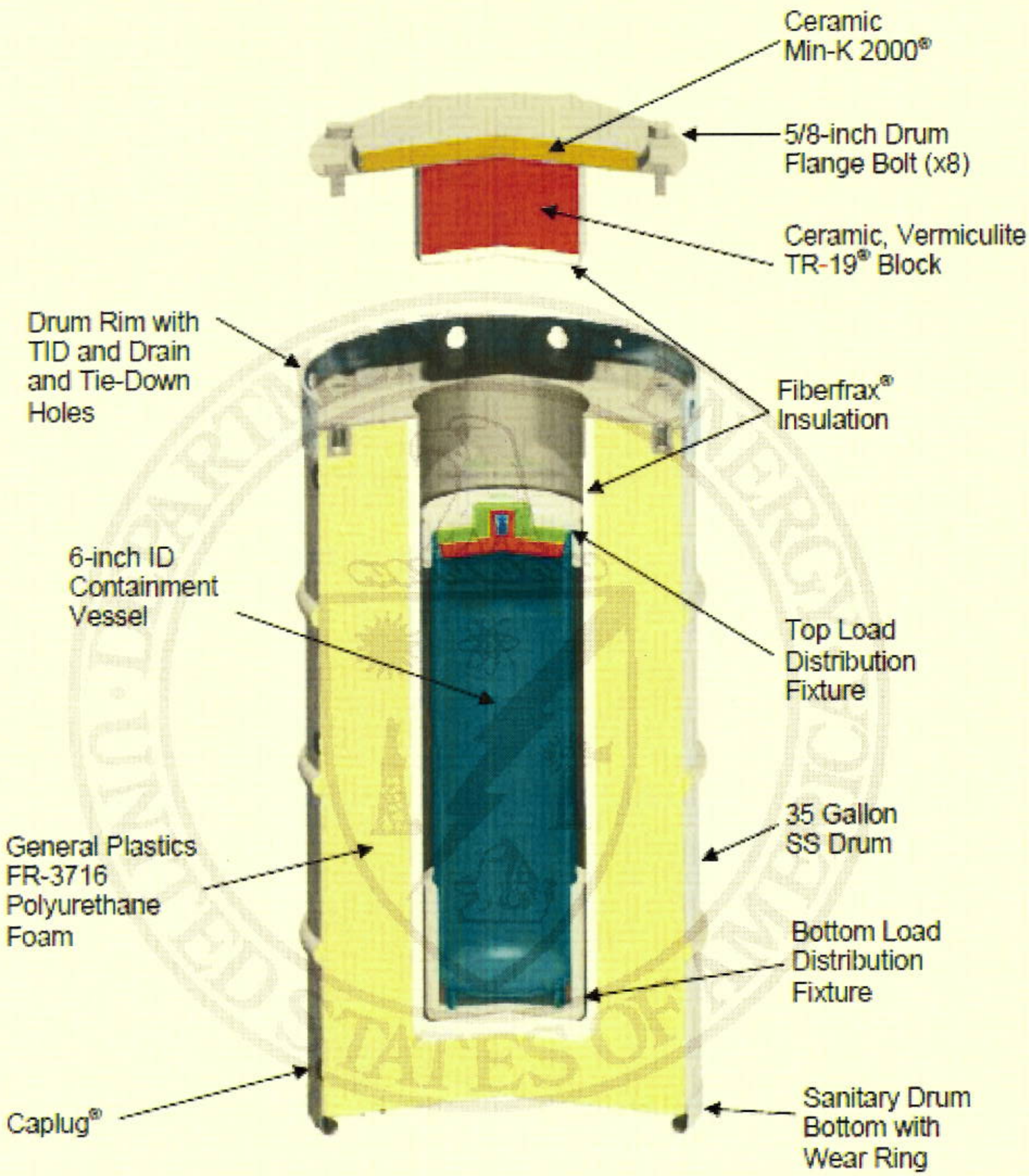


**Figure 1**
**Three-Dimensional Cut Away Illustration of the 9977**

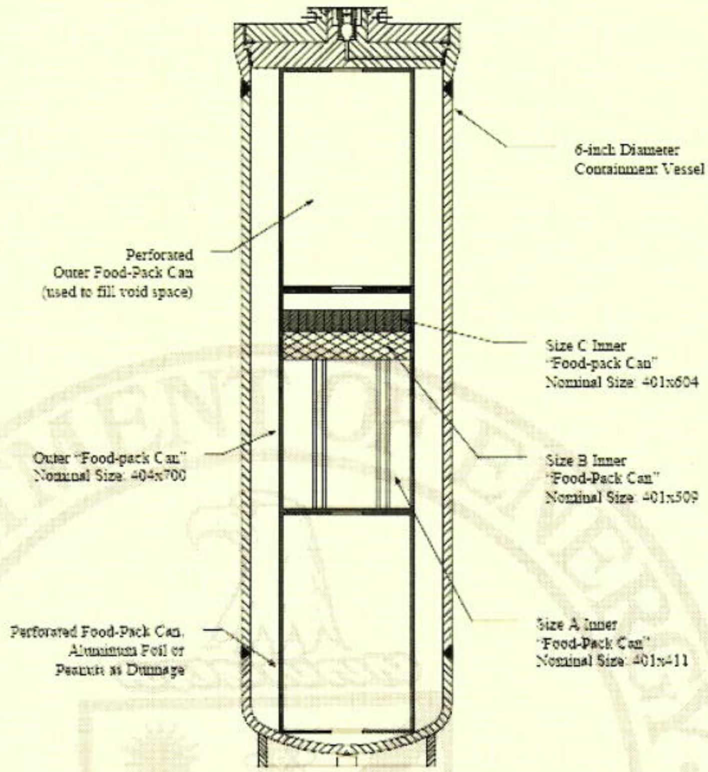


**Figure 2**

**Typical Food-Pack Can Configuration with Spacer Cans**

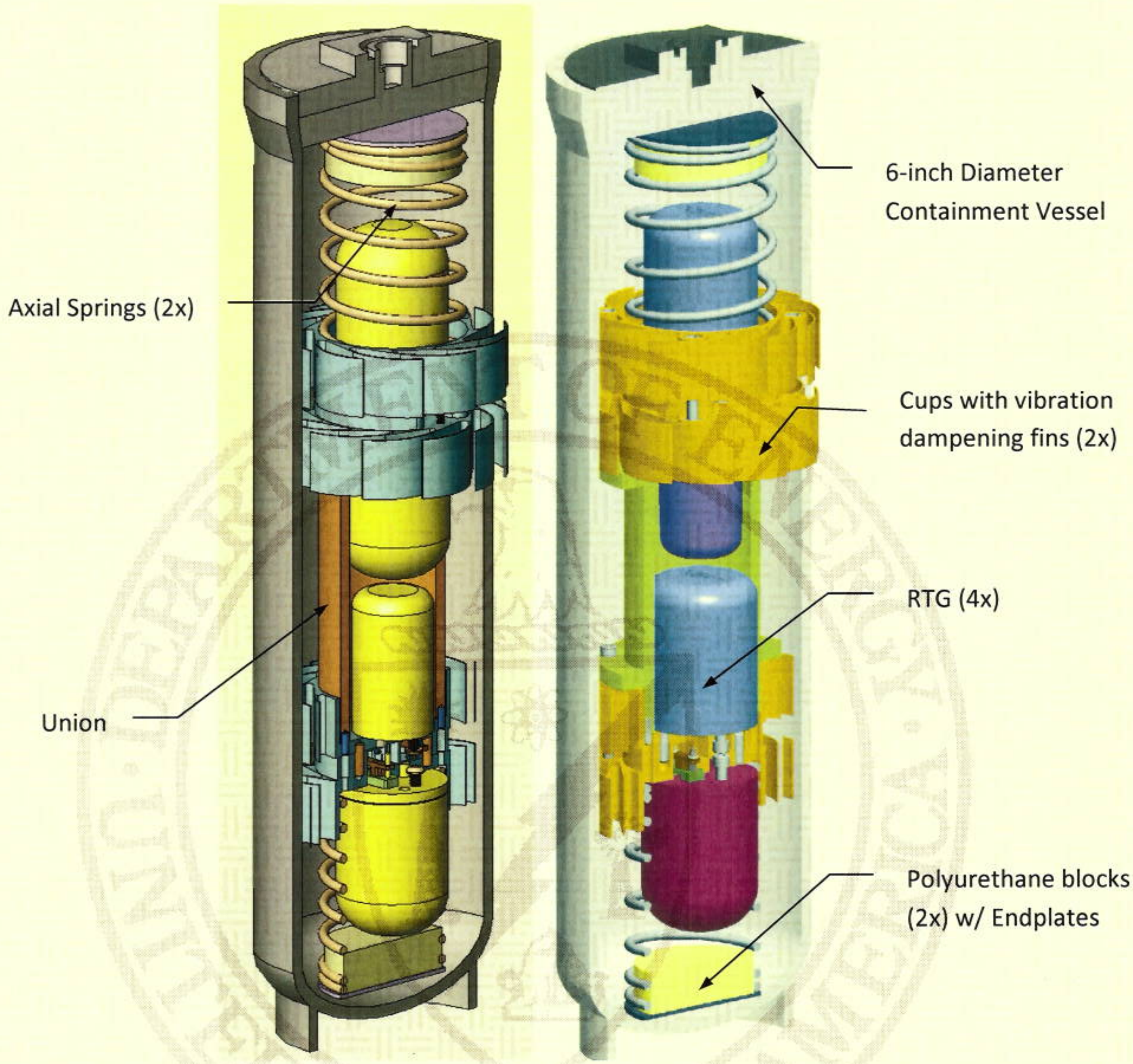


