May 17,2006

Mr. Charles M. Vaughan, Manager
Facility Licensing
Global Nuclear Fuel - Americas, LLC
3901 Castle Hayne Road
Mail Code K-84
Wilmington, NC 28401

SUBJECT: REVISION 6 OF CERTIFICATE OF COMPLIANCE NO. 9309 FOR THE MODEL NO. RAJ-II PACKAGE

Dear Mr. Vaughan:

As requested by your application dated February 16, 2006, as supplemented April 21, 2006, enclosed is Certificate of Compliance No. 9309, Revision No. 6, for the Model No. RAJ-II package. Changes made to the enclosed certificate are indicated by vertical lines in the margin. The staff's Safety Evaluation Report is also enclosed.

This approval constitutes authority to use the package for shipment of radioactive material and for the package to be shipped in accordance with the provisions of 49 CFR 173.471. Those on the attached list have been registered as users of the package under the general license provisions of 10 CFR 71.17 or 49 CFR 173.471. Registered users may request, by letter, to remove their names from the Registered Users List.

If you have any questions regarding this certificate, please contact me or Kim Hardin of my staff at (301) 415-8500.

Sincerely,

/RA by Meraj Rahimi Acting For/

Robert A. Nelson, Chief
Licensing Section
Spent Fuel Project Office
Office of Nuclear Material Safety
and Safeguards

Docket No: 71-9309
TAC No: L23944

Enclosures: 1. Certificate of Compliance No. 9309, Rev. No. 6
2. Safety Evaluation Report
3. Registered Users

cc w/encls 1 & 2: R. Boyle, Department of Transportation
J. Shuler, Department of Energy
RAMCERTS
Registered Users

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SAFETY EVALUATION REPORT
Docket No. 71-9309
Model No. RAJ-II Package
Certificate of Compliance No. 9309
Revision No. 6

SUMMARY

By application dated February 16, 2006, Global Nuclear Fuel (GNF or the applicant) requested an amendment to Certificate of Compliance No. 9309, for the Model No. RAJ-II package. The original submittal was dated February 3, 2006; however, the electronic formatting for the submittal was corrected by letter dated February 16, 2006. In the application, GNF provided clarifications to the general information in the Safety Analysis Report (SAR) and some of the drawings. GNF re-analyzed the most reactive accident condition that must be considered in the establishment of the Criticality Safety Index (CSI) for the package, and a change was requested by GNF. The changes to the contents include revisions to fuel assembly parameters and a decrease in the CSIs for fuel assembly and loose rod transport from 3.0, for 10x10 fuel assemblies, and 50, for 8x8 and 9x9 fuel assemblies, respectively, to 1.0 for all fuel assembly types. Supplemental information to support this request was dated March 13 and April 21, 2006.

CRITICALITY EVALUATION

This section presents the criticality analysis results for the RAJ-II transportation package. The purpose of this review is to verify that the package design meets the criticality safety requirements of 10 CFR Part 71 after having been evaluated under both normal conditions of transport and hypothetical accident conditions.

Chapter 6 was reviewed for completeness of information and consistency with other chapters and the drawings. The information, parameters, and dimensions provided were sufficient to perform a review and are consistent throughout the application. Chapter 6 presents the results of the applicant's criticality analyses.

The applicant requested changes to the contents and the CSI. The changes to the contents include revisions to fuel assembly parameters and a decrease of the CSIs for fuel assembly transport from 3.0, for 10x10 fuel assemblies, and 50, for 8x8 and 9x9 fuel assemblies, respectively, to 1.0 for all fuel assembly types. The revised fuel assembly parameters proposed by the applicant are shown in Table 3 of the certificate and Table 1 of this evaluation. The applicant did not request changes to either the fuel rod parameters for shipment of loose rods or changes to the maximum number of loose fuel rods in a shipment, but did request that the CSI be decreased from 50 to 1.0. Additionally, the applicant requested that the maximum polyethylene thickness, when a fuel rod is placed in a polyethylene sleeve be authorized at 0.0152 cm.

