U.S. Department of Transportation

Pipeline and Hazardous Materials Safety Administration

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

COMPETENT AUTHORITY CERTIFICATION FOR A TYPE B(U)F FISSILE RADIOACTIVE MATERIALS PACKAGE DESIGN CERTIFICATE USA/9309/B(U)F-96, REVISION 8

The Competent Authority of the United States certifies that the radioactive material package design described in this certificate satisfies the regulatory requirements for a Type B(U)F package for fissile material as prescribed in the regulations of the International Atomic Energy Agency[1] and the United States of America[2].

1. Package Identification - RAJ-II.

2. Package Description and Authorized Radioactive Contents - as described in U.S. Nuclear Regulatory Commission Certificate of Compliance No. 9309, Revision 12 (attached).

3. Criticality - The minimum criticality safety index is as assigned in the NRC certificate. The maximum number of packages per conveyance is determined in accordance with Table 11 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 Engineering and Research, (PHH-23), Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation, Washington D.C. 20590-0001.

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[1] "Regulations for the Safe Transport of Radioactive Material, 2012 Edition, No. SSR-6" published by the International Atomic Energy Agency (IAEA), Vienna, Austria.

[2] Title 49, Code of Federal Regulations, Parts 100-199, United States of America.

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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.

d. This certificate provides no relief from the limitations for transportation of plutonium by air in the United States as cited in the regulations of the U.S. Nuclear Regulatory Commission 10 CFR 71.88.

e. Records of Management System activities required by Paragraph 306 of the IAEA regulations[1] 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. Marking and Labeling - The package shall bear the marking USA/9309/B(U)F-96 in addition to other required markings and labeling.

6. Expiration Date - This certificate expires on January 31, 2024. USA/9309/B(U)F-96 Revision 7 may be used until November 30, 2019. All other revisions are not authorized for use.

This certificate is issued in accordance with paragraph(s) 810 and 816 of the IAEA Regulations and Section 173.471 and 173.472 of Title 49 of the Code of Federal Regulations, in response to the January 28, 2019 petition by Global Nuclear Fuels - Americas, Wilmington, NC, and in consideration of other information on file in this Office.

Certified By:

for William Schoonover
Associate Administrator for Hazardous Materials Safety

February 11, 2019
(DATE)

Revision 8 - Issued to endorse U.S. Nuclear Regulatory Commission Certificate of Compliance No. 9309, Revision 12.

CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE		PAGES
9309	12	71-9309	USA/9309/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 *(Name and Address)*

Global Nuclear Fuel - Americas, LLC
P.O. Box 780
Wilmington, NC 28402

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION

NEDO-33869, Revision 10, Global Nuclear Fuel - Americas, LLC, application dated September 4, 2018, 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.: RAJ-II

(2) Description

The RAJ-II package is a rectangular box that is 742 millimeters (mm) (29.21 inches (in.)) high by 720 mm (28.35 in.) wide by 5,068 mm (199.53 in) long to transport a maximum of two Boiling Water Reactor (BWR) fuel assemblies or individual rods that meet the ASTM C996 standard of enriched commercial grade uranium, enriched reprocessed uranium, uranium oxide generic pressurized water reactor (PWR) or uranium carbide loose fuel rods in a 5-inch diameter stainless steel pipe.

The RAJ-II packaging is comprised of one inner container and one outer container both made of stainless steel. The inner container is comprised of a double-wall stainless steel sheet structure with alumina silicate thermal insulator filling the gap between the two walls to reduce the heat flowing into the contents in the event of a fire. Polyethylene foam cushioning material is placed on the inside of the inner container for protection of the fuel assembly. The outer container is comprised of a stainless steel angular framework covered with stainless steel plates. The inner container clamps are installed inside the outer container with a vibro-isolating device between to alleviate vibration occurring during transportation. Wood and honeycomb resin impregnated kraft paper are placed as shock absorbers to reduce shock in the event of a drop of the package. The fuel rod cladding and welded end plugs provide primary containment of the radioactive material. The radioactive material is bound in ceramic pellets with limited solubility and minimal propensity to suspend in air.

