

**CERTIFICATE OF COMPLIANCE
FOR SPENT FUEL STORAGE CASKS**

The U.S. Nuclear Regulatory Commission is issuing this Certificate of Compliance pursuant to Title 10 of the Code of Federal Regulations, Part 72, "Licensing Requirements for Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste" (10 CFR Part 72). This certificate is issued in accordance with 10 CFR 72.238, certifying that the storage design and contents described below meet the applicable safety standards set forth in 10 CFR Part 72, Subpart L, and on the basis of the Final Safety Analysis Report (FSAR) of the cask design. This certificate is conditional upon fulfilling the requirements of 10 CFR Part 72, as applicable, and the conditions specified below.

Certificate No.	Effective Date	Expiration Date	Docket No.	Amendment No.	Amendment Effective Date	Package Identification No.
1014	05/31/00	06/01/20	72-1014	5TBD	TBD	USA/72-1014

Issued To: (Name/Address)

Holtec International
Holtec Center
555 Lincoln Drive West
Marlton, NJ 08053

Safety Analysis Report Title

Holtec International
Final Safety Analysis Report for the
HI-STORM 100 Cask System

CONDITIONS

This certificate is conditioned upon fulfilling the requirements of 10 CFR Part 72, as applicable, the attached Appendix A (Technical Specifications) and Appendix B (Approved Contents and Design Features), and the conditions specified below:

1. CASK

a. Model No.: HI-STORM 100 Cask System

The HI-STORM 100 Cask System (the cask) consists of the following components: (1) interchangeable multi-purpose canisters (MPCs), which contain the fuel; (2) a storage overpack (HI-STORM), which contains the MPC during storage; and (3) a transfer cask (HI-TRAC), which contains the MPC during loading, unloading and transfer operations. The cask stores up to 32 pressurized water reactor (PWR) fuel assemblies or 68 boiling water reactor (BWR) fuel assemblies.

b. Description

The HI-STORM 100 Cask System is certified as described in the Final Safety Analysis Report (FSAR) and in the U.S. Nuclear Regulatory Commission's (NRC) Safety Evaluation Report (SER) accompanying the Certificate of Compliance. The cask comprises three discrete components: the MPC, the HI-TRAC transfer cask, and the HI-STORM storage overpack.

The MPC is the confinement system for the stored fuel. It is a welded, cylindrical canister with a honeycombed fuel basket, a baseplate, a lid, a closure ring, and the canister shell. All MPC components that may come into contact with spent fuel pool water or the ambient environment are made entirely of stainless steel except for the neutron absorbers, aluminum seals on vent and drain port caps, and aluminum heat conduction elements (AHCEs), which are installed in some early-vintage MPCs. The canister shell, baseplate, lid, vent and drain port cover plates, and closure ring are the main confinement boundary components. All confinement boundary components are made entirely of stainless steel. The honeycombed basket, which is equipped with neutron absorbers, provides criticality control.

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1. b. Description (continued)

There are eight types of MPCs: the MPC-24, MPC-24E, MPC-24EF, MPC-32, MPC-32F, MPC-68, MPC-68F, and MPC-68FF. The number suffix indicates the maximum number of fuel assemblies permitted to be loaded in the MPC. All eight MPC models have the same external diameter.

The HI-TRAC transfer cask provides shielding and structural protection of the MPC during loading, unloading, and movement of the MPC from the spent fuel pool to the storage overpack. The transfer cask is a multi-walled (carbon steel/lead/carbon steel) cylindrical vessel with a neutron shield jacket attached to the exterior. Two sizes of HI-TRAC transfer casks are available: the 125 ton-HI-TRAC and the 100 ton HI-TRAC. The weight designation is the maximum weight of a loaded transfer cask during any loading, unloading or transfer operation. Both transfer cask sizes have identical cavity diameters. The 125 ton HI-TRAC transfer cask has thicker shielding and larger outer dimensions than the 100 ton HI-TRAC transfer cask.

The HI-STORM 100 or 100S storage overpack provides shielding and structural protection of the MPC during storage. The HI-STORM 100S is a variation of the HI-STORM 100 overpack design that includes a modified lid which incorporates the air outlet ducts into the lid, allowing the overpack body to be shortened. The overpack is a heavy-walled steel and concrete, cylindrical vessel. Its side wall consists of plain (un-reinforced) concrete that is enclosed between inner and outer carbon steel shells. The overpack has four air inlets at the bottom and four air outlets at the top to allow air to circulate naturally through the cavity to cool the MPC inside. The inner shell has supports attached to its interior surface to guide the MPC during insertion and removal, provide a medium to absorb impact loads, and allow cooling air to circulate through the overpack. A loaded MPC is stored within the HI-STORM 100 or 100S storage overpack in a vertical orientation. The HI-STORM 100A and 100SA are variants of the HI-STORM 100 family outfitted with an extended baseplate and gussets to enable the overpack to be anchored to the concrete storage pad in high seismic applications.

2. OPERATING PROCEDURES

Written operating procedures shall be prepared for cask handling, loading, movement, surveillance, and maintenance. The user's site-specific written operating procedures shall be consistent with the technical basis described in Chapter 8 of the FSAR.

3. ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

Written cask acceptance tests and maintenance program shall be prepared consistent with the technical basis described in Chapter 9 of the FSAR.

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4. QUALITY ASSURANCE

Activities in the areas of design, purchase, fabrication, assembly, inspection, testing, operation, maintenance, repair, modification of structures, systems and components, and decommissioning that are important to safety shall be conducted in accordance with a Commission-approved quality assurance program which satisfies the applicable requirements of 10 CFR Part 72, Subpart G, and which is established, maintained, and executed with regard to the cask system.

5. HEAVY LOADS REQUIREMENTS

Each lift of an MPC, a HI-TRAC transfer cask, or any HI-STORM overpack must be made in accordance to the existing heavy loads requirements and procedures of the licensed facility at which the lift is made. A plant-specific regulatory review (under 10 CFR 50.59 or 10 CFR 72.48, if applicable) is required to show operational compliance with existing plant specific heavy loads requirements. Lifting operations outside of structures governed by 10 CFR Part 50 must be in accordance with Section 5.5 of Appendix A and/or Sections 3.4.6 and Section 3.5 of Appendix B to this certificate, as applicable.

6. APPROVED CONTENTS

Contents of the HI-STORM 100 Cask System must meet the fuel specifications given in Appendix B to this certificate.

7. DESIGN FEATURES

Features or characteristics for the site, cask, or ancillary equipment must be in accordance with Appendix B to this certificate.

8. CHANGES TO THE CERTIFICATE OF COMPLIANCE

The holder of this certificate who desires to make changes to the certificate, which includes Appendix A (Technical Specifications) and Appendix B (Approved Contents and Design Features), shall submit an application for amendment of the certificate.

9. SPECIAL REQUIREMENTS FOR FIRST SYSTEMS IN PLACE

The air mass flow rate through the cask system will be determined by direct measurements of air velocity in the overpack cooling passages for the first HI-STORM Cask Systems placed into service by any user with a heat load equal to or greater than 20 kW. The velocity will be measured in the annulus formed between the MPC shell and the overpack inner shell. An analysis shall be performed that demonstrates the measurements validate the analytic methods and thermal performance predicted by the licensing-basis thermal models in Chapter 4 of the FSAR.

Each first time user of a HI-STORM 100 Cask System Supplemental Cooling System (SCS) that uses components or a system that is not essentially identical to components or a system that has been previously tested, shall measure and record coolant temperatures for the inlet and outlet of cooling provided to the annulus between the HI-TRAC and MPC and the coolant flow rate. The user shall also record the MPC operating pressure and decay heat. An analysis shall be performed, using this information, that validates the thermal methods described in the FSAR which were used to determine the type and amount of supplemental cooling necessary.

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9. SPECIAL REQUIREMENTS FOR FIRST SYSTEMS IN PLACE (continued)

Letter reports summarizing the results of each thermal validation test and SCS validation test and analysis shall be submitted to the NRC in accordance with 10 CFR 72.4. Cask users may satisfy these requirements by referencing validation test reports submitted to the NRC by other cask users.

10. PRE-OPERATIONAL TESTING AND TRAINING EXERCISE

A dry run training exercise of the loading, closure, handling, unloading, and transfer of the HI-STORM 100 Cask System shall be conducted by the licensee prior to the first use of the system to load spent fuel assemblies. The training exercise shall not be conducted with spent fuel in the MPC. The dry run may be performed in an alternate step sequence from the actual procedures, but all steps must be performed. The dry run shall include, but is not limited to the following:

- a. Moving the MPC and the transfer cask into the spent fuel pool.
- b. Preparation of the HI-STORM 100 Cask System for fuel loading.
- c. Selection and verification of specific fuel assemblies to ensure type conformance.
- d. Loading specific assemblies and placing assemblies into the MPC (using a dummy fuel assembly), including appropriate independent verification.
- e. Remote installation of the MPC lid and removal of the MPC and transfer cask from the spent fuel pool.
- f. MPC welding, NDE inspections, pressure testing, draining, moisture removal (by vacuum drying or forced helium dehydration, as applicable), and helium backfilling. . (A mockup may be used for this dry-run exercise.)
- g. Operation of the Supplemental Cooling System, if applicable.
- h. Transfer cask upending/downending on the horizontal transfer trailer or other transfer device, as applicable to the site's cask handling arrangement.
- i. Transfer of the MPC from the transfer cask to the overpack.
- j. Placement of the HI-STORM 100 Cask System at the ISFSI, for aboveground systems only.
- k. HI-STORM 100 Cask System unloading, including flooding MPC cavity, removing MPC lid welds. (A mockup may be used for this dry-run exercise.)

11. When the Supplemental Cooling System is in operation to provide for decay heat removal in accordance with Section 3.1.4 of Appendix A the licensee is exempt from the requirements of 10 CFR 72.236(f).

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12. AUTHORIZATION

The HI-STORM 100 Cask System, which is authorized by this certificate, is hereby approved for general use by holders of 10 CFR Part 50 licenses for nuclear reactors at reactor sites under the general license issued pursuant to 10 CFR 72.210, subject to the conditions specified by 10 CFR 72.212, and the attached Appendix A and Appendix B. The HI-STORM 100 Cask System may be fabricated and used in accordance with any approved amendment to CoC No. 1014 listed in 10 CFR 72.214. Each of the licensed HI-STORM 100 System components (i.e., the MPC, overpack, and transfer cask), if fabricated in accordance with any of the approved CoC Amendments, may be used with one another provided an assessment is performed by the CoC holder that demonstrates design compatibility.

FOR THE U. S. NUCLEAR REGULATORY COMMISSION

Robert Nelson TBD, Chief
Licensing Section
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety and Safeguards
Washington, DC 20555

Dated, TBD

- Attachments:
1. Appendix A
2. Appendix B

1.0 Definitions

-----NOTE-----

The defined terms of this section appear in capitalized type and are applicable throughout these Technical Specifications and Bases.

<u>Term</u>	<u>Definition</u>
CASK TRANSFER FACILITY (CTF)	A CASK TRANSFER FACILITY is an aboveground or underground system used during the transfer of a loaded MPC between a transfer cask and a storage OVERPACK. The CASK TRANSFER FACILITY includes the following components and equipment: (1) a Cask Transfer Structure used to stabilize the OVERPACK, TRANSFER CASK and/or MPC during lifts involving spent fuel not bounded by the regulations of 10 CFR Part 50, and (2) Either a stationary lifting device or a mobile lifting device used in concert with the stationary structure to lift the OVERPACK, TRANSFER CASK, and/or MPC.
DAMAGED FUEL ASSEMBLY	DAMAGED FUEL ASSEMBLIES are fuel assemblies with known or suspected cladding defects, as determined by a review of records, greater than pinhole leaks or hairline cracks, empty fuel rod locations that are not filled with dummy fuel rods, missing structural components such as grid spacers, whose structural integrity has been impaired such that geometric rearrangement of fuel or gross failure of the cladding is expected based on engineering evaluations, or that cannot be handled by normal means. Fuel assemblies that cannot be handled by normal means due to fuel cladding damage are considered FUEL DEBRIS.
DAMAGED FUEL CONTAINER (DFC)	DFCs are specially designed enclosures for DAMAGED FUEL ASSEMBLIES or FUEL DEBRIS which permit gaseous and liquid media to escape while minimizing dispersal of gross particulates. DFCs authorized for use in the HI-STORM 100 System are as follows: <ol style="list-style-type: none"> 1. Holtec Dresden Unit 1/Humboldt Bay design 2. Transnuclear Dresden Unit 1 design 3. Holtec Generic BWR design 4. Holtec Generic PWR design

(continued)

1.0 Definitions (continued)

FUEL DEBRIS	FUEL DEBRIS is ruptured fuel rods, severed rods, loose fuel pellets, containers or structures that are supporting these loose fuel assembly parts, or fuel assemblies with known or suspected defects which cannot be handled by normal means due to fuel cladding damage.
INTACT FUEL ASSEMBLY	INTACT FUEL ASSEMBLIES are fuel assemblies without known or suspected cladding defects greater than pinhole leaks or hairline cracks and which can be handled by normal means. Fuel assemblies without fuel rods in fuel rod locations shall not be classified as INTACT FUEL ASSEMBLIES unless dummy fuel rods are used to displace an amount of water greater than or equal to that displaced by the fuel rod(s).
LOADING OPERATIONS	LOADING OPERATIONS include all licensed activities on an OVERPACK or TRANSFER CASK while it is being loaded with fuel assemblies. LOADING OPERATIONS begin when the first fuel assembly is placed in the MPC and end when the OVERPACK or TRANSFER CASK is suspended from or secured on the transporter. LOADING OPERATIONS does not include MPC transfer between the TRANSFER CASK and the OVERPACK, which begins when the MPC is lifted off the HI-TRAC bottom lid and ends when the MPC is supported from beneath by the OVERPACK.
MINIMUM ENRICHMENT	MINIMUM ENRICHMENT is the minimum assembly average enrichment. Natural uranium blankets are not considered in determining minimum enrichment.
MULTI-PURPOSE CANISTER (MPC)	MPCs are the sealed spent nuclear fuel canisters which consist of a honeycombed fuel basket contained in a cylindrical canister shell which is welded to a baseplate, lid with welded port cover plates, and closure ring. The MPC provides the confinement boundary for the contained radioactive materials.
NON-FUEL HARDWARE	NON-FUEL HARDWARE is defined as Burnable Poison Rod Assemblies (BPRAs), Thimble Plug Devices (TPDs), Control Rod Assemblies (CRAs), Axial Power Shaping Rods (APSRs), Wet Annular Burnable Absorbers (WABAs), Rod Cluster Control Assemblies (RCCAs), Control Element Assemblies (CEAs), Neutron Source Assemblies (NSAs), water displacement guide tube plugs, orifice rod assemblies, <i>instrument tube tie-rods (ITTRs)</i> , vibration suppressor inserts, and components of these devices such as individual rods.

