

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1.	a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
	9358	8	71-9358	USA/9358/B(U)F-96	1 OF	36

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."
- This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or
- b. 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 (<i>Name and Address</i>)
TN Americas LLC
7160 Riverwood Drive, Suite 200
Columbia, MD 21046 | b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION
TN-LC Transportation Package Safety Analysis
Report, Revision No. 11, dated June 2023. |
|--|---|

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.: TN-LC
- (2) Description

The packaging, designed for transport of irradiated test, research, and commercial reactor fuel in either a closed transport vehicle or an ISO container, consists of a payload basket, a shielded body, a shielded closure lid and top and bottom impact limiters. The packaging body is a right circular cylinder, approximately 197.5 inches long and 30 inches in diameter, composed of top and bottom end flange forgings connected by inner and outer shells. Lead shielding, made of ASTM B29 copper lead, is placed between the two cylindrical shells, in the bottom end assembly, and in the lid. Neutron shielding, composed of a borated resin compound inserted into twenty aluminum shield boxes, is set between the outer shell and a 0.25 inch-thick Type 304 stainless steel outer sheet. Two removable trunnions are bolted to the packaging body using eight 1-8UNC bolts for each trunnion. Two pocket trunnions in the bottom flange, used for rotating the package, may also be used for horizontal package lifting. Impact limiters, with an approximate outside diameter of 66 inches and height of 22.75 inches, consisting of balsa and redwood blocks encased in stainless steel shells, are attached to each end of the packaging during shipment, each with eight 1-8UNC bolts.

Four basket designs are provided for transport of Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), Mixed Oxide Fuel (MOX), Evolutionary Pressurized Reactor (EPR), National Research Universal Reactor (NRU), National Research Experimental

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1.	a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
	9358	8	71-9358	USA/9358/B(U)F-96	2 OF	36

5.(a)(2) Description (Continued)

Reactor (NRX), Material Test Reactor (MTR), and Training, Research, and Isotope General Atomics Reactor (TRIGA) fuel assemblies, fuel elements or fuel rods. The packaging may be loaded or unloaded either in a pool or a hot cell environment. The spent fuel payload is shipped dry in a helium atmosphere. The first fabricated packaging, Unit 1, shall only be loaded with the TN-LC 1FA basket.

Nominal weights and dimensions are as follows:

- Overall length with impact limiters: 230 inches
- Overall length without impact limiters: 197.50 inches
- Cavity length (minimum): 182.50 inches
182.10 inches for Unit 1
- Cavity inner diameter: 18 inches
- Lid thickness: 7.50 inches
- Weight of contents: 7,100 lbs
- Weight of lid: 1,000 lbs
- Weight of impact limiters: 3,000 lbs
- Total loaded weight of the package: 51,000 lbs

(3) Drawings

The packaging is constructed and assembled in accordance with the following drawings:

- | | |
|-------------------------|--|
| 65200-71-01 Revision 10 | TN-LC Cask Assembly (11 sheets) |
| 65200-71-20 Revision 5 | TN-LC
Impact Limiter Assembly (2 sheets) |
| 65200-71-21 Revision 2 | TN-LC Transport Packaging
Transport Configuration (1 sheet) |
| 65200-71-40 Revision 4 | TN-LC-NRUX Basket
Basket Assembly (5 sheets) |
| 65200-71-50 Revision 4 | TN-LC-NRUX Basket
Basket Tube Assembly (5 sheets) |

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1.	a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
	9358	8	71-9358	USA/9358/B(U)F-96	3 OF	36

65200-71-60 Revision 4	TN-LC-MTR Basket General Assembly (4 sheets)
65200-71-70 Revision 4	TN-LC-MTR Basket Fuel Bucket (2 sheets)
65200-71-80 Revision 4	TN-LC-TRIGA Basket (5 sheets)
65200-71-90 Revision 9	TN-LC-1FA Basket (5 sheets)
65200-71-96 Revision 5	TN-LC-1FA BWR Sleeve and Hold-Down Ring (2 sheets)
65200-71-102 Revision 7	TN-LC-1FA Pin Can Basket (5 sheets)
65200-71-92 Revision 0	TN-LC-1FA PWR Basket Damaged Fuel End Caps (1 Sheet)

5.(b) Contents

(1) Type and Form of Material

- (i) Intact or damaged NRU and NRX Mk I fuel assemblies which meet the specifications listed in Table 1 below, respectively, are authorized for transportation in the TN-LC-NRUX basket.

Intact fuel assemblies are fuel assemblies containing fuel rods with no known or suspected cladding defects greater than hairline cracks or pinhole leaks.

Damaged fuel assemblies, with cladding damage in excess of pin hole leaks or hairline cracks, are authorized only if the total surface area of the damaged cladding does not exceed 5% of the total surface area of each rod.

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
9358	8	71-9358	USA/9358/B(U)F-96	4 OF	36

5.(b)(1) Type and Form of Materials (continued)

Table 1

NRU and NRX Mk I Fuel Specifications for Transport in the TN-LC-NRUX Basket

Parameter	NRU	NRX Mk I
Physical and Material Description		
Number of Assemblies	≤ 26	≤ 26
Number of rods/assembly	≤ 12	7
Assembly length (inch) ⁽¹⁾	≤ 116	≤ 116
Nominal Assembly mass (g)	4660	5780
Fuel form	U-Al	U-Al
²³⁵ U per rod (g)	≤ 45.4	≤ 75.2
Enrichment (wt. % ²³⁵ U)	≤ 93	≤ 93
Cladding and Spacer Material	Al	Al
Thermal and Radiological Parameters		
Cooling Time (years) ⁽²⁾	≥ 10	≥ 10
Depletion (wt. % ²³⁵ U) ⁽³⁾	≤ 80	≤ 80
Decay Heat per Assembly (watts) ⁽⁴⁾	≤ 15	≤ 15

Notes:

- Maximum length of the fuel assembly (unirradiated) for shipment.
- The cooling time of the fuel assembly rounded down to 0.5 years.
- The depletion (or burnup) of the fuel assembly rounded up to 0.5%.
- The decay heat of the fuel assembly is less than 15 watts at the maximum burnup and minimum cooling time.

- (ii) Intact or damaged MTR fuel elements that are enveloped or bounded by the fuel element design characteristics listed in Table 2 below, with an average burnup and minimum cooling time as specified in Table 3 below, and a maximum decay heat of 25 watts per element, are authorized for transportation in the TN-LC-MTR basket.

Intact fuel elements are fuel elements containing fuel plates with no known or suspected cladding defects greater than hairline cracks or pinhole leaks.

Damaged fuel elements, with cladding damage in excess of pin hole leaks or hairline cracks, are authorized only if the total surface area of the damaged cladding does not exceed 5% of the total surface area of each element.

The MTR fuel assemblies shall meet all the requirements in Table 3.

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
9358	8	71-9358	USA/9358/B(U)F-96	5 OF	36

5.(b)(1) Type and Form of Materials (continued)

Table 2

MTR Fuel Element Design Characteristics

Fuel Element Class	M-01	M-02	M-03	M-04	M-05	M-06	M-07	M-08 ⁽¹⁾
Number of Fuel Plates ⁽²⁾	≤23	≤21	≤19	≤17	≤10	≤18	≤17	≤23
²³⁵ U mass per Plate (g)	≤16	≤16.5	≤17.5	≤19	≤22	≤20.5	≤11.5	≤22
Active Fuel Width (cm)	≤6.7	≤6.7	≤6.7	≤6.7	≤6.7	≤5.9	≤6.7	≤6.7
Active Fuel Length (cm)	≥ 56	≥ 56	≥ 56	≥ 56	≥ 56	≥ 56	≥ 27.5	≥ 56
Enrichment (wt. % ²³⁵ U)	≤ 94	≤ 94	≤ 94	≤ 94	≤ 94	≤ 94	≤ 94	≤ 94
Fuel Element Depth (cm)	≥7.5	≥7.5	≥7.5	≥7.5	≥7.5	≥7.5	≥7.5	≥7.5

Notes:

1. The M-08 Element class requires that the central stack of fuel elements remain empty. Also, the total ²³⁵U mass is limited by the maximum value in Table 3.
2. The plate thickness is greater than 0.12 cm and the clad thickness is greater than 0.02 cm.

Table 3

MTR Fuel Element Qualification

Enrichment Type	Burnup (MWd/MTU)	Cooling Time (days)
Type A ²³⁵ U Enrichment ≥ 90% ²³⁵ U Mass ≤ 380 g	66,000	740
	165,000	1120
	330,000	1440
	495,000	1680
	660,000	1950
Type B ²³⁵ U Enrichment ≥ 90% 380 g < ²³⁵ U Mass ≤ 460 g	57,750	770
	144,375	1150
	288,750	1470
	433,125	1710
	577,500	1950
Type C 40% ≤ ²³⁵ U Enrichment < 90% ²³⁵ U Mass ≤ 380 g	29,330	740
	73,325	1120
	146,650	1440
	219,975	1690
	293,300	1940
Type D 19% ≤ ²³⁵ U Enrichment < 40% ²³⁵ U Mass ≤ 470 g	13,930	830
	34,825	1220
	69,650	1560
	104,475	1850
	139,300	2150

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1.	a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
	9358	8	71-9358	USA/9358/B(U)F-96	6 OF	36

5.(b)(1) Type and Form of Materials (continued)

Notes

- Burnup = fuel element average burnup.
- Use burnup (MWd/MTU) and Enrichment Type (A, B, C, or D with limits on ²³⁵U enrichment and ²³⁵U mass per element) to look up minimum cooling time in days. Licensee is responsible for ensuring that uncertainties in burnup, enrichment, and mass are applied conservatively.
- Fuel with burnups greater than those listed for each Enrichment Type is not authorized for transport.
- Burnups may be either rounded up to the next higher burnup or linear interpolation may be used to determine the minimum cooling time. However, for conservatism, an additional cooling time of 30 days must be added to any linearly interpolated value.
- Example: An M-06 class element with an enrichment of 45 wt.% ²³⁵U and a ²³⁵U mass of 350 grams is classified as enrichment Type C. A burnup of 100,000 MWd/MTU is acceptable for transport after 1440 days cooling time as defined by 146,650 MWd/MTU from the qualification table (when linear interpolation is not employed). When linear interpolation is employed the minimum required cooling time is 1267 days (1237 days based on interpolation + 30 days additional cooling time).

