

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

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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 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

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| a. ISSUED TO (<i>Name and Address</i>)
U.S. Department of Energy
Washington, DC 20585 | b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION
BWXT Y-12, L.L.C., application dated March 3, 2011, as supplemented. |
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4. CONDITIONS

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

5.

(a) Packaging

- (1) Model No.: ES-3100
- (2) Description

The ES-3100 package is a cylindrical container that is approximately 110 cm (43 in) in overall height and 49 cm (19 in) in overall diameter and is composed of an outer drum assembly and an inner containment vessel. The containment vessel is placed inside the drum and surrounded by a cement based borated neutron absorber, Catalog 277-4. The purpose of the ES-3100 is to transport bulk high enriched uranium in various forms.

The outer drum assembly consists of a reinforced stainless steel, standard mil spec 30-gal drum with an increased length. The volume formed between the drum and the attached inner liner is filled with an inorganic, castable refractory material, Kaolite 1600™, which is comprised of concrete and vermiculite. The Kaolite 1600™ acts as both a thermal insulating and an impact limiting material.

The containment vessel is approximately 82 cm (32 in) in overall height and 13 cm (5 in) in overall diameter and is constructed of 304L stainless steel. The containment boundary consists of the 0.1 in thick containment vessel body and the lid assembly. The lid assembly consists of a sealing lid, a closure nut, and external retaining ring, which holds both the assembly and closure nut together. The double ethylene-propylene elastomer O-rings in the top flange of the containment vessel permit leak testing of the containment vessel. The maximum gross weight of the package, including contents, is 190.5 kg (420 lb).

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5.(a) Packaging (continued)

(3) Drawings

The Model No. ES-3100 package is constructed and assembled in accordance with:

- (i) BWXT Y-12, L.L.C., Drawing No. M2E801580A037, sheets 1 through 6, Rev. C, "Consolidated Assembly Drawing."
- (ii) BWXT Y-12, L.L.C., Drawing No. M2E801580A026, Rev. C, "Heavy Can Spacer Assembly."
- (iii) Equipment Specification JS-YMN3-801580-A001, Rev. E, "ES-3100 Containment Vessel."
- (iv) Equipment Specification JS-YMN3-801580-A002, Rev. D, "ES-3100 Drum Assembly."
- (v) Equipment Specification JS-YMN3-801580-A003, Rev. C, "Manufacturing Process Specification for Casting Kaolite 1600™ into the ES-3100 Shipping Package."
- (vi) Equipment Specification JS-YMN3-801580-A005, Rev. G, "Casting Catalog No. 277-4 Neutron Absorber for the ES-3100 Shipping Package."
- (vii) BWXT Y-12, L.L.C., Drawing No. M2E801580-A043, Rev. 0, "Heavy Can Spacer Assembly (SST)."

5.(b) Contents (Type and form of material, maximum quantity of material per package, and Criticality Safety Index (CSI)).

The weight of the radioactive contents, convenience containers, can lift attachments, polyethylene bags, spacers, and other material in the containment vessel shall not exceed 90 lb. The maximum mass of off-gassing packaging materials in the containment vessel (e.g., polyethylene containers or bagging, silicone rubber pads, nylon bags, etc.) shall not exceed 500 grams. The maximum content decay heat load shall not exceed 0.4 watts.

With the use of Teflon bottles as convenience containers, an additional 990 g of off-gassing material is authorized in the containment vessel. The additional 990 g must be Teflon (e.g., three Teflon bottles weighing 330 g each). With Teflon bottles, the maximum mass of off-gassing materials is 1490 g: 990 g Teflon and 500 g of any type of hydrogenous material, except in the case of shipping uranium in the form of broken metal, in which case the hydrogenous material must have a hydrogen atom density less than or equal to that of water.

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5.(b) Contents (continued)

The concentration limits of uranium and transuranic constituents shall be the following:

Isotope	Maximum Concentration
U-232	0.040 µg/gU ^a
U-233	0.006 g/gU ^b
U-234	0.02 g/gU
U-235	1.00 g/gU
U-236	0.40 g/gU
Transuranics (except Np)	40.0 µg/gU
Np-237	0.025 g/gU

^a µg/gU = 10⁻⁶ grams per gram of total uranium

^b g/gU = grams per gram of total uranium

- (1) Uranium as solid metal or alloy, packaged in stainless-steel or tin-plated carbon steel convenience cans. Alloys of uranium include uranium-aluminum, uranium-molybdenum, and uranium-zirconium. Mass of the non-uranium portion of the alloy shall be assumed to be uranium-235.

The maximum uranium enrichment is 100 weight percent U-235.

For contents that must be shipped with spacers, the spacers must be in accordance with BWXT Y-12, L.L.C., Drawing No. M2E801580A026 or M2E801580A043, and Equipment Specification JS-YMN3-801580-A005, as specified in Condition No. 5.(a)(3). The quantity of fissile material in any convenience can shall not exceed one third of the mass loading limit per package for that content. Spacers must be positioned between every two convenience cans, or in the case of shipping one convenience can only, the spacer must be positioned on top of the single can.