(continued)

1.0 Definitions (continued)

OVERPACK	OVERPACKs are the casks which receive and contain the sealed MPCs for interim storage on the ISFSI. They provide gamma and neutron shielding, and provide for ventilated air flow to promote heat transfer from the MPC to the environs. The OVERPACK does not include the TRANSFER CASK.
PLANAR-AVERAGE INITIAL ENRICHMENT	PLANAR AVERAGE INITIAL ENRICHMENT is the average of the distributed fuel rod initial enrichments within a given axial plane of the assembly lattice.
SPENT FUEL STORAGE CASKS (SFSCs)	An SFSC is a container approved for the storage of spent fuel assemblies at the ISFSI. The HI-STORM 100 SFSC System consists of the OVERPACK and its integral MPC.
TRANSFER CASK	TRANSFER CASKs are containers designed to contain the MPC during and after loading of spent fuel assemblies and to transfer the MPC to or from the OVERPACK. The HI-STORM 100 System employs either the 125-Ton or the 100-Ton HI-TRAC TRANSFER CASK.
TRANSPORT OPERATIONS	TRANSPORT OPERATIONS include all licensed activities performed on an OVERPACK or TRANSFER CASK loaded with one or more fuel assemblies when it is being moved to and from the ISFSI. TRANSPORT OPERATIONS begin when the OVERPACK or TRANSFER CASK is first suspended from or secured on the transporter and end when the OVERPACK or TRANSFER CASK is at its destination and no longer secured on or suspended from the transporter. TRANSPORT OPERATIONS include transfer of the MPC between the OVERPACK and the TRANSFER CASK which begins when the MPC is lifted off the HI-TRAC bottom lid and ends when the MPC is supported from beneath by the OVERPACK (or the reverse).

(continued)

1.0 Definitions (continued)

UNLOADING OPERATIONS

UNLOADING OPERATIONS include all licensed activities on an SFSC to be unloaded of the contained fuel assemblies. UNLOADING OPERATIONS begin when the OVERPACK or TRANSFER CASK is no longer suspended from or secured on the transporter and end when the last fuel assembly is removed from the SFSC. UNLOADING OPERATIONS does not include MPC transfer between the TRANSFER CASK and the OVERPACK which begins when the MPC is no longer supported from beneath by the OVERPACK and ends when the MPC is lowered onto the HI-TRAC bottom lid.

ZR

ZR means any zirconium-based fuel cladding or fuel channel material authorized for use in a commercial nuclear power plant reactor.

2.0 APPROVED CONTENTS

2.1 Fuel Specifications and Loading Conditions

2.1.1 Fuel To Be Stored In The HI-STORM 100 SFSC System

- a. INTACT FUEL ASSEMBLIES, DAMAGED FUEL ASSEMBLIES, FUEL DEBRIS, and NON-FUEL HARDWARE meeting the limits specified in Table 2.1-1 and other referenced tables may be stored in the HI-STORM 100 SFSC System.
- b. For MPCs partially loaded with stainless steel clad fuel assemblies, all remaining fuel assemblies in the MPC shall meet the decay heat generation limit for the stainless steel clad fuel assemblies.
- c. For MPCs partially loaded with array/class 6x6A, 6x6B, 6x6C, 7x7A, or 8x8A fuel assemblies, all remaining ZR clad INTACT FUEL ASSEMBLIES in the MPC shall meet the decay heat generation limits for the 6x6A, 6x6B, 6x6C, 7x7A and 8x8A fuel assemblies.
- d. All BWR fuel assemblies may be stored with or without ZR channels with the exception of array/class 10x10D and 10x10E fuel assemblies, which may be stored with or without ZR or stainless steel channels.

2.1.2 Uniform Fuel Loading

Any authorized fuel assembly may be stored in any fuel storage location, subject to other restrictions related to DAMAGED FUEL, FUEL DEBRIS, and NON-FUEL HARDWARE specified in the CoC.

(continued)

2.0 Approved Contents

2.1 Fuel Specifications and Loading Conditions (cont'd)

2.1.3 Regionalized Fuel Loading

Users may choose to store fuel using regionalized loading in lieu of uniform loading to allow higher heat emitting fuel assemblies to be stored than would otherwise be able to be stored using uniform loading. Regionalized loading is limited to those fuel assemblies with ZR cladding. Figures 2.1-1 through 2.1-4 define the regions for the MPC-24, MPC-24E, MPC-24EF, MPC-32, MPC-32F, MPC-68, and MPC-68FF models, respectively¹. Fuel assembly burnup, decay heat, and cooling time limits for regionalized loading are specified in Section 2.4.2. Fuel assemblies used in regionalized loading shall meet all other applicable limits specified in Tables 2.1-1 through 2.1-3.

2.2 Violations

If any Fuel Specifications or Loading Conditions of 2.1 are violated, the following actions shall be completed:

2.2.1 The affected fuel assemblies shall be placed in a safe condition.

2.2.2 Within 24 hours, notify the NRC Operations Center.

2.2.3 Within 30 days, submit a special report which describes the cause of the violation, and actions taken to restore compliance and prevent recurrence.

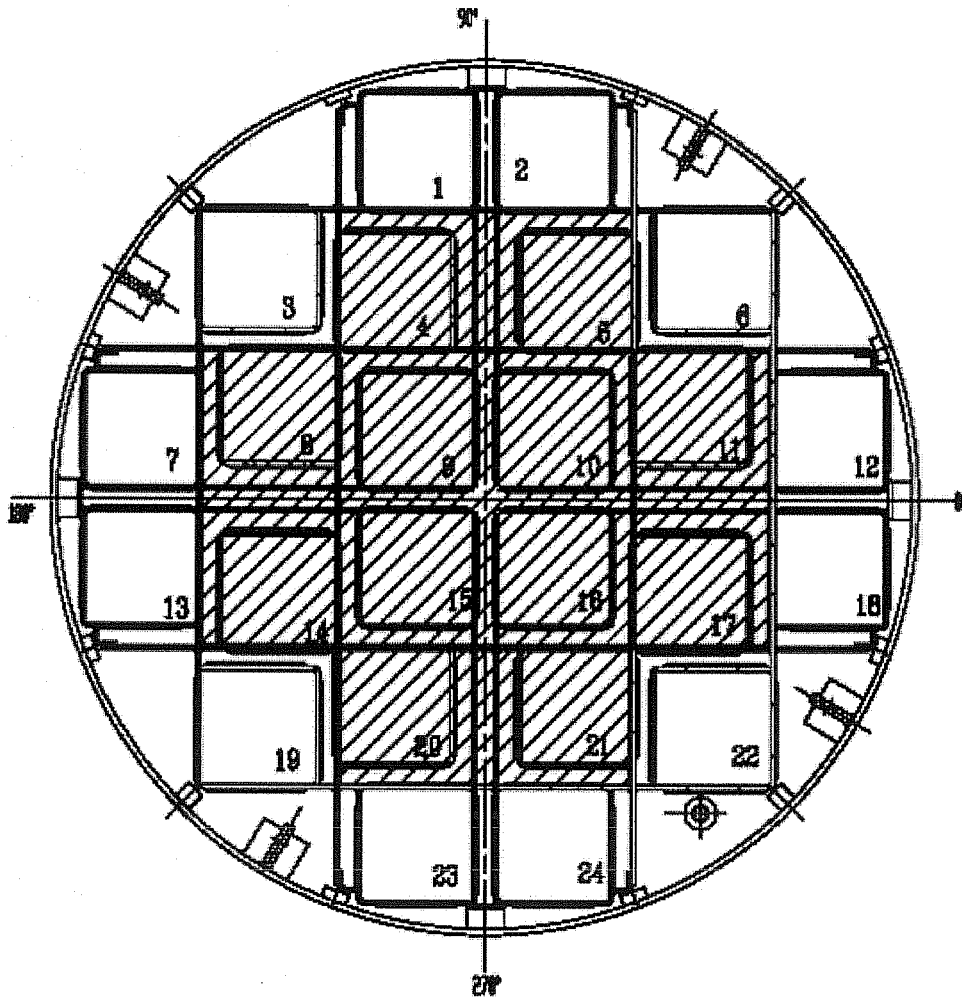
2.3 Not Used

¹ These figures are only intended to distinguish the fuel loading regions. Other details of the basket design are illustrative and may not reflect the actual basket design details. The design drawings should be consulted for basket design details.

LEGEND:



REGION 1: 

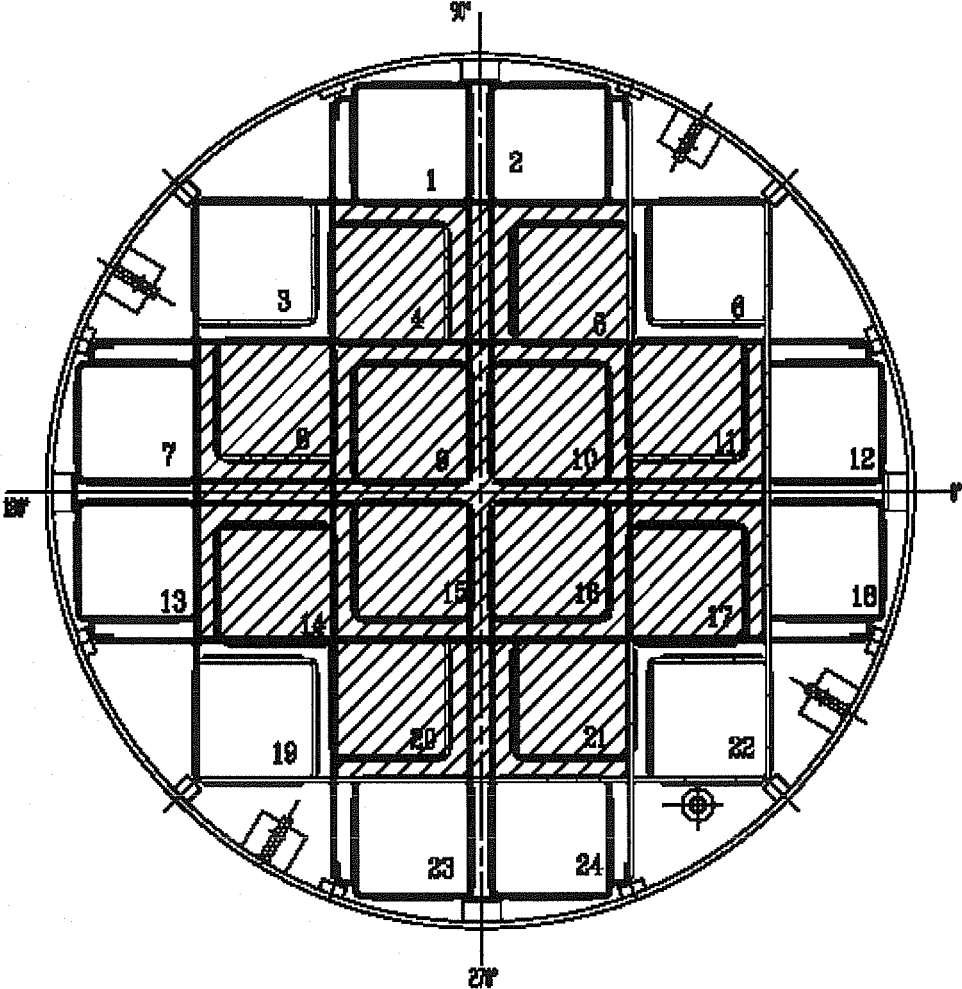
REGION 2: 



**Figure 2.1-1
Fuel Loading Regions - MPC-24**


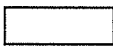
LEGEND:

- REGION 1:** 
- REGION 2:** 



**Figure 2.1-2
Fuel Loading Regions - MPC-24E/24EF**

LEGEND:

- REGION 1: 
- REGION 2: 