- (iii) Intact TRIGA fuel assemblies/elements that are enveloped by the fuel assemblies/element design characteristics listed in Table 4, intact TRIGA fuel follower control rods that are enveloped by the fuel assembly/element design characteristics listed in Table 5, with an average burnup and minimum cooling time meeting the specifications of Table 6 for fuel assemblies/elements or of Table 7 for follower control rods, and a maximum decay heat of 8 watts per assembly/element, are authorized for shipment with the TN-LC-TRIGA basket.

Intact fuel assemblies/elements are fuel assemblies/elements containing fuel rods with no known or suspected cladding defects greater than hairline cracks or pinhole leaks. The design characteristics of the TRIGA fuel assemblies/elements are described in Tables 4 and 5 below.

The fuel qualification Tables 6 and 7 specify the maximum assembly/element average burnup and minimum cooling time. The fuel elements/assemblies shall meet all the requirements of Tables 6 and 7.

The poison plates in TN-LC-TRIGA basket are constructed from either boron aluminum alloy, or metal matrix composite (MMC), or Boral®. The minimum areal density of Boron-10 (¹⁰B) for either the boron enriched aluminum alloy or the metal matrix composite is 5.56 mg/cm². The minimum areal density of ¹⁰B for Boral® is 6.67 mg/cm².

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
9358	8	71-9358	USA/9358/B(U)F-96	7 OF	36

5.(b)(1) Type and Form of Materials (continued)

Table 4

TRIGA Fuel Assembly/Element Design Characteristics

Assembly/Element Type	Al Clad	ACPR ⁽¹⁾	Standard	FLIP ⁽²⁾	FLIP ⁽²⁾ LEU-I ⁽³⁾	FLIP ⁽²⁾ LEU-II ⁽³⁾
Element ID	T-01	T-02	T-03	T-04	T-05	T-06
Fuel Material	U-ZrH	U-ZrH	U-ZrH	U-ZrH	U-ZrH	U-ZrH
Enrichment (wt. % ²³⁵ U)	≤ 20	≤ 20	≤ 20	≤ 70	≤ 20	≤ 20
²³⁵ U-Mass (g)	≤ 41	≤ 56	≤ 41	≤ 137	≤ 101	≤ 169
Active Fuel Length (inch)	≤ 15	≤ 15	≤ 15	≤ 15	≤ 15	≤ 15
Pellet Diameter (inch)	≤ 1.41	≤ 1.41	≤ 1.44	≤ 1.44	≤ 1.44	≤ 1.44
Clad Material	Al	SS304	SS304	SS304	SS304	SS304
H/Zr, max.	1.0	1.7	1.7	1.6	1.6	1.6

Table 5

TRIGA Fuel Follower Control Rods Design Characteristics

Assembly/Element Type	Standard	FLIP ⁽²⁾ LEU-I ⁽³⁾	ACPR ⁽¹⁾
Element ID	T-07	T-08	T-09
Fuel Material	U-ZrH	U-ZrH	U-ZrH
Enrichment (wt. % ²³⁵ U)	≤ 20	≤ 20	≤ 20
²³⁵ U-Mass (g)	≤ 38	≤ 97	≤ 56
Active Fuel Length (inch)	≤ 15	≤ 15	≤ 15
Pellet Diameter (inch)	≤ 1.32	≤ 1.32	≤ 1.32
Clad Material	SS304	SS304	SS304
H/Zr, max.	1.7	1.6	1.7

Notes:

1. ACPR - Annular Core Pulse Reactor
2. FLIP - Fuel Life Improvement Program
3. LEU - Low Enriched Uranium

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1.	a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
	9358	8	71-9358	USA/9358/B(U)F-96	8 OF	36

5.(b)(1) Type and Form of Materials (continued)

Table 6

TRIGA Fuel Qualification for Fuel Assembly/Elements

Element ID	Burnup (MWd/MTU)	Cooling Time (days)
T-01	35,750	400
	71,500	560
	107,250	640
	143,000	710
T-02	35,750	650
	71,500	970
	107,250	1310
	143,000	1870
T-03	35,750	520
	71,500	840
	107,250	1170
	143,000	1730
T-04	112,500	1000
	225,000	1380
	337,500	1820
	450,000	2520
T-05	35,750	920
	71,500	1290
	107,250	1710
	143,000	2360
T-06	36,500	1190
	73,000	1690
	109,500	2320
	146,000	3170

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1.	a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
	9358	8	71-9358	USA/9358/B(U)F-96	9 OF	36

5.(b)(1) Type and Form of Materials (continued)

Table 7

TRIGA Fuel Qualification for Fuel Follower Control Rods

Element ID	Burnup (MWd/MTU)	Cooling Time (days)
T-07	35,750	540
	71,500	890
	107,250	1280
	143,000	1960
T-08	35,750	940
	71,500	1350
	107,250	1840
	143,000	2580
T-09	35,750	670
	71,500	1020
	107,250	1420
	143,000	2100

Notes for Tables 6 and 7:

- Burnup = fuel element / assembly / follower control rod average burnup.
- Use burnup (MWd/MTU) and Element ID to look-up minimum cooling time in days. Licensee is responsible for ensuring that uncertainties in burnup are applied conservatively.
- Fuel with a burnup greater than that listed for each element type in Tables 6 and 7 is unacceptable for transport.
- Burnups may be either rounded up to the next higher burnup or linear interpolation may be used to determine the minimum cooling time. However, for conservatism, an additional cooling time of 30 days must be added to any linearly interpolated value.
- Example: A T-03 element with a burnup of 100,000 MWd/MTU is acceptable for transport after 1170 days cooling time as defined by 107,250 MWd/MTU (Table 6, rounding up) on the qualification table (when linear interpolation is not employed). When linear interpolation is employed the minimum required cooling time is 1133 days (1103 days based on interpolation + 30 days additional cooling time).

- (iv) Intact or damaged PWR fuel assembly, as specified in Table 8, or intact BWR fuel assembly, as specified in Table 13, or intact or damaged fuel rods in a pin can are authorized for transport with the TN-LC-1FA basket.

Intact fuel assemblies are fuel assemblies containing fuel rods with no known or suspected cladding defects greater than hairline cracks or pinhole leaks.

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1.	a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
	9358	8	71-9358	USA/9358/B(U)F-96	10 OF	36

5.(b)(1) Type and Form of Materials (continued)

Damaged Fuel assemblies have missing or partial-length fuel rods or fuel rods with known or suspected cladding defects greater than hairline cracks or pinhole leaks. The extent of cladding damage is to be limited such that it can be handled by normal means and that a fuel pellet is not able to pass through the gap created by the cladding opening. Damaged fuel assemblies can also contain top and bottom end fittings or nozzles or tie plates depending on the fuel type. Damaged PWR fuel assembly is authorized for transport only when confined by damaged fuel end caps.

Damaged Fuel rods are complete or partial-length fuel rods with known or suspected cladding defects greater than hairline cracks or pinhole leaks. The extent of cladding damage in the fuel rod is limited such that it can be handled by normal means and that a fuel pellet is not able to pass through the gap created by the cladding opening.

The fuel rods include irradiated PWR, BWR, MOX, and EPR fuel rods. Intact or damaged PWR and intact BWR fuel rods may be from any of the fuel assemblies listed in Table 8 or Table 13, respectively.

MOX rods have the same geometry as PWR or BWR rods, as defined in Table 8 and Table 13. The composition of MOX fuel is specified in Table 12.

The EPR fuel rods are specified in Table 10.

The poison plates in the TN-LC-1FA basket are constructed from boron aluminum alloy, or metal matrix composite (MMC), or Boral®. The minimum ¹⁰B areal density of the poison plate is 16.7 mg/cm² for either the boron aluminum alloy or the MMC. The minimum ¹⁰B areal density of the poison plate is 20.0 mg/cm² for Boral®.

In addition to the poison plates provided in the basket, Poison Rod Assemblies (PRAs) may be used for transportation of PWR fuel assemblies. The minimum required B₄C content of the absorber rods in the PRA is 40% Theoretical Density (TD). A summary of the number of absorber rods required in the PRA for each PWR fuel class is shown in Table 11. PRA loading configurations are also illustrated in Figure 1 through Figure 5. Alternatively, in the absence of PRAs, burnup credit restrictions as shown in Table 11a and Table 11b are required for transportation of PWR fuel assemblies. Burnup credit is not applicable to BW 15x15 fuel class.

The PWR fuel assemblies fuel qualification table (FQT) is provided in Tables 15 and 15a. The BWR fuel assemblies FQT is provided in Table 16. The PWR rod FQTs are shown in Table 17 and Table 18 for the 21 and 9 rod configurations, respectively, and in Table 17a for the Unit 1 packaging. The BWR rod FQTs are shown in Table 19 and Table 20 for the 21 and 9 rod configurations, respectively. The MOX rod FQT, provided in Table 21 for both 21 and 9 rods, is applicable to both BWR and PWR MOX rods. The FQTs for the UO₂ Standard EPR rods are governed by the PWR rod FQTs (Tables 17, 17a and 18), while the FQT for the MOX EPR rods is governed by the MOX rod FQT (Table 21).

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1.	a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
	9358	8	71-9358	USA/9358/B(U)F-96	11 OF	36

5.(b)(1) Type and Form of Materials (continued)
Table 8
PWR Fuel Specifications for Transport in the TN-LC-1FA Basket

Fuel Class ⁽¹⁾ ⁽²⁾	One intact or damaged unconsolidated B&W 17x17, WE 17x17, CE 16x16, B&W 15x15, WE 15x15, CE 15x15, WE 14x14, WE 16x16 or CE 14x14 class PWR assembly (without control components) that are enveloped by the fuel assembly design characteristics listed in Table 9. Reload fuel manufactured by the same or other vendors, but enveloped by the design characteristics listed in Table 9, is also acceptable.
Maximum Assembly + PRA + damaged fuel ends caps weight (as applicable)	1850 lbs. (839 kg)
Fissile Material	UO ₂
Maximum Initial Uranium Content ⁽⁴⁾	490 kg/assembly
Maximum Unirradiated Assembly Length	178.3 inches (4528.8 mm)
Fuel Assembly Average Burnup, Enrichment and Minimum Cooling Time	Per Tables 15 and 15a
Maximum Planar Initial Enrichment	5.0 ⁽³⁾ wt.% ²³⁵ U
Maximum Decay Heat ⁽⁵⁾	3.0 kW per Assembly
Minimum ¹⁰ B areal density in poison plates	16.7 mg/cm² (Natural or Enriched Boron Aluminum Alloy / Metal Matrix Composite (MMC)) 20.0 mg/cm² (Boral®)
Minimum number of absorber rods per PRA as a function of assembly class	Per Table 11 (Use of PRAs is optional except for BW 15x15)
Burnup credit Restrictions in the absence of PRAs	Per Table 11a or 11b

Notes:

- Up to 21 PWR fuel rods from any of the PWR fuel assemblies listed in Table 9 may also be transported in the TN-LC-1FA basket in a 21 pin can. The fuel rods are loaded in a 21 pin can with a cavity length of 169.55 inches (Option 3) which is placed within the TN-LC-1FA basket. The maximum peak burnup for the fuel rods is 90 GWd/MTU. The required cooling time, as a function of a PWR fuel rod burnup and enrichment, is provided in Table 17 or 17a for 21 rods and Table 18 for 9 rods, respectively.
- Up to 21 EPR fuel rods from any of the fuel class listed in Table 9 and meeting EPR rod parameters specified in Table 10 may also be loaded in the TN-LC-1FA basket. The fuel rods are loaded in a 21 pin can with a cavity length of 180.24 inches (Option 1 and Option 2) which is placed within the TN-LC-1FA basket. The maximum peak burnup for the fuel rods is 90 GWd/MTU. The required cooling time, as a function of an EPR fuel rod burnup and enrichment, is provided in Tables 17 or 17a for 21 rods and Table 18 for 9 rods, respectively.
- For CE 15x15, the maximum planar average initial enrichment is 3.60 wt.% ²³⁵U.

