



U.S. Department  
of Transportation  
**Pipeline and  
Hazardous Materials  
Safety Administration**

**COMPETENT AUTHORITY CERTIFICATION  
FOR A TYPE B(U)F FISSILE  
RADIOACTIVE MATERIALS PACKAGE DESIGN  
CERTIFICATE USA/9315/B(U)F-96, REVISION 5**

East Building, PHH-23  
1200 New Jersey Avenue Southeast  
Washington, D.C. 20590

This certifies that the radioactive material package design described has been certified by the Competent Authority of the United States as meeting the regulatory requirements for a Type B(U)F packaging for fissile radioactive material as prescribed in the regulations of the International Atomic Energy Agency<sup>1</sup> and the United States of America<sup>2</sup>.

1. Package Identification - ES-3100.
2. Package Description and Authorized Radioactive Contents - as described in U.S. Department of Energy Certificate of Compliance No. 9315, Revision 3 (attached).
3. Criticality - The minimum criticality safety index is as described in the DOE Certificate of Compliance. The maximum number of packages per conveyance is determined in accordance with Table X of the IAEA regulations cited in this certificate.
4. General Conditions -
  - a. Each user of this certificate must have in his possession a copy of this certificate and all documents necessary to properly prepare the package for transportation. The user shall prepare the package for shipment in accordance with the documentation and applicable regulations.
  - b. Each user of this certificate, other than the original petitioner, shall register his identity in writing to the Office of Hazardous Materials Technology, (PHH-23), Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation, Washington D.C. 20590-0001.
  - c. This certificate does not relieve any consignor or carrier from compliance with any requirement of the Government of any country through or into which the package is to be transported.

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<sup>1</sup> "Regulations for the Safe Transport of Radioactive Material, 1996 Edition (Revised), No. TS-R-1 (ST-1, Revised)," published by the International Atomic Energy Agency (IAEA), Vienna, Austria.

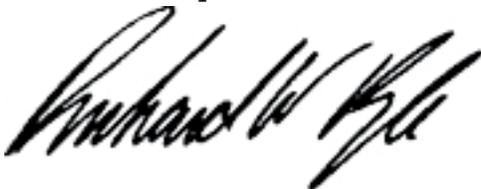
<sup>2</sup> Title 49, Code of Federal Regulations, Parts 100-199, United States of America.

**CERTIFICATE USA/9315/B(U)F-96, REVISION 5**

- d. Records of Quality Assurance activities required by Paragraph 310 of the IAEA regulations<sup>1</sup> shall be maintained and made available to the authorized officials for at least three years after the last shipment authorized by this certificate. Consignors in the United States exporting shipments under this certificate shall satisfy the applicable requirements of Subpart H of 10 CFR 71.
5. Special Conditions -
- a. Transport by air is not authorized, except for shipment of contents as described and limited in Condition No. 5(d)(11) of the DOE Certificate of Compliance.
- b. 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.
- c. All requirements of Conditions 5.(d)(1)- (12) contained in U.S. Department of Energy Certificate of Compliance No. 9315, Revision 3 must be met.
6. Marking and Labeling - The package shall bear the marking USA/9315/B(U)F-96 in addition to other required markings and labeling.
7. Expiration Date - This certificate expires on September 30, 2014. On May 31, 2012, this certificate supersedes all previous revisions of USA/9315/B(U)F-96.

This certificate is issued in accordance with paragraph 814 of the IAEA Regulations and Section 173.471 and 173.472 of Title 49 of the Code of Federal Regulations, in response to the June 14, 2011 petition by Department of Energy, Washington, DC, and in consideration of other information on file in this Office.

