

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a CERTIFICATE NUMBER	b REVISION NUMBER	c DOCKET NUMBER	d PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
9315	15	71-9315	USA/9315/B(U)F-96	1	OF 8

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

- | | |
|---|--|
| a. ISSUED TO (<i>Name and Address</i>)
U.S. Department of Energy
Washington, DC 20585 | b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION
Consolidated Nuclear Security, L.L.C., application dated
March 24, 2016, as supplemented. |
|---|--|

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).

5.(a) Packaging (continued)

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
9315	15	71-9315	USA/9315/B(U)F-96	2 OF	8

(3) Drawings

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

- (i) Drawing No. M2E801580A037, sheets 1 through 6, Rev. C, "Consolidated Assembly Drawing."
- (ii) Equipment Specification JS-YMN3-801580-A001, Rev. G, "ES-3100 Containment Vessel."
- (iii) Equipment Specification JS-YMN3-801580-A002, Rev. D, "ES-3100 Drum Assembly."
- (iv) Equipment Specification JS-YMN3-801580-A003, Rev. C, "Manufacturing Process Specification for Casting Kaolite 1600™ into the ES-3100 Shipping Package."
- (v) Equipment Specification JS-YMN3-801580-A005, Rev. G, "Casting Catalog No. 277-4 Neutron Absorber for the ES-3100 Shipping Package."
- (vi) Drawing No. M2E801580-A043, Rev. B, "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 1200 g of off-gassing material is authorized in the containment vessel. The additional 1200 g must be Teflon (e.g., three Teflon bottles weighing 400 g each). With Teflon bottles, the maximum mass of off-gassing materials is 1600 g: 1200 g Teflon and 400 g of any type of off-gassing packaging.

In the case of shipping uranium in the form of broken metal, hydrogenous materials used in the containment vessel must have a hydrogen atom density less than or equal to that of water.

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a CERTIFICATE NUMBER 9315	b REVISION NUMBER 15	c DOCKET NUMBER 71-9315	d PACKAGE IDENTIFICATION NUMBER USA/9315/B(U)F-96	PAGE 3	PAGES OF 8
---------------------------------	-------------------------	----------------------------	--	-----------	---------------

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 ^c
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

^c for 100 weight percent U-235

- (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 Drawing No. 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)

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a CERTIFICATE NUMBER 9315	b. REVISION NUMBER 15	c. DOCKET NUMBER 71-9315	d. PACKAGE IDENTIFICATION NUMBER USA/9315/B(U)F-96	PAGE 4	PAGES OF 8
---------------------------------	--------------------------	-----------------------------	---	-----------	---------------

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.

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a. CERTIFICATE NUMBER 9315	b. REVISION NUMBER 15	c. DOCKET NUMBER 71-9315	d. PACKAGE IDENTIFICATION NUMBER USA/9315/B(U)F-96	PAGE 5	PAGES OF 8
----------------------------------	--------------------------	-----------------------------	---	-----------	---------------

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	27.443

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a. CERTIFICATE NUMBER 9315	b. REVISION NUMBER 15	c. DOCKET NUMBER 71-9315	d. PACKAGE IDENTIFICATION NUMBER USA/9315/B(U)F-96	PAGE 6	PAGES OF 8
----------------------------------	--------------------------	-----------------------------	---	-----------	---------------

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.

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a. CERTIFICATE NUMBER 9315	b. REVISION NUMBER 15	c. DOCKET NUMBER 71-9315	d. PACKAGE IDENTIFICATION NUMBER USA/9315/B(U)F-96	PAGE 7	PAGES OF 8
----------------------------------	--------------------------	-----------------------------	---	-----------	---------------

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.
11. The mass of unidentified constituents in the content to be shipped shall be counted against the fissile mass

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
9315	15	71-9315	USA/9315/B(U)F-96	8 OF	8

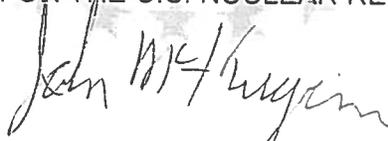
loading limit. Content shall not contain unevaluated moderating materials.

12. Transport by air is not authorized, except for shipment of (a) unirradiated TRIGA fuel pellets, as described and limited in Condition No. 5(b)(4), and (b) U metal and alloys in the form of broken metal as described in Condition No. 5(b)(1)(ii) with a limit of 408 grams U-235 and a CSI of 0.0. For air transport of metal alloy, the U-235 mass limit is not required to include the non-uranium portion of the alloy.
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. Revision 14 of this certificate may be used until July 31, 2017.
16. Expiration date: April 30, 2021.