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
9358	8	71-9358	USA/9358/B(U)F-96	12 OF	36

5.(b)(1) Type and Form of Materials (continued)

4. The maximum initial uranium content is based on the shielding analysis. The listed value is higher than the actual.
5. The maximum decay heat per rod is 220 watts when loading up to 9 rods. The maximum decay heat per rod is 120 watts when loading 10 or more (up to 21) rods.

Table 9

PWR Fuel Assembly Design Characteristics for Transportation in the TN-LC-1FA Basket

Assembly Class	B&W 15x15	B&W 17x17	WE 17x17	CE 15x15	WE 15x15	CE 14x14	WE 14x14	CE 16x16	WE 16x16
Maximum Number of Fuel Rods	208	264	264	216	204	176	179	236	235
Maximum Number of Guide/Instrument Tubes	17	25	25	9	21	5	17	5	21
Rod Pitch ⁽¹⁾ (inch)	≤ 0.568	≤ 0.502	≤ 0.496	≤ 0.550	≤ 0.563	≤ 0.580	≤ 0.556	≤ 0.506	≤ 0.496
Pellet Diameter ⁽¹⁾ (inch)	≤ 0.374	≤ 0.323	≤ 0.323	≤ 0.360	≤ 0.367	≤ 0.382	≤ 0.368	≤ 0.326	≤ 0.323
Clad Outer Diameter ⁽¹⁾ (inch)	≥ 0.416	≥ 0.379	≥ 0.360	≥ 0.417	≥ 0.422	≥ 0.440	≥ 0.400	≥ 0.374	≥ 0.360
Clad Thickness ⁽¹⁾ (inch)	≥ 0.024	≥ 0.024	≥ 0.022	≥ 0.026	≥ 0.024	≥ 0.026	≥ 0.022	≥ 0.023	≥ 0.022

Note 1. The fuel assembly fabrication documentation may be used to demonstrate compliance with these parameters which are design nominal values. Maximum and minimum dimensions are specified to bound variations in design nominal values among fuel assemblies within a fuel assembly class or an array type.

Table 10

Irradiated EPR Fuel Rod Parameters

Parameter	Value
Maximum Unirradiated Length	179.5 inches
Cladding Thickness	Nominal 0.022 inch
Maximum Initial Uranium Content	2.05 kgU/rod

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
9358	8	71-9358	USA/9358/B(U)F-96	13 OF	36

5.(b)(1)

Type and Form of Materials (continued)

Table 11

Summary of PRA Requirements for PWR Fuel Assembly Classes

Assembly Class	Number of Absorber Rods in PRAs and Locations	Diameter of B ₄ C Absorber (cm)	Minimum B ₄ C Content (g/cm)
WE 17x17	8, Per Figure 4	0.88	0.613
CE 16x16	5, All Guide Tubes	1.02	0.824
BW 15x15	8, Per Figure 3	0.88	0.613
CE 15x15	1, Center Guide Tube	0.76	0.475
WE 15x15	8, Per Figure 2	0.88	0.613
CE 14x14	5, All Guide Tubes	1.02	0.824
WE 14x14 / WE 16x16	8, Per Figure 1 / 5	0.88 / 0.68	0.613
BW 17x17	8, Per Figure 4	0.76	0.475

Table 11a

Maximum Planar Average Initial Enrichment/Minimum Burnup Combination – PWR Fuel Assembly Classes

WE 17x17, WE 16x16, WE 15x15, CE 14x14, CE 15x15 and CE 16x16 Fuel Assembly Classes				
Fresh Fuel	2.90 wt. % U-235			
Cooling Time	5 Years	10 Years	15 Years	20 Years
Burnup (GWd/MTU)	Fuel Initial Enrichment (wt. % U-235)			
5	3.04	3.05	3.06	3.08
10	3.37	3.40	3.42	3.44
15	3.66	3.70	3.74	3.76
20	4.43	4.53	4.61	4.65
25	4.87	5.00	5.00	5.00

WE 14x14 Fuel Assembly Class				
Fresh Fuel	2.95 wt. % U-235			
Cooling Time	5 Years	10 Years	15 Years	20 Years
Burnup (GWd/MTU)	Fuel Initial Enrichment (wt. % U-235)			
5	3.26	3.26	3.27	3.28
10	3.65	3.65	3.66	3.68
15	3.92	3.96	4.00	4.03
20	4.67	4.80	4.86	4.93
25	5.00	5.00	5.00	5.00

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1.	a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
	9358	8	71-9358	USA/9358/B(U)F-96	14 OF	36

5.(b)(1) Type and Form of Materials (continued)

Table 11b

Maximum Planar Average Initial Enrichment/Minimum Burnup Combination – PWR Fuel Assembly Classes – With Control Rod Insertion ⁽¹⁾

	WE 17x17, WE 16x16, WE 15x15, CE 14x14, CE 15x15 and CE 16x16 Fuel Assembly Classes			
Fresh Fuel	2.90 wt. % U-235			
Cooling Time	5 Years	10 Years	15 Years	20 Years
Burnup (GWd/MTU)	Fuel Initial Enrichment (wt. % U-235)			
5	2.97	2.99	3.00	3.01
10	3.29	3.31	3.34	3.36
15	3.54	3.60	3.64	3.66
20	4.21	4.38	4.45	4.53
25	4.75	4.91	4.98	5.00
30	5.00	5.00	5.00	

	WE 14x14 Fuel Assembly Class			
Fresh Fuel	2.95 wt. % U-235			
Cooling Time	5 Years	10 Years	15 Years	20 Years
Burnup (GWd/MTU)	Fuel Initial Enrichment (wt. % U-235)			
5	3.20	3.20	3.21	3.23
10	3.57	3.57	3.59	3.59
15	3.81	3.86	3.90	3.90
20	4.48	4.62	4.71	4.78
25	5.00	5.00	5.00	5.00

⁽¹⁾ Fuel assemblies with accumulated control rod insertion through the first 15 GWd/MTU. Fuel assemblies with accumulated control rod insertion greater than the first MTU are not authorized.

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1.	a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
	9358	8	71-9358	USA/9358/B(U)F-96	15 OF	36

5.(b)(1) Type and Form of Materials (continued)

Table 12
MOX Fuel Rods Specifications for Transport in the TN-LC-1FA Basket

PHYSICAL PARAMETERS:	- Up to 21 PWR MOX fuel rods with physical parameters as those listed in Table 8. - Up to 21 BWR MOX fuel rods with physical parameters as those listed in Table 13. - Up to 21 EPR MOX fuel rods with physical parameters as those listed in Table 10.
Fissile Material	UO ₂ , PuO ₂ (Mixed Oxide or MOX)
Heavy Metal (HM) Content	≤ 2.5 kgU/rod
CRITICALITY PARAMETERS:	²³⁵U Content in UO₂: 0.5 ≤ ²³⁵U ≤ 0.7 wt. % - Plutonium Content: Pu / (U + Pu) ≤ 7.0 wt. % - Initial ²³⁹Pu Content in PuO₂ ≤ 60.0 wt. % - Initial ²⁴¹Pu Content in PuO₂ ≤ 7.5 wt. %
Initial MOX composition	
THERMAL/RADIOLOGICAL PARAMETERS:	²³⁸Pu / ²³⁹Pu ≤ 4.0 wt. % ²³⁹Pu / PuO₂ ≥ 50 wt. % ²⁴¹Am / PuO₂ ≤ 70 ppm ²³⁵U / U ≤ 0.5 wt. %
Initial MOX Composition for Fuel Qualification	
Burnup and Minimum cooling time for MOX rods	Per Table 21.
Maximum Decay heat per 25 pin can	2.5 kW for the pin can with up to 21 rods 1.8 kW for the pin can with up to 9 rods
Minimum ¹⁰ B areal density in poison plates	16.7 mg/cm² Boron Aluminum Alloy / Metal Matrix Composite (MMC) 20.0 mg/cm² (Boral®)

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
9358	8	71-9358	USA/9358/B(U)F-96	16 OF	36

5.(b)(1) Type and Form of Materials (continued)

Table 13
BWR Fuel Specification for Transport in the TN-LC-1FA Basket

PHYSICAL PARAMETERS: Fuel Class ⁽¹⁾	One intact 7x7, 8x8, 9x9, or 10x10 BWR assembly manufactured by General Electric or Exxon/ANF or FANP or ABB or reload fuel manufactured by same or other vendors that are enveloped by the fuel assembly design characteristics listed in Table 14.
Channels	Fuel may be transported with or without channels, channel fasteners, or finger springs.
Fissile Material	UO ₂
Maximum Assembly Weight with Channels	790 lbs
Maximum Unirradiated Assembly Length	176.6 inches
THERMAL/RADIOLOGICAL PARAMETERS: Maximum Planar Average Initial Enrichment	5.0 wt. % ²³⁵ U
Fuel Assembly Average Burnup, Enrichment and Minimum Cooling Time	Per Table 16.
Maximum Decay Heat ⁽²⁾	2.0 kW per Assembly
Minimum ¹⁰ B areal density in poison plates	16.7 mg/cm² Boron Aluminum Alloy / Metal Matrix Composite (MMC) 20.0 mg/cm² (Boral®)

Notes:

- Up to 21 fuel rods from any of the BWR fuel assemblies listed in Table 14 may also be transported in the TN-LC-1FA basket in the 21 pin can. The fuel rods are loaded in a 21 pin can with a cavity length of 169.55 inches which is placed within the TN-LC-1FA basket. The required cooling time as a function of BWR fuel rod burnup and enrichment are provided in Table 19 for 21 rods and Table 20 for 9 rods, respectively.
- The maximum decay heat per rod is 220 watts when loading up to 9 rods. The maximum decay heat per rod is 120 watts when loading 10 or more (up to 25) rods.