**Figure 3**
**6CV with Original and Modified Radioisotope Thermoelectric Generator (RTG) Assembly Configurations**

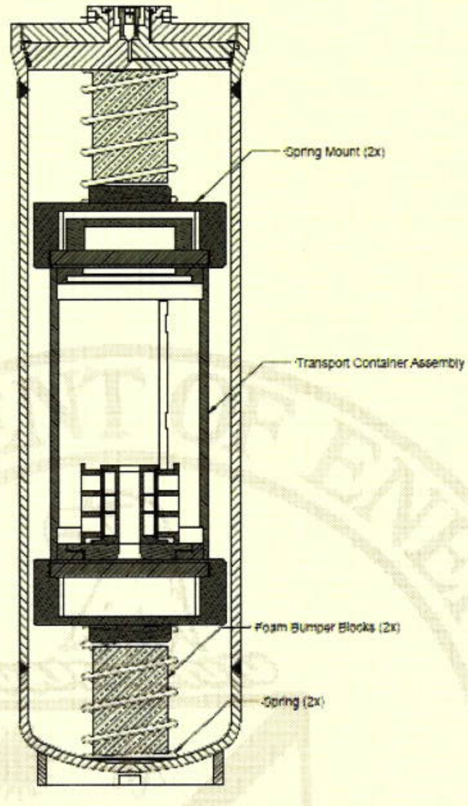


**Figure 4**
**6CV with ICE Apparatus Transport Container Assembly**

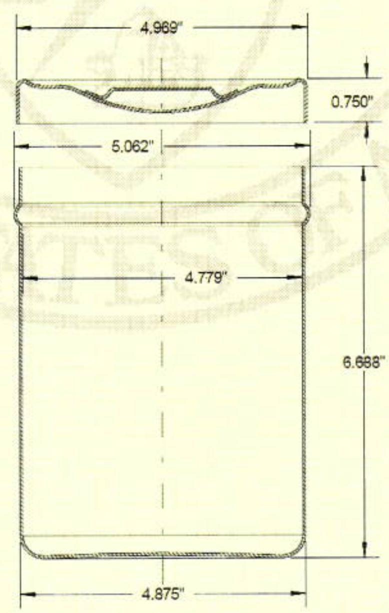