REFERENCES

Consolidated Nuclear Security, L.L.C., application dated March 24, 2016: "Safety Analysis Report, Y-12 National Security Complex, Model ES-3100 Package with Bulk HEU Contents, Y/LF-717, Revision No. 5."
U.S. Department of Energy letter dated July 12, 2016.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION



John McKirgan, Chief
Spent Fuel Licensing Branch
Division of Spent Fuel Management
Office of Nuclear Material Safety
and Safeguards

Date: July 27, 2016



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION REPORT

Docket No. 71-9315
Model No. ES-3100 Package
Certificate of Compliance No. 9315
Revision No. 15

SUMMARY

By letter dated July 12, 2016, the Department of Energy (DOE or the applicant) requested a revision to Certificate of Compliance (CoC) No. 9315 for the Model No. ES-3100 package. DOE had previously consolidated its application by letter dated March 2, 2016.

There were no changes to the packaging design, but DOE requested to authorize air transportation of Uranium/Molybdenum metal alloy with not more than 408 grams of U-235.

CoC No. 9315 has been amended based on the statements and representations in the application, and staff agrees that the changes do not affect the ability of the package to meet the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 71.

EVALUATION

The submittal was evaluated against the regulatory standards in 10 CFR Part 71, including the general standards for all packages, standards for fissile material packages, and performance standards under normal conditions of transport (NCT) and hypothetical accident conditions (HAC).

DOE requested to add 408 g of U-235 in the form of Uranium metal and alloys, in the form of broken metal, for air transport. Such content is already approved for non-air transport, as described in Condition No. 5(b)(1)(ii) of the CoC, with a criticality safety index (CSI) of 0.0, for up to 100% enriched U-235. The currently allowable U-235 is a higher quantity than what the applicant is requesting for air transport, i.e., 0.925kg U-235 per convenience can and 2.774 kg U-235 per package.

On June 28, 2007, staff issued Revision No. 4 of the CoC to authorize air shipment of TRIGA fuel components with a loading of up to 408 grams U-235 per package and a CSI of 0.0. This same content is authorized in Revision No. 14 of the CoC issued on June 8, 2016.

The applicant's basis for demonstrating compliance with 10 CFR Part 71 is a comparison of U/Mo alloy plates, with an enrichment of 19.75% and a total U-235 content of 408 grams per package, with the authorized TRIGA fuel components with a loading of up to 408 grams U-235 per package and a CSI of 0.0, to demonstrate that the criticality analysis of TRIGA fuel is bounding for the U/Mo alloy plates.

For air transport, 10 CFR 71.55(f) requires contents to be subcritical with an additional 20 cm reflection after additional tests. The applicant has described the criticality safety model for air transport in Section 6.3.1.4 of the application. The applicant did not perform any evaluation to demonstrate that the package or its contents would remain intact under the conditions of 10 CFR 71.55(f). The applicant did not credit the structural properties of the package or contents

and, for the criticality safety analysis, modeled it in a conservative worst case spherical geometry.

To support air transport of the TRIGA fuel content, the most reactive configuration was found to be Model 5, which has a homogenized sphere of U-235 and polyethylene mixed with water, blanketed by a Kaolite shell and reflected by 20 cm of water. The applicant showed that this configuration has a maximum k_{eff} below the USL. Staff evaluated and discussed this content in its safety evaluation report (ADAMS Accession No.: ML072350442).

The staff reviewed the air transport model in the application and found it applicable to the content described in Condition No. 5(b)(1)(ii) of the CoC, for 408 g U-235 metal and alloys in the form of broken metal. Therefore the staff finds air transport of this content in this amount acceptable for the Model No. ES-3100 package.

The CoC currently requires the mass of the non-uranium portion of alloys to be counted as U-235. For air transport, the mass is limited to 408 g of U-235 and an additional metal mass would not cause reactivity to increase if included in the air transport model; thus, the staff finds that it is not necessary to include the metal mass as part of the allowable mass of U-235.

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

CONDITIONS

The following changes are included in Revision No. 15 to Certificate of Compliance No. 9315:

Condition No. 12 has been revised to read: "Transport by air is not authorized, except for shipment of (a) unirradiated TRIGA fuel pellets, as described and limited in Condition No. 5(b)(4), and (b) U metal and alloys in the form of broken metal as described in Condition No. 5(b)(1)(ii) with a limit of 408 grams U-235 and a CSI of 0.0. For air transport of metal alloy, the U-235 mass limit is not required to include the non-uranium portion of the alloy."

Condition No. 15 was modified to authorize the use of Revision 14 of this certificate until July 31, 2017.

The expiration date of the certificate is not changed.

The July 12, 2016, amendment request letter is referenced in the Reference Section of this certificate.

CONCLUSION

Based on the statements and representations in the application, and the conditions listed above, the staff concludes that the Model No. ES-3100 package design has been adequately described and evaluated and that these changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 9315, Revision No. 15, on July 27, 2016.