Certified By:



Dr. Magdy El-Sibaie  
Associate Administrator for Hazardous Materials Safety

**Jun 27 2011**

(DATE)

U.S. DEPARTMENT OF ENERGY  
**CERTIFICATE OF COMPLIANCE**  
For Radioactive Materials Packages

1a. Certificate Number	1b. Revision No	1c. Package Identification No	1d. Page No.	1e. Total No. Pages
9315	3	USA/9315/B(U)F-96 (DOE)	1	10

2. PREAMBLE

- 2a. This certificate is issued under the authority of 49 CFR Part 173.7(d)
- 2b. The packaging and contents described in Item 5 below meet the safety standards set forth in subpart E, "Package Approval Standards" and subpart F, "Package Special Form, and LSA-III Tests" Title 10, Code of Federal Regulations, Part 71.
- 2c. This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies including the government of any country through or into which the package will be transported.

3. This certificate is issued on the basis of a safety analysis report of the package design or application --		
(1) Prepared by (Name and Address):	(2) Title and identification of report or application:	(3) Date:
U.S. Department of Energy NNSA Y-12 National Security Complex P.O. Box 2009 Oak Ridge, TN 37831	Safety Analysis Report for Packaging, Y-12 National Security Complex, Model ES-3100 Package with Bulk HEU Contents, SP-PKG- 801940-A001, Revision 0, as supplemented [See 5(e)]	August 2010

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

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

(a) Packaging

(1) Model Number: ES-3100

(2) Description:

The ES-3100 packaging, which is depicted in Figure 1.1 below, is a cylindrical container that is approximately 43.5 inches (110 cm) in overall height, including the cover and lid and approximately 19 inches (49 cm) in overall diameter.

The packaging is composed of an outer drum assembly and an inner containment vessel (CV). The main functions of the packaging are to provide containment, shielding, and nuclear criticality safety. Table 2.7 of the SARP provides detailed material specifications for the packaging components.

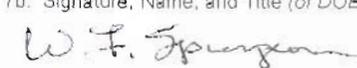
The outer drum assembly consists of (a) a reinforced stainless steel, standard military specification 30 gallon drum with an increased length; (b) a cylindrical layer of castable refractory material (Kaolite 1600™), which is comprised of concrete and vermiculite, and which acts as both an impact-absorbing and thermal-insulating material; (c) a cylindrical layer of castable refractory (277-4 special dry mix) for neutron attenuation; (d) an inner steel liner; and (e) a removable top plug that also has a layer of the castable refractory material (Kaolite 1600™) for impact absorption and thermal insulation.