5.(a)(2) Description (continued)

The approximate dimensions and weights of the package are as follows:

Maximum gross shipping weight	1,614 kilograms (kg) (3,558 pounds (lbs.))
Maximum weight of inner container	308 kg (679 lbs.)
Maximum weight of outer container	622 kg (1,371 lbs.)
Maximum weight of packaging	930 kg (2,050 lbs.)
Loose rods pipe nominal mass per component	106 kg (234 lbs.)
Protective case nominal mass per component	87 kg (192 lbs.)
Dimensions of inner container	
Length	4,686 mm (184.49 in.)
Width	459 mm (18.07 in.)
Height	286 mm (11.26 in.)
Dimensions of outer container	
Length	5,068 mm (199.53 in.)
Width	720 mm (28.35 in.)
Height	742 mm (29.21 in.)

(3) Drawings

This packaging is constructed in accordance with the following Global Nuclear Fuel (GNF) Drawing Nos.:

(i) <u>Outer Container Drawings</u>
105E3737, Rev. 8
105E3738, Sheet 1, Rev. 11
105E3738, Sheets 2- 3, Rev. 10
105E3739, Rev. 6
105E3740, Rev. 6
105E3741, Rev. 3
105E3742, Rev. 5
105E3743, Rev. 7
105E3744, Rev. 8

(ii) <u>Inner Container Drawings</u>
105E3745, Sheets 1-4, Rev. 10
105E3746, Rev. 3
105E3747, Rev. 6
105E3748, Rev. 4
105E3749, Rev. 8

5.(a) (3) Drawings (Continue)

(iii) Contents Containers
105E3773, Rev. 2
0028B98, Rev. 2

5.(b) Contents

(1) Type and form of material

Enriched commercial grade uranium or enriched reprocessed uranium, as defined in ASTM C996, uranium oxide or uranium carbide fuel rods enriched to no more than 5.0 weight percent in the Uranium-235 (^{235}U) isotope, with limits specified in Tables 1 and 2 below.

Table 1. Maximum Weight of Uranium Dioxide Pellets per Fuel Assembly

Type 8x8 fuel assembly	Type 9x9 fuel assembly	Type 10x10 fuel assembly
235 kg	240 kg	275 kg

Table 2. Maximum Authorized Concentrations

Isotope	Maximum content
^{232}U	5.00×10^{-8} g/gU
^{234}U	2.00×10^{-3} g/gU
^{235}U	5.00×10^{-2} g/gU
^{236}U	2.50×10^{-2} g/gU
^{237}Np	1.66×10^{-6} g/gU
^{238}Pu	6.20×10^{-11} g/gU
^{239}Pu	3.04×10^{-9} g/gU
^{240}Pu	3.04×10^{-9} g/gU
Gamma Emitters	4.4×10^{5} MeV - Bq/kgU

5.(b) (1) Type and form of material (continued)

(i) 8 x 8 fuel assemblies comprised of 60 to 64 rods in a square array with a maximum active fuel rod length of 381 cm. The maximum pellet diameter, minimum clad thickness, rod pitch, water rod specifications, and poison rod specification are in accordance with Table 3 below.

(ii) 9 x 9 fuel assemblies comprised of 72 to 81 rods in a square array with a maximum active fuel rod length of 381 cm. The maximum pellet diameter, minimum clad thickness, rod pitch, water rod specifications, and poison rod specification are in accordance with Table 3 below.

(iii) 10 x 10 fuel assemblies comprised of 91 to 100 rods in a square array with a maximum active fuel rod length of 385 cm. The maximum pellet diameter, minimum clad thickness, rod pitch, water rod specifications, and poison rod specification are in accordance with Table 3 below.