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
9358	8	71-9358	USA/9358/B(U)F-96	17 OF	36

5.(b)(1) Type and Form of Materials (continued)

Table 14
BWR Fuel Assembly Design Characteristics⁽¹⁾ for Transportation in the TN-LC-1FA Basket
(Part 1 of 3)

Transnuclear ID	7x7-49/0	8x8-63/1	8x8-62/2	8x8-60/4	8x8-60/1	9x9-74/2
Initial Design or Reload Fuel Designation	GE1	GE4	GE-5	GE8 Type II	GE9	GE11
	GE2		GE-Pres		GE10	GE13
	GE3		GE-Barrier			
			GE8 Type I			
			FANP 8x8-2			
Maximum Number of Fuel Rods	49	63	62	60	60	74
Maximum Initial Uranium Content (kg)	198	192	192	192	192	192
Rod Pitch ⁽⁵⁾ (inch)	≤ 0.738	≤ 0.640	≤ 0.640	≤ 0.640	≤ 0.640	≤ 0.566
Pellet Diameter ⁽⁵⁾ (inch)	≤ 0.487	≤ 0.416	≤ 0.411	≤ 0.411	≤ 0.411	≤ 0.376
Clad Outer Diameter ⁽⁵⁾ (inch)	≥ 0.563	≥ 0.493	≥ 0.483	≥ 0.483	≥ 0.483	≥ 0.440
Clad Thickness ⁽⁵⁾ (inch)	≥ 0.032	≥ 0.034	≥ 0.032	≥ 0.032	≥ 0.032	≥ 0.028

Table 14
BWR Fuel Assembly Design Characteristics⁽¹⁾ for Transportation in the TN-LC-1FA Basket
(Part 2 of 3)

Transnuclear ID	10x10-92/2	7x7-49/0Z	7x7-48/1Z	8x8-60/4Z	FANP 9x9	Siemens QFA
Initial Design or Reload Fuel Designation	GE12	ENC-III A	ENC-III ⁽²⁾	ENC Va	FANP9 9x9 ⁽³⁾	9x9
	GE14			ENC Vb		
Maximum Number of Fuel Rods	92	49	48	60	81	72
Maximum Initial Uranium Content (kg)	192	198	198	192	192	192
Rod Pitch ⁽⁵⁾ (inch)	≤ 0.510	≤ 0.738	≤ 0.738	≤ 0.642	≤ 0.572	≤ 0.570
Pellet Diameter ⁽⁵⁾ (inch)	≤ 0.345	≤ 0.488	≤ 0.491	≤ 0.420	≤ 0.357	≤ 0.374
Clad Outer Diameter ⁽⁵⁾ (inch)	≥ 0.404	≥ 0.570	≥ 0.570	≥ 0.501	≥ 0.424	≥ 0.433
Clad Thickness ⁽⁵⁾ (inch)	≥ 0.026	≥ 0.035	≥ 0.035	≥ 0.036	≥ 0.030	≥ 0.026

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
9358	8	71-9358	USA/9358/B(U)F-96	18 OF	36

5.(b)(1) Type and Form of Materials (continued)

Table 14
BWR Fuel Assembly Design Characteristics⁽¹⁾ for Transportation in the TN-LC-1FA Basket
(Part 3 of 3)

Transnuclear ID	10x10-91/1	ABB-8x8	ABB-10x10	LaCrosse
Initial Design or Reload Fuel Designation	ATRIUM 10	SVEA-64	SVEA-100 ⁽⁴⁾	Allis Chalmers - 10x10
	ATRIUM 10XM			Exxon/ANF 10x10
Maximum Number of Fuel Rods	91	64	100	100
Maximum Initial Uranium Content (kg)	192	192	192	125
Rod Pitch ⁽⁵⁾ (inch)	≤ 0.510	≤ 0.622	≤ 0.512	≤ 0.565
Pellet Diameter ⁽⁵⁾ (inch)	≤ 0.350	≤ 0.411	≤ 0.346	≤ 0.350
Clad Outer Diameter ⁽⁵⁾ (inch)	≥ 0.405	≥ 0.378	≥ 0.378	≥ 0.394
Clad Thickness ⁽⁵⁾ (inch)	≥ 0.023	≥ 0.024	≥ 0.022	≥ 0.020

Notes:

- Any fuel channel average thickness up to 0.120 inch is acceptable on any of the fuel designs.
- Includes ENC-IIIE and ENC-IIIF.
- Includes FANP 9x9-72, 9x9-79, 9x9-80, and 9x9-81.
- Includes SVEA-92, SVEA-96, SVEA-96+, SVEA-96 OPTIMA, SVEA-96 OPTIMA2, SVEA-96+/L.
- The fuel assembly fabrication documentation may be used to demonstrate compliance with these fuel assembly parameters. The fuel assembly parameters are design nominal values. The maximum and minimum dimensions are specified to bound variations in design nominal values among fuel assemblies within a fuel assembly class (or an array type).

(2) Maximum quantity of material per package

- For the contents described in Item 5(b)(1)(i): 26 intact or damaged either NRU or NRX Mk I fuel assemblies, with an approximate maximum payload of 331 lb.
- For the contents described in Item 5(b)(1)(ii): 54 intact or damaged MTR fuel elements, with an approximate maximum payload of 1,620 lb.
- For the contents described in Item 5(b)(1)(iii): 180 intact TRIGA fuel elements/assemblies with an approximate maximum payload of 2,380 lb.

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1.	a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
	9358	8	71-9358	USA/9358/B(U)F-96	19 OF	36

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

- (iv) For the contents described in Item 5(b)(1)(iv): one intact PWR fuel assembly, one damaged PWR fuel assembly confined by damaged fuel ends caps, or one intact BWR fuel assembly, or up to 21 intact or damaged PWR (including intact MOX and EPR) or intact BWR fuel rods in a pin can. When transporting 9 or fewer fuel rods, the rods shall be placed in the center 3x3 region of the pin can. The approximate maximum payload is 1,850 lb per PWR assembly with PRAs and damaged fuel end caps (as applicable), 790 lb per BWR assembly with channels, and 16 lb per fuel rod.
- (v) For the Unit 1 packaging, contents described in Item 5(b)(1)(iv) are limited to: one intact PWR fuel assembly, one damaged PWR fuel assembly confined in damaged fuel end caps, or up to 21 intact or damaged PWR (excluding intact MOX and EPR) fuel rods in a pin can. When transporting 9 or fewer fuel rods, the rods shall be placed in the center 3x3 region of the pin can. The approximate maximum payload is 1,850 lb per PWR assembly with PRAs (and damaged fuel end caps as applicable), and 16 lb per fuel rod.

(3) The maximum decay heat for any payload is 3.0 kW.

5(c) Criticality Safety Index (CSI):

For NRU and NRX fuel assemblies described in 5(b)(1)(i) and limited in 5(b)(2)(i)	100
For MTR fuel elements described in 5(b)(1)(ii) and limited in 5(b)(2)(ii)	100
For TRIGA fuel assemblies/elements described in 5(b)(1)(iii) and limited in 5(b)(2)(iii)	0
For intact BWR fuel assemblies described in 5(b)(1)(iv) and limited in 5(b)(2)(iv)	0
For PWR fuel assemblies described in 5(b)(1)(iv) and limited in 5(b)(2)(iv) and 5(b)(2)(v)	100
For fuel rods in a 21 pin can described in 5(b)(1)(iv) and limited in 5(b)(2)(iv) and 5(b)(2)(v)	0

Table 15
Fuel Qualification Table for a PWR Fuel Assembly
 (Minimum required years of cooling time after reactor core discharge)

Burnup, GWd/ MTU	Enrichment (wt. % ²³⁵ U)																																					
	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0		
10	2.25	2.25	2.20	2.10	2.05	2.05	2.05	2.00	2.00	2.00	2.00	2.00	2.00	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90		
20	3.37	3.35	3.30	3.20	3.05	2.90	2.90	2.85	2.85	2.80	2.80	2.80	2.75	2.75	2.75	2.75	2.75	2.75	2.70	2.70	2.70	2.70	2.65	2.65	2.65	2.65	2.65	2.65	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.55	
30				4.70	4.35	4.10	3.80	3.70	3.65	3.60	3.60	3.55	3.50	3.45	3.45	3.40	3.35	3.35	3.35	3.30	3.30	3.25	3.25	3.20	3.20	3.15	3.15	3.15	3.15	3.15	3.15	3.10	3.10	3.10	3.05	3.05	3.05	
39						4.95	4.85	4.75	4.65	4.55	4.45	4.40	4.35	4.25	4.20	4.15	4.10	4.00	3.95	3.95	3.90	3.85	3.80	3.75	3.70	3.70	3.70	3.65	3.65	3.60	3.55	3.55	3.50	3.50	3.50	3.50		
40												4.55	4.45	4.35	4.30	4.25	4.15	4.15	4.10	4.05	4.00	3.90	3.90	3.90	3.85	3.80	3.75	3.70	3.70	3.65	3.65	3.65	3.60	3.55	3.55	3.50	3.55	3.50
45												5.40	5.25	5.15	5.05	4.95	4.85	4.80	4.70	4.60	4.55	4.50	4.45	4.35	4.35	4.30	4.20	4.15	4.10	4.10	4.05	4.00	3.95	3.95	3.90	3.85		
50												6.80	6.60	6.50	6.25	6.15	6.00	5.85	5.75	5.60	5.50	5.40	5.30	5.20	5.10	5.05	4.95	4.90	4.85	4.75	4.70	4.65	4.55	4.55	4.50	4.40		
55												8.85	8.60	8.30	8.05	7.85	7.65	7.35	7.15	7.00	6.80	6.65	6.45	6.30	6.20	6.05	5.90	5.85	5.70	5.65	5.50	5.45	5.35	5.30	5.25	5.15		
60												11.55	11.20	10.85	10.50	10.15	9.80	9.55	9.20	8.95	8.70	8.45	8.25	8.00	7.80	7.55	7.40	7.20	7.05	6.85	6.75	6.60	6.45	6.35	6.25	6.10		
61												12.15	11.80	11.45	11.10	10.70	10.35	10.10	9.75	9.45	9.20	8.90	8.65	8.35	8.20	7.90	7.75	7.55	7.40	7.20	7.00	6.85	6.75	6.55	6.50	6.40		
62												12.80	12.40	12.05	11.65	11.30	10.90	10.65	10.25	9.95	9.70	9.40	9.10	8.85	8.55	8.35	8.15	7.90	7.70	7.50	7.30	7.20	7.05	6.85	6.75	6.65		
	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0		

