GLOBAL NUCLEAR FUEL-AMERICAS
WESTINGHOUSE
AREVA NP Inc.

BWR Shipping Package
RAJ-II
Status Report

Presented to USNRC

April 28, 2009

Agenda

1. RAJ-II Team Changes
2. License Renewal Schedule
3. SAR Revision Overview
4. Proposed Revisions to RAJ-II SAR
5. Proposed Revisions to RAJ-II Certificate of Compliance

Agenda

1. **RAJ-II Team Changes**
2. License Renewal Schedule
3. SAR Revision Overview
4. Proposed Revisions to RAJ-II SAR
5. Proposed Revisions to RAJ-II Certificate of Compliance

1. RAJ-II Team Changes

Jan 2009

- (GNFA) Tanya Sloma joins as NCS analyst
- (GNFA) Geoff Luft (Project Manager) leaves GNFA
  Barry Miles appointed Project Manager

Mar 2009

- (WEC) Owen Connelly (NCS) out on disability

Apr 2009

- (GNFA) Barry Miles reassigned
  John Zino appointed interim PM

1. RAJ-II Team Changes April 2009 Team

Function	GNFA	WEC
Project Mgmt	J. Zino	N. Kent
Licensing – USA	S. Murray	N. Kent
Licensing – Europe	J. Zino	N. Kent
Mechanical	A. Langston	B. Hempy
Thermal	A. Langston	Novatech
Criticality Safety	J. Zino T. Sloma	P. Vescovi

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1. RAJ-II Team Changes
2. **License Renewal Schedule**
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5. Proposed Revisions to RAJ-II Certificate of Compliance

2. License Renewal Schedule

Revision 7 effective now. Expires 30 November 2009.

Submit renewal application (five year) in May 2009.

- Primarily administrative – no technical changes
- NRC issue Revision 8 on the consolidated application
- Licensee obtain DOT endorsement and foreign validations to avoid gap licenses

Submit amendment request to CoC in June - July.

- Includes technical changes.
- Adds WEC fuel to contents.
- Replace wood runners with synthetic.

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Agenda

1. RAJ-II Team Changes
2. License Renewal Schedule
3. **SAR Revision Overview**
4. Proposed Revisions to RAJ-II SAR
5. Proposed Revisions to RAJ-II Certificate of Compliance

3. SAR Revision Overview

General Information

- Simplify license drawings
- Add section describing compliance with QA requirements contained in 10CFR71 Subpart H

Structural

- Replace wood runners with composite or steel
- FEA developed to address the French Authorities questions

Thermal

- Add 3D analysis results

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3. SAR Revision Overview (cont'd)

Criticality Safety

- Reduce number of enrichment dependent specifications
- Specify contents based on more realistic assumptions about arrangement, number and GdO2 content

Maintenance

- Add information regarding maintenance and inspection procedures.
- Include test data on the wet honeycomb

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1. RAJ-II Team Changes
2. License Renewal Schedule
3. SAR Revision Overview
4. **Proposed Revisions to RAJ-II SAR**
5. Proposed Revisions to RAJ-II Certificate of Compliance

4. RAJ-II Safety Analysis Report (SAR)
Proposed Changes

1.	Chapter 1 GENERAL INFORMATION	Minor revision
2.	Chapter 2 STRUCTURAL EVALUATION	Minor revision
3.	Chapter 3 THERMAL EVALUATION	Minor revision
4.	Chapter 4 CONTAINMENT	
5.	Chapter 5 SHIELDING EVALUATION	
6.	Chapter 6 CRITICALITY EVALUATION	Significant revision
7.	Chapter 7 PACKAGE OPERATIONS	
8.	Chapter 8 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM	Minor revision

✓ No Changes

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4. RAJ-II Safety Analysis Report (SAR)

1. **Chapter 1 GENERAL INFORMATION**
2. **Chapter 2 STRUCTURAL EVALUATION**
3. **Chapter 3 THERMAL EVALUATION**
4. **Chapter 4 CONTAINMENT**
5. **Chapter 5 SHIELDING EVALUATION**
6. **Chapter 6 CRITICALITY EVALUATION**
7. **Chapter 7 PACKAGE OPERATIONS**
8. **Chapter 8 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM**

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4. RAJ-II Safety Analysis Report (SAR)
Chapter 1: General Information

License Drawings

1. Removed fabrication details.
2. Removed unneeded or unreferenced views held over from the Japanese Licensing drawings.
3. Removed brand specific designation for materials.
4. Provided allowance for replacing Japanese Hemlock with a US wood equivalent.
5. Allowed for the use of Nylok style nuts in place of the nut/washer used to restrain the honeycomb blocks.
6. Allowed for the use of a different skid material. The Europeans have specifically requested the elimination of all wood other than dunnage material.

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4. RAJ-II Safety Analysis Report (SAR)

1. Chapter 1 GENERAL INFORMATION
2. Chapter 2 STRUCTURAL EVALUATION
3. Chapter 3 THERMAL EVALUATION
4. Chapter 4 CONTAINMENT
5. Chapter 5 SHIELDING EVALUATION
6. Chapter 6 CRITICALITY EVALUATION
7. Chapter 7 PACKAGE OPERATIONS
8. Chapter 8 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

4. RAJ-II Safety Analysis Report (SAR)
Chapter 2: Structural Evaluation

Requested by French Authorities

- Complete comparison of the package, closing system, and fuel contents for the drop test. The documentation must indicate that the “worst case” drop orientation is covered by the drop tests that were performed.

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4. RAJ-II Safety Analysis Report (SAR)

1. Chapter 1 GENERAL INFORMATION
2. Chapter 2 STRUCTURAL EVALUATION
3. Chapter 3 THERMAL EVALUATION
4. Chapter 4 CONTAINMENT
5. Chapter 5 SHIELDING EVALUATION
6. Chapter 6 CRITICALITY EVALUATION
7. Chapter 7 PACKAGE OPERATIONS
8. Chapter 8 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

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4. RAJ-II Safety Analysis Report (SAR)
Chapter 3: Thermal Evaluation

Requested by French Authorities

- Include results of a comprehensive 3D thermal model of the RAJ-II, comparing results against the 2D model.

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4. RAJ-II Safety Analysis Report (SAR)

1. Chapter 1 GENERAL INFORMATION
2. Chapter 2 STRUCTURAL EVALUATION
3. Chapter 3 THERMAL EVALUATION
4. Chapter 4 CONTAINMENT
5. Chapter 5 SHIELDING EVALUATION
6. Chapter 6 CRITICALITY EVALUATION
7. Chapter 7 PACKAGE OPERATIONS
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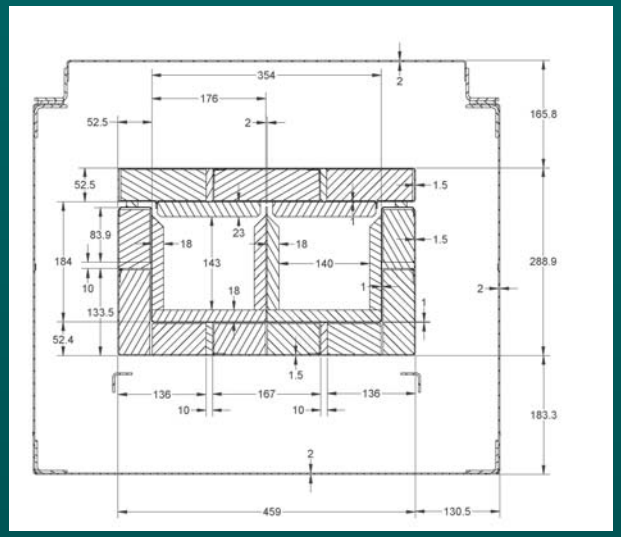
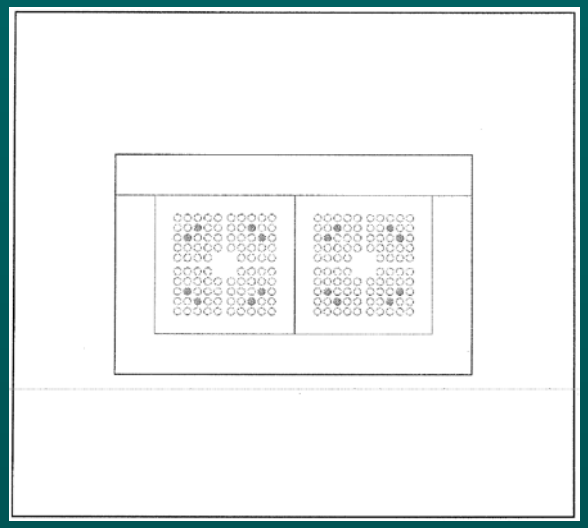
4. RAJ-II Safety Analysis Report (SAR)
Chapter 6: Criticality Evaluation