(iv) Uranium oxide fuel rods configured loose, in a 5-in. diameter schedule 40 stainless steel pipe/protective case or strapped together. The maximum pellet diameter, minimum clad thickness, and rod specifications are in accordance with Table 4 below.

(v) Uranium carbide or generic PWR uranium oxide fuel rods configured loose, in a 5-in. diameter schedule 40 stainless steel pipe. The maximum pellet diameter, minimum clad thickness, and rod specifications are in accordance with Table 4 below.

5.(b) (1) Type and form of material (continued)

Table 3. Fuel Assembly Parameters

Parameter	Units	Type	Type	Type	Type
Fuel Assembly Type	Rods	8 x 8	9 x 9	FANP 10 x 10	GNF 10 x 10
UO_2 Density	% Theoretical	≤ 98			
Number of water rods (See Condition 8)	Water rods	0, 2 x 2	0, 2-2 x 2 off-center diagonal, 3x3	0, 2-2 x 2 off-center diagonal, 3x3	0, 2-2 x 2 off-center diagonal, 3x3, 1-axially varying centered
Number of fuel rods	Number	60 - 64	72 – 81	91 - 100	
Fuel Rod OD	cm	≥ 1.176	≥ 1.093	≥ 1.000	≥ 1.010
Fuel Pellet OD	cm	≤ 1.05	≤ 0.96	≤ 0.895	
Cladding Type	N/A	Zirconium Alloy			
Cladding ID	cm	≤ 1.10	≤ 1.02	≤ 0.933	≤ 0.934
Cladding Thickness	cm	≥ 0.038	≥ 0.036	≥ 0.033	≥ 0.038
Active fuel length	cm	≤ 381		≤ 385	
Fuel Rod Pitch	cm	≤1.692	≤ 1.51	≤ 1.35	≤1.363
^{235}U Pellet Enrichment	wt%	≤ 5.0			
Lattice Average Enrichment	wt%	≤ 5.0			
Channel Thickness	cm	0.17 – 0.3048			Any
Partial Length Fuel Rods	Fuel Rods	None	≤12	≤14	≤16
Gadolinia Requirements Lattice Average Enrichment	# @ wt% Gd_2O_3				
≤ 5.0 wt % ^{235}U		7 @ 2 wt %	10 @ 2 wt %	12 @ 2 wt %	12 @ 2 wt %
≤ 4.9 wt % ^{235}U		7 @ 2 wt %	10 @ 2 wt %	12 @ 2 wt %	11 @ 2 wt %
≤ 4.7 wt % ^{235}U		6 @ 2 wt %	8 @ 2 wt %	12 @ 2 wt %	11 @ 2 wt %
≤ 4.6 wt % ^{235}U		6 @ 2 wt %	8 @ 2 wt %	10 @ 2 wt %	10 @ 2 wt %
≤ 4.5 wt % ^{235}U		6 @ 2 wt %	8 @ 2 wt %	10 @ 2 wt %	9 @ 2 wt %
≤ 4.3 wt % ^{235}U		6 @ 2 wt %	8 @ 2 wt %	9 @ 2 wt %	9 @ 2 wt %
≤ 4.2 wt % ^{235}U		6 @ 2 wt %	6 @ 2 wt %	8 @ 2 wt %	8 @ 2 wt %
≤ 4.1 wt % ^{235}U		4 @ 2 wt %	6 @ 2 wt %	8 @ 2 wt %	8 @ 2 wt %
≤ 3.9 wt % ^{235}U		4 @ 2 wt %	6 @ 2 wt %	6 @ 2 wt %	7 @ 2 wt %
≤ 3.8 wt % ^{235}U		4 @ 2 wt %	4 @ 2 wt %	6 @ 2 wt %	7 @ 2 wt %
≤ 3.7 wt % ^{235}U		2 @ 2 wt %	4 @ 2 wt %	6 @ 2 wt %	6 @ 2 wt %
≤ 3.6 wt % ^{235}U		2 @ 2 wt %	4 @ 2 wt %	4 @ 2 wt %	5 @ 2 wt %
≤ 3.4 wt % ^{235}U		2 @ 2 wt %	2 @ 2 wt %	4 @ 2 wt %	4 @ 2 wt %
≤ 3.3 wt % ^{235}U		2 @ 2 wt %	2 @ 2 wt %	2 @ 2 wt %	3 @ 2 wt %
≤ 3.2 wt % ^{235}U		2 @ 2 wt %	2 @ 2 wt %	2 @ 2 wt %	2 @ 2 wt %
≤ 3.1 wt % ^{235}U		None	2 @ 2 wt %	2 @ 2 wt %	1 @ 2 wt %
≤ 2.9 wt % ^{235}U		None	None	None	None
Polyethylene Equivalent Mass per assembly	kg	≤11		≤10.2	
Thermal Performance Criteria[d]	MPa	r/t (P_f 921/293 - P_a) ≤ 31.1 MPa (4,514 psi)			