Notes:

1. Explanatory notes and limitations regarding the use of this table follow Table 21.

Table 15a
Fuel Qualification Table for a PWR Fuel Assembly – Unit 1 Packaging
 (Minimum required years of cooling time after reactor core discharge)

Burn-up, GWd/ MTU	Enrichment, wt. % U-235																																					
	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0		
10	3.0	3.0	2.9	2.9	2.8	2.8	2.8	2.8	2.7	2.7	2.7	2.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.4	2.4	2.4	2.4	2.4		
20	4.7	4.6	4.5	4.4	4.3	4.2	4.2	4.1	4.0	4.0	3.9	3.9	3.8	3.8	3.8	3.7	3.7	3.6	3.6	3.6	3.5	3.5	3.5	3.5	3.5	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.3	3.3	3.3	3.3	3.3	
30				6.7	6.5	6.3	6.2	6.0	5.9	5.7	5.6	5.5	5.3	5.2	5.1	5.1	5.0	4.9	4.8	4.7	4.7	4.6	4.6	4.5	4.5	4.4	4.4	4.3	4.3	4.2	4.2	4.2	4.1	4.1	4.1	4.1	4.0	
39						7.1	6.9	6.7	6.6	6.4	6.3	6.2	6.0	5.9	5.8	5.7	5.6	5.5	5.4	5.4	5.3	5.2	5.2	5.1	5.0	5.0	4.9	4.9	4.8	4.8	4.8	4.7	4.7	4.6	4.6	4.6		
40												6.4	6.2	6.1	6.0	5.9	5.8	5.7	5.6	5.5	5.4	5.4	5.3	5.2	5.2	5.1	5.1	5.0	5.0	4.9	4.9	4.8	4.8	4.8	4.7	4.7	4.7	4.7
50												9.6	9.4	9.2	8.9	8.7	8.5	8.3	8.1	7.9	7.8	7.6	7.5	7.3	7.2	7.1	6.9	6.8	6.7	6.6	6.5	6.4	6.3	6.2	6.2	6.2	6.1	
55												12.0	11.7	11.4	11.1	10.8	10.5	10.3	10.0	9.8	9.6	9.4	9.1	8.9	8.8	8.6	8.4	8.2	8.1	7.9	7.8	7.7	7.5	7.4	7.3	7.2		
60												14.8	14.4	14.1	13.7	13.4	13.0	12.7	12.4	12.1	11.8	11.5	11.1	10.9	10.7	10.5	10.3	10.1	9.8	9.6	9.4	9.3	9.1	8.9	8.8	8.6		
61												15.4	15.0	14.6	14.3	13.9	13.6	13.2	12.9	12.6	12.3	12.0	11.7	11.4	11.1	10.9	10.7	10.5	10.2	10.0	9.8	9.6	9.4	9.3	9.1	8.9		
62												16.1	15.7	15.3	14.9	14.6	14.2	13.9	13.6	13.3	13.0	12.7	12.4	12.1	11.8	11.5	11.2	11.0	10.7	10.4	10.1	9.8	9.6	9.4	9.3			
Enr. wt. %	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0		

Note:

1. Explanatory notes and limitations regarding the use of this table follow Table 21.

Table 16
Fuel Qualification Table for a BWR Fuel Assembly
 (Minimum required years of cooling time after reactor core discharge)

Burnup, GWd/ MTU	Enrichment (wt. % ²³⁵ U)																																						
	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0			
10	0.65	0.65	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60			
20	0.95	0.95	0.90	0.85	0.80	0.80	0.80	0.80	0.80	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75			
30				1.25	1.20	1.15	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.95	0.95	0.95	0.95			
39				1.40	1.40	1.40	1.35	1.35	1.35	1.35	1.30	1.30	1.30	1.30	1.30	1.25	1.25	1.25	1.25	1.25	1.20	1.20	1.20	1.20	1.20	1.20	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15			
40				1.40	1.40	1.35	1.35	1.35	1.35	1.35	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20		
45				1.60	1.60	1.60	1.55	1.55	1.55	1.55	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45		
50				1.85	1.85	1.85	1.80	1.80	1.80	1.80	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.70	1.70	1.70	1.70	1.70	1.70	1.65	1.65	1.65	1.65	1.65	1.65		
55				2.10	2.10	2.10	2.05	2.05	2.05	2.05	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.15	2.15	2.15	2.15	2.15	2.10	2.10	2.10	2.10	2.05	2.05
60				2.35	2.35	2.35	2.30	2.30	2.30	2.30	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
61				2.40	2.40	2.40	2.35	2.35	2.35	2.35	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30
62				2.45	2.45	2.45	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0			

Notes:

1. Explanatory notes and limitations regarding the use of this table follow Table 21.

Table 17
Fuel Qualification Table for 21 PWR/EPR Fuel Rods (UO₂)
 (Minimum required years of cooling time after reactor core discharge)

Burnup, GWd/ MTU	Enrichment (wt. % ²³⁵ U)																																																						
	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0																			
10	0.30	0.30	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
20	0.30	0.30	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
30			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
39			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
40			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
45			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
50			0.30	0.30	0.30	0.30	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																		
55			0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30																		
60			0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35																		
61			0.40	0.40	0.40	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35																		
62			0.40	0.40	0.40	0.40	0.40	0.40	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35																		
65																								0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
70	0.50	0.50																						0.50	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45		
75	0.65	0.65																						0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
80	0.85	0.85																						0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
85	1.05	1.05																						1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
90	1.25	1.25																						1.25	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0																			

Notes:

1. Explanatory notes and limitations regarding the use of this table follow Table 21.

Table 17a
Fuel Qualification Table for 21 PWR Fuel Rods (UO₂) – Unit 1 Packaging

(Minimum required years of cooling time after reactor core discharge)

Burn-up, GWd/ MTU	Enrichment, wt. % U-235																																						
	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0			
10	0.34	0.35	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36		
20	0.34	0.35	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
30			0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	
39						0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
40												0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
45												0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
50												0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
55												0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
60												0.50	0.48	0.48	0.47	0.4	0.46	0.45	0.45	0.44	0.44	0.43	0.43	0.42	0.42	0.4	0.41	0.41	0.40	0.40	0.40	0.39	0.38	0.38	0.38	0.38	0.38	0.38	
61												0.50	0.50	0.50	0.5	0.5	0.49	0.48	0.47	0.47	0.46	0.46	0.45	0.44	0.44	0.4	0.43	0.43	0.42	0.42	0.42	0.41	0.4	0.4	0.4	0.40	0.4	0.4	
62												0.50	0.50	0.50	0.50	0.5	0.50	0.50	0.50	0.49	0.49	0.48	0.48	0.47	0.46	0.46	0.4	0.43	0.43	0.42	0.42	0.42	0.41	0.4	0.4	0.4	0.40	0.4	0.4
65																							0.5	0.50	0.50	0.5	0.50	0.50	0.50	0.50	0.50	0.5	0.5	0.50	0.49	0.49	0.4	0.4	
70																							0.7	0.70	0.69	0.6	0.67	0.67	0.66	0.65	0.65	0.64	0.63	0.62	0.62	0.62	0.6	0.6	
75																							0.8	0.86	0.85	0.8	0.83	0.83	0.8	0.79	0.79	0.78	0.77	0.76	0.75	0.75	0.7	0.7	
80																							1.0	1.03	1.0	1.0	0.99	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.90	0.8	0.8	
85																							1.2	1.22	1.20	1.1	1.16	1.15	1.13	1.12	1.10	1.09	1.08	1.06	1.05	1.05	1.0	1.0	
90																							1.4	1.44	1.4	1.3	1.37	1.34	1.32	1.3	1.29	1.27	1.25	1.23	1.22	1.22	1.2	1.2	
Enr. wt. %	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0			

Note1. Explanatory notes and limitations regarding the use of this table follow Table 21.

Table 18
Fuel Qualification Table for 9 PWR/EPR Fuel Rods (UO₂)

(Minimum required years of cooling time after reactor core discharge)

Burnup, GWd/ MTU	Enrichment (wt. % ²³⁵ U)																																																							
	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0																				
10	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																				
20	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
30			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
39			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
40			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
45			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
50			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
55			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
60			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
61			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
62			0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
65																									0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
70	0.25	0.25																							0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	
75	0.25	0.25																							0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
80	0.25	0.25																							0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
85	0.25	0.25																							0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
90																							0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25		
																							0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8

Notes:

1. Explanatory notes and limitations regarding the use of this table follow Table 21.

Table 19
Fuel Qualification Table for 21 BWR Fuel Rods (UO₂)
 (Minimum required years of cooling time after reactor core discharge)

Burnup, GWd/ MTU	Enrichment (wt. % ²³⁵ U)																																										
	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0							
10	0.30	0.30	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.2	0.25	0.25	0.25	0.2	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25							
20	0.30	0.30	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.2	0.25	0.25	0.25	0.2	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25						
30			0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.3	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30						
39					0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.3	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35						
40												0.40	0.40	0.40	0.3	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35					
45												0.45	0.45	0.45	0.4	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40				
50												0.60	0.60	0.60	0.6	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55			
55												0.75	0.75	0.75	0.7	0.75	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65			
60												1.00	1.00	1.00	1.0	0.90	0.90	0.90	0.90	0.90	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75			
61												1.05	1.05	1.00	1.0	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.75	0.75	0.75	0.75	0.75		
62												1.10	1.05	1.05	1.0	1.05	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85		
65																							1.05	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.90	0.90	0.90	0.90	0.90			
70																							1.20	1.20	1.20	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15		
75																							1.45	1.45	1.45	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	
80																							1.70	1.70	1.65	1.65	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
85																							2.15	2.05	2.00	2.00	1.95	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85	1.85
90																							2.60	2.55	2.50	2.40	2.35	2.30	2.20	2.15	2.10	2.10	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.95	1.95	1.95	
	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0							

Notes:

1. Explanatory notes and limitations regarding the use of this table follow Table 21.

Table 20
Fuel Qualification Table for 9 BWR Fuel Rods (UO₂)

(Minimum required years of cooling time after reactor core discharge)

Burnup, GWd/ MTU	Enrichment (wt. % ²³⁵ U)																																																							
	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0																				
10	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																				
20	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
30				0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
39						0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																			
40													0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																
45														0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25																
50															0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25															
55																0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25													
60																	0.30	0.30	0.30	0.30	0.30	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25											
61																	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.25	0.25	0.25	0.25											
62																	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30											
65																							0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
70																							0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	
75																							0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	
80																							0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
85																							0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	
90																							0.60	0.60	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	
	0.7	0.8	0.9	1.2	1.5	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0																				

Notes:

- Explanatory notes and limitations regarding the use of this table follow Table 21.