**Figure 5**
**Diagram of Vollrath 88020 Slip-Lid Can**

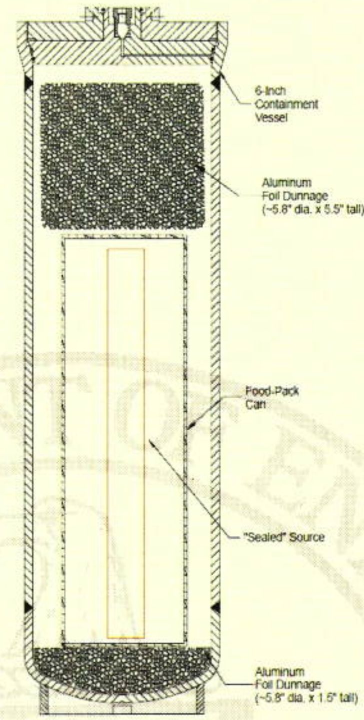


**Figure 6**
**Typical Engineered Container Configuration**

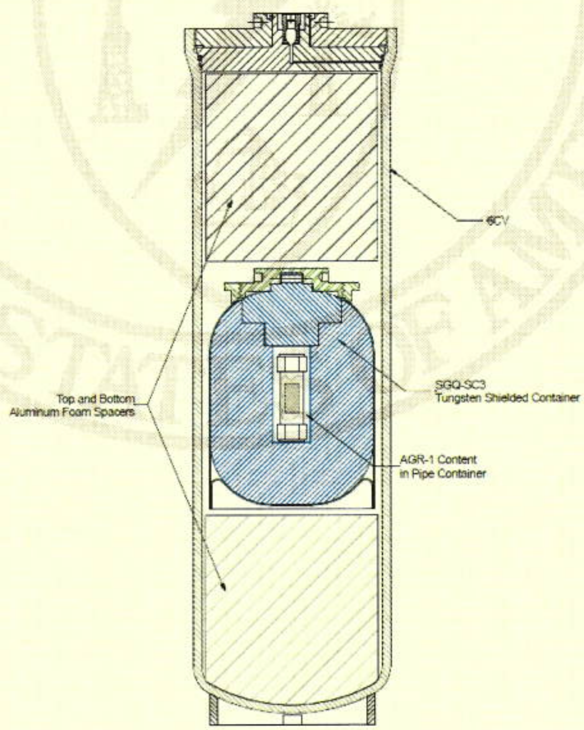