6a. Date of Issuance: JUN 7 2011

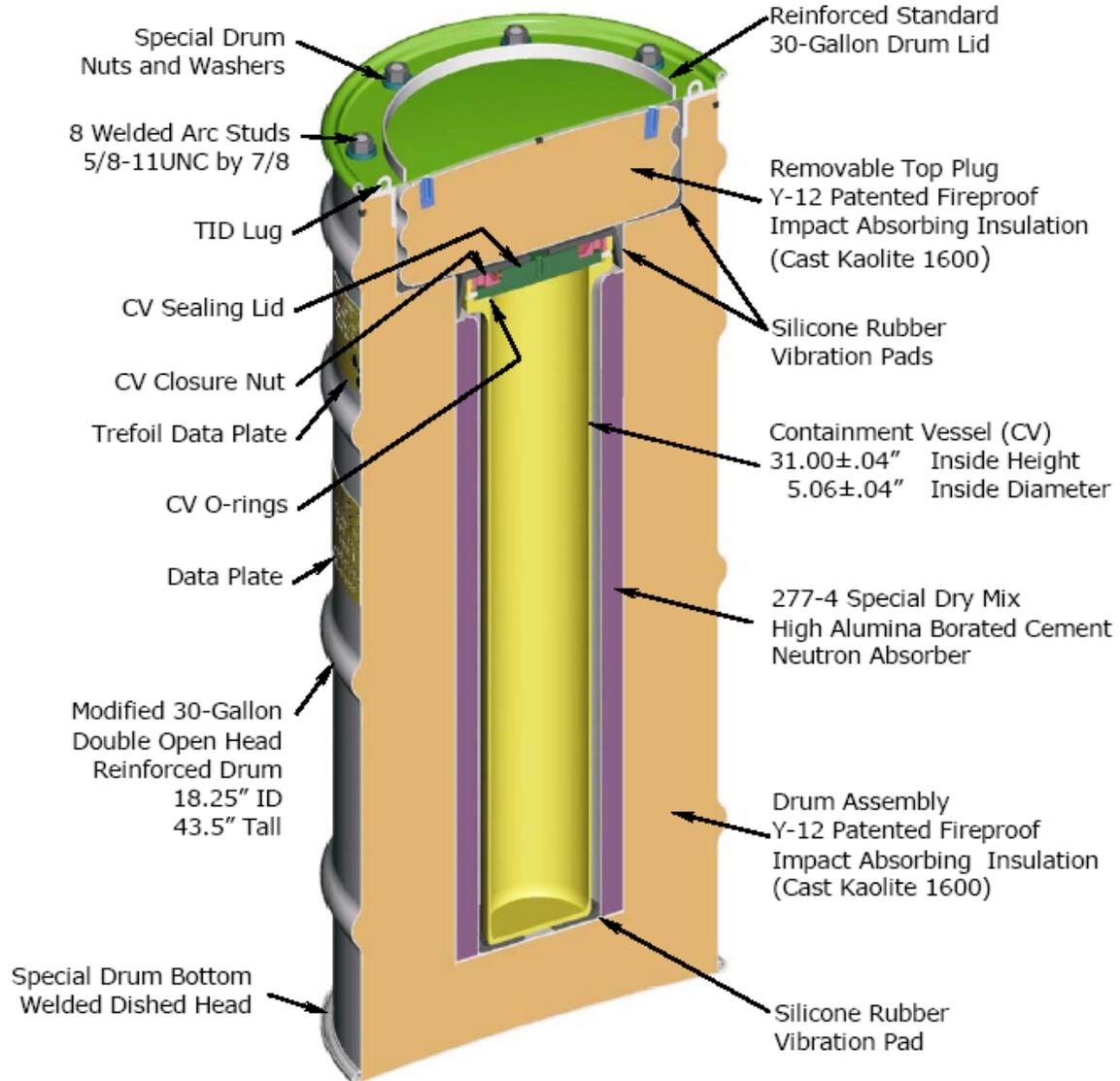
6b. Expiration Date: September 30, 2014

FOR THE U.S. DEPARTMENT OF ENERGY

7a. Address (of DOE Issuing Office)  
U.S. Department of Energy  
Office of Packaging and Transportation, EM-45  
1000 Independence Avenue, SW  
Washington, DC 20585

7b. Signature, Name, and Title (of DOE Approving Official)  
  
Stephen C. O'Connor  
Headquarters Certifying Official

The 30-gallon drum is manufactured from 16-gauge Type 304 or 304L stainless steel. The fabrication is accomplished according to requirements specified in NUREG/CR-3854, and is in accordance with the dimensional requirements of MIL-D-6054F as modified according to Drawing M2E801580A004. The inner liner is also manufactured from Type 304 or 304L stainless steel.



**Figure 1.1. Schematic of the ES-3100 shipping package.**

The CV is placed inside the outer drum assembly, surrounded by the neutron-attenuating and the impact-absorbing and thermal-insulating materials. It is approximately 32 in. (82 cm) in overall height and 5 in. (13 cm) in overall diameter, and is constructed of Type 304L stainless steel. The lid assembly consists of a sealing lid; a closure nut; an external retaining ring that holds both the assembly and closure nut together; and double ethylene-propylene elastomer O-rings. The double O-rings in the top flange of the CV permit leak testing of the CV. The containment boundary consists of the 0.1 in. (0.254 cm) thick CV body, the CV sealing lid assembly, and the inner ethylene-propylene elastomer O-ring.

(3) Drawings:

The drawings that pertain to the ES-3100 package are listed in Table 1.0.