a. Transport with or without channels is acceptable.
b. Required gadolinia rods must be distributed symmetrically about the major diagonal. Minimum required number of gadolinia rods applies for full-length rod locations, excluding the lattice peripheral locations. Additional gadolinia rods in other locations are allowed as long as the minimum is met. After seven (7) gadolinia rods, there must be at least one (1) gadolinia rod in at least two out of the four quadrants of the fuel rod array (refer to Section 6.3.4.2, "Fuel Assembly Gadolinia Rod Study (2N=448)," of the application).
c. Polyethylene equivalent mass calculation (refer to Section 6.3.2.2, "Material Specification," of the application)
d. r/t is the fuel rod inner radius to thickness ratio, P_f is the absolute fill pressure, and P_a is atmospheric pressure (refer to Section 3.4.4 of the application)

5.(b) (1) Type and form of material (continued)

Table 4. Fuel Rod Parameters

Parameter	Units	Type					
Fuel Assembly Type	N/A	8 x 8 (UO_2)	9 x 9 (UO_2)	10 x 10 (UO_2)	CANDU-14 (UC)	CANDU-25 (UC)	Generic PWR (UO_2)
Fuel Density	% theoretical	≤ 98			≤ 97		≤ 100
Fuel rod OD	cm	≥ 1.10	≥ 1.02	≥ 1.00	≥ 1.340	≥ 0.996	≥ 1.118
Fuel Pellet OD	cm	≤ 1.05	≤ 0.96	≤ 0.90	≤ 1.254	≤ 0.950	≤ 0.98
Cladding Type	N/A	Zirconium Alloy			Zirconium Alloy or SS		
Cladding ID	cm	≤ 1.10	≤ 1.02	≤ 1.00	≤ 1.267	≤ 0.951	≤ 1.004
Cladding Thickness	cm	≥ 0.038	≥ 0.036	≥ 0.038	≥ 0.033		
Active Fuel Length	cm	≤ 381		≤ 385	≤ 47.752	≤ 40.013	≤ 450
^{235}U Pellet Enrichment	wt.%	≤ 5.0					
Average Fuel Rod Enrichment	wt.%	≤ 5.0					
Polyethylene Equivalent Mass[a] per Compartment[b]	kg	Unlimited			Protective Sleeves: < 2.3 All other packing materials: < 27.5 within SS pipe, unlimited outside of SS pipe		
Reference Density for Polyethylene Equivalent Mass[a] Calculation[b]	g/cm^3	Protective Sleeves: 0.925 All Other Packaging Materials: 0.08			Protective Sleeves: 1.005 All Other Packing Materials: 0.70		
Thermal Performance Criteria[f]	MPa	$r/t\ (P_f\ 921/293 - P_a) \leq 31.1$ MPa			$r/t\ (P_f\ 921/293 - P_a) \leq 56.3$ MPa		
Loose Rod Configuration	N/A	Maximum Number of Rods per Compartment based on the Maximum Active Fuel Length					
Freely Loose	No. of fuel rods	≤ 25			N/A		
Packed in 5-in. SS Pipe or Protective Case[c]	No. of fuel rods	≤ 22	≤ 26	≤ 30	≤ 695[d,e]	≤ 1,458[d,e]	≤ 105[d]
Strapped Together	No. of fuel rods	≤ 25			N/A		