Packaging - RAJ-II



ACTUAL

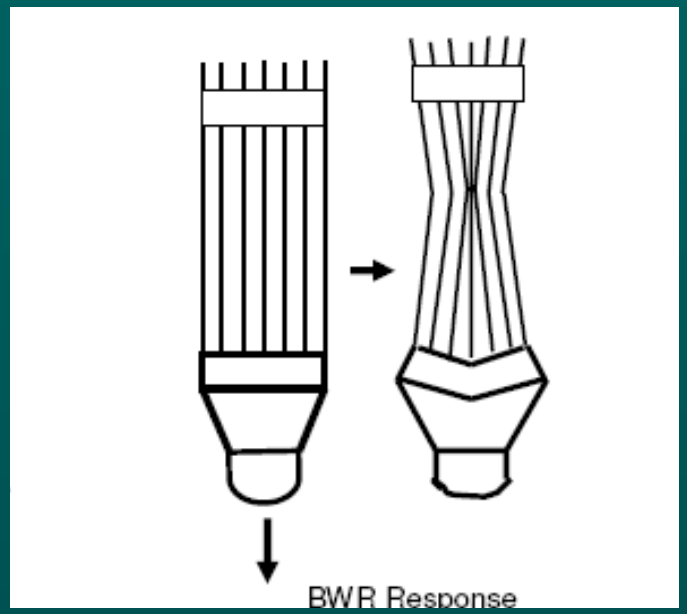


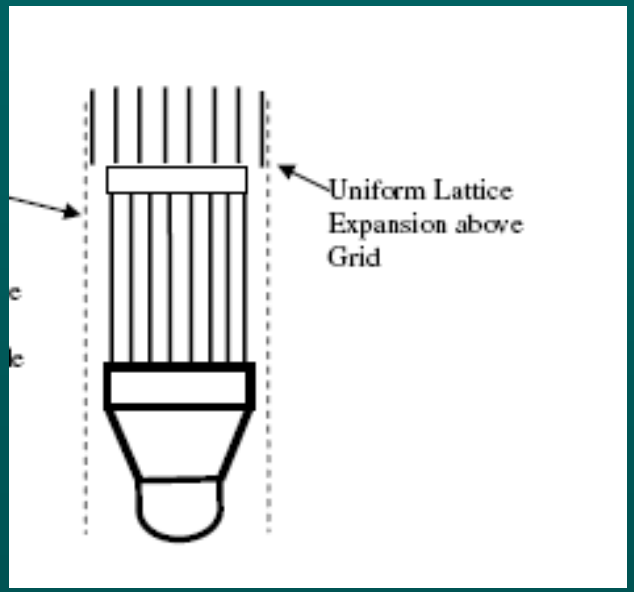
KENO VI

mod·el \mä-dəl a system of postulates, data, and inferences presented as a mathematical description of an entity or state of affairs ; *also* **:** a computer simulation based on such a system

4. RAJ-II Safety Analysis Report (SAR)
Chapter 6: Criticality Evaluation

Contents-BWR Fuel Assembly





Revised model simulates fuel reconfiguration as uniform lattice expansion limited to 50 cm along axis of fuel.

4. RAJ-II Safety Analysis Report (SAR)
Chapter 6: Criticality Evaluation

Fuel Assembly Lattice

ACTUAL

2.00	3.40	4.00	4.00	3.40	3.40	4.00	4.40	3.40	2.00	J
3.40	4.00	4.60	4.95	4.95	4.95	4.60	4.95	4.60	3.40	I
		8.00				8.00				
4.00	4.60	4.95	4.60	4.95	4.95	4.95	4.60	4.95	4.95	H
	8.00		8.00				5.00			
4.00	4.95	4.60	4.95	4.95	4.95	4.60	4.95	4.60	4.95	G
		8.00				2.00		8.00		
3.40	4.95	4.95	4.95			4.95	4.95	4.95	4.40	F
3.40	4.95	4.95	4.95			4.95	4.95	4.95	4.60	E
3.40	4.60	4.95	4.60	4.95	4.95	4.95	4.95	4.60	4.95	D
	8.00		2.00			2.00		8.00		
4.00	4.95	4.60	4.95	4.95	4.95	4.95	4.60	4.95	4.95	C
							5.00			
3.40	4.60	4.95	4.60	4.95	4.95	4.60	4.95	4.60	4.60	B
			8.00			8.00		8.00		
2.00	3.40	4.95	4.95	4.40	4.60	4.95	4.95	4.60	4.00	A
10	9	8	7	6	5	4	3	2	1	

REVISED

4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	J
4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	I
		4.00					4.00			
4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	H
	4.00							4.00		
4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	G
4.95	4.95	4.95	4.95			4.95	4.95	4.95	4.95	F
4.95	4.95	4.95	4.95			4.95	4.95	4.95	4.95	E
4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	D
4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	C
	4.00							4.00		
4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	B
		4.00					4.00			
4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	A
10	9	8	7	6	5	4	3	4	1	

CURRENT

4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	1.60	J
									2.00	
4.95	4.95	4.95	4.95	4.95	4.95	1.60	1.60	1.60	4.95	I
						2.00	2.00	2.00		
4.95	4.95	4.95	4.95	4.95	4.95	1.60	1.60	1.60	4.95	H
						2.00	2.00	2.00		
4.95	4.95	4.95	4.95	4.95	4.95	1.60	1.60	1.60	4.95	G
						2.00	2.00	2.00		
4.95	4.95	4.95	4.95			4.95	4.95	4.95	4.95	F
4.95	4.95	4.95	4.95			4.95	4.95	4.95	4.95	E
4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	D
4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	C
4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	B
4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	4.95	A
10	9	8	7	6	5	4	3	2	1	

k_{eff} increasing →

Revised model simulates **Gadolinia rod locations** placement similar to actual lattice and **enrichment** is maximum < 5.00 wt% U235