**Table 1.0. List of Drawings Pertaining to the ES-3100 Package**

Drawing No.	Revision	Title
M2E801580A001	C	Drum Assembly
M2E801580A002	B	Body Weldment
M2E801580A003	B	Inner Liner Weldment (2 sheets)
M2E801580A004	B	Double Open Head Reinforced Drum
M2E801580A005	D	Misc. Details
M2E801580A006	B	Drum Lid Weldment
M2E801580A007	B	18.25" Diameter Drum Lid
M2E801580A008	B	Top Plug Weldment
M2E801580A009	C	Pad Details
M2E801580A010	E	Data Plate Details
M2E801580A011	D	Containment Vessel Assembly
M2E801580A012	C	Containment Vessel Body Assembly (2 sheets)
M2E801580A013	C	Containment Vessel O-ring Details
M2E801580A014	B	Containment Vessel Lid Assembly
M2E801580A015	C	Containment Vessel Sealing Lid
M2E801580A016	B	Containment Vessel Closure Nut
M2E801580A023	C	Containment Vessel Leak Test Assemblies
M2E801580A024	B	Containment Vessel Vibration Absorbing Silicone 4.25" Can Pad
M2E801580A031	E	Main Assembly
M2E801580A037	D	Consolidated Assembly Drawing (3 sheets)
M2E801580A043	0	Heavy Can Spacer Assembly (SST)
T2E801827A008	A	Leak Check Flange Assembly

(b) Contents

The contents to be shipped in the ES-3100 package consist of bulk HEU in the form of oxide ( $UO_2$ ,  $UO_3$ ,  $U_3O_8$ ,  $U_3O_8-Al$ ,  $UO_2-Mg$ , and  $UO_2-ZrO_2$ ); uranium metal and alloy in the form of solid geometric shapes or broken pieces; uranium compounds; uranyl nitrate crystals (UNX); and research reactor fuel elements and components.

The maximum content decay heat load shall not exceed 5.0 watts.

The radioactive materials are placed in convenience cans, polyethylene bottles, teflon bottles. Long fuel elements may be bagged or wrapped in polyethylene or nylon. Protective end caps may be placed over bagged contents. Typical loading of the bulk HEU into the packaging, using convenience cans is depicted in Figure 1.2 of the SARP. Typical shipping configurations inside the CV are depicted in Figure 1.4 of the SARP.

The maximum concentrations of uranium isotopes that are permitted in the ES-3100 package contents are listed in Table 1.1.

**Table 1.1. Uranium Concentration Limits**

Uranium Isotope	Limit
<sup>232</sup> U	0.040 µg/gU
<sup>233</sup> U	0.006 g/gU
<sup>234</sup> U	0.02 g/gU
<sup>235</sup> U	1.00 g/gU
<sup>236</sup> U	0.40 g/gU
<sup>238</sup> U	1.00 g/gU

The bounding uranium isotopic concentration in oxide is listed in Table 1.2a.

**Table 1.2a. Bounding Uranium Isotopic Concentration in Oxide**

Isotope	Bounding Limit
<sup>232</sup> U	40 ppb
<sup>233</sup> U	200 ppm
<sup>234</sup> U	2.0 wt %
<sup>235</sup> U	100.0 wt %
<sup>236</sup> U	40.0 wt %

In addition to the uranium isotopes shown in Table 1.1, transuranic isotopes may be present in the HEU metal and alloy contents, and are allowed to be transported according to the limits shown Table 1.2b.

**Table 1.2b. Concentration Limits for Transuranics**

Type and Form of Contents Mode of Transport	Concentration Limits		
	<sup>237</sup> Np (in All Forms)	Transuranics Other Than <sup>237</sup> Np (As Metal or Alloy)	Transuranics Other Than <sup>237</sup> Np (as Other Than Metal or Alloy)
Ground	0.0250 g/gU	800.0 µg/gU	40.0 µg/gU
Air	0.0250 g/gU	40.0 µg/gU	40.0 µg/gU

Weights and Contents Descriptions

The maximum gross shipping weight of the ES-3100 package, with any contents, is 420 lb (190.5 kg).

The weight of the radioactive contents in the ES-3100 package is limited to 77.6 lb (35.2 kg). The maximum weight of all contents, including the radioactive contents, the convenience cans or bottles, can spacers, polyethylene bagging and other packing materials, is limited to 90 lb (40.82 kg). There is no minimum content weight requirement.