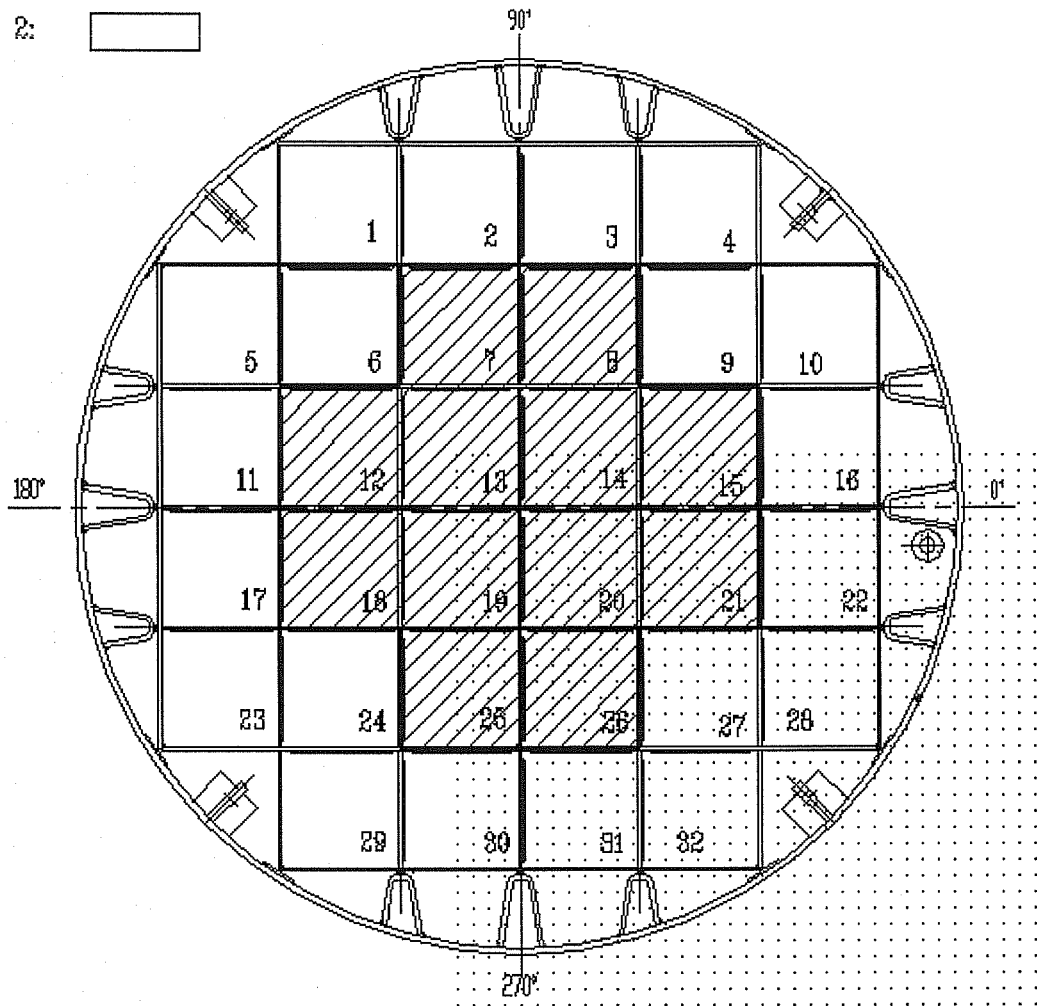

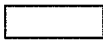


Figure 2.1-3
Fuel Loading Regions - MPC-32/32F

LEGEND:

- REGION 1: 
- REGION 2: 

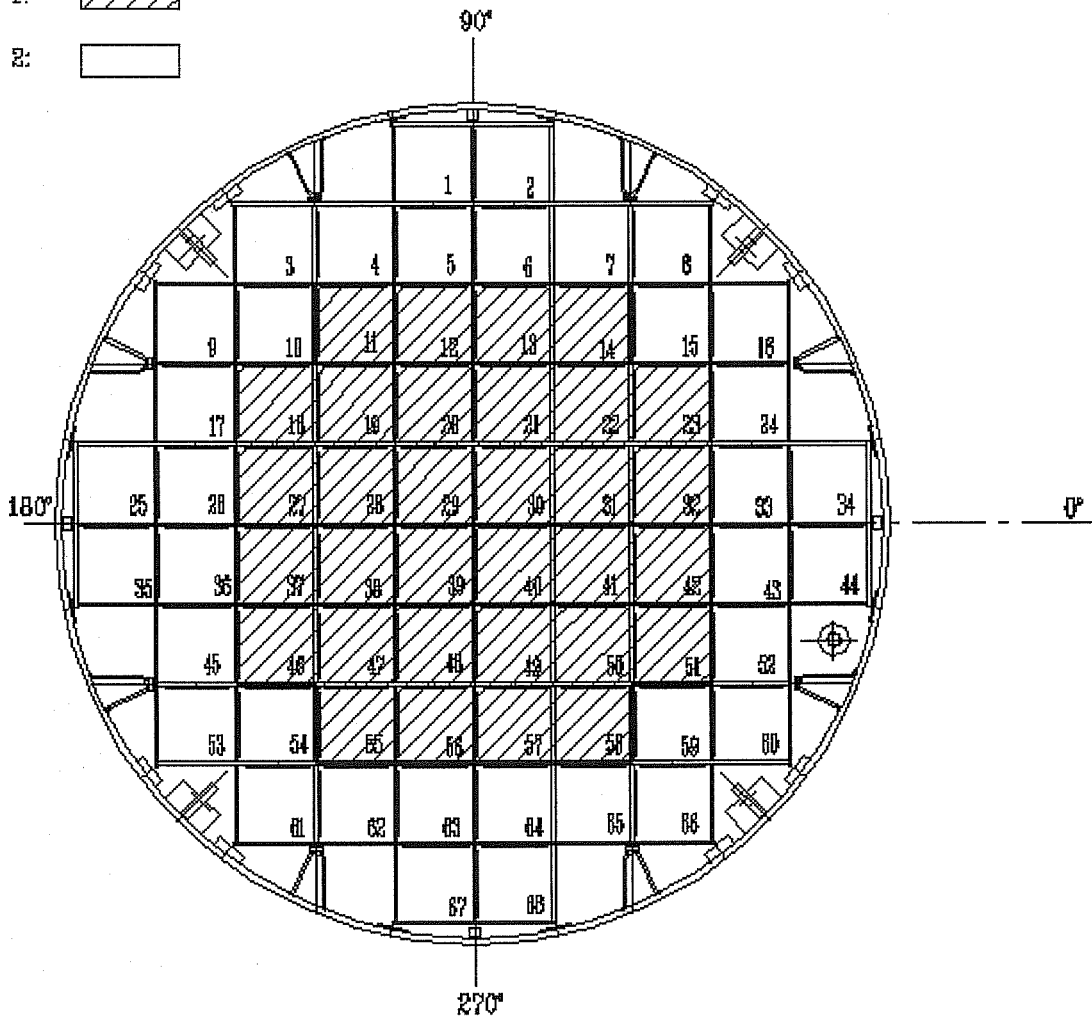


Figure 2.1-4
Fuel Loading Regions - MPC-68/68FF

Table 2.1-1 (page 1 of 2440)
Fuel Assembly Limits

I. MPC MODEL: MPC-24

A. Allowable Contents

1. Uranium oxide, PWR INTACT FUEL ASSEMBLIES listed in Table 2.1-2, with or without NON-FUEL HARDWARE and meeting the following specifications (Note 1):

- | | |
|---|--|
| a. Cladding Type: | ZR or Stainless Steel (SS) as specified in Table 2.1-2 for the applicable fuel assembly array/class. |
| b. Initial Enrichment: | As specified in Table 2.1-2 for the applicable fuel assembly array/class. |
| c. Post-irradiation Cooling Time and Average Burnup Per Assembly: | |
| i. Array/Classes
14x14D, 14x14E, and
15x15G | Cooling time \geq 8 years and an average burnup \leq 40,000 MWD/MTU. |
| ii. All Other Array/Classes | Cooling time and average burnup as specified in Section 2.4. |
| iii. NON-FUEL HARDWARE | As specified in Table 2.1-8. |

Table 2.1-1 (page 2 of 2440)
Fuel Assembly Limits

I. MPC MODEL: MPC-24 (continued)

A. Allowable Contents (continued)

d. Decay Heat Per Fuel Storage Location:

i. Array/Classes 14x14D, 14x14E, and 15x15G ≤ 710 Watts

ii All Other Array/Classes As specified in Section 2.4.

e. Fuel Assembly Length: ≤ 176.8 inches (nominal design)

f. Fuel Assembly Width: ≤ 8.54 inches (nominal design)

g. Fuel Assembly Weight: ≤ 1720 lbs (including NON-FUEL HARDWARE) for assemblies that do not require fuel spacers, otherwise ≤ 1680 lbs (including NON-FUEL HARDWARE)

B. Quantity per MPC: Up to 24 fuel assemblies.

C. Deleted.

D. DAMAGED FUEL ASSEMBLIES and FUEL DEBRIS are not authorized for loading into the MPC-24.

E. One NSA is authorized for loading into the MPC-24.

Note 1: Fuel assemblies containing BPRAs, TPDs, WABAs, water displacement guide tube plugs, orifice rod assemblies, or vibration suppressor inserts, *with or without ITTRs*, may be stored in any fuel storage location. Fuel assemblies containing APSRs or NSAs may only be loaded in fuel storage locations 9, 10, 15, and/or 16. Fuel assemblies containing CRAs, RCCAs, CEAs may only be stored in fuel storage locations 4, 5, 8 - 11, 14 - 17, 20 and/or 21 (see Figure 2.1-1). These requirements are in addition to any other requirements specified for uniform or regionalized fuel loading.

Table 2.1-1 (page 311 of 2440)
Fuel Assembly Limits

II. MPC MODEL: MPC-68F

A. Allowable Contents

1. Uranium oxide, BWR INTACT FUEL ASSEMBLIES, with or without ZR channels. Uranium oxide BWR INTACT FUEL ASSEMBLIES shall meet the criteria specified in Table 2.1-3 for fuel assembly array class 6x6A, 6x6C, 7x7A or 8x8A, and meet the following specifications:

- | | |
|---|---|
| a. Cladding Type: | ZR |
| b. Maximum PLANAR-AVERAGE INITIAL ENRICHMENT: | As specified in Table 2.1-3 for the applicable fuel assembly array/class. |
| c. Initial Maximum Rod Enrichment: | As specified in Table 2.1-3 for the applicable fuel assembly array/class. |
| d. Post-irradiation Cooling Time and Average Burnup Per Assembly: | Cooling time \geq 18 years and an average burnup \leq 30,000 MWD/MTU. |
| e. Decay Heat Per Assembly | \leq 115 Watts |
| f. Fuel Assembly Length: | \leq 135.0 inches (nominal design) |
| g. Fuel Assembly Width: | \leq 4.70 inches (nominal design) |
| h. Fuel Assembly Weight: | \leq 400 lbs, including channels |

Table 2.1-1 (page 412 of 2440)
Fuel Assembly Limits

II. MPC MODEL: MPC-68F (continued)

A. Allowable Contents (continued)

2. Uranium oxide, BWR DAMAGED FUEL ASSEMBLIES, with or without ZR channels, placed in DAMAGED FUEL CONTAINERS. Uranium oxide BWR DAMAGED FUEL ASSEMBLIES shall meet the criteria specified in Table 2.1-3 for fuel assembly array/class 6x6A, 6x6C, 7x7A, or 8x8A, and meet the following specifications:

- | | |
|---|---|
| a. Cladding Type: | ZR |
| b. Maximum PLANAR-AVERAGE INITIAL ENRICHMENT: | As specified in Table 2.1-3 for the applicable fuel assembly array/class. |
| c. Initial Maximum Rod Enrichment: | As specified in Table 2.1-3 for the applicable fuel assembly array/class. |
| d. Post-irradiation Cooling Time and Average Burnup Per Assembly: | Cooling time \geq 18 years and an average burnup \leq 30,000 MWD/MTU. |
| e. Decay Heat Per Assembly: | \leq 115 Watts |
| f. Fuel Assembly Length: | \leq 135.0 inches (nominal design) |
| g. Fuel Assembly Width: | \leq 4.70 inches (nominal design) |
| h. Fuel Assembly Weight: | \leq 550 lbs, including channels and DFC |

Table 2.1-1 (page 513 of 2440)
Fuel Assembly Limits

II. MPC MODEL: MPC-68F (continued)

A. Allowable Contents (continued)

3. Uranium oxide, BWR FUEL DEBRIS, with or without ZR channels, placed in DAMAGED FUEL CONTAINERS. The original fuel assemblies for the uranium oxide BWR FUEL DEBRIS shall meet the criteria specified in Table 2.1-3 for fuel assembly array/class 6x6A, 6x6C, 7x7A, or 8x8A, and meet the following specifications:

a. Cladding Type:	ZR
b. Maximum PLANAR-AVERAGE INITIAL ENRICHMENT:	As specified in Table 2.1-3 for the applicable original fuel assembly array/class.
c. Initial Maximum Rod Enrichment:	As specified in Table 2.1-3 for the applicable original fuel assembly array/class.
d. Post-irradiation Cooling Time and Average Burnup Per Assembly	Cooling time \geq 18 years and an average burnup \leq 30,000 MWD/MTU for the original fuel assembly.
e. Decay Heat Per Assembly	\leq 115 Watts
f. Original Fuel Assembly Length	\leq 135.0 inches (nominal design)
g. Original Fuel Assembly Width	\leq 4.70 inches (nominal design)
h. Fuel Debris Weight	\leq 550 lbs, including channels and DFC

Table 2.1-1 (page 614 of 2440)
Fuel Assembly Limits

II. MPC MODEL: MPC-68F (continued)

A. Allowable Contents (continued)

4. Mixed oxide (MOX), BWR INTACT FUEL ASSEMBLIES, with or without ZR channels. MOX BWR INTACT FUEL ASSEMBLIES shall meet the criteria specified in Table 2.1-3 for fuel assembly array/class 6x6B, and meet the following specifications:

- | | |
|---|---|
| a. Cladding Type: | ZR |
| b. Maximum PLANAR-AVERAGE INITIAL ENRICHMENT: | As specified in Table 2.1-3 for fuel assembly array/class 6x6B. |
| c. Initial Maximum Rod Enrichment: | As specified in Table 2.1-3 for fuel assembly array/class 6x6B. |
| d. Post-irradiation Cooling Time and Average Burnup Per Assembly: | Cooling time \geq 18 years and an average burnup \leq 30,000 MWD/MTIHM. |
| e. Decay Heat Per Assembly | \leq 115 Watts |
| f. Fuel Assembly Length: | \leq 135.0 inches (nominal design) |
| g. Fuel Assembly Width: | \leq 4.70 inches (nominal design) |
| h. Fuel Assembly Weight: | \leq 400 lbs, including channels |

Table 2.1-1 (page 745 of 2440)
Fuel Assembly Limits

II. MPC MODEL: MPC-68F (continued)

A. Allowable Contents (continued)

5. Mixed oxide (MOX), BWR DAMAGED FUEL ASSEMBLIES, with or without ZR channels, placed in DAMAGED FUEL CONTAINERS. MOX BWR DAMAGED FUEL ASSEMBLIES shall meet the criteria specified in Table 2.1-3 for fuel assembly array/class 6x6B, and meet the following specifications:

- | | |
|---|---|
| a. Cladding Type: | ZR |
| b. Maximum PLANAR-AVERAGE INITIAL ENRICHMENT: | As specified in Table 2.1-3 for fuel assembly array/class 6x6B. |
| c. Initial Maximum Rod Enrichment: | As specified in Table 2.1-3 for fuel assembly array/class 6x6B. |
| d. Post-irradiation Cooling Time and Average Burnup Per Assembly: | Cooling time \geq 18 years and an average burnup \leq 30,000 MWD/MTIHM. |
| e. Decay Heat Per Assembly | \leq 115 Watts |
| f. Fuel Assembly Length: | \leq 135.0 inches (nominal design) |
| g. Fuel Assembly Width: | \leq 4.70 inches (nominal design) |
| h. Fuel Assembly Weight: | \leq 550 lbs, including channels and DFC |

Table 2.1-1 (page 846 of 2440)
Fuel Assembly Limits

II. MPC MODEL: MPC-68F (continued)

A. Allowable Contents (continued)

6. Mixed Oxide (MOX), BWR FUEL DEBRIS, with or without ZR channels, placed in DAMAGED FUEL CONTAINERS. The original fuel assemblies for the MOX BWR FUEL DEBRIS shall meet the criteria specified in Table 2.1-3 for fuel assembly array/class 6x6B, and meet the following specifications:

- | | |
|---|--|
| a. Cladding Type: | ZR |
| b. Maximum PLANAR-AVERAGE INITIAL ENRICHMENT: | As specified in Table 2.1-3 for original fuel assembly array/class 6x6B. |
| c. Initial Maximum Rod Enrichment: | As specified in Table 2.1-3 for original fuel assembly array/class 6x6B. |
| d. Post-irradiation Cooling Time and Average Burnup Per Assembly: | Cooling time \geq 18 years and an average burnup \leq 30,000 MWD/MTIHM for the original fuel assembly. |
| e. Decay Heat Per Assembly | \leq 115 Watts |
| f. Original Fuel Assembly Length: | \leq 135.0 inches (nominal design) |
| g. Original Fuel Assembly Width: | \leq 4.70 inches (nominal design) |
| h. Fuel Debris Weight: | \leq 550 lbs, including channels and DFC |

Table 2.1-1 (page 917 of 2440)
Fuel Assembly Limits

II. MPC MODEL: MPC-68F (continued)

A. Allowable Contents (continued)

7. Thoria rods (ThO_2 and UO_2) placed in Dresden Unit 1 Thoria Rod Canisters and meeting the following specifications:

- | | |
|---|--|
| a. Cladding Type: | ZR |
| b. Composition: | 98.2 wt.% ThO_2 , 1.8 wt. % UO_2 with an enrichment of 93.5 wt. % ^{235}U . |
| c. Number of Rods Per Thoria Rod Canister: | ≤ 18 |
| d. Decay Heat Per Thoria Rod Canister: | ≤ 115 Watts |
| e. Post-irradiation Fuel Cooling Time and Average Burnup Per Thoria Rod Canister: | A fuel post-irradiation cooling time ≥ 18 years and an average burnup $\leq 16,000$ MWD/MTIHM. |
| f. Initial Heavy Metal Weight: | ≤ 27 kg/canister |
| g. Fuel Cladding O.D.: | ≥ 0.412 inches |
| h. Fuel Cladding I.D.: | ≤ 0.362 inches |
| i. Fuel Pellet O.D.: | ≤ 0.358 inches |
| j. Active Fuel Length: | ≤ 111 inches |
| k. Canister Weight: | ≤ 550 lbs, including fuel |

Table 2.1-1 (page 108 of 2440)
Fuel Assembly Limits

II. MPC MODEL: MPC-68F (continued)

B. Quantity per MPC (up to a total of 68 assemblies):

(All fuel assemblies must be array/class 6x6A, 6x6B, 6x6C, 7x7A, or 8x8A):

Up to four (4) DFCs containing uranium oxide BWR FUEL DEBRIS or MOX BWR FUEL DEBRIS. The remaining MPC-68F fuel storage locations may be filled with fuel assemblies of the following type, as applicable:

1. Uranium oxide BWR INTACT FUEL ASSEMBLIES;
 2. MOX BWR INTACT FUEL ASSEMBLIES;
 3. Uranium oxide BWR DAMAGED FUEL ASSEMBLIES placed in DFCs;
 4. MOX BWR DAMAGED FUEL ASSEMBLIES placed in DFCs; or
 5. Up to one (1) Dresden Unit 1 Thoria Rod Canister.
- C. Fuel assemblies with stainless steel channels are not authorized for loading in the MPC-68F.
- D. Dresden Unit 1 fuel assemblies with one Antimony-Beryllium neutron source are authorized for loading in the MPC-68F. The Antimony-Beryllium source material shall be in a water rod location.

Table 2.1-1 (page 1127 of 2440)
Fuel Assembly Limits

III. MPC MODEL: MPC-68 and MPC-68FF

A. Allowable Contents

1. Uranium oxide or MOX BWR INTACT FUEL ASSEMBLIES listed in Table 2.1-3, with or without channels and meeting the following specifications:

- | | |
|--|---|
| a. Cladding Type: | ZR or Stainless Steel (SS) as specified in Table 2.1-3 for the applicable fuel assembly array/class |
| b. Maximum PLANAR-AVERAGE INITIAL ENRICHMENT: | As specified in Table 2.1-3 for the applicable fuel assembly array/class. |
| c. Initial Maximum Rod Enrichment | As specified in Table 2.1-3 for the applicable fuel assembly array/class. |
| e. Post-irradiation Cooling Time and Average Burnup Per Assembly | |
| i. Array/Classes 6x6A, 6x6B, 6x6C, 7x7A, and 8x8A | Cooling time \geq 18 years and an average burnup \leq 30,000 MWD/MTU (or MTU/MTIHM). |
| ii. Array/Class 8x8F | Cooling time \geq 10 years and an average burnup \leq 27,500 MWD/MTU. |
| iii. Array/Classes 10x10D and 10x10E | Cooling time \geq 10 years and an average burnup \leq 22,500 MWD/MTU. |
| iv. All Other Array/Classes | As specified in Section 2.4. |

Table 2.1-1 (page 128 of 2440)
Fuel Assembly Limits

III. MPC MODEL: MPC-68 and MPC-68FF (continued)

A. Allowable Contents (continued)

e. Decay Heat Per Assembly

- | | |
|--|------------------------------|
| i. Array/Classes 6x6A, 6X6b,
6x6C, 7x7A, and 8x8A | ≤ 115 Watts |
| ii. Array/Class 8x8F | ≤ 183.5 Watts |
| iii. Array/Classes 10x10D and
10x10E | ≤ 95 Watts |
| iv. All Other Array/Classes | As specified in Section 2.4. |

f. Fuel Assembly Length

- | | |
|---|--------------------------------------|
| i. Array/Class 6x6A, 6x6B,
6x6C, 7x7A, or 8x8A | ≤ 135.0 inches (nominal design) |
| ii. All Other Array/Classes | ≤ 176.5 inches (nominal design) |

g. Fuel Assembly Width

- | | |
|---|-------------------------------------|
| i. Array/Class 6x6A, 6x6B, 6x6C,
7x7A, or 8x8A | ≤ 4.70 inches (nominal design) |
| ii. All Other Array/Classes | ≤ 5.85 inches (nominal design) |

h. Fuel Assembly Weight

- | | |
|---|------------------------------------|
| i. Array/Class 6x6A, 6x6B, 6x6C,
7x7A, or 8x8A | ≤ 550 lbs, including channels |
| ii. All Other Array/Classes | ≤ 730 lbs, including channels |

Table 2.1-1 (page 1329 of 2440)
Fuel Assembly Limits

III. MPC MODEL: MPC-68 and MPC-68FF (continued)

A. Allowable Contents (continued)

2. Uranium oxide or MOX BWR DAMAGED FUEL ASSEMBLIES or FUEL DEBRIS, with or without channels, placed in DAMAGED FUEL CONTAINERS. Uranium oxide and MOX BWR DAMAGED FUEL ASSEMBLIES and FUEL DEBRIS shall meet the criteria specified in Table 2.1-3, and meet the following specifications:

- | | |
|---|---|
| a. Cladding Type: | ZR or Stainless Steel (SS) in accordance with Table 2.1-3 for the applicable fuel assembly array/class. |
| b. Maximum PLANAR-AVERAGE INITIAL ENRICHMENT: | |
| i. Array/Classes 6x6A, 6x6B, 6x6C, 7x7A, and 8x8A. | As specified in Table 2.1-3 for the applicable fuel assembly array/class. |
| ii. All Other Array Classes | ≤ 4.0 wt.% ²³⁵ U. |
| c. Initial Maximum Rod Enrichment | As specified in Table 2.1-3 for the applicable fuel assembly array/class. |
| d. Post-irradiation Cooling Time and Average Burnup Per Assembly: | |
| i. Array/Class 6x6A, 6x6B, 6x6C, 7x7A, or 8x8A | Cooling time ≥ 18 years and an average burnup $\leq 30,000$ MWD/MTU (or MWD/MTIHM). |
| ii. Array/Class 8x8F | Cooling time ≥ 10 years and an average burnup $\leq 27,500$ MWD/MTU. |
| iii. Array/Class 10x10D and 10x10E | Cooling time ≥ 10 years and an average burnup $\leq 22,500$ MWD/MTU. |
| iv. All Other Array/Classes | As specified in Section 2.4. |

Table 2.1-1 (page ~~1430~~ of ~~2440~~)
Fuel Assembly Limits

III. MPC MODEL: MPC-68 and MPC-68FF (continued)

A. Allowable Contents (continued)

e. Decay Heat Per Assembly

- | | | |
|------|--|------------------------------|
| i. | Array/Class 6x6A, 6x6B, 6x6C,
7x7A, or 8x8A | ≤ 115 Watts |
| ii. | Array/Class 8x8F | ≤ 183.5 Watts |
| iii. | Array/Classes 10x10D and
10x10E | ≤ 95 Watts |
| iv. | All Other Array/Classes | As specified in Section 2.4. |

f. Fuel Assembly Length

- | | | |
|-----|--|--------------------------------------|
| i. | Array/Class 6x6A, 6x6B, 6x6C,
7x7A, or 8x8A | ≤ 135.0 inches (nominal design) |
| ii. | All Other Array/Classes | ≤ 176.5 inches (nominal design) |

g. Fuel Assembly Width

- | | | |
|-----|--|-------------------------------------|
| i. | Array/Class 6x6A, 6x6B, 6x6C,
7x7A, or 8x8A | ≤ 4.70 inches (nominal design) |
| ii. | All Other Array/Classes | ≤ 5.85 inches (nominal design) |

h. Fuel Assembly Weight

- | | | |
|-----|--|--|
| i. | Array/Class 6x6A, 6x6B, 6x6C,
7x7A, or 8x8A | ≤ 550 lbs, including channels and DFC |
| ii. | All Other Array/Classes | ≤ 730 lbs, including channels and DFC |

Table 2.1-1 (page 1531 of 2440)
Fuel Assembly limits

III. MPC MODEL: MPC-68 and MPC-68FF (continued)

A. Allowable Contents (continued)

3. Thoria rods (ThO_2 and UO_2) placed in Dresden Unit 1 Thoria Rod Canisters and meeting the following specifications:
 - a. Cladding type: ZR
 - b. Composition: 98.2 wt.% ThO_2 , 1.8 wt.% UO_2 with an enrichment of 93.5 wt.% ^{235}U .
 - c. Number of Rods per Thoria Rod Canister: ≤ 18
 - d. Decay Heat Per Thoria Rod Canister: ≤ 115 Watts
 - e. Post-irradiation Fuel Cooling Time and Average Burnup per Thoria Rod Canister: A fuel post-irradiation cooling time ≥ 18 years and an average burnup $\leq 16,000$ MWD/MTIHM
 - f. Initial Heavy Metal Weight: ≤ 27 kg/canister
 - g. Fuel Cladding O.D.: ≥ 0.412 inches
 - h. Fuel Cladding I.D.: ≤ 0.362 inches
 - i. Fuel Pellet O.D.: ≤ 0.358 inches
 - j. Active Fuel Length: ≤ 111 inches
 - k. Canister Weight: ≤ 550 lbs, including fuel

Table 2.1-1 (page 1632 of 2440)
Fuel Assembly Limits

III. MPC MODEL: MPC-68 and MPC-68FF (continued)

B. Quantity per MPC (up to a total of 68 assemblies)

1. For fuel assembly array/classes 6x6A, 6X6B, 6x6C, 7x7A, or 8x8A, up to 68 BWR INTACT FUEL ASSEMBLIES and/or DAMAGED FUEL ASSEMBLIES. Up to eight (8) DFCs containing FUEL DEBRIS from these array/classes may be stored.
2. For all other array/classes, up to sixteen (16) DFCs containing BWR DAMAGED FUEL ASSEMBLIES and/or up to eight (8) DFCs containing FUEL DEBRIS. DFCs shall be located only in fuel storage locations 1, 2, 3, 8, 9, 16, 25, 34, 35, 44, 53, 60, 61, 66, 67, and/or 68. The remaining fuel storage locations may be filled with fuel assemblies of the following type:
 - i. Uranium Oxide BWR INTACT FUEL ASSEMBLIES; or
 - ii. MOX BWR INTACT FUEL ASSEMBLIES.
3. Up to one (1) Dresden Unit 1 Thoria Rod Canister

C. Dresden Unit 1 fuel assemblies with one Antimony-Beryllium neutron source are authorized for loading. The Antimony-Beryllium source material shall be in a water rod location.

D. Array/Class 10x10D and 10x10E fuel assemblies in stainless steel channels must be stored in fuel storage locations 19 - 22, 28 - 31, 38 -41, and/or 47 - 50 (see Figure 2.1-4).