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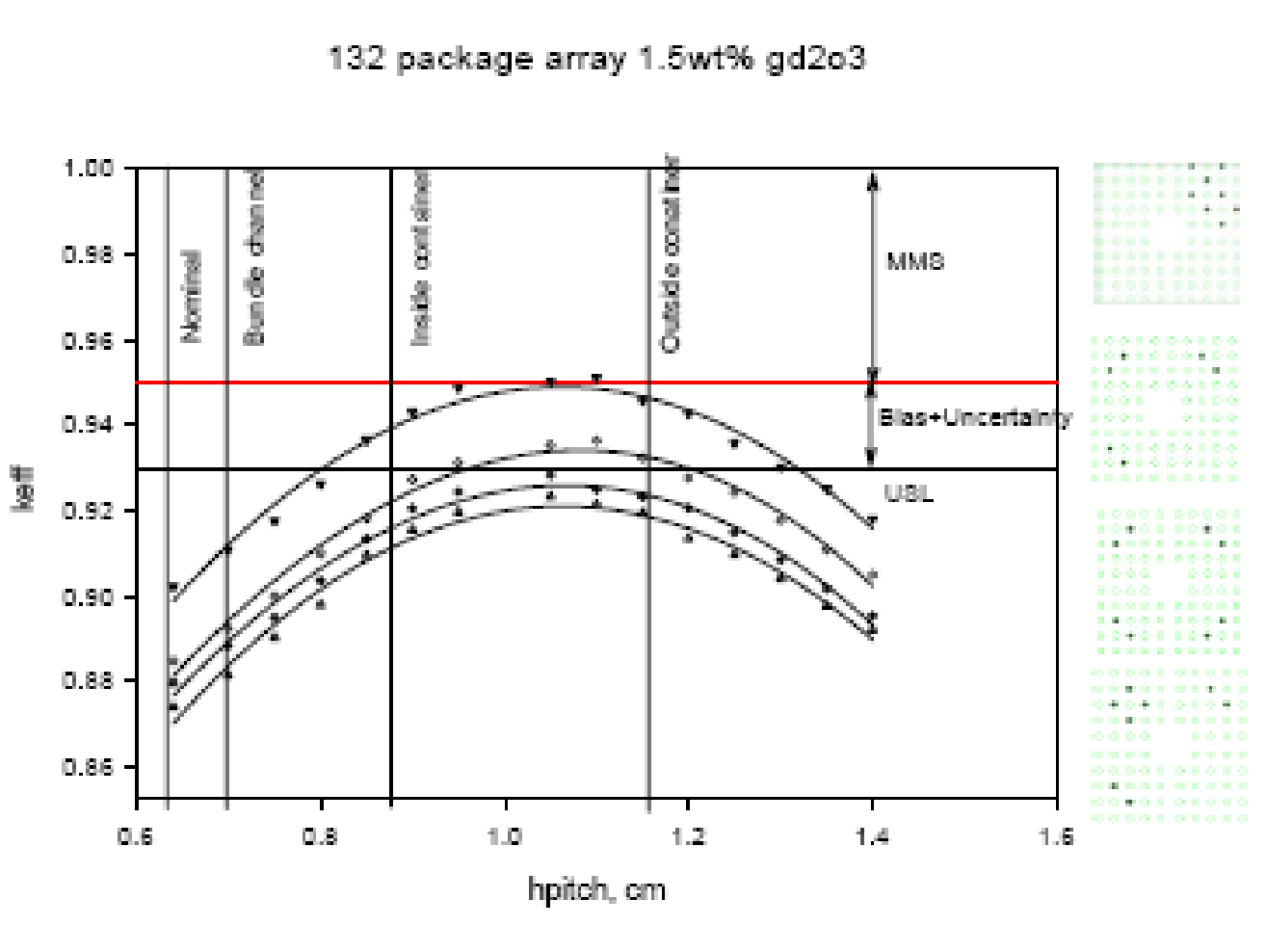
4. RAJ-II Safety Analysis Report (SAR)
Chapter 6: Criticality Evaluation



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4. RAJ-II Safety Analysis Report (SAR)
Chapter 6: Criticality Evaluation

Gadolinia Rod Placement

Infinite SVEA96 Bundles, 9-box doped with 0.1% Gd2O3, all sides reflected after void of 1.867 cm (1.78 cm for H2O and 0.087 for SS304)

	10	9	8	7	6	5	4	3	2	1	
Information/Model Location	1/3 Length Rod	109	108	107	106	105	104	103	102	1/3 Length Rod	
U-235 Sensitivity	2.2918E-03	2.3470E-03	2.1771E-03	2.1292E-03	2.1606E-03	1.9278E-03	1.9961E-03	2.3901E-03	2.4187E-03	2.1456E-03	J
U238 Sensitivity	-1.3471E-03	-1.2007E-03	-1.1544E-03	-1.2015E-03	-1.3602E-03	-1.3693E-03	-1.1862E-03	-1.1851E-03	-1.2170E-03	-1.3657E-03	10
Gadolinium-157 Sensitivity	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	
Information/Model Location	910	99	98	97	96	95	94	93	92	91	
U-235 Sensitivity	2.4059E-03	2.8369E-03	2.7307E-03	2.8797E-03	2.5357E-03	2.4722E-03	2.8766E-03	2.7362E-03	2.7404E-03	2.3445E-03	I
U238 Sensitivity	-1.2166E-03	-9.7027E-04	-9.1166E-04	-9.5940E-04	-1.3024E-03	-1.3151E-03	-9.7913E-04	-8.9675E-04	-9.2453E-04	-1.2399E-03	9
Gadolinium-157 Sensitivity	----------	-2.2016E-03	-1.8823E-03	-2.3365E-03	----------	----------	-2.2384E-03	-1.8549E-03	-2.1457E-03	----------	
Information/Model Location	810	89	88	87	86	85	84	83	82	81	
U-235 Sensitivity	2.3222E-03	2.7956E-03	2.8263E-03	3.1313E-03	3.0918E-03	3.1040E-03	3.1037E-03	2.7855E-03	2.7574E-03	2.2788E-03	H
U238 Sensitivity	-1.1684E-03	-9.2182E-04	-8.7477E-04	-9.4025E-04	-1.2992E-03	-1.3229E-03	-9.1971E-04	-8.6939E-04	-9.1181E-04	-1.1852E-03	8
Gadolinium-157 Sensitivity	----------	-1.8458E-03	-1.5628E-03	-2.1963E-03	----------	----------	-2.1364E-03	-1.5278E-03	-1.8607E-03	----------	
Information/Model Location	710	79	78	77	2/3 Length Rod	2/3 Length Rod	74	73	72	71	
U-235 Sensitivity	2.1283E-03	2.9344E-03	3.1607E-03	3.8063E-03	5.1490E-03	5.0355E-03	3.8851E-03	3.1337E-03	2.9201E-03	2.1807E-03	G
U238 Sensitivity	-1.1473E-03	-9.3269E-04	-8.8302E-04	-9.7412E-04	-1.8572E-03	-1.9231E-03	-9.9920E-04	-9.0994E-04	-9.3951E-04	-1.1992E-03	7
Gadolinium-157 Sensitivity	----------	-2.2172E-03	-2.1489E-03	-3.0677E-03	----------	----------	-3.1769E-03	-2.1597E-03	-2.2094E-03	----------	
Information/Model Location	610	69	68	2/3 Length Rod	Water Hole	Water Hole	2/3 Length Rod	63	62	61	
U-235 Sensitivity	2.1876E-03	2.7496E-03	3.1845E-03	5.1172E-03			5.0534E-03	3.3896E-03	2.7640E-03	1.9135E-03	F
U238 Sensitivity	-1.3235E-03	-1.2636E-03	-1.2995E-03	-1.8948E-03			-1.9052E-03	-1.3327E-03	-1.2868E-03	-1.3338E-03	6
Gadolinium-157 Sensitivity	----------	----------	----------	----------			----------	----------	----------	----------	
Information/Model Location	510	59	58	2/3 Length Rod	Water Hole	Water Hole	2/3 Length Rod	53	52	51	
U-235 Sensitivity	2.1889E-03	2.6079E-03	3.3903E-03	5.2671E-03			5.1091E-03	3.2738E-03	2.7896E-03	2.1604E-03	E
U238 Sensitivity	-1.3359E-03	-1.2911E-03	-1.3066E-03	-1.8967E-03			-1.9104E-03	-1.3268E-03	-1.2939E-03	-1.3746E-03	5
Gadolinium-157 Sensitivity	----------	----------	----------	----------			----------	----------	----------	----------	
Information/Model Location	410	49	48	47	2/3 Length Rod	2/3 Length Rod	44	43	42	41	
U-235 Sensitivity	2.1895E-03	2.9126E-03	3.1397E-03	3.8430E-03	5.3599E-03	4.8536E-03	3.8492E-03	3.1739E-03	2.8527E-03	2.3138E-03	D
U238 Sensitivity	-1.1804E-03	-9.1692E-04	-9.2736E-04	-9.8466E-04	-1.9627E-03	-1.9611E-03	-9.7722E-04	-9.2574E-04	-9.4038E-04	-1.2179E-03	4
Gadolinium-157 Sensitivity	----------	-2.2277E-03	-2.1509E-03	-2.9938E-03	----------	----------	-3.1507E-03	-2.1487E-03	-2.2395E-03	----------	
Information/Model Location	310	39	38	37	36	35	34	33	32	31	
U-235 Sensitivity	2.7444E-03	2.2473E-03	2.7803E-03	3.2017E-03	3.2976E-03	3.2180E-03	3.0911E-03	2.8035E-03	2.7081E-03	2.2183E-03	C
U238 Sensitivity	-9.0641E-04	-1.1603E-03	-8.7849E-04	-8.8953E-04	-1.3211E-03	-1.2962E-03	-9.1794E-04	-8.7811E-04	-8.9911E-04	-1.1960E-03	3
Gadolinium-157 Sensitivity	----------	-1.8831E-03	-1.5034E-03	-2.1037E-03	----------	----------	-2.1909E-03	-1.5266E-03	-1.8192E-03	----------	
Information/Model Location	210	29	28	27	26	25	24	23	22	21	
U-235 Sensitivity	2.3701E-03	2.7907E-03	2.6955E-03	2.8477E-03	2.2579E-03	2.6877E-03	2.8712E-03	2.7740E-03	2.7161E-03	2.2579E-03	B
U238 Sensitivity	-1.2241E-03	-9.4251E-04	-8.9826E-04	-9.0352E-04	-1.2221E-03	-1.2916E-03	-9.1711E-04	-9.1595E-04	-9.2649E-04	-1.2221E-03	2
Gadolinium-157 Sensitivity	----------	-2.1177E-03	-1.8498E-03	-2.2683E-03	----------	----------	-2.2583E-03	-1.8145E-03	-2.1475E-03	----------	
Information/Model Location	1/3 Length Rod	19	18	17	16	15	14	13	12	1/3 Length Rod	
U-235 Sensitivity	1.9508E-03	2.2817E-03	2.2232E-03	2.1207E-03	2.3684E-03	2.2205E-03	2.3800E-03	2.3204E-03	2.2090E-03	2.1241E-03	A
U238 Sensitivity	-1.3516E-03	-1.2221E-03	-1.1224E-03	-1.1744E-03	-1.3004E-03	-1.3497E-03	-1.2216E-03	-1.1808E-03	-1.1836E-03	-1.3290E-03	1
Gadolinium-157 Sensitivity	----------	----------	----------	----------	----------	----------	----------	----------	----------	----------	