For contents that must be shipped with spacers (see Table 1.3), the spacers must be in accordance with BWXT Y-12, L.L.C., Drawing No. M2E801580A043.

**Radioactive/Fissile Constituents**

The maximum number of A<sub>2</sub>s is 4752.8 (at 70 yrs) and the maximum activity is 0.72554 TBq (at 10 yrs).

The following loading limits are imposed based on the mode of transport:

- a) For ground transport, fissile material loading limits are presented in Tables 1.3 and 1.3a.
- b) For air transport, HEU in the form of metal/alloy and research reactor fuel elements and components, the fissile material mass loading limits are presented in Table 1.3b.
- c) The loading limit for mixed-mode transport is taken as the most restrictive limit for either ground or air mode of transportation (Table 1.3 or 1.3b).

**Table 1.3 –Authorized Content and Fissile Mass Loading Limits for Ground Transportation<sup>a, b, c</sup>**

Content description		Enrichment	CSI	No Spacers, <sup>235</sup> U (kg)	277-4 can Spacers, <sup>235</sup> U (kg) <sup>d</sup>
Solid HEU metal or alloy (specified geometric shape) <sup>e</sup>	Cylinder A	≤ 100%	0.0	15.000	25.000
	Cylinder B	≤ 100%	0.0	18.000	30.000
	Square bars	≤ 100%	0.0	30.000	35.200 <sup>f</sup>
	Slugs	≤ 95%	0.0	17.374	-
	Slugs	≤ 80%	0.0	-	29.318
	Slugs	> 80%, ≤ 95%	0.0	-	24.324
	Slugs	>80%, ≤ 95%	0.4	-	34.749
Broken HEU metal or alloy <sup>g</sup>	>95%, ≤ 100%	0.0	Spacers req'd <sup>d</sup>	2.774	
		0.4	Spacers req'd	5.549	
		0.8	Spacers req'd	9.248	
		2.0	Spacers req'd	13.872	
		3.2	Spacers req'd	24.969	
	>90%, ≤ 95%	0.0	Spacers req'd	3.516	
		0.4	Spacers req'd	6.154	
		0.8	Spacers req'd	10.549	
		2.0	Spacers req'd	18.461	
		3.2	Spacers req'd	26.373	
	>80%, ≤ 90%	0.0	Spacers req'd	3.333	
		0.4	Spacers req'd	7.500	
		0.8	Spacers req'd	12.500	
		2.0	Spacers req'd	20.000	
	3.2	Spacers req'd	28.334		