In support of the changes, the applicant submitted a complete revision to Chapter 6, "Criticality Evaluation." The applicant evaluated a single package and array configurations for both normal conditions of transport and hypothetical accident conditions. The models in Section 6 of the application were reviewed and found to be consistent with the drawings and contents in Section 1 of the application. Components important to criticality safety are described below.

The RAJ-II is comprised of two primary components: 1) an inner stainless steel container, and 2) an outer stainless steel container. The inner container is lined with polyethylene foam having a density up to 0.080 g/cm^3. The fuel assemblies rest against the polyethylene foam in a fixed position, and the inner container is positioned within the outer container as shown in Figure 6-5 of the SAR. The inner container has alumina silicate thermal insulation between the inner and outer walls. Water at 1.0 g/cm^3 between the inner and outer containers is used as a conservative replacement in the model for the honeycomb shock absorbers because it is more effective in thermalizing neutrons; and, therefore, more reactive for the single package hypothetical accident conditions model. The inner stainless steel container is 468.6 cm (184.49 in) in length, 45.9 cm (18.07 in) in width, and 28.6 cm (11.26 in) in height. Containment is provided by the cylindrical zirconium alloy tubes. The fuel assemblies are located inside one of two compartments within the inner container. The compartments are fabricated from 18-gauge (0.122 cm thick) stainless steel, 456.7 cm (179.8 in) in length, 17.6 cm (6.93in) in width and height.

The outer container is 506.8 cm (199.53 in) in length, 72.0 cm (28.35 in) in width, and 64.2 cm (25.28 in) in height (with the skids attached the height is 74.2 cm (29.21 in)). The inner container is held rigidly within the outer stainless steel container by four evenly spaced stainless steel fixture assemblies. Shock absorbers, fabricated from a phenol impregnated cardboard material, are placed at six locations above and below the inner container, and twelve locations on either side of the inner container. The wall for the outer container is fabricated from 14-gauge (0.2 cm thick) stainless steel.

Table 1: RAJ-II Fuel Assembly Loading Parameters

Parameter	Units	Fuel Assembly Parameter Values			
Fuel Assembly Type	rods	8x8	9x9	FANP 10x10	GNF 10x10
UO_2 Theoretical Density		#98%	#98%	#98%	#98%
Number of water rods	# rods	0, 2x2	0, 2-2x2 off-center diagonal,3x3	0, 2-2x2 off-center diagonal,3x3	0, 2-2x2 off-center diagonal,3x3
Number of fuel rods	# rods	60-64	72-81	91-100	91-100
Fuel Rod OD	cm	$1.176	$1.093	$1.0	$1.01
Fuel Pellet OD	cm	#1.05	#0.96	#0.895	#0.895
Cladding Material		Zirconium Alloy	Zirconium Alloy	Zirconium Alloy	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	#381	#385	#385
Fuel Rod Pitch	cm	#1.692	#1.51	#1.35	#1.35
^{235}U Enrichment	w/o	#5.0	#5.0	#5.0	#5.0
Lattice Average Enrichment	w/o	#5.0	#5.0	#5.0	#5.0

Channel Thickness[a]	cm	0.17-0.3048	0.17-0.3048	0.17-0.3048	0.17-0.3048
Part Length Fuel Rods	Max #	None	12	14	14
Gadolinia Requirements per Lattice Average Enrichment[b] #5.0 w/o U-235 #4.7 w/o U-235 #4.6 w/o U-235 #4.3 w/o U-235 #4.2 w/o U-235 #4.1 w/o U-235 #3.9 w/o U-235 #3.8 w/o U-235 #3.7 w/o U-235 #3.6 w/o U-235 #3.5 w/o U-235 #3.3 w/o U-235 #3.1 w/o U-235 #3.0 w/o U-235 #2.9 w/o U-235	# @ w/o Gd_2O_3	7 @ 2 w/o 6 @ 2 w/o 6 @ 2 w/o 6 @ 2 w/o 6 @ 2 w/o 4 @ 2 w/o 4 @ 2 w/o 4 @ 2 w/o 2 @ 2 w/o 2 @ 2 w/o 2 @ 2 w/o 2 @ 2 w/o None None None	10 @ 2 w/o 8 @ 2 w/o 8 @ 2 w/o 8 @ 2 w/o 6 @ 2 w/o 6 @ 2 w/o 6 @ 2 w/o 4 @ 2 w/o 4 @ 2 w/o 4 @ 2 w/o 2 @ 2 w/o 2 @ 2 w/o 2 @ 2 w/o None None	12 @ 2 w/o 12 @ 2 w/o 10 @ 2 w/o 9 @ 2 w/o 8 @ 2 w/o 8 @ 2 w/o 6 @ 2 w/o 6 @ 2 w/o 6 @ 2 w/o 4 @ 2 w/o 4 @ 2 w/o 2 @ 2 w/o 2 @ 2 w/o 2 @ 2 w/o None	12 @ 2 w/o 12 @ 2 w/o 10 @ 2 w/o 9 @ 2 w/o 8 @ 2 w/o 8 @ 2 w/o 6 @ 2 w/o 6 @ 2 w/o 6 @ 2 w/o 4 @ 2 w/o 4 @ 2 w/o 2 @ 2 w/o 2 @ 2 w/o 2 @ 2 w/o None
Polyethylene Equivalent Mass (Max. per Assembly)[c]	kg	11	11	10.2	10.2