GE11 for BWR 4, 5, 6: doped with 0.1% Gd2O3, void+SS casing, all sides mirrored (infinite array)

	9	8	7	6	5	4	3	2	1
Information/Model Location	110	109	108	107	106	105	104	103	101
U-235 Sensitivity	3.0247E-03	2.8445E-03	3.0083E-03	3.2776E-03	2.9973E-03	3.0746E-03	3.1199E-03	2.6209E-03	2.7706E-03
U238 Sensitivity	-1.6923E-03	-1.7081E-03	-1.6147E-03	-1.6132E-03	-1.6238E-03	-1.6168E-03	-1.6450E-03	-1.7317E-03	-1.6720E-03
Gadolinium-157 Sensitivity	----------	----------	----------	----------	----------	----------	----------	----------	----------
Information/Model Location	100	99	98	97	96	95	94	93	91
U-235 Sensitivity	2.9566E-03	3.4121E-03	4.2785E-03	4.4340E-03	3.9055E-03	4.3684E-03	4.1933E-03	3.3445E-03	2.5900E-03
U238 Sensitivity	-1.6944E-03	-1.7618E-03	-1.3874E-03	-1.3924E-03	-1.7122E-03	-1.3915E-03	-1.4148E-03	-1.7990E-03	-1.7018E-03
Gadolinium-157 Sensitivity	----------	----------	-2.7144E-03	-2.9060E-03	----------	-2.8037E-03	-2.7097E-03	----------	----------
Information/Model Location	90	89	88	87	86	85	84	83	81
U-235 Sensitivity	2.8216E-03	4.0089E-03	4.9021E-03	6.5345E-03	6.7729E-03	5.4321E-03	4.4455E-03	4.0558E-03	2.9807E-03
U238 Sensitivity	-1.6427E-03	-1.3519E-03	-1.3404E-03	-1.4187E-03	-1.4365E-03	-1.3764E-03	-1.2626E-03	-1.3869E-03	-1.6430E-03
Gadolinium-157 Sensitivity	----------	-2.8826E-03	-2.8293E-03	-3.8276E-03	-4.0500E-03	-2.8796E-03	-2.3038E-03	-2.6868E-03	----------
Information/Model Location	80	79	78	77	76	75	74	73	71
U-235 Sensitivity	2.9864E-03	4.1702E-03	6.8758E-03			9.0669E-03	5.4915E-03	4.2243E-03	3.0194E-03
U238 Sensitivity	-1.6409E-03	-1.3398E-03	-1.4108E-03			-1.5042E-03	-1.3095E-03	-1.3442E-03	-1.6247E-03
Gadolinium-157 Sensitivity	----------	-2.8846E-03	-3.7952E-03			-4.9241E-03	-2.8500E-03	-2.8045E-03	----------
Information/Model Location	70	69	68	67	66	65	64	63	61
U-235 Sensitivity	2.8549E-03	4.1525E-03	6.9532E-03				6.9915E-03	3.9800E-03	3.1290E-03
U238 Sensitivity	-1.6834E-03	-1.6843E-03	-1.4622E-03				-1.4424E-03	-1.7544E-03	-1.6888E-03
Gadolinium-157 Sensitivity	----------	----------	-4.0867E-03				-4.0324E-03	----------	----------
Information/Model Location	60	59	58	57	56	55	54	53	51
U-235 Sensitivity	3.0517E-03	4.2945E-03	5.2457E-03	9.3270E-03			6.8043E-03	4.3183E-03	3.0835E-03
U238 Sensitivity	-1.6448E-03	-1.3496E-03	-1.2848E-03	-1.4835E-03			-1.4352E-03	-1.3505E-03	-1.6201E-03
Gadolinium-157 Sensitivity	----------	-2.7025E-03	-2.7722E-03	-4.8609E-03			-3.7291E-03	-2.7425E-03	----------
Information/Model Location	50	49	48	47	46	45	44	43	41
U-235 Sensitivity	2.8584E-03	4.1143E-03	4.4074E-03	5.3362E-03	6.7678E-03	6.3930E-03	4.8417E-03	4.2112E-03	2.8277E-03
U238 Sensitivity	-1.6228E-03	-1.3904E-03	-1.2832E-03	-1.2805E-03	-1.5029E-03	-1.4325E-03	-1.3590E-03	-1.3780E-03	-1.5980E-03
Gadolinium-157 Sensitivity	----------	-2.6645E-03	-2.2985E-03	-2.7819E-03	-4.1695E-03	-3.7437E-03	-2.8317E-03	-2.8096E-03	----------
Information/Model Location	40	39	38	37	36	35	34	33	31
U-235 Sensitivity	2.9843E-03	3.1903E-03	4.1419E-03	4.3791E-03	4.2831E-03	4.2588E-03	4.2940E-03	3.3431E-03	2.7232E-03
U238 Sensitivity	-1.7299E-03	-1.7455E-03	-1.3863E-03	-1.3337E-03	-1.8152E-03	-1.3674E-03	-1.4047E-03	-1.8088E-03	-1.6855E-03
Gadolinium-157 Sensitivity	----------	----------	-2.8633E-03	-2.8820E-03	----------	-2.7874E-03	-2.7494E-03	----------	----------
Information/Model Location	30	29	28	27	26	25	24	23	21
U-235 Sensitivity	2.9162E-03	2.8144E-03	3.0405E-03	3.2390E-03	3.1511E-03	3.1189E-03	3.1385E-03	2.7383E-03	2.7468E-03
U238 Sensitivity	-1.7182E-03	-1.7155E-03	-1.6815E-03	-1.6408E-03	-1.6581E-03	-1.6427E-03	-1.6170E-03	-1.7159E-03	-1.7083E-03
Gadolinium-157 Sensitivity	----------	----------	----------	----------	----------	----------	----------	----------	----------