Content description	Enrichment	CSI	No Spacers, <sup>235</sup> U (kg)	277-4 can Spacers, <sup>235</sup> U (kg)	
	>70%, ≤ 80%	0.0	2.967	4.450	
		0.4	5.192	8.900	
		0.8	8.900	16.317	
		2.0	17.059	25.218	
		3.2	27.692	28.184	
	>60%, ≤ 70%	0.0	3.249	5.198	
		0.4	5.848	12.996	
		0.8	13.646	20.793	
		2.0	21.444	24.692	
		3.2	24.692	24.692	
	≤ 60%	0.0	5.576 kg U	11.154 kg U	
		0.4	14.872 kg U	28.813 kg U	
		0.8	28.814 kg U	35.20 kg U <sup>f</sup>	
		2.0	35.20 kg U <sup>f</sup>	35.20 kg U <sup>f</sup>	
	3.2	35.20 kg U <sup>f</sup>	35.20 kg U <sup>f</sup>		
HEU oxide <sup>h,j</sup> (UO <sub>2</sub> , UO <sub>3</sub> , U <sub>3</sub> O <sub>8</sub> , U <sub>3</sub> O <sub>8</sub> -Al, UO <sub>2</sub> -Mg, <sup>n</sup> UO <sub>2</sub> -ZrO <sub>2</sub> )	≤ 100%	0.0	15.13 kg oxide 9.682 kg <sup>235</sup> U 921 g carbon	Spacers not req'd	
Research reactor fuel elements and components <sup>k</sup>	UZrH <sub>x</sub> (TRIGA)	≤ 20%	0.0	0.921 <sup>i</sup>	Spacers not req'd
		> 20%, ≤ 70%	0.0	0.408 <sup>i</sup>	Spacers not req'd
	UZrH <sub>x</sub> (SNAP)	≥ 93%	0.0	0.857 <sup>i</sup>	Spacers not req'd
	U-Zr	≤ 100%	varies	See limit for broken metal or alloy <sup>g</sup>	Spacers as req'd
	U-Al	≤ 100%	0.0	7.333 kg U-Al 525 g U 473 g <sup>235</sup> U	Spacers not req'd
	U <sub>3</sub> O <sub>8</sub> -Al	≤ 100%	0.0	15.13 kg oxide 9.682 kg <sup>235</sup> U <sup>l</sup> 921 g carbon	Spacers not req'd
	UO <sub>2</sub>	≤ 100%	0.0	21.937 kg UO <sub>2</sub> 19.308 kg <sup>235</sup> U	Spacers not req'd
	Oxides of U-Zr <sup>m</sup>	≤ 100%	0.0	15.13 kg oxide 9.682 kg <sup>235</sup> U <sup>l</sup> 921 g carbon	Spacers not req'd
	UO <sub>2</sub> -Mg <sup>n</sup>	≤ 100%	0.0	15.13 kg oxide 9.682 kg <sup>235</sup> U <sup>l</sup> 921 g carbon	Spacers not req'd
Uranium compounds	UF <sub>4</sub>	≤ 100%	0.0	3 kg UF <sub>4</sub> 2.267 kg <sup>235</sup> U	Spacers not req'd
	UO <sub>2</sub> F <sub>2</sub>	≤ 100%	0.0	3 kg UO <sub>2</sub> F <sub>2</sub>	Spacers

Content description	Enrichment	CSI	No Spacers, <sup>235</sup> U (kg)	277-4 can Spacers, <sup>235</sup> U (kg)
			2.067 kg <sup>235</sup> U	not req'd
UC	≤ 100%	0.0	2 kg UC 1.815 kg <sup>235</sup> U	Spacers not req'd
UN	≤ 100%	0.0	2 kg UN 1.888 kg <sup>235</sup> U	Spacers not req'd
TRISO	≤ 100%	0.0	2 kg TRISO 1.815 kg <sup>235</sup> U	Spacers not req'd

- a With the exception of the UNX crystals (Section 1.2.2.2 of the SARP), which are loaded for shipment in crystalline solid form, HEU in solution form is not permitted for shipment in the ES-3100.
- b All limits are expressed in kg <sup>235</sup>U unless otherwise indicated.
- c Mass loadings cannot be rounded up.
- d 277-4 can spacers as described on Drawing No. M2E801580A043 (Appendix 1.3.7 of the SARP).
- e Geometries of solid shapes are as follows:  
 - Cylinder A is larger than 3.24 in. diameter but no larger than 4.25 in. diameter: maximum of 1 cylinder per can.  
 - Cylinder B is no larger than 3.24 in. diameter: maximum of 1 cylinder per can.  
 - Square bars are no larger than 2.29 in. × 2.29 in. (cross section): maximum of 1 bar per can.  
 - Slugs are a maximum of 1.5 in. diameter × 2.0 in. tall: a maximum of 10 per convenience can where the actual number permitted is restricted by the stated loading limit.
- f Maximum planned content weight is 35.20 kg. Maximum analyzed content weight for criticality safety is 35.32 kg.
- g Mass limits for alloys (uranium with aluminum, molybdenum, zirconium, stainless steel, titanium, tungsten, niobium, silicon, or vanadium) must assume that non-uranium portion is <sup>235</sup>U.
- h Seal time must be 12 months or less. Seal time is the length of time after the ES-3100 containment vessel is sealed that the shipment must be complete.
- i Evaluation limit based on specific fuel type as opposed to a maximum calculated limit for UZrH<sub>x</sub>.
- j Allowable HEU bulk oxide densities are 2.0-6.54 g/cm<sup>3</sup>. Non-uranium metallic constituents must be counted as <sup>235</sup>U. Moisture content in oxide is limited to 3 weight percent water.
- k For SNAP UZrH<sub>x</sub>, x ≤ 2. For TRIGA UZrH<sub>x</sub>, x ≤ 1.6. For oxides, research reactor fuel elements or components refer to actual clad or unclad fuel components such as pressed and sintered pellets, clad fuel rods, etc. These are fundamentally different from the HEU oxide powder form (see footnote j), and the densities of the research reactor fuel are much higher, up to theoretical oxide density of 10.96 g/cm<sup>3</sup>.
- l Non-uranium metallic constituents must be counted as <sup>235</sup>U.
- m Oxides of U-Zr are UO<sub>2</sub>-Zr and UO<sub>2</sub>-ZrO<sub>2</sub>.
- n Enriched uranium oxide in the form of UO<sub>2</sub>-Mg will be shipped in either a glass vial or bottle or a metal vial or bottle inside a metal convenience can under an inert cover gas.