Table 21**Fuel Qualification Table for MOX PWR/BWR/EPR 21 Rods and MOX PWR/BWR/EPR 9 Rods**

Burnup, GWd/MTHM	9 Rods		25 Rods	
	0.5 wt.% of ^{235}U	0.7 wt.% of ^{235}U	0.5 wt.% of ^{235}U	0.7 wt.% of ^{235}U
10	0.25	0.25	0.25	0.25
20	0.25	0.25	0.30	0.30
30	0.25	0.25	0.50	0.50
40	0.25	0.25	0.95	0.95
45	0.25	0.25	1.25	1.25
50	0.35	0.35	1.70	1.70
55	0.40	0.40	2.20	2.10
60	0.45	0.45	2.80	2.70
62	0.55	0.55	3.75	3.65

Notes:

1. Explanatory notes and limitation regarding the use of this table are provided on the following page.

Notes:

General

1. Use burnup and enrichment to look up minimum cooling time in years. Licensee is responsible for ensuring that uncertainties in fuel enrichment and burnup are correctly accounted for during fuel qualification.
2. For values not explicitly listed in the tables, round burnups **up** to the first value shown, round enrichments **down**, and select the cooling time listed.
3. UO_2 Fuel with an initial enrichment less than 0.7 (or less than the minimum provided above for each burnup) or greater than 5.0 wt.% ^{235}U is unacceptable for transportation.
4. Shaded areas in these Tables indicate fuel is not analyzed for loading.

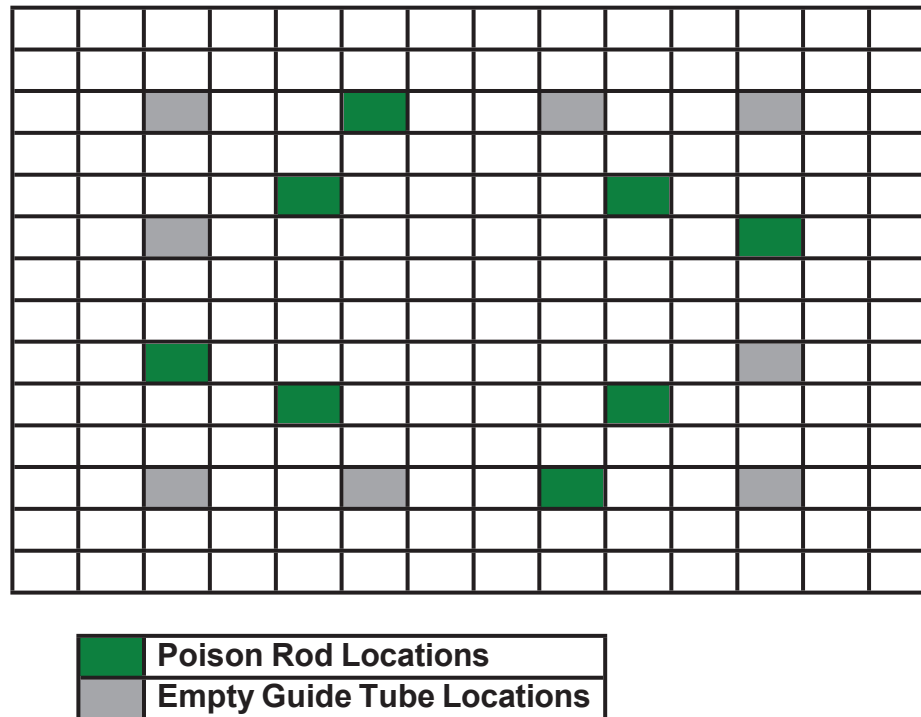
For Fuel Assemblies

1. Burnup = Assembly Average burnup.
2. Enrichment = Assembly Average Enrichment.
3. Fuel assembly with a burnup greater than 62 GWd/MTU is unacceptable for transportation.

For Fuel Rods

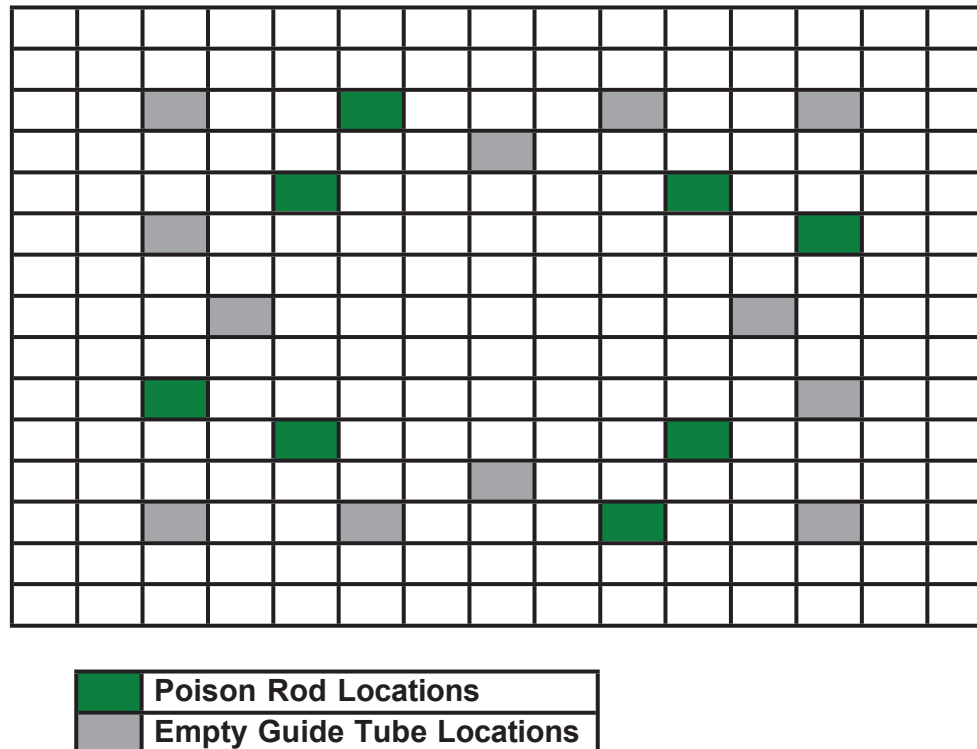
4. Burnup = Maximum burnup.
5. Enrichment = Rod Average Enrichment.
6. When transporting 21 or less fuel rods, the rods shall be placed in a specially designed pin can.
7. When transporting 9 or less fuel rods, the rods shall be placed in the 3x3 region of the pin can.
8. Fuel rods with a burnup greater than 90 GWd/MTU are unacceptable for transportation.

Example: Per Table 15, a PWR assembly with an initial enrichment of 4.85 wt.% ^{235}U and a burnup of 41.5 GWd/MTU is acceptable for transport after a 3.95-year cooling time as defined by 4.8 wt.% ^{235}U (rounding down) and 45 GWd/MTU (rounding up) on the qualification table (other considerations not withstanding).



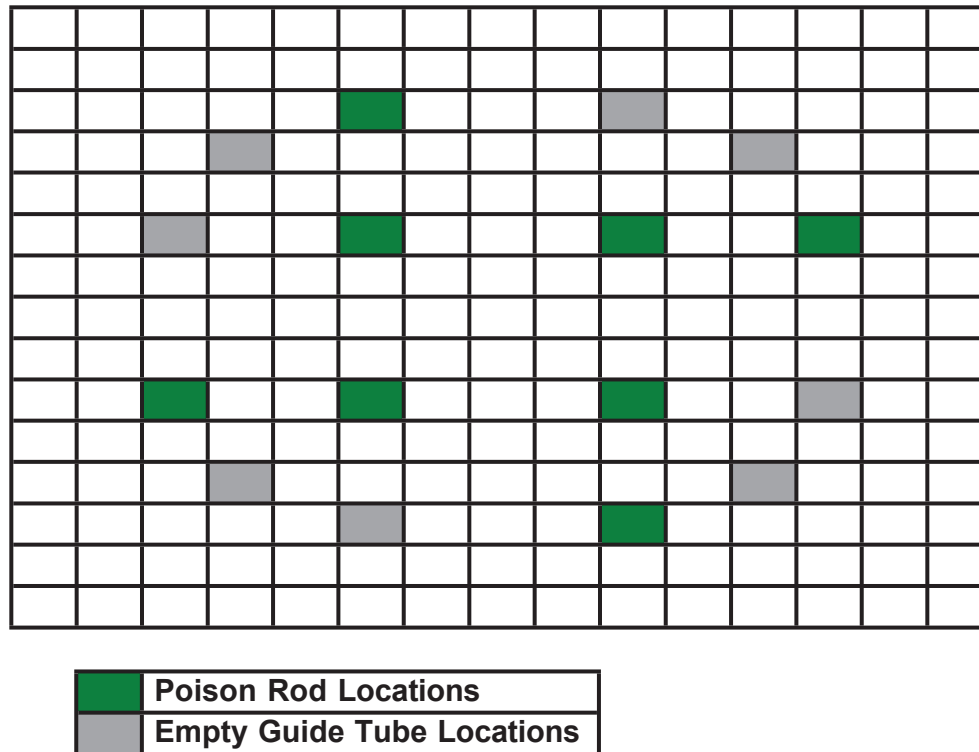
Note: This configuration indicates the relative location of the poison rods within the guide tubes and does not provide any other fuel class specific information. Any other configuration of poison rods that is rotationally symmetric is also acceptable.

