NRC FORM 618
(8-2000)
10 CFR 71

U.S. NUCLEAR REGULATORY COMMISSION

CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES

1 a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE		PAGES
9309	11	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 9, Global Nuclear Fuel - Americas, LLC, application dated September 30, 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.: 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 ~~-96~~ 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.

It 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 flow of the heat into the contents in the event of a fire. Foam polyethylene 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. 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 ~~ceramic nature of the fuel pellets~~welded end plugs provide primary containment of the radioactive material. The radioactive material is bound in ceramic pellets with ~~very~~ 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) Outer Container Drawings

105E3737, Rev. 68
105E3738, Sheets 1, ~~3, Sheets~~ 1 and 2, ~~Rev. 8~~101
105E3738, Sheets 2~~-~~ 3, Rev. ~~7~~10
105E3739, Rev. ~~4~~6
105E3740, Rev. ~~4~~6
105E3741, Rev. ~~1~~3
105E3742, Rev. ~~3~~5
105E3743, Rev. 7~~5~~
105E3744, Rev. 8~~6~~

(ii) Inner Container Drawings

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~~-96~~, 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~~2~~.00 x 10^{-9}~~8~~ g/gU
^{234}U	2.00 x 10^{-3} g/gU
^{235}U	5.00 x 10^{-2} g/gU
^{236}U	2.50 x 10^{-2} g/gU
^{237}Np	1.66 x 10^{-6} g/gU
^{238}Pu	6.20 x 10^{-11} g/gU
^{239}Pu	3.04 x 10^{-9} g/gU
^{240}Pu	3.04 x 10^{-9} g/gU
Gamma Emitters	~~5.18~~4.4 x 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. ~~When fuel rods are placed in polyethylene sleeves, each polyethylene sleeve shall not exceed 0.0152 cm in thickness.~~ 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. ~~When fuel rods are placed in polyethylene sleeves, each polyethylene sleeve shall not exceed 0.0152 cm in thickness.~~ 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)~~	% Theoretical ~~-~~	≤ 98 ~~% Theoretical~~Theoretical			
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	≤ 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	
~~Nominal~~ Fuel Rod Pitch	cm	≤1.~~63~~692	≤ 1.~~45~~51	≤ 1.~~30~~35	≤1.36~~30~~
^{235}U Pellet Enrichment	wt%	≤ 5.0			
~~Maximum~~ Lattice Average Enrichment	wt%	≤ 5.0			
Channel Thickness[a]	cm	0.17 – 0.3048			~~0.17 – 0.3048~~Any
Partial Length Fuel Rods	Fuel Rods#	None	≤12	≤14	≤16
~~Partial Length Fuel Rods~~	~~-~~	~~-~~	~~-~~	~~-~~	~~-~~
~~(1/3 through 2/3 normal length)~~	~~Max #~~	~~None~~	~~12~~	~~14~~	~~14~~
Gadolinia Requirements Lattice Average Enrichment[b]	# @ 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 %	1~~2~~1 @ 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 %	~~6~~7 @ 2 wt %
≤ 3.8 wt % ^{235}U		4 @ 2 wt %	4 @ 2 wt %	6 @ 2 wt %	~~7~~6 @ 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 %	~~4~~5 @ 2 wt %
≤ 3.54 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 %	~~2~~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 %	~~2~~1 @ 2 wt %
≤ ~~3~~2.09 wt % ^{235}U ~~≤ 2.9 wt % U-235~~		None ~~None~~	None ~~None~~	None2 @ 2 wt % ~~None~~	2None @ 2 wt % ~~None~~
Polyethylene Equivalent Mass per assembly[c] ~~(Maximum per Assembly)[e]~~	kg	≤11		≤10.2	
Thermal Performance Criteria[d]	MPa	r/t~~B~~WR (P_i 921/293 - P_e) ≤ 31.1 MPa (4,514 psi)			

a. Transport with or without channels is acceptable.
Required gadolinia rods must be distributed symmetrically about the major diagonal. Minimum required number of gadolinia rods. Aaapplies 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).
b. Polyethylene equivalent mass calculation (refer to Section 6.3.2.2, "Material Specification," of the application)

Commented [GSN1]: Suggested change to simplify the table. If this does not work, please let me know, and I will return it to the original format.

Commented [GSN2]: Suggested change to simplify the table. If this does not work, please let me know, and I will return it to the original format.

Commented [GSN3]: Suggested change to simplify the table. If this does not work, please let me know, and I will return it to the original format.

Commented [GSN4]: Suggested change to simplify the table. If this does not work, please let me know, and I will return it to the original format.

Commented [LKS5]: Table 6-1 of the SAR

Commented [LKS6]: Table 6-1 of the SAR

Commented [LKS7]: Table 6-1 of the SAR

Commented [GSN8]: Suggested change to simplify the table. If this does not work, please let me know, and I will return it to the original format.

Commented [GSN9]: Suggested change to simplify the table. If this does not work, please let me know, and I will return it to the original format.

Commented [GSN10]: Suggested change to simplify the table. If this does not work, please let me know, and I will return it to the original format.