a. Transport with or without channels is acceptable.
b. Required gadolinia rods must be distributed symmetrically about the major diagonal.
c. Polyethylene equivalent mass calculation, refer to 6.3.2.2 of the application.

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 - 2x2 off-center diagonal, 3x3 in the table.

The material specifications used in the criticality analysis were reviewed by the staff for completeness and correctness. The applicant took credit for 75 percent of the gadolinia present in the fuel rods. The staff agrees that the material property delineations presented in Sections 6.3.1 and 6.3.2 of the application are consistent with the condition of the package after the tests for normal conditions of transport and hypothetical accident conditions.

The applicant performed the criticality evaluation using the SCALE-PC (version 4.4a) and the 44GROUPNDFB-V cross section set library. Each case was run using the CSAS25 sequence of codes, i.e., BONAMI, NITAWL, and KENO V.a. For each case, 400 generations with 2,500 neutrons per generation were run to ensure proper behavior about the mean value.

The applicant performed an evaluation of optimum moderation in the inner container. The applicant varied the density of the water in the inner container and the fuel parameters to determine the optimum reactivity for each type of fuel assembly for each parameter in Table 1. Additionally, the applicant determined the maximum k_{eff} for each enrichment and fissile loading based on the minimum number of gadolinia rods. Additionally, the applicant determined optimum moderation for the loose fuel rods in a similar manner. For the evaluation of loose rods, a fuel rod pitch sensitivity study was conducted for each fuel rod type to determine the number of fuel rods that can be transported. The loose rod analysis was used to bound a fuel rod shipment in which fuel rods are strapped or bundled together.

The single package normal conditions of transport and hypothetical accident conditions models are described in Section 6.3.1.1 of the application. The results of the calculations are shown in Figures 6-39 and 6-40 of the application, and summarized in Table 2, below.

The applicant performed calculations for package arrays after the tests for both normal conditions of transport and hypothetical accident conditions. The applicant modeled a 21x3x24 array packages for normal conditions of transport, surrounded by a 30.48 cm layer of full density water for reflection, with each package as described in Section 6.3.1.1 of the application. For the current analysis, the applicant included the polyethylene foam in the criticality calculations for hypothetical accident conditions, the array size analyzed was10x10x1.

The applicant evaluated the package arrays with optimum moderation (fully flooded) in the inner container. The biggest difference between the two calculations is that for the array, after the tests for normal conditions of transport, the moderator between the inner and outer container was varied uniformly. For the hypothetical accident conditions array, no interspersed water between packages or in the outer container was modelled to increase neutron interaction between packages. Additionally, for hypothetical accident conditions, the applicant determined the effects on reactivity of replacing the aluminum silicate and polyethylene foam. The applicant's evaluation of the effect of replacing the aluminum silicate with water and void showed that void was most reactive. Additionally, the applicant evaluated varying the thickness of the polyethylene foam to determine the effect of melting of the foam. When the polyethylene foam thickness was reduced, the lost foam thickness was replaced with water moderation. The applicant found that the maximum foam thickness was most reactive.