**Table 1.3a – Loading Limits for Uranyl Nitrate Crystals for Ground Transport**

Product <sup>a, b</sup>	Seal time <sup>c</sup> (months)	CSI	Loading limit <sup>d</sup> (kg UNX)	U content <sup>e</sup> (wt%)
UNX 0 < X ≤ 3	2	0.4	11.90	52 < U ≤ 61
	4	0.4	6.70	52 < U ≤ 61
UNX X > 3	2	0.4	9.17	46 < U ≤ 52
	4	0.0	4.75	46 < U ≤ 52

- a UNX is uranyl nitrate hydrate [UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub> \* XH<sub>2</sub>O] where 0 < X ≤ 6.

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- b Must be shipped in Teflon bottles.
- c Seal Time – length of time after the ES-3100 containment vessel is sealed that the shipment must be complete.
- d Total mass of UNX crystals. Spacers are not required for this content type.
- e Enrichment up to 100%.

**Table 1.3b - Loading Limits for Air Transport** <sup>a, b, c</sup>

Content description	Enrichment	CSI	<sup>235</sup> U (kg)
HEU metal or alloy <sup>d</sup>	≤ 100%	— <sup>g</sup>	7.00
Research reactor fuel elements and components (UZrH <sub>x</sub> , <sup>e</sup> U-Zr, U-Al, U <sub>3</sub> O <sub>8</sub> -Al, UO <sub>2</sub> , oxides of U-Zr, <sup>f</sup> UO <sub>2</sub> -Mg)	≤ 20%	— <sup>g</sup>	0.921
	> 20%	— <sup>g</sup>	0.408

- a All limits are expressed in kg <sup>235</sup>U unless otherwise indicated.
- b Mass loadings cannot be rounded up.
- c The loading limit for mixed-mode transport is taken as the most restrictive limit for either ground or air mode of transportation (Table 1.3 or 1.3b).
- d Mass limits for alloys (uranium with aluminum, molybdenum, zirconium, stainless steel, titanium, tungsten, niobium, silicon, or vanadium) must assume that non-uranium portion is <sup>235</sup>U.
- e For SNAP UZrH<sub>x</sub>, x ≤ 2. For TRIGA UZrH<sub>x</sub>, x ≤ 1.6.
- f Oxides of U-Zr are UO<sub>2</sub>-Zr and UO<sub>2</sub>-ZrO<sub>2</sub>.
- g CSI is governed by ground transport mode.

(c) Criticality Safety Index

The Criticality Safety Index (CSI) assigned for each content is shown above in section 5(b) of this certificate.