**Figure 7**
**SGQ-SC3 Configuration in 9977 (Tungsten Shielding) Showing AGR-1 Content in Pipe Container**

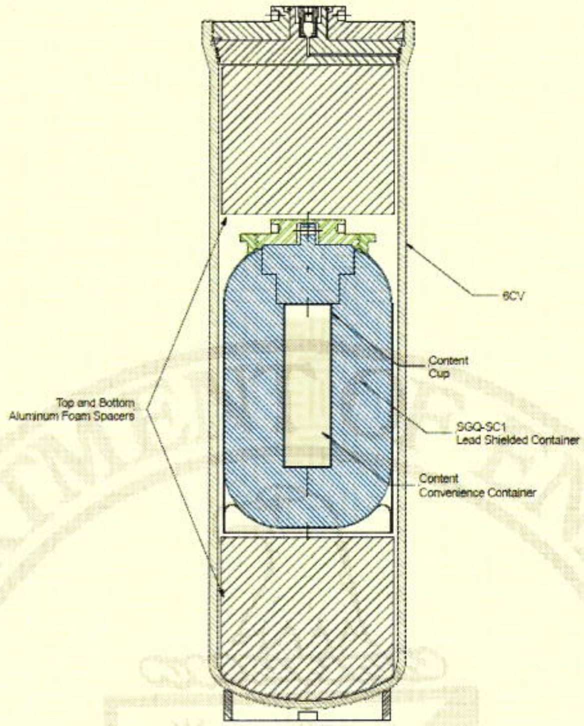


**Figure 8**

**SGQ-SC1 Configuration in 9977 (Lead Shielding)**

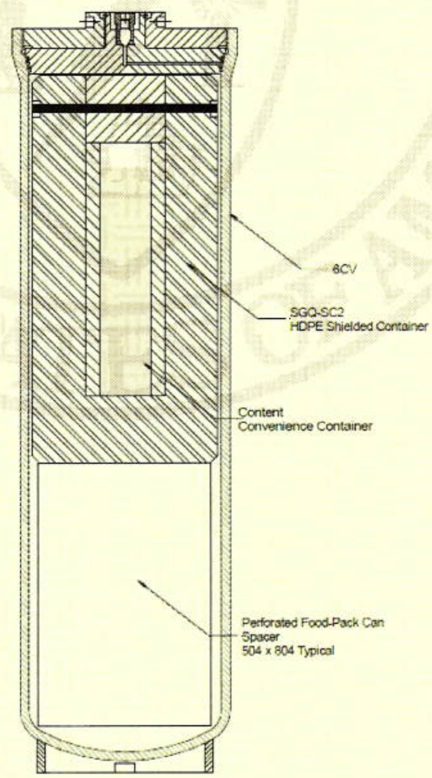