Use perturbation methods to determine the least worth integral neutron absorber (Gd_2O_3 rod) locations in the fuel lattice

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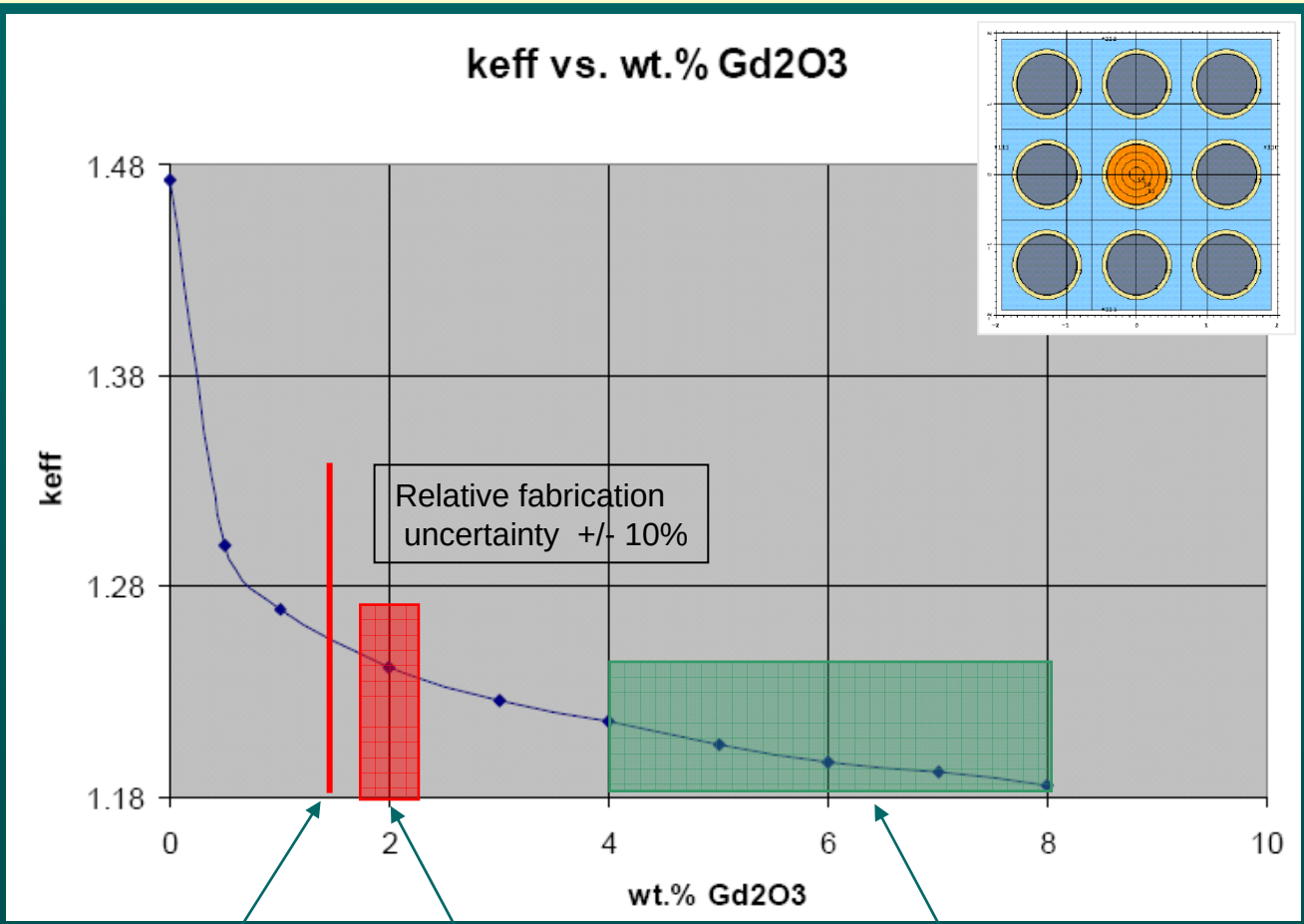
4. RAJ-II Safety Analysis Report (SAR)
Chapter 6: Criticality Evaluation