Table 2.1-1 (page 1733 of 2440)
Fuel Assembly Limits

IV. MPC MODEL: MPC-24E and MPC-24EF

A. Allowable Contents

1. Uranium oxide, PWR INTACT FUEL ASSEMBLIES listed in Table 2.1-2, with or without NON-FUEL HARDWARE and meeting the following specifications (Note 1):

- | | |
|---|---|
| a. Cladding Type: | ZR or Stainless Steel (SS) as specified in Table 2.1-2 for the applicable fuel assembly array/class |
| b. Initial Enrichment: | As specified in Table 2.1-2 for the applicable fuel assembly array/class. |
| c. Post-irradiation Cooling Time and Average Burnup Per Assembly: | |
| i. Array/Classes 14x14D, 14x14E, and 15x15G | Cooling time \geq 8 years and an average burnup \leq 40,000 MWD/MTU. |
| ii. All Other Array/Classes | As specified in Section 2.4. |
| iii. NON-FUEL HARDWARE | As specified in Table 2.1-8. |

Table 2.1-1 (page 1834 of 2440)
Fuel Assembly Limits

IV. MPC MODEL: MPC-24E and MPC-24EF (continued)

A. Allowable Contents (continued)

- d. Decay Heat Per Fuel Storage Location:
 - i. Array/Classes 14x14D, 14x14E, and 15x15G ≤ 710 Watts.
 - ii. All other Array/Classes As specified in Section 2.4.
- e. Fuel Assembly Length: ≤ 176.8 inches (nominal design)
- f. Fuel Assembly Width: ≤ 8.54 inches (nominal design)
- g. Fuel Assembly Weight: $\leq 1,720$ lbs (including NON-FUEL HARDWARE and DFC) for assemblies that do not require fuel spacers, otherwise, $\leq 1,680$ lbs (including NON-FUEL HARDWARE and DFC)

Table 2.1-1 (page 1935 of 2440)
Fuel Assembly Limits

IV. MPC MODEL: MPC-24E and MPC-24EF (continued)

A. Allowable Contents (continued)

2. Uranium oxide, PWR DAMAGED FUEL ASSEMBLIES and FUEL DEBRIS, with or without NON-FUEL HARDWARE, placed in DAMAGED FUEL CONTAINERS. Uranium oxide PWR DAMAGED FUEL ASSEMBLIES and FUEL DEBRIS shall meet the criteria specified in Table 2.1-2 and meet the following specifications (Note 1):

- | | |
|---|---|
| a. Cladding Type: | ZR or Stainless Steel (SS) as specified in Table 2.1-2 for the applicable fuel assembly array/class |
| b. Initial Enrichment: | As specified in Table 2.1-2 for the applicable fuel assembly array/class. |
| c. Post-irradiation Cooling Time and Average Burnup Per Assembly: | |
| i. Array/Classes 14x14D, 14x14E, and 15x15G | Cooling time \geq 8 years and an average burnup \leq 40,000 MWD/MTU. |
| ii. All Other Array/Classes | As specified in Section 2.4. |
| iii. NON-FUEL HARDWARE | As specified in Table 2.1-8. |

Table 2.1-1 (page 2036 of 2440)
Fuel Assembly Limits

IV. MPC MODEL: MPC-24E and MPC-24EF (continued)

A. Allowable Contents (continued)

- d. Decay Heat Per Fuel Storage Location:
 - ≤ 710 Watts.
 - i. Array/Classes 14x14D, 14x14E, and 15x15G
As specified in Section 2.4.
 - ii. All Other Array/Classes
- e. Fuel Assembly Length ≤ 176.8 inches (nominal design)
- f. Fuel Assembly Width ≤ 8.54 inches (nominal design)
- g. Fuel Assembly Weight ≤ 1,720 lbs (including NON-FUEL HARDWARE and DFC) for assemblies that do not require fuel spacers, otherwise, ≤ 1,680 lbs (including NON-FUEL HARDWARE and DFC)

B. Quantity per MPC: Up to four (4) DAMAGED FUEL ASSEMBLIES and/or FUEL DEBRIS in DAMAGED FUEL CONTAINERS, stored in fuel storage locations 3, 6, 19 and/or 22. The remaining fuel storage locations may be filled with PWR INTACT FUEL ASSEMBLIES meeting the applicable specifications.

C. One NSA is permitted for loading.

Note 1: Fuel assemblies containing BPRAs, TPDs, WABAs, water displacement guide tube plugs, orifice rod assemblies, or vibration suppressor inserts, *with or without ITTRs*, may be stored in any fuel storage location. Fuel assemblies containing APSRs or NSAs may only be loaded in fuel storage locations 9, 10, 15, and/or 16 (see Figure 2.1-2). Fuel assemblies containing CRAs, RCCAs, or CEAs may only be stored in fuel storage locations 4, 5, 8-11, 14-17, 20 and/or 21 (see Figure 2.1-2). These requirements are in addition to any other requirements specified for uniform or regionalized fuel loading.

Table 2.1-1 (page 2137 of 2440)
Fuel Assembly Limits

V. MPC MODEL: MPC-32 and MPC-32F

A. Allowable Contents

1. Uranium oxide, PWR INTACT FUEL ASSEMBLIES listed in Table 2.1-2, with or without NON-FUEL HARDWARE and meeting the following specifications (Note 1):

- | | |
|---|--|
| a. Cladding Type: | ZR or Stainless Steel (SS) as specified in Table 2.1-2 for the applicable fuel assembly array/class |
| b. Initial Enrichment: | As specified in Table 2.1-2 for the applicable fuel assembly array/class. |
| c. Post-irradiation Cooling Time and Average Burnup Per Assembly: | |
| i. Array/Classes 14x14D, 14x14E, and 15x15G | Cooling time \geq 9 years and an average burnup \leq 30,000 MWD/MTU or cooling time \geq 20 years and an average burnup \leq 40,000 MWD/MTU. |
| ii. All Other Array/Classes | As specified in Section 2.4. |
| iii. NON-FUEL HARDWARE | As specified in Table 2.1-8. |

Table 2.1-1 (page 2238 of 2440)
Fuel Assembly Limits

V. MPC MODEL: MPC-32 and MPC-32F (cont'd)

A. Allowable Contents (cont'd)

d. Decay Heat Per Fuel
Storage Location:

i. Array/Classes 14x14D, 14x14E, and 15x15G ≤ 500 Watts.

ii. All Other Array/Classes As specified in Section 2.4.

e. Fuel Assembly Length ≤ 176.8 inches (nominal design)

f. Fuel Assembly Width ≤ 8.54 inches (nominal design)

g. Fuel Assembly Weight $\leq 1,720$ lbs (including NON-FUEL HARDWARE and DFC) for assemblies that do not require fuel spacers, otherwise, $\leq 1,680$ lbs (including NON-FUEL HARDWARE and DFC)

Table 2.1-1 (page 2339 of 2440)
Fuel Assembly Limits

V. MPC MODEL: MPC-32 and MPC-32F (cont'd)

A. Allowable Contents (cont'd)

2. Uranium oxide, PWR DAMAGED FUEL ASSEMBLIES and FUEL DEBRIS, with or without NON-FUEL HARDWARE, placed in DAMAGED FUEL CONTAINERS. Uranium oxide PWR DAMAGED FUEL ASSEMBLIES and FUEL DEBRIS shall meet the criteria specified in Table 2.1-2 and meet the following specifications (Note 1):

- | | |
|---|--|
| a. Cladding Type: | ZR or Stainless Steel (SS) as specified in Table 2.1-2 for the applicable fuel assembly array/class |
| b. Initial Enrichment: | As specified in Table 2.1-2 for the applicable fuel assembly array/class. |
| c. Post-irradiation Cooling Time and Average Burnup Per Assembly: | |
| i. Array/Classes 14x14D, 14x14E, and 15x15G | Cooling time \geq 9 years and an average burnup \leq 30,000 MWD/MTU or cooling time \geq 20 years and an average burnup \leq 40,000 MWD/MTU. |
| ii. All Other Array/Classes | As specified in Section 2.4. |
| iii. NON-FUEL HARDWARE | As specified in Table 2.1-8. |

Table 2.1-1 (page 2440 of 2440)
Fuel Assembly Limits

V. MPC MODEL: MPC-32 and MPC-32F (cont'd)

A. Allowable Contents (cont'd)

d. Decay Heat Per Fuel
Storage Location:

- | | |
|--|--|
| i. Array/Classes 14x14D,
14x14E, and 15x15G | ≤ 500 Watts. |
| ii. All Other Array/Classes | As specified in Section 2.3. |
| e. Fuel Assembly Length | ≤ 176.8 inches (nominal design) |
| f. Fuel Assembly Width | ≤ 8.54 inches (nominal design) |
| g. Fuel Assembly Weight | $\leq 1,720$ lbs (including NON-FUEL
HARDWARE and DFC) for assemblies
that do not require fuel spacers,
otherwise, $\leq 1,680$ lbs (including NON-
FUEL HARDWARE and DFC) |

B. Quantity per MPC: Up to eight (8) DAMAGED FUEL ASSEMBLIES and/or FUEL DEBRIS in DAMAGED FUEL CONTAINERS, stored in fuel storage locations 1, 4, 5, 10, 23, 28, 29, and/or 32. The remaining fuel storage locations may be filled with PWR INTACT FUEL ASSEMBLIES meeting the applicable specifications.

C. One NSA is permitted for loading.

Note 1: Fuel assemblies containing BPRAs, TPDs, WABAs, water displacement guide tube plugs, orifice rod assemblies, or vibration suppressor inserts, *with or without ITTRs*, may be stored in any fuel storage location. Fuel assemblies containing NSAs may only be loaded in fuel storage locations 13, 14, 19 and/or 20 (see Figure 2.1-3). Fuel assemblies containing CRAs, RCCAs, CEAs or APSRs may only be loaded in fuel storage locations 7, 8, 12-15, 18-21, 25 and/or 26 (see Figure 2.1-3). These requirements are in addition to any other requirements specified for uniform or regionalized fuel loading.

Table 2.1-2 (page 1 of 4)
PWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Fuel Assembly Array/Class	14x14A	14x14B	14x14C	14x14D	14x14E
Clad Material	ZR	ZR	ZR	SS	SS
Design Initial U (kg/assy.) (Note 3)	≤ 365	≤ 412	≤ 438	≤ 400	≤ 206
Initial Enrichment (MPC-24, 24E and 24EF without soluble boron credit) (wt % ²³⁵ U) (Note 7)	≤ 4.6 (24) ≤ 5.0 (24E/24EF)	≤ 4.6 (24) ≤ 5.0 (24E/24EF)	≤ 4.6 (24) ≤ 5.0 (24E/24EF)	≤ 4.0 (24) ≤ 5.0 (24E/24EF)	≤ 5.0 (24) ≤ 5.0 (24E/24EF)
Initial Enrichment (MPC-24, 24E, 24EF, 32, or 32F with soluble boron credit - see Note 5) (wt % ²³⁵ U)	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
No. of Fuel Rod Locations	179	179	176	180	173
Fuel Rod Clad O.D. (in.)	≥ 0.400	≥ 0.417	≥ 0.440	≥ 0.422	≥ 0.3415
Fuel Rod Clad I.D. (in.)	≤ 0.3514	≤ 0.3734	≤ 0.3880	≤ 0.3890	≤ 0.3175
Fuel Pellet Dia. (in.) (Note 8)	≤ 0.3444	≤ 0.3659	≤ 0.3805	≤ 0.3835	≤ 0.3130
Fuel Rod Pitch (in.)	≤ 0.556	≤ 0.556	≤ 0.580	≤ 0.556	Note 6
Active Fuel Length (in.)	≤ 150	≤ 150	≤ 150	≤ 144	≤ 102
No. of Guide and/or Instrument Tubes	17	17	5 (Note 4)	16	0
Guide/Instrument Tube Thickness (in.)	≥ 0.017	≥ 0.017	≥ 0.038	≥ 0.0145	N/A

Table 2.1-2 (page 2 of 4)
PWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Fuel Assembly Array/Class	15x15A	15x15B	15x15C	15x15D	15x15E	15x15F
Clad Material	ZR	ZR	ZR	ZR	ZR	ZR
Design Initial U (kg/assy.) (Note 3)	≤ 473	≤ 473	≤ 473	≤ 495	≤ 495	≤ 495
Initial Enrichment (MPC-24, 24E and 24EF without soluble boron credit) (wt % ²³⁵ U) (Note 7)	≤ 4.1 (24) ≤ 4.5 (24E/24EF)	≤ 4.1 (24) ≤ 4.5 (24E/24EF)	≤ 4.1 (24) ≤ 4.5 (24E/24EF)	≤ 4.1 (24) ≤ 4.5 (24E/24EF)	≤ 4.1 (24) ≤ 4.5 (24E/24EF)	≤ 4.1 (24) ≤ 4.5 (24E/24EF)
Initial Enrichment (MPC-24, 24E, 24EF, 32, or 32F with soluble boron credit - see Note 5) (wt % ²³⁵ U)	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
No. of Fuel Rod Locations	204	204	204	208	208	208
Fuel Rod Clad O.D. (in.)	≥ 0.418	≥ 0.420	≥ 0.417	≥ 0.430	≥ 0.428	≥ 0.428
Fuel Rod Clad I.D. (in.)	≤ 0.3660	≤ 0.3736	≤ 0.3640	≤ 0.3800	≤ 0.3790	≤ 0.3820
Fuel Pellet Dia. (in.) (Note 8)	≤ 0.3580	≤ 0.3671	≤ 0.3570	≤ 0.3735	≤ 0.3707	≤ 0.3742
Fuel Rod Pitch (in.)	≤ 0.550	≤ 0.563	≤ 0.563	≤ 0.568	≤ 0.568	≤ 0.568
Active Fuel Length (in.)	≤ 150	≤ 150	≤ 150	≤ 150	≤ 150	≤ 150
No. of Guide and/or Instrument Tubes	21	21	21	17	17	17
Guide/Instrument Tube Thickness (in.)	≥ 0.0165	≥ 0.015	≥ 0.0165	≥ 0.0150	≥ 0.0140	≥ 0.0140