- (i) For metal and alloy in the form of solid geometric shapes, meeting the following restrictions, mass limits are listed in Table 1. Contents not meeting the following restrictions must be shipped as broken metal (see Condition No. 5.(b)(1)(ii)).

- (A) Cylinders having a diameter no larger than 4.25 in
(maximum of one cylinder per convenience can)
- (B) Square bars having a cross section no larger than 2.29 in × 2.29 in
(maximum of one bar per convenience can)
- (C) Slugs having dimensions of 1.5 in diameter × 2 in tall
(maximum of 10 slugs per convenience can)

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5.(b)(1) Contents (continued)

Table 1: Loading Limits for Metal and Alloy in Solid Geometric Shapes

Solid uranium metal or alloy (specified geometric shapes)	Uranium Enrichment (weight percent U-235)	CSI	With Spacers Maximum Mass U-235 (kg)		No Spacers Maximum Mass U-235 Per Package (kg)
			Per Convenience Can	Per Package	
Cylinders (3.24 in. < diameter ≤ 4.25 in.)	≤ 100	0.0	8.333	25.000	15.000
Cylinders (diameter ≤ 3.24 in.)	≤ 100	0.0	10.000	30.000	18.000
Square Bars	≤ 100	0.0	11.733	35.200	30.000
Slugs	≤ 95	0.0	-	-	17.374
Slugs	> 80 and ≤ 95	0.0	8.108	24.324	Spacer req'd
Slugs	> 80 and ≤ 95	0.4	11.583	34.749	Spacer req'd
Slugs	≤ 80	0.0	9.773	29.318	Spacer req'd

- (ii) For metal and alloy defined as broken metal, mass limits are specified in Table 2. Uranium metal and alloy pieces must have a surface-area-to-mass ratio of not greater than 1.00 cm²/g or must not pass freely through a 3/8-inch (0.0095m) mesh sieve. The uranium metal must also have had no more than a limited contact with water and been subsequently dried. Particles and small shapes that do not pass this size restriction, as well as powders, foils, turnings, and wires, are not permitted, unless they are in a sealed container under an inert cover gas. Uranium material or alloy which has been stored in water or is visibly wet at the time of packaging is not authorized to be shipped in this package.

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5.(b)(1) Contents (continued)

Table 2: Loading Limits for Solid Metal or Alloy in the Form Defined as Broken Metal

Uranium Enrichment (weight percent U-235)	CSI	With Spacers Maximum Mass U-235 (kg) ^a		No Spacers Maximum Mass U-235 Per Package (kg) ^a
		Per Convenience Can	Per Package	
> 95 and ≤ 100	0.0	0.925	2.774	Spacer req'd
	0.4	1.850	5.549	Spacer req'd
	0.8	3.083	9.248	Spacer req'd
	2.0	4.624	13.872	Spacer req'd
	3.2	8.323	24.969	Spacer req'd
> 90 and ≤ 95	0.0	1.172	3.516	Spacer req'd
	0.4	2.051	6.154	Spacer req'd
	0.8	3.516	10.549	Spacer req'd
	2.0	6.154	18.461	Spacer req'd
	3.2	8.791	26.373	Spacer req'd
> 80 and ≤ 90	0.0	1.111	3.333	Spacer req'd
	0.4	2.500	7.500	Spacer req'd
	0.8	4.167	12.500	Spacer req'd
	2.0	6.667	20.000	Spacer req'd
	3.2	9.445	28.334	Spacer req'd
> 70 and ≤ 80	0.0	1.483	4.450	2.967
	0.4	2.967	8.900	5.192
	0.8	5.439	16.317	8.900
	2.0	8.406	25.218	17.059
	3.2	9.395	28.184	27.692

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Uranium Enrichment (weight percent U-235)	CSI	With Spacers Maximum Mass U-235 (kg) ^a		No Spacers Maximum Mass U-235 Per Package (kg) ^a
		Per Convenience Can	Per Package	
> 60 and ≤ 70	0.0	1.733	5.198	3.249
	0.4	4.332	12.996	5.848
	0.8	6.931	20.793	13.646
	2.0	8.231	24.692	21.444
	3.2	8.231	24.692	24.692
≤ 60	0.0	3.718 kgU	11.154 kgU	5.576 kgU
	0.4	9.604 kgU	28.813 kgU	14.872 kgU
	0.8	11.733 kgU	35.200 kgU	28.814 kgU
	2.0	11.733 kgU	35.200 kgU	35.200 kgU
	3.2	11.733 kgU	35.200 kgU	35.200 kgU

^a All limits are expressed in kg U-235 unless specified as kgU, which means kilograms of total uranium.

- (2) Uranium as oxide, which may include UO₂, UO₃, and U₃O₈, packaged in stainless-steel, tin-plated carbon steel, or nickel-alloy convenience cans, or polyethylene bottles. The physical form of all contents is dense, loose powder which may contain clumps and pellets. Moisture content in oxide is limited to 3 weight percent water. Carbide compounds are not authorized. Two types of loading are authorized:
- (i) A mass limit of 15.13 kg of oxide, with a maximum mass of 9.682 kg U-235 and 921 g carbon, with a CSI of 0.0.
 - (ii) A mass limit of 15.13 kg oxide, with a maximum mass of 12.32 kg U-235 and no carbon, with a CSI of 0.4.