Gadolinia Content



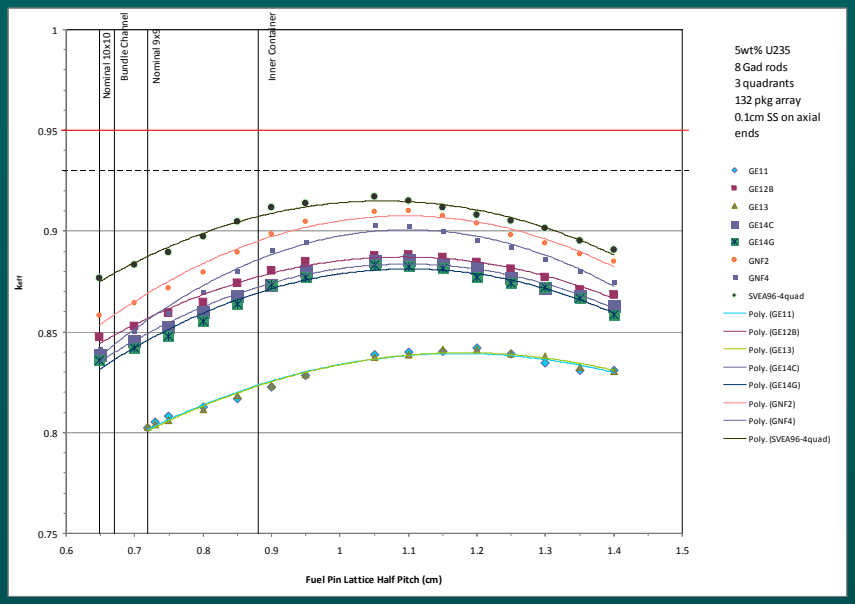
Evaluate 1.5%

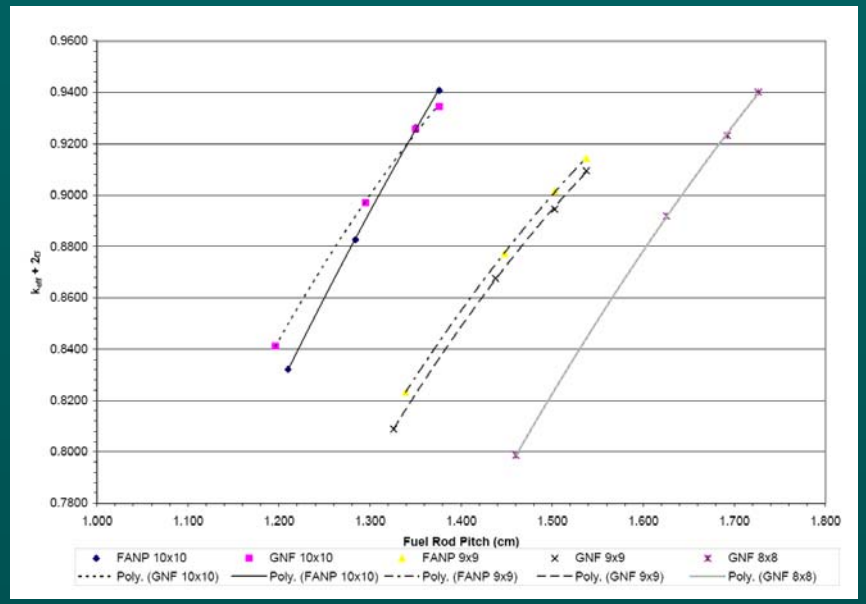
Content Spec 2.0%

Actual fuel design ~4 to 8%

4. RAJ-II Safety Analysis Report (SAR)
Chapter 6: Criticality Evaluation

Package Array – Accident Condition





4. RAJ-II Safety Analysis Report (SAR)
Chapter 6: Criticality Evaluation

Bias and Uncertainties

- Calculation tools and methodology (Validation)
- Different fuel designs
- Placement of BA rods
- Enrichment distribution
- Material compositions
- Representation of geometry
- Omission of contents and packaging components (Zircaloy flow channel, SS structure)
- Transport condition configurations (partial flooding, preferential flooding, lattice expansion)

$$\Delta k_{TotalUnc} = \sqrt{\sum \Delta k_i^2} + M_{95/95}\sqrt{\sigma_{Method}^2 + \sigma_{KENO}^2}$$

$$\Delta k_{designbasis} = \left(k_{eff}^{perturbed} + \sigma^{perturbed}\right) - \left(k_{eff}^{nom} - \sigma^{nom}\right)$$

$$k_{95/95} = k_{KENO} + \Delta k_{bias} + \Delta k_{TotalUnc}$$

Case Description	k_{eff}	Δk_{eff}
Nominal Case	0.92158 ± 0.00031	
Decrease in Cell Pitch	0.92453 ± 0.00031	0.00357
Decrease in Cell Wall Thickness	0.92406 ± 0.00032	0.00311
Decrease in Poison Wrapper Thickness	0.92464 ± 0.00030	0.00367
Off-Center Assembly Positioning	0.92385 ± 0.00028	0.00286
Minimum Cladding Thickness	0.92180 ± 0.00031	0.00084
Maximum Fuel Pellet Diameter	0.92188 ± 0.00029	0.00090
Methodology Uncertainty		0.00709
Methodology Bias		0.00283
Pool Temperature Bias		0.01249

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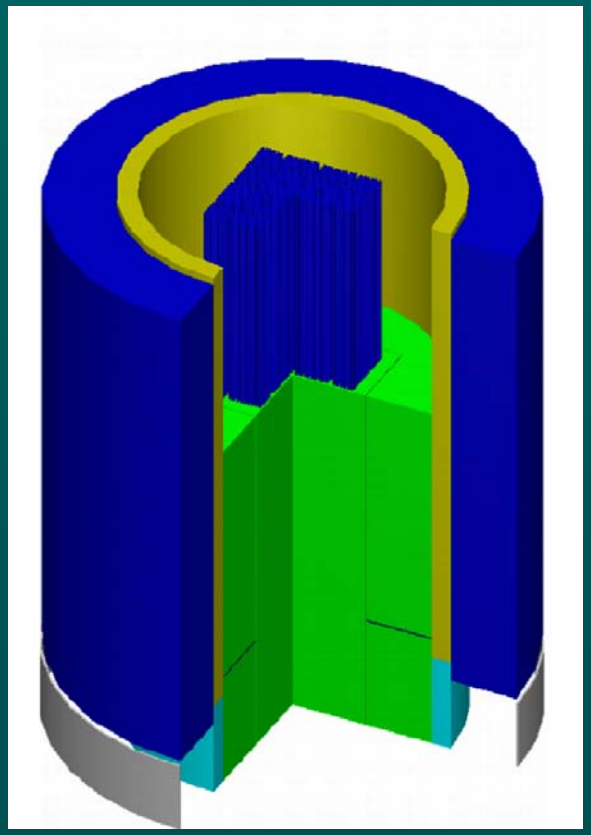
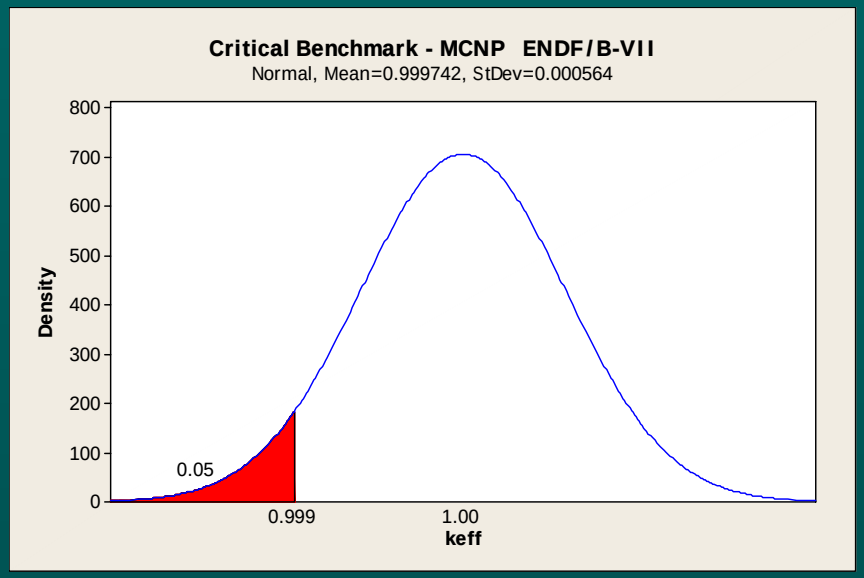
4. RAJ-II Safety Analysis Report (SAR)
Chapter 6: Criticality Evaluation

Validation – TOSHIBA Experiments





KENO-VI ENDF/B-VI similar calculation bias that is ~0.001 Δk_{eff}

4. RAJ-II Safety Analysis Report (SAR)

1. Chapter 1 GENERAL INFORMATION
2. Chapter 2 STRUCTURAL EVALUATION
3. Chapter 3 THERMAL EVALUATION
4. Chapter 4 CONTAINMENT
5. Chapter 5 SHIELDING EVALUATION
6. Chapter 6 CRITICALITY EVALUATION
7. Chapter 7 PACKAGE OPERATIONS
8. Chapter 8 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

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4. RAJ-II Safety Analysis Report (SAR)
Chapter 8: Acceptance Test and Maintenance Program

Requested by French Authorities

- Include steps to periodically examine materials that are susceptible to water absorption to ensure there is no damage.
- Include measures to examine or replace certain components.

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Agenda

1. RAJ-II Team Changes
2. License Renewal Schedule
3. SAR Revision Overview
4. Proposed Revisions to RAJ-II SAR
5. **Proposed Revisions to RAJ-II Certificate of Compliance**

3. RAJ-II Certificate of Compliance
Proposed Changes

Section 5(a) Packaging

No Changes

NRC FORM 618
(9-2003)
10 CFR 71

U.S. NUCLEAR REGULATORY COMMISSION

CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES

a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE		PAGES
9309	7	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
Global Nuclear Fuel - Americas, LLC, application dated March 31, 2004, as supplemented.