Figure 1
PRA Insertion Locations for WE 14x14 Class Assemblies



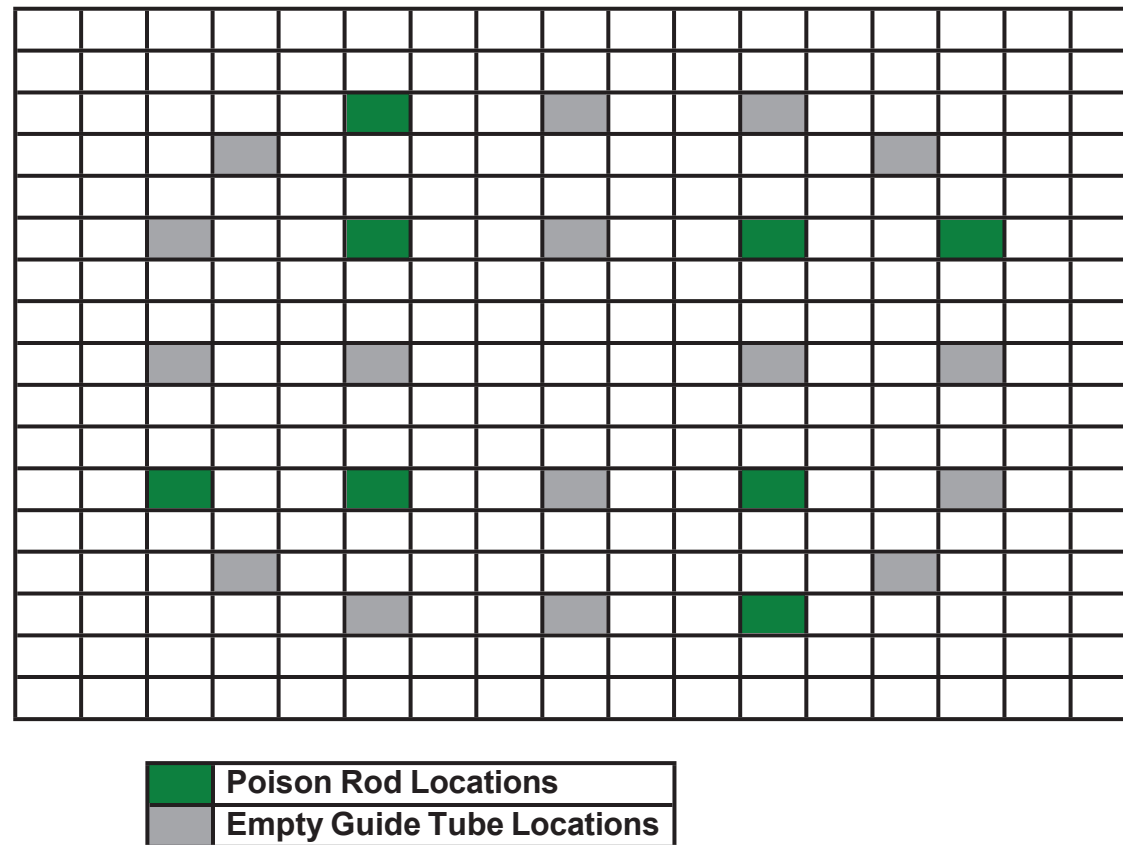
Note: This configuration indicates the relative location of the poison rods within the guide tubes and does not provide any other fuel class specific information. Any other configuration of poison rods that is rotationally symmetric is also acceptable.

Figure 2
PRA Insertion Locations for WE 15x15 Class Assemblies



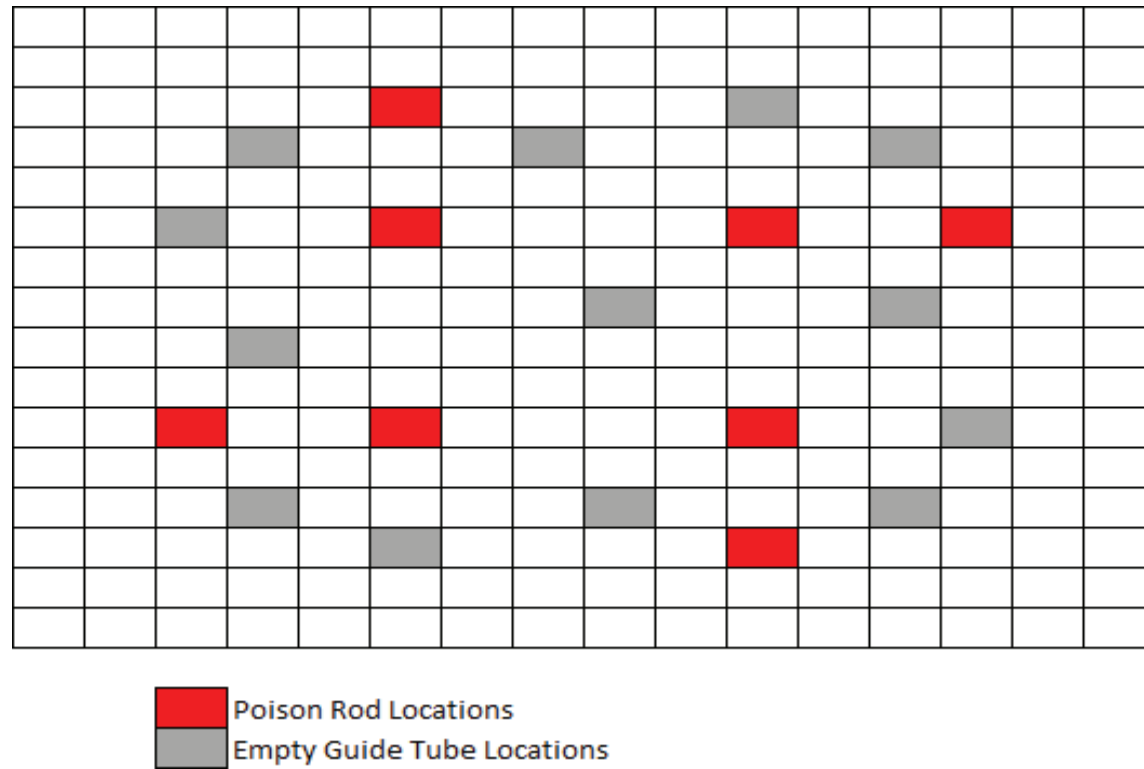
Note: This configuration indicates the relative location of the poison rods within the guide tubes and does not provide any other fuel class specific information. Any other configuration of poison rods that is rotationally symmetric is also acceptable.

Figure 3
PRA Insertion Locations for BW 15x15 Class Assemblies



Note: This configuration indicates the relative location of the poison rods within the guide tubes and does not provide any other fuel class specific information. Any other configuration of poison rods that is rotationally symmetric is also acceptable.

Figure 4
PRA Insertion Locations for BW 17x17 and WE 17x17 Class Assemblies



Note: This configuration indicates the relative location of the poison rods within the guide tubes and does not provide any other fuel class specific information. Any other configuration of poison rods that is rotationally symmetric is also acceptable.

Figure 5
PRA Insertion Locations for WE 16x16 Class Assemblies

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1.	a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
	9358	8	71-9358	USA/9358/B(U)F-96	35 OF	36

6. In addition to the requirements of Subpart G of 10 CFR Part 71:
- (a) The package must be prepared for shipment and operated in accordance with the Operating Procedures of Chapter No. 7 of the application, and
 - (b) Each packaging must meet the Acceptance Tests and Maintenance Program of Chapter No. 8 of the application.
7. Transport by air of fissile material is not authorized.
8. Prior to the first shipment, the package shall be tested for the entire containment boundary, e.g., all base metal, all joining containment welds, vent port plug seal, drain port plug seal, lid seal, and bottom plug seal, in accordance with ANSI N14.5-2014, by helium leakage rate testing to meet the leaktight criteria of 1.0×10^{-7} ref-cm³/sec for fabrication leakage tests.
9. Poison Rod Assemblies, required for shipment of PWR assemblies if burnup credit is not considered, shall be installed such that the active fuel length is covered by the absorber, and measures shall be taken against their inadvertent removal from the fuel assembly.
10. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR 71.17.
11. Revision No. 7 of this certificate may be used until July 31, 2024.
12. Expiration date: May 31, 2027.

**CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES**

1.	a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
	9358	8	71-9358	USA/9358/B(U)F-96	36 OF	36

REFERENCES

TN-LC Transportation Package Safety Analysis Report, Revision No. 11, dated June 2023.

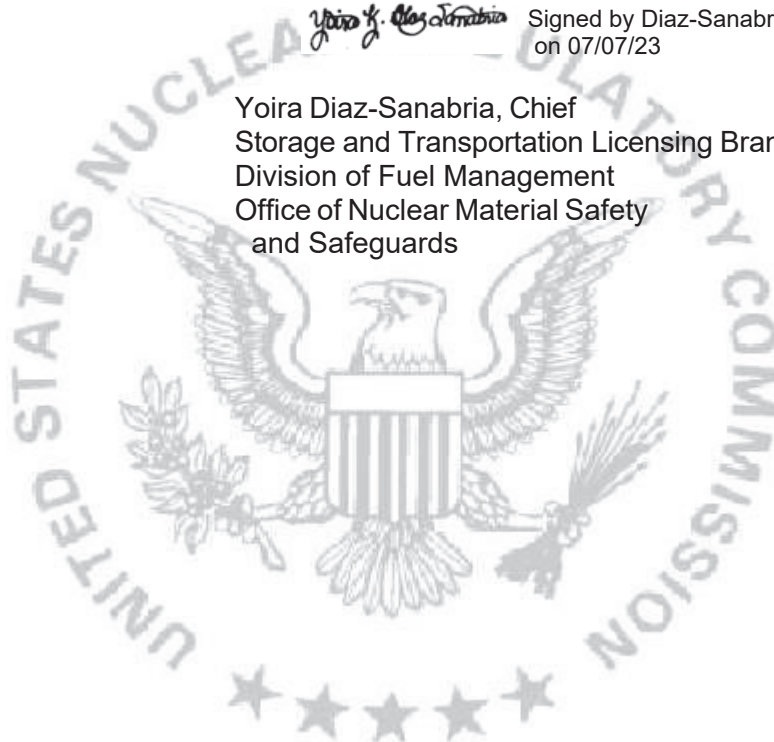
FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Date: July 7, 2023



Signed by Diaz-Sanabria, Yaira
on 07/07/23

Yaira Diaz-Sanabria, Chief
Storage and Transportation Licensing Branch
Division of Fuel Management
Office of Nuclear Material Safety
and Safeguards





**UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001**

**SAFETY EVALUATION REPORT
Docket No. 71-9358
Model No. TN-LC Package
Certificate of Compliance No. 9358
Revision No. 8**

SUMMARY

By letter dated February 15, 2023 (Agencywide Documents Access and Management System [ADAMS] Accession No. ML23046A179), TN Americas LLC (TN) submitted an application to revise Certificate of Compliance (CoC) No. 9358 for the TN-LC packaging. The amendment request introduced top and bottom damaged fuel ends caps (for damaged Pressurized Water Reactor (PWR) fuel assemblies) in lieu of the Fuel Assembly Can (FAC) that had been previously approved.