Table 2.1-2 (page 3 of 4)
PWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Fuel Assembly Array/ Class	15x15G	15x15H	16x16A	17x17A	17x17B	17x17C
Clad Material	SS	ZR	ZR	ZR	ZR	ZR
Design Initial U (kg/assy.) (Note 3)	≤ 420	≤ 495	≤ 448	≤ 433	≤ 474	≤ 480
Initial Enrichment (MPC-24, 24E, and 24EF without soluble boron credit) (wt % ²³⁵ U) (Note 7)	≤ 4.0 (24) ≤ 4.5 (24E/24EF)	≤ 3.8 (24) ≤ 4.2 (24E/24EF)	≤ 4.6 (24) ≤ 5.0 (24E/24EF)	≤ 4.0 (24) ≤ 4.4 (24E/24EF)	≤ 4.0 (24) ≤ 4.4 (24E/24EF)	≤ 4.0 (24) ≤ 4.4 (24E/24EF)
Initial Enrichment (MPC-24, 24E, 24EF, 32, or 32F with soluble boron credit - see Note 5) (wt % ²³⁵ U)	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
No. of Fuel Rod Locations	204	208	236	264	264	264
Fuel Rod Clad O.D. (in.)	≥ 0.422	≥ 0.414	≥ 0.382	≥ 0.360	≥ 0.372	≥ 0.377
Fuel Rod Clad I.D. (in.)	≤ 0.3890	≤ 0.3700	≤ 0.3350	≤ 0.3150	≤ 0.3310	≤ 0.3330
Fuel Pellet Dia. (in.) (Note 8)	≤ 0.3825	≤ 0.3622	≤ 0.3255	≤ 0.3088	≤ 0.3232	≤ 0.3252
Fuel Rod Pitch (in.)	≤ 0.563	≤ 0.568	≤ 0.506	≤ 0.496	≤ 0.496	≤ 0.502
Active Fuel Length (in.)	≤ 144	≤ 150	≤ 150	≤ 150	≤ 150	≤ 150
No. of Guide and/or Instrument Tubes	21	17	5 (Note 4)	25	25	25
Guide/Instrument Tube Thickness (in.)	≥ 0.0145	≥ 0.0140	≥ 0.0350	≥ 0.016	≥ 0.014	≥ 0.020

Table 2.1-2 (page 4 of 4)
PWR FUEL ASSEMBLY CHARACTERISTICS

Notes:

1. All dimensions are design nominal values. Maximum and minimum dimensions are specified to bound variations in design nominal values among fuel assemblies within a given array/class.
2. Deleted.
3. Design initial uranium weight is the nominal uranium weight specified for each assembly by the fuel manufacturer or reactor user. For each PWR fuel assembly, the total uranium weight limit specified in this table may be increased up to 2.0 percent for comparison with users' fuel records to account for manufacturer's tolerances.
4. Each guide tube replaces four fuel rods.
5. Soluble boron concentration per LCO 3.3.1.
6. This fuel assembly array/class includes only the Indian Point Unit 1 fuel assembly. This fuel assembly has two pitches in different sectors of the assembly. These pitches are 0.441 inches and 0.453 inches.
7. For those MPCs loaded with both INTACT FUEL ASSEMBLIES and DAMAGED FUEL ASSEMBLIES or FUEL DEBRIS, the maximum initial enrichment of the INTACT FUEL ASSEMBLIES, DAMAGED FUEL ASSEMBLIES and FUEL DEBRIS is 4.0 wt.% ²³⁵U.
8. Annular fuel pellets are allowed in the top and bottom 12" of the active fuel length.

Table 2.1-3 (page 1 of 5)
BWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Fuel Assembly Array/Class	6x6A	6x6B	6x6C	7x7A	7x7B	8x8A
Clad Material	ZR	ZR	ZR	ZR	ZR	ZR
Design Initial U (kg/assy.) (Note 3)	≤ 110	≤ 110	≤ 110	≤ 100	≤ 198	≤ 120
Maximum PLANAR-AVERAGE INITIAL ENRICHMENT (wt.% ²³⁵ U) (Note 14)	≤ 2.7	≤ 2.7 for the UO ₂ rods. See Note 4 for MOX rods	≤ 2.7	≤ 2.7	≤ 4.2	≤ 2.7
Initial Maximum Rod Enrichment (wt.% ²³⁵ U)	≤ 4.0	≤ 4.0	≤ 4.0	≤ 5.5	≤ 5.0	≤ 4.0
No. of Fuel Rod Locations	35 or 36	35 or 36 (up to 9 MOX rods)	36	49	49	63 or 64
Fuel Rod Clad O.D. (in.)	≥ 0.5550	≥ 0.5625	≥ 0.5630	≥ 0.4860	≥ 0.5630	≥ 0.4120
Fuel Rod Clad I.D. (in.)	≤ 0.5105	≤ 0.4945	≤ 0.4990	≤ 0.4204	≤ 0.4990	≤ 0.3620
Fuel Pellet Dia. (in.)	≤ 0.4980	≤ 0.4820	≤ 0.4880	≤ 0.4110	≤ 0.4910	≤ 0.3580
Fuel Rod Pitch (in.)	≤ 0.710	≤ 0.710	≤ 0.740	≤ 0.631	≤ 0.738	≤ 0.523
Active Fuel Length (in.)	≤ 120	≤ 120	≤ 77.5	≤ 80	≤ 150	≤ 120
No. of Water Rods (Note 11)	1 or 0	1 or 0	0	0	0	1 or 0
Water Rod Thickness (in.)	> 0	> 0	N/A	N/A	N/A	≥ 0
Channel Thickness (in.)	≤ 0.060	≤ 0.060	≤ 0.060	≤ 0.060	≤ 0.120	≤ 0.100

Table 2.1-3 (2 of 5)
BWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Fuel Assembly Array/Class	8x8B	8x8C	8x8D	8x8E	8x8F	9x9A
Clad Material	ZR	ZR	ZR	ZR	ZR	ZR
Design Initial U (kg/assy.) (Note 3)	≤ 192	≤ 190	≤ 190	< 190	≤ 191	≤ 180
Maximum PLANAR-AVERAGE INITIAL ENRICHMENT (wt.% ²³⁵ U) (Note 14)	≤ 4.2	≤ 4.2	≤ 4.2	≤ 4.2	≤ 4.0	≤ 4.2
Initial Maximum Rod Enrichment (wt.% ²³⁵ U)	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
No. of Fuel Rod Locations	63 or 64	62	60 or 61	59	64	74/66 (Note 5)
Fuel Rod Clad O.D. (in.)	≥ 0.4840	≥ 0.4830	≥ 0.4830	≥ 0.4930	≥ 0.4576	≥ 0.4400
Fuel Rod Clad I.D. (in.)	≤ 0.4295	≤ 0.4250	≤ 0.4230	≤ 0.4250	≤ 0.3996	≤ 0.3840
Fuel Pellet Dia. (in.)	≤ 0.4195	≤ 0.4160	≤ 0.4140	≤ 0.4160	≤ 0.3913	≤ 0.3760
Fuel Rod Pitch (in.)	≤ 0.642	≤ 0.641	≤ 0.640	≤ 0.640	≤ 0.609	≤ 0.566
Design Active Fuel Length (in.)	≤ 150	≤ 150	≤ 150	≤ 150	≤ 150	≤ 150
No. of Water Rods (Note 11)	1 or 0	2	1 - 4 (Note 7)	5	N/A (Note 12)	2
Water Rod Thickness (in.)	≥ 0.034	> 0.00	> 0.00	≥ 0.034	≥ 0.0315	> 0.00
Channel Thickness (in.)	≤ 0.120	≤ 0.120	≤ 0.120	≤ 0.100	≤ 0.055	≤ 0.120

Table 2.1-3 (page 3 of 5)
BWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Fuel Assembly Array/Class	9x9B	9x9C	9x9D	9x9E (Note 13)	9x9F (Note 13)	9x9G
Clad Material	ZR	ZR	ZR	ZR	ZR	ZR
Design Initial U (kg/assy.) (Note 3)	≤ 180	≤ 182	≤ 182	≤ 183	≤ 183	≤ 164
Maximum PLANAR-AVERAGE INITIAL ENRICHMENT (wt.% ²³⁵ U) (Note 14)	≤ 4.2	≤ 4.2	≤ 4.2	≤ 4.0	≤ 4.0	≤ 4.2
Initial Maximum Rod Enrichment (wt.% ²³⁵ U)	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
No. of Fuel Rod Locations	72	80	79	76	76	72
Fuel Rod Clad O.D. (in.)	≥ 0.4330	≥ 0.4230	≥ 0.4240	≥ 0.4170	≥ 0.4430	≥ 0.4240
Fuel Rod Clad I.D. (in.)	≤ 0.3810	≤ 0.3640	≤ 0.3640	≤ 0.3640	≤ 0.3860	≤ 0.3640
Fuel Pellet Dia. (in.)	≤ 0.3740	≤ 0.3565	≤ 0.3565	≤ 0.3530	≤ 0.3745	≤ 0.3565
Fuel Rod Pitch (in.)	≤ 0.572	≤ 0.572	≤ 0.572	≤ 0.572	≤ 0.572	≤ 0.572
Design Active Fuel Length (in.)	≤ 150	≤ 150	≤ 150	≤ 150	≤ 150	≤ 150
No. of Water Rods (Note 11)	1 (Note 6)	1	2	5	5	1 (Note 6)
Water Rod Thickness (in.)	> 0.00	≥ 0.020	≥ 0.0300	≥ 0.0120	≥ 0.0120	≥ 0.0320
Channel Thickness (in.)	≤ 0.120	≤ 0.100	≤ 0.100	≤ 0.120	≤ 0.120	≤ 0.120

Table 2.1-3 (page 4 of 5)
BWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

Fuel Assembly Array/Class	10x10A	10x10B	10x10C	10x10D	10x10E
Clad Material	ZR	ZR	ZR	SS	SS
Design Initial U (kg/assy.) (Note 3)	≤ 188	≤ 188	≤ 179	≤ 125	≤ 125
Maximum PLANAR-AVERAGE INITIAL ENRICHMENT (wt.% ²³⁵ U) (Note 14)	≤ 4.2	≤ 4.2	≤ 4.2	≤ 4.0	≤ 4.0
Initial Maximum Rod Enrichment (wt.% ²³⁵ U)	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
No. of Fuel Rod Locations	92/78 (Note 8)	91/83 (Note 9)	96	100	96
Fuel Rod Clad O.D. (in.)	≥ 0.4040	≥ 0.3957	≥ 0.3780	≥ 0.3960	≥ 0.3940
Fuel Rod Clad I.D. (in.)	≤ 0.3520	≤ 0.3480	≤ 0.3294	≤ 0.3560	≤ 0.3500
Fuel Pellet Dia. (in.)	≤ 0.3455	≤ 0.3420	≤ 0.3224	≤ 0.3500	≤ 0.3430
Fuel Rod Pitch (in.)	≤ 0.510	≤ 0.510	≤ 0.488	≤ 0.565	≤ 0.557
Design Active Fuel Length (in.)	≤ 150	≤ 150	≤ 150	≤ 83	≤ 83
No. of Water Rods (Note 11)	2	1 (Note 6)	5 (Note 10)	0	4
Water Rod Thickness (in.)	≥ 0.0300	> 0.00	≥ 0.031	N/A	≥ 0.022
Channel Thickness (in.)	≤ 0.120	≤ 0.120	≤ 0.055	≤ 0.080	≤ 0.080

Table 2.1-3 (page 5 of 5)
BWR FUEL ASSEMBLY CHARACTERISTICS

Notes:

1. All dimensions are design nominal values. Maximum and minimum dimensions are specified to bound variations in design nominal values among fuel assemblies within a given array/class.
2. Deleted.
3. Design initial uranium weight is the nominal uranium weight specified for each assembly by the fuel manufacturer or reactor user. For each BWR fuel assembly, the total uranium weight limit specified in this table may be increased up to 1.5 percent for comparison with users' fuel records to account for manufacturer tolerances.
4. ≤ 0.635 wt. % ^{235}U and ≤ 1.578 wt. % total fissile plutonium (^{239}Pu and ^{241}Pu), (wt. % of total fuel weight, i.e., UO_2 plus PuO_2).
5. This assembly class contains 74 total rods; 66 full length rods and 8 partial length rods.
6. Square, replacing nine fuel rods.
7. Variable.
8. This assembly contains 92 total fuel rods; 78 full length rods and 14 partial length rods.
9. This assembly class contains 91 total fuel rods; 83 full length rods and 8 partial length rods.
10. One diamond-shaped water rod replacing the four center fuel rods and four rectangular water rods dividing the assembly into four quadrants.
11. These rods may also be sealed at both ends and contain Zr material in lieu of water.
12. This assembly is known as "QUAD+." It has four rectangular water cross segments dividing the assembly into four quadrants.
13. For the SPC 9x9-5 fuel assembly, each fuel rod must meet either the 9x9E or the 9x9F set of limits for clad O.D., clad I.D., and pellet diameter.
14. For those MPCs loaded with both INTACT FUEL ASSEMBLIES and DAMAGED FUEL ASSEMBLIES or FUEL DEBRIS, the maximum PLANAR AVERAGE INITIAL ENRICHMENT for the INTACT FUEL ASSEMBLIES is limited to 3.7 wt.% ^{235}U , as applicable.