4. CONDITIONS

This certificate is conditional upon fulfilling the requirements of 10 CFR Part 71, as applicable, and the conditions specified below.

(a) Packaging

(1) Model No.: RAJ-II

(2) Description

The RAJ-II package is a rectangular box that is 742 mm (29.21 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 clad and ceramic nature of the fuel pellets provide primary containment of the radioactive material.

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mate dimensions and weights of the package are as follows:

laximum gross shipping weight	1,614 kg (3,558 lbs)
laximum weight of inner container	308 kg (679 lbs)
laximum weight of outer container	622 kg (1,371 lbs)
laximum weight of packaging	930 kg (2,050 lbs)
imensions of inner container	
Length	4,686 mm (184.49 in)
Width	459 mm (18.07 in)
Height	286 mm (11.26 in)
imensions of outer container	
Length	5,068 mm (199.53 in)
Width	720 mm (28.35 in)
Height	742 mm (29.21 in)

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

Outer Container Drawings	Inner Container Drawings	Contents Containers
105E3737, Rev. 6	105E3745, Rev. 8	105E3773, Rev. 1
105E3738, Rev. 7	105E3746, Rev. 1	0028B98, Rev. 1
105E3739, Rev. 4	105E3747, Rev. 4	
105E3740, Rev. 4	105E3748, Rev. 2	
105E3741, Rev. 1	105E3749, Rev. 6	
105E3742, Rev. 3		
105E3743, Rev. 4		
105E3744, Rev. 5		

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3. RAJ-II Certificate of Compliance
Proposed Changes

Section 5(b) (1)

Type and Form of Material

Table 1:

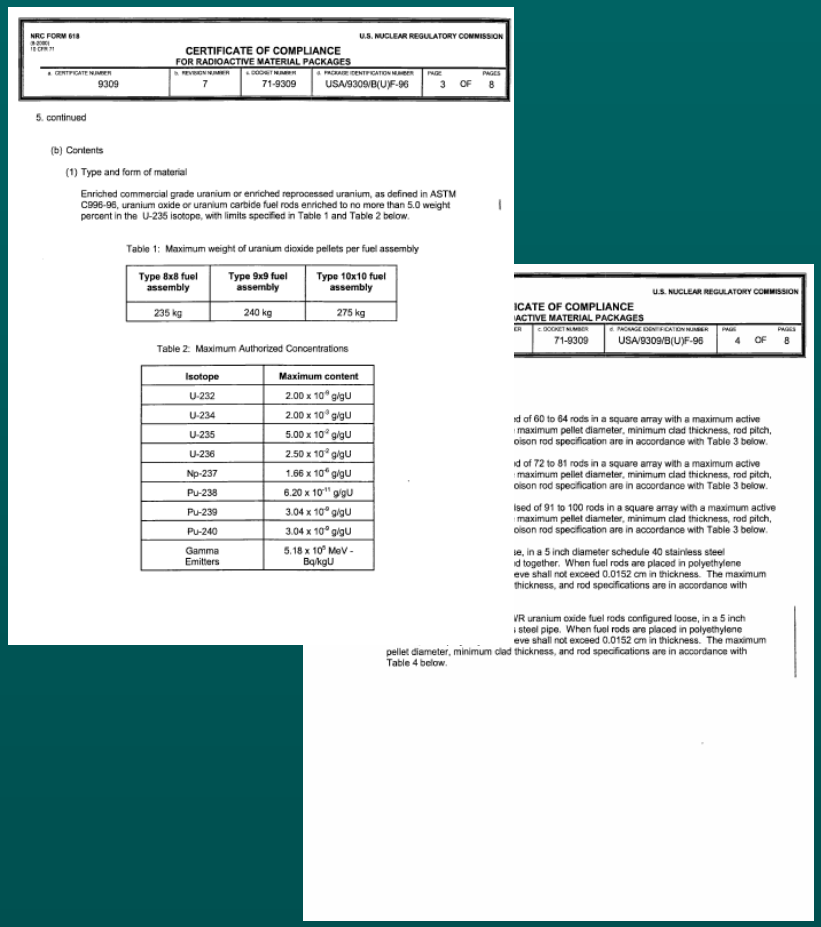
Maximum weight of uranium dioxide pellets per fuel assembly

Table 2:

Maximum Authorized Concentrations

Para. i – v

Descriptions of fuel bundles and loose rods.



NRC FORM 618 (9-2000) 10 CFR 71

U.S. NUCLEAR REGULATORY COMMISSION

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5. continued

(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 U-235 isotope, with limits specified in Table 1 and Table 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
U-232	2.00×10^{-8} g/gU
U-234	2.00×10^{-3} g/gU
U-235	5.00×10^{-2} g/gU
U-236	2.50×10^{-2} g/gU
Np-237	1.66×10^{-6} g/gU
Pu-238	6.20×10^{-11} g/gU
Pu-239	3.04×10^{-6} g/gU
Pu-240	3.04×10^{-9} g/gU
Gamma Emitters	5.18×10^{6} MeV - Bq/kgU

U.S. NUCLEAR REGULATORY COMMISSION

ICATE OF COMPLIANCE
ACTIVE MATERIAL PACKAGES

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d of 60 to 64 rods in a square array with a maximum active maximum pellet diameter, minimum clad thickness, rod pitch, oison rod specification are in accordance with Table 3 below.

d of 72 to 81 rods in a square array with a maximum active maximum pellet diameter, minimum clad thickness, rod pitch, oison rod specification are in accordance with Table 3 below.

lsed of 91 to 100 rods in a square array with a maximum active maximum pellet diameter, minimum clad thickness, rod pitch, oison rod specification are in accordance with Table 3 below.

ıe, in a 5 inch diameter schedule 40 stainless steel d together. When fuel rods are placed in polyethylene eve shall not exceed 0.0152 cm in thickness. The maximum thickness, and rod specifications are in accordance with

VR uranium oxide fuel rods configured loose, in a 5 inch steel pipe. When fuel rods are placed in polyethylene eve 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.

No Changes

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3. RAJ-II Certificate of Compliance
Proposed Changes

Section 5(b) (1) continued

Type and Form of Material

Table 3:

Fuel Assembly Maximum Parameters

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CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES

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Table 3: Fuel Assembly Parameters