a. Polyethylene equivalent mass for packing materials (refer to Section 6.3.2.2 of the application).
b. Polyethylene packing materials examples: protective sleeves, end caps, and cushioning foam.
c. Protective case consists of stainless steel (SS) box with lid.
d. Only in 5-inch SS pipes. Including partial rods: applying dense packing of congruent rods in the pipe will result in maximum number of rods that can physically fit within the pipe to be less than the number provided in the table above.
e. Allows for dense loading of the relatively short UC rods axially along the length of the component.
f. r/t is the fuel rod inner radius to thickness ratio, P_f is the absolute fill pressure, and P_a is atmospheric pressure (refer to Section 3.4.4 of the application).

5.(b) (2) Maximum quantity of material per package

Total weight of payload contents (fuel assemblies, or fuel rods and rod shipping containers) not to exceed 684 kg (1,508 pounds). The maximum uranium payload is 484 kg (1,069 pounds).

(i) For the contents described in 5(b)(1)(i), 5(b)(1)(ii), and 5(b)(1)(iii): two fuel assemblies.

(ii) For the contents described in 5(b)(1)(iv) and 5(b)(1)(v): allowable number of fuel rods, as specified in Table 4, per compartment (2 compartments per package).

(c) Criticality Safety Index, except for contents described in 5.(b)(1)(v) and limited in 5.(b)(2)(ii) 1.0

Criticality Safety Index for contents described in 5.(b)(1)(v) and limited in 5.(b)(2)(ii) 1.6

6. 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 of Chapter 7 of the application.

(b) The packaging must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the application.

(c) Prior to each shipment, the stainless steel components of the packaging must be visually inspected. Packages in which stainless steel components show pitting corrosion, cracking, or pinholes are not authorized for transport.

(d) If wrapping is used on the unirradiated fuel assemblies, the ends must be assured to be open during the shipment in the package.

7. Cluster separators are optional and may be comprised of polyethylene or other plastics. Polyethylene or plastic mass limits shall be determined in accordance with Section 6.3.2.2, “Material Specifications,” of the application.

8. Water rods are limited as shown in Table 3 above.

   For 8 x 8 fuel assembly designs, there can be either 0 or 1 water rod, and the water rod location occupies a space equivalent to 2 x 2 fuel rods. This is designated as 0, 2 x 2 in the table.

   For 9 x 9 and 10 x 10 fuel assembly designs, there can be either 0, 1, or 2 water rods in the assembly, and the water rod location occupies a space equivalent to (a) two 2 x 2 fuel rod equivalent spaces on a diagonal at the center of the assembly, or (b) one 3 x 3 fuel rod equivalent space (9 fuel rods space) in the center of the assembly. These configurations are designated as 0, 2 – 2 x 2 off-center diagonal, 3 x 3 in the table. Additionally, for GNF 10 x 10 fuel assembly designs, the water rod can occupy a space equivalent to a single 2 x 2 fuel rod equivalent at the bottom of the assembly and expanded at the top; this configuration is designated as 1-axially varying centered in the table.

9. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR 71.17.

10. Transport by air of fissile material is not authorized.

11. Revision No. 11 of this certificate may be used until November 30, 2019.

12. Expiration date: January 31, 2024.

REFERENCES

NEDO-33869, Revision 10, Global Nuclear Fuel - Americas, LLC, application dated September 4, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession Number (No.) ML18247A218).

Supplement: January 10, 2019 (ADAMS Package Accession No. ML19010A108).

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

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

Date: 1/24/19

U.S. Department of
Transportation

**Pipeline and
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Safety Administration**

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CERTIFICATE NUMBER: USA/9309/B(U)F-96

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