Table 2.1-4

TABLE DELETED

Table 2.1-5

TABLE DELETED

Table 2.1-6

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Table 2.1-7
TABLE DELETED

Table 2.1-8
NON-FUEL HARDWARE COOLING AND AVERAGE BURNUP (Notes 1, 2, and 3, and 8)

Post-irradiation Cooling Time (years)	INSERTS (Note 4) BURNUP (MWD/MTU)	NSA or GUIDE TUBE HARDWARE (Note 5) BURNUP (MWD/MTU)	CONTROL COMPONENT (Note 6) BURNUP (MWD/MTU)	APSR BURNUP (MWD/MTU)
≥ 3	≤ 24,635	NA (Note 7)	NA	NA
≥ 4	≤ 30,000	≤ 20,000	NA	NA
≥ 5	≤ 36,748	≤ 25,000	≤ 630,000	≤ 45,000
≥ 6	≤ 44,102	≤ 30,000	-	≤ 54,500
≥ 7	≤ 52,900	≤ 40,000	-	≤ 68,000
≥ 8	≤ 60,000	≤ 45,000	-	≤ 83,000
≥ 9	-	≤ 50,000	-	≤ 111,000
≥ 10	-	≤ 60,000	-	≤ 180,000
≥ 11	-	≤ 75,000	-	≤ 630,000
≥ 12	-	≤ 90,000	-	-
≥ 13	-	≤ 180,000	-	-
≥ 14	-	≤ 630,000	-	-

- Notes:
1. Burnups for NON-FUEL HARDWARE are to be determined based on the burnup and uranium mass of the fuel assemblies in which the component was inserted during reactor operation.
 2. Linear interpolation between points is permitted, except that NSA or Guide Tube Hardware and APSR burnups > 180,000 MWD/MTU and ≤ 630,000 MWD/MTU must be cooled ≥ 14 years and ≥ 11 years, respectively.
 3. Applicable to uniform loading and regionalized loading.
 4. Includes Burnable Poison Rod Assemblies (BPRAs), Wet Annular Burnable Absorbers (WABAs), and vibration suppressor inserts..
 5. Includes Thimble Plug Devices (TPDs), water displacement guide tube plugs, and orifice rod assemblies.
 6. Includes Control Rod Assemblies (CRAs), Control Element Assemblies (CEAs), and Rod Cluster Control Assemblies (RCCAs).
 7. NA means not authorized for loading at this cooling time.
 8. *Non-fuel hardware burnup and cooling times are not applicable to ITTRs since they are installed post-irradiation.*

2.4 Decay Heat, Burnup, and Cooling Time Limits for ZR-Clad Fuel

This section provides the limits on ZR-clad fuel assembly decay heat, burnup, and cooling time for storage in the HI-STORM 100 System. The method to calculate the limits and verify compliance, including examples, is provided in Chapter 12 of the HI-STORM 100 FSAR.

2.4.1 Uniform Fuel Loading Decay Heat Limits for ZR-clad fuel

Table 2.4-1 provides the maximum allowable decay heat per fuel storage location for ZR-clad fuel in uniform fuel loading for each MPC model.

Table 2.4-1

Maximum Allowable Decay Heat per Fuel Storage Location
(Uniform Loading, ZR-Clad)

MPC Model	Decay Heat per Fuel Storage Location (kW)
Intact Fuel Assemblies	
MPC-24	≤ 1.416
MPC-24E/24EF	≤ 1.416
MPC-32/32F	≤ 1.062
MPC-68/68FF	≤ 0.500

2.4.2 Regionalized Fuel Loading Decay Heat Limits for ZR-Clad Fuel

Table 2.4-2 provides the maximum allowable decay heat per fuel storage location for fuel in regionalized loading is determined using the following equations:

$$Q(X) = 2 \times Q_0 / (1 + X^y)$$

$$y = 0.23 / X^{0.1}$$

2.4.2 Regionalized Fuel Loading Decay Heat Limits for ZR-Clad Fuel (cont'd)

$$q_2 = Q(X) / (n_1 \times X + n_2)$$

$$q_1 = q_2 \times X$$

Where:

$$Q_0 = \text{Maximum uniform storage MPC decay heat (34 kW)}$$

X = Inner region to outer region assembly decay heat ratio ($0.5 \leq X \leq 3$)
 n_1 = Number of storage locations in inner region from Table 2.4-2.
 n_2 = Number of storage locations in outer region from Table 2.4-2.

Table 2.4-2

Fuel Storage Regions per MPC

MPC Model	Number of Storage Locations in Inner Region (Region 1)	Number of Storage Locations in Outer Region (Region 2)
MPC-24 and MPC-24E/EF	12	12
MPC- 32/32F	12	20
MPC-68/68FF	32	36

2.4.3 Burnup Limits as a Function of Cooling Time for ZR-Clad Fuel

The maximum allowable fuel assembly average burnup varies with the following parameters:

- Minimum fuel assembly cooling time
- Maximum fuel assembly decay heat
- Minimum fuel assembly average enrichment

2.4.3 Burnup Limits as a Function of Cooling Time for ZR-Clad Fuel (cont'd)

The maximum allowable ZR-clad fuel assembly average burnup for a given MINIMUM ENRICHMENT is calculated as described below for minimum cooling times between 3 and 20 years using the maximum permissible decay heat determined in Section 2.4.1 or 2.4.2. Different fuel assembly average burnup limits may be calculated for different minimum enrichments (by individual fuel assembly) for use in choosing the fuel assemblies to be loaded into a given MPC.

2.4.3.1 Choose a fuel assembly minimum enrichment, E_{235} .

2.4.3.2 Calculate the maximum allowable fuel assembly average burnup for a minimum cooling time between 3 and 20 years using the equation below.

$$Bu = (A \times q) + (B \times q^2) + (C \times q^3) + [D \times (E_{235})^2] + (E \times q \times E_{235}) + (F \times q^2 \times E_{235}) + G$$

Where:

Bu = Maximum allowable average burnup per fuel assembly (MWD/MTU)

q = Maximum allowable decay heat per fuel storage location determined in Section 2.4.1 or 2.4.2 (kW)

E_{235} = Minimum fuel assembly average enrichment (wt. % ^{235}U)
(e.g., for 4.05 wt.%, use 4.05)

A through G = Coefficients from Tables 2.4-3 and 2.4-4 for the applicable fuel assembly array/class and minimum cooling time

- 2.4.3.3 Calculated burnup limits shall be rounded down to the nearest integer.
 - 2.4.3.4 Calculated burnup limits greater than 68,200 MWD/MTU for PWR fuel and 65,000 MWD/MTU for BWR must be reduced to be equal to these values.
 - 2.4.3.5 Linear interpolation of calculated burnups between cooling times for a given fuel assembly maximum decay heat and minimum enrichment is permitted. For example, the allowable burnup for a cooling time of 4.5 years may be interpolated between those burnups calculated for 4 year and 5 years.
 - 2.4.3.6 Each ZR-clad fuel assembly to be stored must have a MINIMUM ENRICHMENT greater than or equal to the value used in Step 2.4.3.2.
- 2.4.4 When complying with the maximum fuel storage location decay heat limits, users must account for the decay heat from both the fuel assembly and any NON-FUEL HARDWARE, as applicable for the particular fuel storage location, to ensure the decay heat emitted by all contents in a storage location does not exceed the limit.

Table 2.4-3 (Page 1 of 8)

PWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 14x14A						
	A	B	C	D	E	F	G
≥ 3	19311.5	275.367	-59.0252	-139.41	2851.12	-451.845	-615.413
≥ 4	33865.9	-5473.03	851.121	-132.739	3408.58	-656.479	-609.523
≥ 5	46686.2	-13226.9	2588.39	-150.149	3871.87	-806.533	-90.2065
≥ 6	56328.9	-20443.2	4547.38	-176.815	4299.19	-927.358	603.192
≥ 7	64136	-27137.5	6628.18	-200.933	4669.22	-1018.94	797.162
≥ 8	71744.1	-34290.3	9036.9	-214.249	4886.95	-1037.59	508.703
≥ 9	77262	-39724.2	11061	-228.2	5141.35	-1102.05	338.294
≥ 10	82939.8	-45575.6	13320.2	-233.691	5266.25	-1095.94	-73.3159
≥ 11	86541	-49289.6	14921.7	-242.092	5444.54	-1141.6	-83.0603
≥ 12	91383	-54456.7	17107	-242.881	5528.7	-1149.2	-547.579
≥ 13	95877.6	-59404.7	19268	-240.36	5524.35	-1094.72	-933.64
≥ 14	97648.3	-61091.6	20261.7	-244.234	5654.56	-1151.47	-749.836
≥ 15	102533	-66651.5	22799.7	-240.858	5647.05	-1120.32	-1293.34
≥ 16	106216	-70753.8	24830.1	-237.04	5647.63	-1099.12	-1583.89
≥ 17	109863	-75005	27038	-234.299	5652.45	-1080.98	-1862.07
≥ 18	111460	-76482.3	28076.5	-234.426	5703.52	-1104.39	-1695.77
≥ 19	114916	-80339.6	30126.5	-229.73	5663.21	-1065.48	-1941.83
≥ 20	119592	-86161.5	33258.2	-227.256	5700.49	-1100.21	-2474.01

Table 2.4-3 (Page 2 of 8)

PWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 14x14B						
	A	B	C	D	E	F	G
≥ 3	18036.1	63.7639	-24.7251	-130.732	2449.87	-347.748	-858.192
≥ 4	30303.4	-4304.2	598.79	-118.757	2853.18	-486.453	-459.902
≥ 5	40779.6	-9922.93	1722.83	-138.174	3255.69	-608.267	245.251
≥ 6	48806.7	-15248.9	3021.47	-158.69	3570.24	-689.876	833.917
≥ 7	55070.5	-19934.6	4325.62	-179.964	3870.33	-765.849	1203.89
≥ 8	60619.6	-24346	5649.29	-189.701	4042.23	-795.324	1158.12
≥ 9	64605.7	-27677.1	6778.12	-205.459	4292.35	-877.966	1169.88
≥ 10	69083.8	-31509.4	8072.42	-206.157	4358.01	-875.041	856.449
≥ 11	72663.2	-34663.9	9228.96	-209.199	4442.68	-889.512	671.567
≥ 12	74808.9	-36367	9948.88	-214.344	4571.29	-942.418	765.261
≥ 13	78340.3	-39541.1	11173.8	-212.8	4615.06	-957.833	410.807
≥ 14	81274.8	-42172.3	12259.9	-209.758	4626.13	-958.016	190.59
≥ 15	83961.4	-44624.5	13329.1	-207.697	4632.16	-952.876	20.8575
≥ 16	84968.5	-44982.1	13615.8	-207.171	4683.41	-992.162	247.54
≥ 17	87721.6	-47543.1	14781.4	-203.373	4674.3	-988.577	37.9689
≥ 18	90562.9	-50100.4	15940.4	-198.649	4651.64	-982.459	-247.421
≥ 19	93011.6	-52316.6	17049.9	-194.964	4644.76	-994.63	-413.021
≥ 20	95567.8	-54566.6	18124	-190.22	4593.92	-963.412	-551.983

Table 2.4-3 (Page 3 of 8)

PWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 14x14C						
	A	B	C	D	E	F	G
≥ 3	18263.7	174.161	-57.6694	-138.112	2539.74	-369.764	-1372.33
≥ 4	30514.5	-4291.52	562.37	-124.944	2869.17	-481.139	-889.883
≥ 5	41338	-10325.7	1752.96	-141.247	3146.48	-535.709	-248.078
≥ 6	48969.7	-15421.3	2966.33	-163.574	3429.74	-587.225	429.331
≥ 7	55384.6	-20228.9	4261.47	-180.846	3654.55	-617.255	599.251
≥ 8	60240.2	-24093.2	5418.86	-199.974	3893.72	-663.995	693.934
≥ 9	64729	-27745.7	6545.45	-205.385	3986.06	-650.124	512.528
≥ 10	68413.7	-30942.2	7651.29	-216.408	4174.71	-702.931	380.431
≥ 11	71870.6	-33906.7	8692.81	-218.813	4248.28	-704.458	160.645
≥ 12	74918.4	-36522	9660.01	-218.248	4283.68	-696.498	-29.0682
≥ 13	77348.3	-38613.7	10501.8	-220.644	4348.23	-702.266	-118.646
≥ 14	79817.1	-40661.8	11331.2	-218.711	4382.32	-710.578	-236.123
≥ 15	82354.2	-42858.3	12257.3	-215.835	4405.89	-718.805	-431.051
≥ 16	84787.2	-44994.5	13185.9	-213.386	4410.99	-711.437	-572.104
≥ 17	87084.6	-46866.1	14004.8	-206.788	4360.3	-679.542	-724.721
≥ 18	88083.1	-47387.1	14393.4	-208.681	4420.85	-709.311	-534.454
≥ 19	90783.6	-49760.6	15462.7	-203.649	4403.3	-705.741	-773.066
≥ 20	93212	-51753.3	16401.5	-197.232	4361.65	-692.925	-964.628

Table 2.4-3 (Page 4 of 8)

PWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 15x15A/B/C						
	A	B	C	D	E	F	G
≥ 3	15037.3	108.689	-18.8378	-127.422	2050.02	-242.828	-580.66
≥ 4	25506.6	-2994.03	356.834	-116.45	2430.25	-350.901	-356.378
≥ 5	34788.8	-7173.07	1065.9	-124.785	2712.23	-424.681	267.705
≥ 6	41948.6	-11225.3	1912.12	-145.727	3003.29	-489.538	852.112
≥ 7	47524.9	-14770.9	2755.16	-165.889	3253.9	-542.7	1146.96
≥ 8	52596.9	-18348.8	3699.72	-177.17	3415.69	-567.012	1021.41
≥ 9	56055.4	-20837.1	4430.93	-192.168	3625.93	-623.325	1058.61
≥ 10	59611.3	-23402.1	5179.52	-195.105	3699.18	-626.448	868.517
≥ 11	62765.3	-25766.5	5924.71	-195.57	3749.91	-627.139	667.124
≥ 12	65664.4	-28004.8	6670.75	-195.08	3788.33	-628.904	410.783
≥ 13	67281.7	-29116.7	7120.59	-202.817	3929.38	-688.738	492.309
≥ 14	69961.4	-31158.6	7834.02	-197.988	3917.29	-677.565	266.561
≥ 15	72146	-32795.7	8453.67	-195.083	3931.47	-681.037	99.0606
≥ 16	74142.6	-34244.8	9023.57	-190.645	3905.54	-663.682	10.8885
≥ 17	76411.4	-36026.3	9729.98	-188.874	3911.21	-663.449	-151.805
≥ 18	77091	-36088	9884.09	-188.554	3965.08	-708.55	59.3839
≥ 19	79194.5	-37566.4	10477.5	-181.656	3906.93	-682.4	-117.952
≥ 20	81600.4	-39464.5	11281.9	-175.182	3869.49	-677.179	-367.705