**Figure 9**

**SGQ-SC2 Configuration in 9977 (HDPE Shielding)**

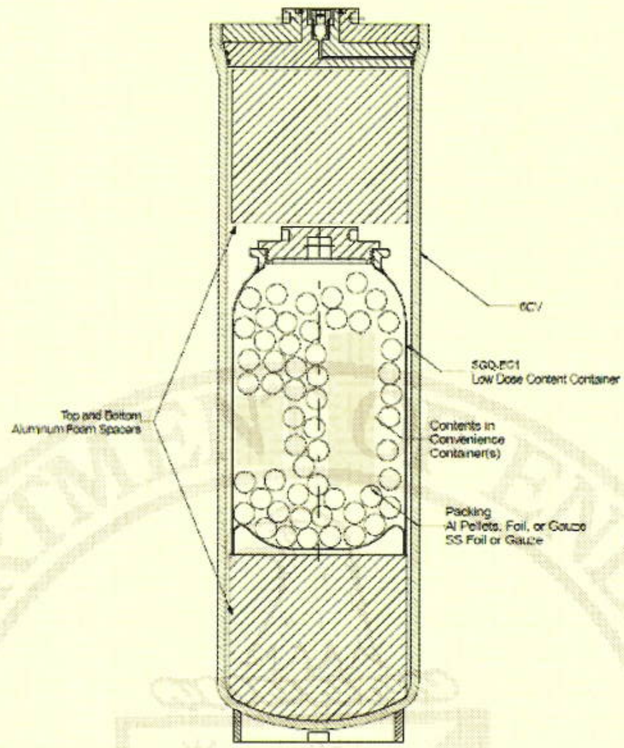


**Figure 10**

**SGQ-EC1 Configuration in 9977 (Confinement)**

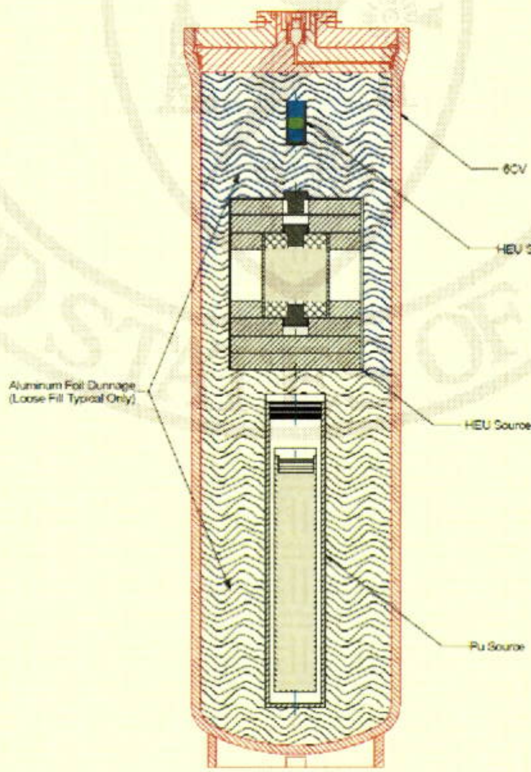


**Figure 11**

**Typical Three Training Sources Engineered Container