(d) Conditions

- (1) 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.
- (2) Content forms may not be mixed in a single ES-3100 containment vessel.
- (3) Where can spacers are required for a “per package” mass loading, the quantity of fissile materials located in any vacancy between or adjacent to can spacers shall not exceed one-third of the mass loading limit in Tables 1.3 and 1.3b. 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.
- (4) Uranium metal and alloy pieces must have a surface-area-to-mass ratio of not greater than 1.00 cm<sup>2</sup>/g or must not pass freely through a 3/8-inch (0.0095 m) mesh sieve, or equivalent size-grading system. 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.
- (5) Fuel pellets from TRIGA reactor elements shall be unirradiated. The fuel sections may be from any of three types of fuel elements: TRIGA standard fuel elements (SFEs), instrumented TRIGA standard fuel elements (FTCs), and TRIGA fuel follower control rods (FFCRs). The <sup>235</sup>U mass for

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SFEs and FTCs is a nominal 136 grams per element, and the  $^{235}\text{U}$  mass for FFCRs is a nominal 113 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. For SFEs and FTCs, the maximum allowable loading per package is 408 grams  $^{235}\text{U}$  per package, and for FFCRs, the maximum allowable loading is 339 grams  $^{235}\text{U}$  per package.

The SNAP fuel pins are approximately 1.25 inches in diameter and approximately 12.45 inches long. The SNAP fuel pins may be packed in appropriate length convenience cans or bundled together and protected on each end with an open-ended can. A maximum of three SNAP fuel elements may be packed into any one convenience can or any one bundle. Up to two loaded convenience cans or two bundles may be shipped in the ES-3100.

- (6) 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 inches). Any closure on the convenience can is allowed.
- (7) The maximum mass of off-gassing packing materials in the containment vessel (e.g., polyethylene containers or bagging, silicone rubber pads, nylon bags, etc.) shall not exceed 500 grams. Off-gassing packing materials may be 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. With the use of Teflon bottles as convenience containers, an additional 990 grams of off-gassing material is authorized in the containment vessel. If closed convenience cans with an outer diameter greater than 4.25 inches are used, the containment vessel cannot contain any materials that off-gas.
- (8) 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. In situations where empty convenience cans are shipped in the package, they must be placed on top of the loaded cans. Empty convenience cans must have a minimum 0.125 inches diameter hole through the lid.
- (9) The contents and the convenience cans may be bagged or wrapped in polyethylene, nylon, or aluminum foil for contamination control provided the limits of Section 5(d)(7) of this certificate are met.
- (10) 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.
- (11) Transport by air is not authorized, except as specified in Table 1.3b.
- (12) In addition to the requirements of Subparts G and H of 10 CFR Part 71, and except as specified in section 5(d) of this certificate, each package must be fabricated, acceptance tested, operated, and maintained in accordance with the Operating Procedures requirements of Chapter 7,

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Acceptance Tests and Maintenance requirements of Chapter 8, and packaging-specific Quality Assurance requirements of Chapter 9 of the SARP as supplemented [See 5(e)].

(13) Revision 0 of this certificate may be used until October 1, 2011. Revision 1 and Revision 2 of this certificate may be used until May 31, 2012.

(e) References

- (1) Safety Analysis Report for Packaging, Y-12 National Security Complex, Model ES-3100 Package with Bulk HEU Contents, SP-PKG-801940-A001, Revision 0, August 2010.
- (2) Safety Analysis Report for Packaging, Y-12 National Security Complex, Model ES-3100 Package with Bulk HEU Contents, SP-PKG-801940-A001, Revision 0, with Page Change 1, November 2010.
- (3) Safety Analysis Report for Packaging, Y-12 National Security Complex, Model ES-3100 Package with Bulk HEU Contents, SP-PKG-801940-A001, Revision 0, with Page Change 2, February 2011.



U.S. Department  
of Transportation

East Building, PHH-23  
1200 New Jersey Avenue SE  
Washington, D.C. 20590

**Pipeline and  
Hazardous Materials  
Safety Administration**

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**ORIGINAL REGISTRANT(S):**

Dr. James M. Shuler  
Manager, Packaging Certification Program  
Department of Energy  
U.S. Department of Energy  
1000 Independence Ave, SW  
EM-60  
Washington, DC 20585