Formatted: Font: (Default) Arial, 8 pt

Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers

Commented [GSN11]: Suggested change to simplify the table. If this does not work, please let me know, and I will return it to the original format.

Formatted: Centered

Formatted: Subscript

Formatted: Subscript

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)

Formatted: Subscript

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 [1] (UO_2)	9 x 9 [1] (UO_2)	10 x 10 [1] (UO_2)	CANDU-14 (UC)	CANDU-25 (UC)	Generic PWR (UO_2)
~~UO_2 or UC~~ Fuel Density ~~(% theoretical)~~	% theoretical	≤ ~~<~~98% ~~theoretical~~ ≤ ~~<98% theoretical~~ ≤ ~~<98% theoretical~~			≤ ~~<~~987% ~~theoretical~~ ≤ ~~<987% theoretical~~		≤ ~~<98~~100% ~~theoretical~~
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~~ ~~Zirc. Alloy~~ ~~Zirc. Alloy~~ ~~Zirc. Alloy~~			Zirconium Alloy ~~Zirc. Alloy~~ or ~~SS~~ ~~Zirc. Alloy or SS~~ ~~Zirc. 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	≥ 0.033	≥ 0.033
Active ~~fuel~~ Fuel Length	cm	≤ 381 ~~≤ 381~~		≤ 385	≤ 47.752	≤ 40.013	≤ 450
~~235Maximum~~ U Pellet Enrichment	wt.%				≤ 5.0 ~~≤5.0~~ ~~≤5.0~~ ~~≤5.0~~ ~~≤5.0~~ ~~≤5.0~~		
~~Maximum~~ Average ~~F~~fuel ~~r~~Rod Enrichment	wt.%				≤ 5.0 ~~≤5.0~~ ~~≤5.0~~ ~~≤5.0~~ ~~≤5.0~~ ~~≤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/cm³	Protective Sleeves: 0.925 ~~All Other Packaging Materials: 0.08~~ All Other Packaging Materials: 0.08			Protective Sleeves: 1.005 ~~All Other Packing Materials: 0.70~~ All Other Packing Materials: 0.70		

Commented [LKS12]: It's Type like Table 3

Commented [GSN13]: Should this be "Fuel Parameters values" Instead of "Type"?

Formatted Table

Formatted Table

Formatted: Left

Formatted: Left

Commented [GSN14]: Suggested change to simplify the table. If this does not work, please let me know, and I will return it to the original format.

Commented [GSN15]: Suggested change to simplify the table. If this does not work, please let me know, and I will return it to the original format.

Formatted Table

CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE		PAGES
9309	11	71-9309	USA/9309/B(U)F-96	8	OF	8

Thermal Performance Criteria[f]	~~Pa or~~ MPa	r/t (P_f 921/293 - P_a) ≤ 31.1 MPa			r/t (P_f 921/293 - P_a) ≤ 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 ~~≤25~~ ~~≤25~~			N/A ~~N/A~~ ~~N/A~~		
Packed in 5~~”~~ in. SS Pipe or Protective Case[c] ~~(3)~~		≤ 22	≤ 26	≤ 30	≤ ~~74~~ 695[d,e] ~~(2)~~	≤ 1,458~~130~~[d,e] ~~(2)~~	≤ 105[d] ~~(2)~~
Strapped Together		≤ 25 ~~≤25~~ ~~≤25~~			N/A ~~N/A~~ ~~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). ~~(1) Previous analysis (Ref. 1) based on most conservative loose rod configuration (i.e., no credit taken for 5” SS pipe)~~

~~(2) Including partial rods (in reality, apply dense packing of congruent rods in the pipe) and only in 5” SS pipes~~

~~(3) Protective case consists of SS box with lid.~~

Commented [GSN16]: Suggested change to simplify the table. If this does not work, please let me know, and I will return it to the original format.

Commented [GSN17]: Suggested change to simplify the table. If this does not work, please let me know, and I will return it to the original format.

Commented [GSN18]: Suggested change to simplify the table. If this does not work, please let me know, and I will return it to the original format.

Commented [GSN19]: Suggested change to simplify the table. If this does not work, please let me know, and I will return it to the original format.

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) ~~2.1~~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, f~~F~~or 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~~can be 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. ~~9~~ 10 of this certificate may be used until July 31, 2018.

12. Expiration date: November 30, 2019.

Commented [GSN20]: Date remains the same until the applicant submits a renewal request.

REFERENCES

NEDO-33869 Revision 9, Global Nuclear Fuel - Americas, LLC, application dated September 30~~,~~ 2016.

As supplemented: July 17, 2014, November 28, 2016 (ML16333A225), and April 7, 2017 (ML17097A102 and ML17102B103).

Commented [LKS21]: This date should be deleted since it pre-dates the RAJ-II SAR Revision 9 application and Revision 9 of the RAJ-II SAR encompasses Revision 7.1 of the RAJ-II SAR...plus changes to reflect GNF3.

Commented [GSN22]: Does the consolidated application include this document?

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

NRC FORM 618
(8-2000)
10 CFR 71

U.S. NUCLEAR REGULATORY COMMISSION

CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
9309	11	71-9309	USA/9309/B(U)F-96	11 OF	8

Date: _____