Parameter	Units	Type	Type	Type	Type
Fuel Assembly Type	Rods	8x8	9x9	FANP 10x10	GNF 10x10
UO_2 Density		≤96% Theoretical	≤96% Theoretical	≤96% Theoretical	≤96% Theoretical
Number of water rods (See Condition 8)	#	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	#	60 - 64	72 - 81	91 - 100	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		Zirconium Alloy	Zirconium Alloy	Zirconium Alloy	Zirconium Alloy
Cladding ID	cm	≤1.10	≤1.02	≤0.953	≤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	≤1.350	≤1.350
U-235 Pellet Enrichment	wt%	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
Maximum Lattice Average Enrichment	wt%	≤ 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
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 % U-235		7 @ 2 wt %	10 @ 2 wt %	12 @ 2 wt %	12 @ 2 wt %
≤ 4.7 wt % U-235		6 @ 2 wt %	8 @ 2 wt %	12 @ 2 wt %	12 @ 2 wt %
≤ 4.6 wt % U-235		6 @ 2 wt %	8 @ 2 wt %	10 @ 2 wt %	10 @ 2 wt %
≤ 4.3 wt % U-235		6 @ 2 wt %	8 @ 2 wt %	9 @ 2 wt %	9 @ 2 wt %
≤ 4.2 wt % U-235		6 @ 2 wt %	6 @ 2 wt %	8 @ 2 wt %	8 @ 2 wt %
≤ 4.1 wt % U-235		4 @ 2 wt %	6 @ 2 wt %	8 @ 2 wt %	8 @ 2 wt %
≤ 3.9 wt % U-235		4 @ 2 wt %	6 @ 2 wt %	6 @ 2 wt %	6 @ 2 wt %
≤ 3.8 wt % U-235		4 @ 2 wt %	4 @ 2 wt %	6 @ 2 wt %	6 @ 2 wt %
≤ 3.7 wt % U-235		2 @ 2 wt %	4 @ 2 wt %	6 @ 2 wt %	6 @ 2 wt %
≤ 3.6 wt % U-235		2 @ 2 wt %	4 @ 2 wt %	4 @ 2 wt %	4 @ 2 wt %
≤ 3.5 wt % U-235		2 @ 2 wt %	2 @ 2 wt %	4 @ 2 wt %	4 @ 2 wt %
≤ 3.3 wt % U-235		2 @ 2 wt %	2 @ 2 wt %	2 @ 2 wt %	2 @ 2 wt %
≤ 3.1 wt % U-235		None	2 @ 2 wt %	2 @ 2 wt %	2 @ 2 wt %
≤ 3.0 wt % U-235		None	None	2 @ 2 wt %	2 @ 2 wt %
≤ 2.9 wt % U-235		None	None	None	None
Polyethylene Equivalent Mass (Maximum 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)

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3. RAJ-II Certificate of Compliance
Proposed Changes

Add column for WEC Fuel Bundle

Parameter	Units	Type	Type	Type	Type	Type
Fuel Assembly Type	Rods	8x8	9x9	FANP 10x10	GNF 10x10	WEC Optima2
UO_2 Density		≤98% Theoretical	≤98% Theoretical	≤98% Theoretical	≤98% Theoretical	≤98% Theoretical
Number of water rods (See Condition 8)	#	0, 2x2	0, 2-2x2 off-center diagonal, 3x3	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	#	60 - 64	72 - 81	91 - 100	91 - 100	91 - 100
Fuel Rod OD	cm	≥1.176	≥1.093	≥1.000	≥1.010	TBD
Fuel Pellet OD	cm	≤1.05	≤0.96	≤0.895	≤0.895	TBD
Cladding Type		Zirconium Alloy	Zirconium Alloy	Zirconium Alloy	Zirconium Alloy	Zirconium Alloy
Cladding ID	cm	≤1.10	≤1.02	≤0.933	≤0.934	≤0.934
Cladding Thickness	cm	≥0.038	≥0.036	≥0.033	≥0.038	TBD
Active fuel length	cm	≤381	≤381	≤385	≤385	TBD
Fuel Rod Pitch	cm	≤1.692	≤1.51	≤1.350	≤1.350	TBD
U-235 Pellet Enrichment	wt%	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
Maximum Lattice Average Enrichment	wt%	≤ 5.0	≤ 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	TBD
Partial Length Fuel Rods (1/3 through 2/3 normal length)	Max #	None	12	14	14	TBD

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3. RAJ-II Certificate of Compliance
Proposed Changes

Simplify Gadolinia Requirements
(Fewer rows)

Parameter	Units	Type	Type	Type	Type
Gadolinia Requirements					
Lattice Average Enrichment[b]	#				
≤ 5.0 wt % U-235	@ wt%	7 @ 2 wt %	10 @ 2 wt %	12 @ 2 wt %	12 @ 2 wt %
≤ 4.7 wt % U-235	Gd_2O_3	6 @ 2 wt %	8 @ 2 wt %	12 @ 2 wt %	12 @ 2 wt %
≤ 4.6 wt % U-235		6 @ 2 wt %	8 @ 2 wt %	10 @ 2 wt %	10 @ 2 wt %
≤ 4.3 wt % U-235		6 @ 2 wt %	8 @ 2 wt %	9 @ 2 wt %	9 @ 2 wt %
≤ 4.2 wt % U-235		6 @ 2 wt %	6 @ 2 wt %	8 @ 2 wt %	8 @ 2 wt %
≤ 4.1 wt % U-235		4 @ 2 wt %	6 @ 2 wt %	8 @ 2 wt %	8 @ 2 wt %
≤ 3.9 wt % U-235		4 @ 2 wt %	6 @ 2 wt %	6 @ 2 wt %	6 @ 2 wt %
≤ 3.8 wt % U-235		4 @ 2 wt %	4 @ 2 wt %	6 @ 2 wt %	6 @ 2 wt %
≤ 3.7 wt % U-235		2 @ 2 wt %	4 @ 2 wt %	6 @ 2 wt %	6 @ 2 wt %
≤ 3.6 wt % U-235		2 @ 2 wt %	4 @ 2 wt %	4 @ 2 wt %	4 @ 2 wt %
≤ 3.5 wt % U-235		2 @ 2 wt %	2 @ 2 wt %	4 @ 2 wt %	4 @ 2 wt %
≤ 3.3 wt % U-235		2 @ 2 wt %	2 @ 2 wt %	2 @ 2 wt %	2 @ 2 wt %
≤ 3.1 wt % U-235		None	2 @ 2 wt %	2 @ 2 wt %	2 @ 2 wt %
≤ 3.0 wt % U-235		None	None	2 @ 2 wt %	2 @ 2 wt %
≤ 2.9 wt % U-235		None	None	None	None

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3. RAJ-II Certificate of Compliance
Proposed Changes

Section 5(b) (1) continued

Table 4:

Fuel Rod Parameters

No Changes

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Table 4: Fuel Rod Parameters

Parameter	Units	Type					
Fuel Assembly Type		8x8 [1] (UO_2)	9x9 [1] (UO_2)	10x10 [1] (UO_2)	CANDU-14 (UC)	CANDU-25 (UC)	Generic PWR (UO_2)
UO_2 or UC Fuel Density		<98% theoretical	<98% theoretical	<98% theoretical	<98% theoretical	<98% theoretical	<98% 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		Zirc. Alloy	Zirc. Alloy	Zirc. 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 Length	cm	≤381	≤381	≤385	≤47.752	≤40.013	≤450
Maximum U-235 Pellet Enrichment	wt.%	≤5.0	≤5.0	≤5.0	≤5.0	≤5.0	≤5.0
Maximum Average fuel rod Enrichment	wt.%	≤5.0	≤5.0	≤5.0	≤5.0	≤5.0	≤5.0
Loose Rod Configuration							
Freely Loose		≤25	≤25	≤25	N/A	N/A	N/A
Packed in 5" SS Pipe or Protective Case [3]		≤22	≤26	≤30	≤74 [2]	≤130 [2]	≤105 [2]
Strapped Together		≤25	≤25	≤25	N/A	N/A	N/A

[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

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Section 5(b) (2)

Maximum quantity of material per package

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 (1508 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 per compartment (2 compartments per package).

No Changes

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Section 5(c)

Criticality Safety Index

(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

CSIs may change based on outcome of criticality safety analyses

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Section 6

In addition to the requirements of Subpart G of 10 CFR Part 71:

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, as supplemented.

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

   (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.

No Changes

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Section 7

Cluster separators

No Changes

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, as supplemented.

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Section 8

Water rods

Perhaps minor revision to accommodate WEC contents.

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

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License Renewal Schedule (Again)

Revision 7 effective now. Expires 30 November 2009.

Submit renewal application (five year) in May 2009.

- Primarily administrative – no technical changes
- NRC issue Revision 8 on the consolidated application
- Licensee obtain DOT endorsement and foreign validations to avoid gap licenses

Submit amendment request to CoC in June - July.

- Includes technical changes.
- Adds WEC fuel to contents.
- Replace wood runners with synthetic.

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End