The maximum uranium enrichment is 100 weight percent U-235. No spacers are required in the containment vessel. Shipments of oxide must be complete within 12 months of sealing the containment vessel.

- (3) Solid uranyl nitrate in the form of uranyl nitrate crystals, UN_x, and [UO₂(NO₃)₂·xH₂O, where x is ≤ 6]. Uranyl nitrate crystals must be contained in a non-metallic convenience container (such as Teflon bottles). The mass limits are specified in Table 3. The maximum uranium enrichment is 100 weight percent U-235. No spacers are required in the containment vessel.

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5.(b)(3) Contents (continued)

Table 3: Loading Limits for Solid Uranyl Nitrate Crystals

UNx (X value)	Seal Time ^a (months)	CSI	UNx loading limit (kg)	U Content (wt %)
> 0 and ≤ 3	2	0.4	11.90	> 52 and ≤ 61
	4	0.4	6.70	> 52 and ≤ 61
> 3 and ≤ 6	2	0.4	9.17	> 46 and ≤ 52
	4	0.0	4.75	> 46 and ≤ 52

a. Seal time is the length of time after the containment vessel is sealed that the shipment must be complete.

- (4) Unirradiated TRIGA fuel elements and pellets (sections). The fuel is composed of uranium zirconium hydride (UZrH). The uranium concentration in the fuel is a nominal 8.5 weight percent, and the maximum H to Zr ratio in the fuel is 2.0. The maximum uranium enrichment is 70 weight percent U-235. The fuel sections may be from any of three types of fuel elements: standard fuel elements, instrumented standard fuel elements, and fuel follower control rods. The U-235 mass for standard and instrumented fuel elements is a nominal 136 grams per element, and the U-235 mass for fuel follower control rods is a nominal 112 grams per element. Each fuel element contains three fuel sections, either stainless steel or aluminum clad or unclad. The fuel elements are approximately 15 inches in length, with sections approximately 5 inches in length; the approximate diameter of the fuel is 1.44 inches for the standard and instrumented fuel elements, and 1.31 inches for the fuel follower control rods. The fuel elements and sections are packaged within stainless steel or tin-plated carbon steel convenience cans. Disassembled fuel elements are to be packaged with a maximum of three fuel sections, or three fuel elements, per convenience can. Fuel sections from different fuel elements may not be mixed within a single convenience can. A maximum of three convenience cans with disassembled fuel elements may be loaded into a single package. Three stainless steel or aluminum clad elements with crimped ends are to be packaged in a single convenience can with a maximum of one can per package. No spacers are required. The maximum quantity of fissile material per package is 408 grams U-235. The CSI is 0.0.

6. The vent holes on the outer steel drum shall be capped closed during transport and storage to preclude entry of rain water into the insulation cavity of the drum.
7. Content forms may not be mixed in a single ES-3100 containment vessel.
8. Any combination of convenience can sizes is allowed in a single package, as long as the total height of the can stack (including silicone rubber pads and spacers, if required) does not exceed the inside working height of the containment vessel (31 in). Any closure on the convenience can is allowed.
9. Empty convenience cans, spacers, silicone rubber pads, and/or stainless-steel scrubbers (i.e., stainless steel trimmings that act as dunnage) may be used to fill the void space in the containment vessel. Empty convenience cans must have a minimum 0.125 in diameter hole through the lid.
10. The contents and the convenience cans may be bagged or wrapped in polyethylene or nylon for contamination control provided the limits of Condition No. 5.(b) are met.

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11. The mass of unidentified constituents in the content to be shipped shall be counted against the fissile mass loading limit. Content shall not contain unevaluated moderating materials.
12. Transport by air is not authorized, except for shipment of unirradiated TRIGA fuel pellets, as described and limited in Condition No. 5(b)(4).
13. In addition to the requirements of Subpart G of 10 CFR Part 71:
 - (a) The package shall be prepared for shipment and operated in accordance with the Package Operations in Section 7 of the application (with the exception of the uranyl nitrate shipping times in Section 7.1.3.3 of the SAR). The uranyl nitrate shipping times shall be in accordance with Condition 5.(b)(3).
 - (b) Each package must meet the Acceptance Tests and Maintenance Program of Section 8 of the application.
 - (c) Either one or two Tamper Indicating Devices (TIDs) may be used for compliance with 10 CFR 71.43(b), as long as the TID(s) attach through both TID lugs.
14. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR 71.17.
15. Expiration date: April 30, 2021.

REFERENCES

BWXT Y-12, L.L.C., application dated March 3, 2011, as supplemented.
U.S. Department of Energy letter dated March 2, 2016.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

/RA/

Steve Ruffin, Acting Chief
Spent Fuel Licensing Branch
Division of Spent Fuel Management
Office of Nuclear Material Safety
and Safeguards

Date: April 25, 2016