The applicant also modeled package deformation after the tests for hypothetical accident conditions by reducing the inner container length 8.1 cm and reducing the outer container length 4.7 cm and the height 2.4 cm to bound the damage incurred in the 9-meter free drop test and the 1-meter puncture test. The results of the applicant's calculations for package arrays after the tests for normal conditions of transport and hypothetical accident conditions are shown in Figures 6-41 and 6-42 of the application, and summarized in Table 2, below.

The technical content of the applicant's criticality evaluation determining the maximum number of loose fuel rods (i.e, fuel rods not contained in a fuel assembly) that may be transported in the RAJ-II package has not been changed in this application. The applicant did revise figure and table number and names and clarified the optimum moderation explanation for loose fuel rods in a pipe. Consistent with the criticality evaluation for fuel assemblies, the applicant modeled the size of the array, after the tests for hypothetical accident conditions, as a 10x10x1 array of packages after including the polyethylene foam in the inner container. The applicant's maximum k_{eff} for loose rods is shown in Table 2 below.

Table 2: RAJ-II Maximum K_{eff} Values		
Case	Fuel Assembly	Loose Rods
Single Package	0.6951	0.6548
Array Under Normal Conditions of Transport	0.8535	0.6381
Array Under Hypothetical Accident Conditions	0.9396	0.8745

The NRC staff performed confirmatory criticality calculations for hypothetical accident conditions. The staff performed calculations for the maximum enrichment of 5 weight percent U-235 and used the most reactive fuel assembly parameters determined by the applicant. Similar to the applicant, the staff used 75 percent credit for the gadolinia present in the fuel rods.

The staff's calculations were performed with SCALE 5.0, using KENO V.a and the 238GROUPNDF/B-V cross section set. The staff's maximum k_{eff} and optimum moderation level agreed well with the applicant's results. Additionally, the staff performed different sensitivity analyses than the applicant. The applicant evaluated the package array for hypothetical accident conditions, with and without the aluminum silicate insulator. Additionally, since the polyethylene foam density is not specified in the drawings, the staff evaluated the effects of increasing and decreasing foam density on reactivity.

The applicant evaluated a 21x3x24 array (5N array) of packages for normal conditions of transport and a 10x10x1 (2N array) array of packages for hypothetical accident conditions, for both fuel assemblies and loose fuel rods. Pursuant to 10 CFR 71.59(a)(2), the more restrictive value of "N" from normal conditions and hypothetical accident conditions. The RAJ-II criticality analysis demonstrates criticality safety for 5N = 1,512 (undamaged) and 2N = 100 (damaged) packages, for an N = 50, which corresponds to a CSI of 1.0 for all packages.

Similar to the loose fuel rod evaluation the technical content of the applicant's benchmarking evaluation has not been changed in this application. The applicant did revise figure and table numbers and names and added clarifying comments to the benchmarking evaluation. The USL for the RAJ-II package still remains at 0.94254, which is larger than all of the maximum k_{eff}s determined by the applicant and summarized in Table 2.

CONDITIONS

The following changes were made to the Certificate of Compliance:

Condition No. 5.(a)(2) was corrected to change the word “inner” to “outer.”

Condition No. 5.(a)(3) was corrected to update drawings 105E3738, 105E3743, and 105E3744.

The thickness of the polyethylene sleeves was limited in Condition No. 5.(b)(1)(iv).

The fuel assembly parameters were modified in Table 3 of Condition 5.(b)(1).

The CSI for transport of the authorized contents in 5.(b)(1) was changed to 1.0.

Condition No. 8 was added to clarify the water rod limits in Table 3 of Condition 5.(b)(1).

Condition No. 10 was added to clarify that air transport is not authorized, since the package was not evaluated under the requirements of 10 CFR 71.55(f).

Condition No. 11 was added to allow continued shipments under Rev. 5 of this certificate for one year.

CONCLUSION

Based on review of the statements and representations in the application, the staff concludes that the nuclear criticality safety design has been adequately described and evaluated and that the package meets the subcriticality requirements of 10 CFR Part 71.

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. 9309, Revision No. 6
on May 17, 2006.