The applicant had found out that the required dimensions for the FAC were so close to the compartment opening dimensions that the FAC will not reasonably fit into the basket. On March 1, 2023, the applicant replaced Drawing Number 65200-71-92 Revision 0A with a new Revision 0B to allow the fabrication of the TN-LC damaged fuel end caps in one single machined piece; this change was made to facilitate the fabrication of the end caps by eliminating welding.

On May 19, 2023 (ADAMS No. ML23139A205), the applicant provided responses to staff's request for additional information (RAI) letter dated May 15, 2023 (ADAMS Accession No. ML23121A133 and ML23121A134)

By letter dated June 27, 2023 (ADAMS No. ML23178A119), the applicant provided a consolidated application Revision No. 11.

Based on the statements and representations in the application, and the conditions listed in the CoC, the U.S. Nuclear Regulatory Commission staff (the staff) concludes that the package meets the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 71.

EVALUATION

1. GENERAL INFORMATION

The TN-LC packaging has been developed for exclusive-use transport of irradiated test, research, and commercial reactor fuel, including several types of Boiling Water Reactor (BWR), PWR, Mixed Oxide Fuel, and Evolutionary Pressurized Reactor fuel assemblies and/or fuel pins. Additional payloads include National Research Universal Reactor, National Research Experimental Reactor, Material Test Reactor (MTR), and Training, Research and Isotope, General Atomics Reactor (TRIGA) fuel assemblies and fuel elements. The fuel is contained in specific baskets which fit into the TN-LC transport cask. The TN-LC transport package is limited to a maximum heat load of 3.0 kW depending on the fuel and basket being transported.

Editorial corrections were made in the application, including for example changing the term “failed” to “damaged” in appendix 6.10.5 of the application: There is no failed fuel transported in the TN-LC, only damaged fuel. Damaged fuel assemblies are defined as having the same configuration as intact fuel assemblies, except they contain missing or partial length or dummy fuel rods with cladding defects greater than hairline cracks or pinhole leaks. End caps are now used to transport those assemblies.

The applicant updated Note 7 of Drawing 65200-71-90 to (i) specify the maximum allowed axial gap (1 inch) between the basket and the cavity, (ii) state the direction of the gap, as well as between which components this gap needs to be verified. Drawing 65200-71-90 has been revised to Revision 9. Note 3 of Drawing 65200-71-92 has been updated to mention American Welding Society (AWS) D1.6 instead of AWS D1.3.

Drawing 65200-71-90 has been revised to change the quality category of the studs (Item 3) and the nuts (Item 7) to ITS Category C, to provide the size and material specification of the studs and nuts (Items 3 and 7), and to clarify on detail B that the studs are welded to the basket plates.

The packaging is constructed and assembled in accordance with the following Drawing Nos.:

65200-71-01 Revision 10	TN-LC Cask Assembly (11 sheets)
65200-71-20 Revision 5	TN-LC Impact Limiter Assembly (3 sheets)
5200-71-21 Revision 2	TN-LC Transport Packaging Transport Configuration (1 sheet)
65200-71-40 Revision 4	TN-LC-NRUX Basket - Basket Assembly (5 sheets)
65200-71-50 Revision 4	TN-LC-NRUX Basket - Basket Tube Assembly (5 sheets)
65200-71-60 Revision 4	TN-LC-MTR Basket General Assembly (4 sheets)
65200-71-70 Revision 4	TN-LC-MTR Basket Fuel Bucket (2 sheets)
65200-71-80 Revision 4	TN-LC-TRIGA Basket (5 sheets)
65200-71-90 Revision 9	TN-LC-1FA Basket (5 sheets)
65200-71-96 Revision 5	TN-LC-1FA BWR Sleeve and Hold-Down Ring (2 sheets)
65200-71-102 Revision 7	TN-LC-1FA Pin Can Basket (5 sheets)
65200-71-92 Revision 0	TN-LC-1FA PWR Basket Damaged fuel end caps (1 sheet)

2. STRUCTURAL EVALUATION

The objective of the structural evaluation is to verify that the applicant has adequately evaluated the structural performance of the package (packaging together with contents) and demonstrated that it meets the regulations in 10 CFR Part 71, “Packaging and Transportation of Radioactive Material.”

This section of the safety evaluation report documents the staff’s reviews, evaluations, and conclusions with respect to structural integrity of the amended transport package.

2.1 Description of the Amendment to the Structural Design

This amendment requests to use the top and bottom damaged fuel end caps in lieu of the previously approved FAC design for transporting damaged PWR fuel assembly, because the FAC cannot be installed into the 1FA basket due to fit-up problems. As described in the safety analysis report (SAR) rev. 11A of the application and SAR rev. 11B documents submitted with the responses to the RAI, the top

and bottom damaged fuel end caps are stainless steel square-section structures, each made of a short sheet metal liner, and a closure plate welded to this liner. The top end cap assembly simply sits within the recess at the top of the basket, above the fuel assembly, which itself sits on top of the bottom end cap assembly, which rests on the bottom of the cask. The TN-LC transport cask, the 1FA basket assembly, fuel contents and other associated components remain unchanged.

In addition, the applicant revised one of the drawings to correct misalignment of the note numbers with the notes.

2.2 Evaluation

For this structural review, the staff focused primarily on any changes to the structural behavior of the packaging that the use of the damaged fuel end caps could have on the TN-LC cask design. Any changes in the configuration, weight, and ability of the damaged fuel end caps to confine the new payload under Normal Conditions of Transport (NCT) and Hypothetical Accident Condition (HAC) are evaluated.

The cover plates of the top and bottom end caps are design features of the packaging that ensure that any fuel material is always confined within the basket compartment, and that fuel material cannot be released outside the basket compartment into the space between the 1FA basket and the TN-LC inner cavity. Per section 1.4.5.2.1 of the application, and as shown on Drawing 65200-71-92, both end caps can freely slide (i.e., they are not mechanically attached to the basket or the cask) along the axis of the cask but are restrained by the basket compartment walls in any direction perpendicular to the axis of the cask cavity.

However, neither end cap can come off of the basket compartment once the cask is closed because the maximum axial gap limit (1 inch) between the basket and the cask cavity is smaller than either the minimum thickness (1.2 inches) of the top end cap plate, or the combined thickness (1.20 inches) of the bottom end cap plate and its spacers including fabrication tolerance. The liners simply cover the slots through the basket walls and help the end caps remain straight as they slide within the compartment.

In table 1.4.5-1 of the application, the applicant identifies the maximum weight of the PWR fuel payload, including the damaged fuel end caps, as 1850 pounds. The weight of the 1FA basket without payload is 4200 pounds per Drawing 65200-71-90, rev. 8.

The staff found that the combined weight of the 1FA basket assembly with its payload including the damaged fuel end caps is less than 6061 pounds, which was the bounding weight accepted in previous structural analyses and evaluations, as provided in table 2 through 10 of the application. Since there is no design change to the 1FA basket and the TN-LC cask, the previous evaluations for the cask and the basket remain applicable for the damaged PWR fuel transport under NCT and HAC.

For side drops under NCT and HAC, both the cover plates of the top and bottom end caps are supported by basket walls. Also, both plates are not slender; therefore, there is no risk of buckling of the plates. For an end drop on the lid, the top end cover plate supports the fuel assembly including the bottom end cap, which in turn transfers this load through bearing on the shielding cap supported by the TN-LC lid. The staff concludes that top cover plate is structurally adequate to carry this load, since the top cover plate is of the same material as that of the

shielding cap and the payload, including the top and bottom end caps, remains bounded by that considered in the initial qualification of the cask lid.

For an end drop on the lid, the PWR fuel assembly is loaded with the bottom end cap, which weighs less than 30 pounds. The structural integrity of the PWR payload fuel assembly and fuel elements during NCT side and end drops was originally evaluated in appendix 2.13.11 of the application. The results of the original analysis indicate that the maximum principal strain in 14x14 fuel rod is 0.206 percent, which is far less than the corresponding yield strain of 0.970 percent.

Considering the magnitude of the additional load on a fuel rod assembly and the margin available in the original analysis to absorb additional strain, the staff expects the PWR fuel assembly to maintain its structural integrity under NCT. The staff notes that this evaluation is intended to provide additional assurance that the fuel geometry will be maintained for the analyzed loads under NCT.

However, the structural integrity of fuel/element geometry as demonstrated is not required under NCT and HAC in the criticality and thermal analyses as described in section 2.13.11.6 of the application. But it requires each fuel element/assembly to be confined within the corresponding fuel/element compartments. The presence of the damaged fuel end caps confines the fuel assembly rods and any fuel debris from a damaged fuel assembly within the 1FA basket compartment and does not change the assumptions for fuel rearrangement that are used in the criticality evaluation.

In addition, the applicant revised Drawing No. 65200-71-90 sheet 1 to correct misalignment of the note numbers and the notes. Also, several sections of the application have been revised to correct misprint errors and to resolve minor discrepancies between the application and supporting documents. The staff's review of these changes established that these are editorial changes and do not affect any important to safety component design. The staff addressed these changes here for completeness of staff's evaluation of this amendment request.

2.3 Evaluation Findings

Based on review of the statements and representations in the application, the staff concludes that the use of the top and bottom damaged fuel end caps is adequately described and evaluated to demonstrate that the package continues to perform its original safety function and meets the structural integrity requirements of 10 CFR Part 71.

CONDITIONS

The following changes were made to the Conditions of the certificate:

Item No. 3.b reflects the latest revision, rev.11, of the application dated June 2023.

Condition No. 5(a)(3) was modified to include revision 9 of licensing drawing 65200-71-90 and revision 0 of the new licensing drawing 65200-71-92 for the TN-LC-1FA PWR Basket Damaged Fuel End Caps.

Condition No. 5(b)(1) was modified to replace the wording of "Fuel Assembly Can" with "damaged fuel ends caps".

Condition No. 5(b)(2) was modified to replace the wording “Fuel Assembly Can” with “damaged fuel end caps”. Condition No. 11 authorizes the previous revision of the certificate for approximately one more year.

The expiration date of the certificate was not changed. The reference section of the certificate was modified to indicate Revision No. 11 of the consolidated application, dated June 2023.

CONCLUSION

Based on the statements and representations in the application, the staff finds that these changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with CoC No. 9358, Revision No. 8.