Configuration**

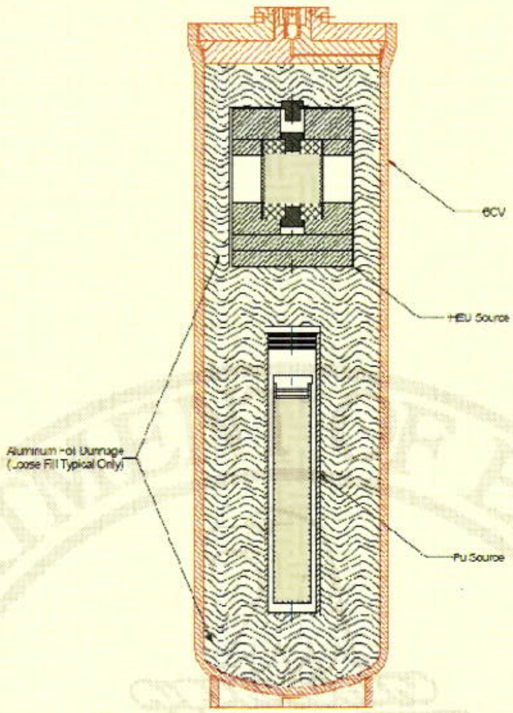


**Figure 12**

**Typical Two Training Sources Engineered Container Configuration**

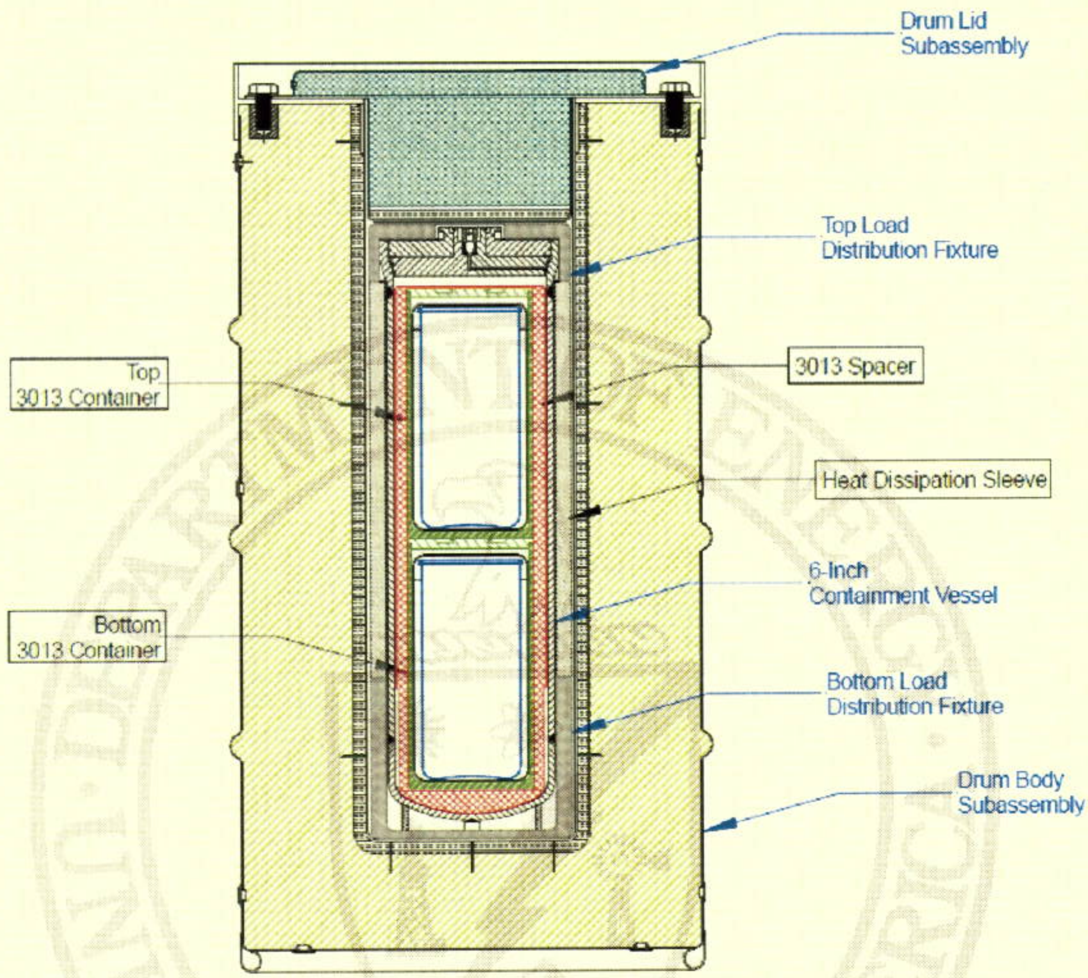


**Figure 13**
**Typical Dual 3013 Container Configuration in the 9977**