Table 2.4-3 (Page 5 of 8)

PWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 15x15D/E/F/H						
	A	B	C	D	E	F	G
≥ 3	14376.7	102.205	-20.6279	-126.017	1903.36	-210.883	-493.065
≥ 4	24351.4	-2686.57	297.975	-110.819	2233.78	-301.615	-152.713
≥ 5	33518.4	-6711.35	958.544	-122.85	2522.7	-371.286	392.608
≥ 6	40377	-10472.4	1718.53	-144.535	2793.29	-426.436	951.528
≥ 7	46105.8	-13996.2	2515.32	-157.827	2962.46	-445.314	1100.56
≥ 8	50219.7	-16677.7	3198.3	-175.057	3176.74	-492.727	1223.62
≥ 9	54281.2	-19555.6	3983.47	-181.703	3279.03	-499.997	1034.55
≥ 10	56761.6	-21287.3	4525.98	-195.045	3470.41	-559.074	1103.3
≥ 11	59820	-23445.2	5165.43	-194.997	3518.23	-561.422	862.68
≥ 12	62287.2	-25164.6	5709.9	-194.771	3552.69	-561.466	680.488
≥ 13	64799	-27023.7	6335.16	-192.121	3570.41	-561.326	469.583
≥ 14	66938.7	-28593.1	6892.63	-194.226	3632.92	-583.997	319.867
≥ 15	68116.5	-29148.6	7140.09	-192.545	3670.39	-607.278	395.344
≥ 16	70154.9	-30570.1	7662.91	-187.366	3649.14	-597.205	232.318
≥ 17	72042.5	-31867.6	8169.01	-183.453	3646.92	-603.907	96.0388
≥ 18	73719.8	-32926.1	8596.12	-177.896	3614.57	-592.868	46.6774
≥ 19	75183.1	-33727.4	8949.64	-172.386	3581.13	-586.347	3.57256
≥ 20	77306.1	-35449	9690.02	-173.784	3636.87	-626.321	-205.513

Table 2.4-3 (Page 6 of 8)

PWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 16X16A						
	A	B	C	D	E	F	G
≥ 3	16226.8	143.714	-32.4809	-136.707	2255.33	-291.683	-699.947
≥ 4	27844.2	-3590.69	444.838	-124.301	2644.09	-411.598	-381.106
≥ 5	38191.5	-8678.48	1361.58	-132.855	2910.45	-473.183	224.473
≥ 6	46382.2	-13819.6	2511.32	-158.262	3216.92	-532.337	706.656
≥ 7	52692.3	-18289	3657.18	-179.765	3488.3	-583.133	908.839
≥ 8	57758.7	-22133.7	4736.88	-199.014	3717.42	-618.83	944.903
≥ 9	62363.3	-25798.7	5841.18	-207.025	3844.38	-625.741	734.928
≥ 10	66659.1	-29416.3	6993.31	-216.458	3981.97	-642.641	389.366
≥ 11	69262.7	-31452.7	7724.66	-220.836	4107.55	-681.043	407.121
≥ 12	72631.5	-34291.9	8704.8	-219.929	4131.5	-662.513	100.093
≥ 13	75375.3	-36589.3	9555.88	-217.994	4143.15	-644.014	-62.3294
≥ 14	78178.7	-39097.1	10532	-221.923	4226.28	-667.012	-317.743
≥ 15	79706.3	-40104	10993.3	-218.751	4242.12	-670.665	-205.579
≥ 16	82392.6	-42418.9	11940.7	-216.278	4274.09	-689.236	-479.752
≥ 17	84521.8	-44150.5	12683.3	-212.056	4245.99	-665.418	-558.901
≥ 18	86777.1	-45984.8	13479	-204.867	4180.8	-621.805	-716.366
≥ 19	89179.7	-48109.8	14434.5	-206.484	4230.03	-648.557	-902.1
≥ 20	90141.7	-48401.4	14702.6	-203.284	4245.54	-670.655	-734.604

Table 2.4-3 (Page 7 of 8)

PWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 17x17A						
	A	B	C	D	E	F	G
≥ 3	15985.1	3.53963	-9.04955	-128.835	2149.5	-260.415	-262.997
≥ 4	27532.9	-3494.41	428.199	-119.504	2603.01	-390.91	-140.319
≥ 5	38481.2	-8870.98	1411.03	-139.279	3008.46	-492.881	388.377
≥ 6	47410.9	-14479.6	2679.08	-162.13	3335.48	-557.777	702.164
≥ 7	54596.8	-19703.2	4043.46	-181.339	3586.06	-587.634	804.05
≥ 8	60146.1	-24003.4	5271.54	-201.262	3830.32	-621.706	848.454
≥ 9	65006.3	-27951	6479.04	-210.753	3977.69	-627.805	615.84
≥ 10	69216	-31614.7	7712.58	-222.423	4173.4	-672.33	387.879
≥ 11	73001.3	-34871.1	8824.44	-225.128	4238.28	-657.259	101.654
≥ 12	76326.1	-37795.9	9887.35	-226.731	4298.11	-647.55	-122.236
≥ 13	78859.9	-40058.9	10797.1	-231.798	4402.14	-669.982	-203.383
≥ 14	82201.3	-43032.5	11934.1	-228.162	4417.99	-661.61	-561.969
≥ 15	84950	-45544.6	12972.4	-225.369	4417.84	-637.422	-771.254
≥ 16	87511.8	-47720	13857.7	-219.255	4365.24	-585.655	-907.775
≥ 17	90496.4	-50728.9	15186	-223.019	4446.51	-613.378	-1200.94
≥ 18	91392.5	-51002.4	15461.4	-220.272	4475.28	-636.398	-1003.81
≥ 19	94343.9	-53670.8	16631.6	-214.045	4441.31	-616.201	-1310.01
≥ 20	96562.9	-55591.2	17553.4	-209.917	4397.67	-573.199	-1380.64

Table 2.4-3 (Page 8 of 8)

PWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 17x17B/C						
	A	B	C	D	E	F	G
≥ 3	14738	47.5402	-13.8187	-127.895	1946.58	-219.289	-389.029
≥ 4	25285.2	-3011.92	350.116	-115.75	2316.89	-319.23	-220.413
≥ 5	34589.6	-7130.34	1037.26	-128.673	2627.27	-394.58	459.642
≥ 6	42056.2	-11353.7	1908.68	-150.234	2897.38	-444.316	923.971
≥ 7	47977.6	-15204.8	2827.4	-173.349	3178.25	-504.16	1138.82
≥ 8	52924	-18547.6	3671.08	-183.025	3298.64	-501.278	1064.68
≥ 9	56465.5	-21139.4	4435.67	-200.386	3538	-569.712	1078.78
≥ 10	60190.9	-23872.7	5224.31	-203.233	3602.88	-562.312	805.336
≥ 11	63482.1	-26431.1	6035.79	-205.096	3668.84	-566.889	536.011
≥ 12	66095	-28311.8	6637.72	-204.367	3692.68	-555.305	372.223
≥ 13	67757.4	-29474.4	7094.08	-211.649	3826.42	-606.886	437.412
≥ 14	70403.7	-31517.4	7807.15	-207.668	3828.69	-601.081	183.09
≥ 15	72506.5	-33036.1	8372.59	-203.428	3823.38	-594.995	47.5175
≥ 16	74625.2	-34620.5	8974.32	-199.003	3798.57	-573.098	-95.0221
≥ 17	76549	-35952.6	9498.14	-193.459	3766.52	-556.928	-190.662
≥ 18	77871.9	-36785.5	9916.91	-195.592	3837.65	-599.45	-152.261
≥ 19	79834.8	-38191.6	10501.9	-190.83	3812.46	-589.635	-286.847
≥ 20	81975.5	-39777.2	11174.5	-185.767	3795.78	-595.664	-475.978

Table 2.4-4 (Page 1 of 10)

BWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 7x7B						
	A	B	C	D	E	F	G
≥ 3	26409.1	28347.5	-16858	-147.076	5636.32	-1606.75	1177.88
≥ 4	61967.8	-6618.31	-4131.96	-113.949	6122.77	-2042.85	-96.7439
≥ 5	91601.1	-49298.3	17826.5	-132.045	6823.14	-2418.49	-185.189
≥ 6	111369	-80890.1	35713.8	-150.262	7288.51	-2471.1	86.6363
≥ 7	126904	-108669	53338.1	-167.764	7650.57	-2340.78	150.403
≥ 8	139181	-132294	69852.5	-187.317	8098.66	-2336.13	97.5285
≥ 9	150334	-154490	86148.1	-193.899	8232.84	-2040.37	-123.029
≥ 10	159897	-173614	100819	-194.156	8254.99	-1708.32	-373.605
≥ 11	166931	-186860	111502	-193.776	8251.55	-1393.91	-543.677
≥ 12	173691	-201687	125166	-202.578	8626.84	-1642.3	-650.814
≥ 13	180312	-215406	137518	-201.041	8642.19	-1469.45	-810.024
≥ 14	185927	-227005	148721	-197.938	8607.6	-1225.95	-892.876
≥ 15	191151	-236120	156781	-191.625	8451.86	-846.27	-1019.4
≥ 16	195761	-244598	165372	-187.043	8359.19	-572.561	-1068.19
≥ 17	200791	-256573	179816	-197.26	8914.28	-1393.37	-1218.63
≥ 18	206068	-266136	188841	-187.191	8569.56	-730.898	-1363.79
≥ 19	210187	-273609	197794	-182.151	8488.23	-584.727	-1335.59
≥ 20	213731	-278120	203074	-175.864	8395.63	-457.304	-1364.38

Table 2.4-4 (Page 2 of 10)

BWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 8x8B						
	A	B	C	D	E	F	G
≥ 3	28219.6	28963.7	-17616.2	-147.68	5887.41	-1730.96	1048.21
≥ 4	66061.8	-10742.4	-1961.82	-123.066	6565.54	-2356.05	-298.005
≥ 5	95790.7	-53401.7	19836.7	-134.584	7145.41	-2637.09	-298.858
≥ 6	117477	-90055.9	41383.9	-154.758	7613.43	-2612.69	-64.9921
≥ 7	134090	-120643	60983	-168.675	7809	-2183.3	-40.8885
≥ 8	148186	-149181	81418.7	-185.726	8190.07	-2040.31	-260.773
≥ 9	159082	-172081	99175.2	-197.185	8450.86	-1792.04	-381.705
≥ 10	168816	-191389	113810	-195.613	8359.87	-1244.22	-613.594
≥ 11	177221	-210599	131099	-208.3	8810	-1466.49	-819.773
≥ 12	183929	-224384	143405	-207.497	8841.33	-1227.71	-929.708
≥ 13	191093	-240384	158327	-204.95	8760.17	-811.708	-1154.76
≥ 14	196787	-252211	169664	-204.574	8810.95	-610.928	-1208.97
≥ 15	203345	-267656	186057	-208.962	9078.41	-828.954	-1383.76
≥ 16	207973	-276838	196071	-204.592	9024.17	-640.808	-1436.43
≥ 17	213891	-290411	211145	-202.169	9024.19	-482.1	-1595.28
≥ 18	217483	-294066	214600	-194.243	8859.35	-244.684	-1529.61
≥ 19	220504	-297897	219704	-190.161	8794.97	-10.9863	-1433.86
≥ 20	227821	-318395	245322	-194.682	9060.96	-350.308	-1741.16

Table 2.4-4 (Page 3 of 10)

BWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 8x8C/D/E						
	A	B	C	D	E	F	G
≥ 3	28592.7	28691.5	-17773.6	-149.418	5969.45	-1746.07	1063.62
≥ 4	66720.8	-12115.7	-1154	-128.444	6787.16	-2529.99	-302.155
≥ 5	96929.1	-55827.5	21140.3	-136.228	7259.19	-2685.06	-334.328
≥ 6	118190	-92000.2	42602.5	-162.204	7907.46	-2853.42	-47.5465
≥ 7	135120	-123437	62827.1	-172.397	8059.72	-2385.81	-75.0053
≥ 8	149162	-152986	84543.1	-195.458	8559.11	-2306.54	-183.595
≥ 9	161041	-177511	103020	-200.087	8632.84	-1864.4	-433.081
≥ 10	171754	-201468	122929	-209.799	8952.06	-1802.86	-755.742
≥ 11	179364	-217723	137000	-215.803	9142.37	-1664.82	-847.268
≥ 12	186090	-232150	150255	-216.033	9218.36	-1441.92	-975.817
≥ 13	193571	-249160	165997	-213.204	9146.99	-1011.13	-1119.47
≥ 14	200034	-263671	180359	-210.559	9107.54	-694.626	-1312.55
≥ 15	205581	-275904	193585	-216.242	9446.57	-1040.65	-1428.13
≥ 16	212015	-290101	207594	-210.036	9212.93	-428.321	-1590.7
≥ 17	216775	-299399	218278	-204.611	9187.86	-398.353	-1657.6
≥ 18	220653	-306719	227133	-202.498	9186.34	-181.672	-1611.86
≥ 19	224859	-314004	235956	-193.902	8990.14	145.151	-1604.71
≥ 20	228541	-320787	245449	-200.727	9310.87	-230.252	-1570.18

Table 2.4-4 (Page 4 of 10)

BWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 9x9A						
	A	B	C	D	E	F	G
≥ 3	30538.7	28463.2	-18105.5	-150.039	6226.92	-1876.69	1034.06
≥ 4	71040.1	-16692.2	1164.15	-128.241	7105.27	-2728.58	-414.09
≥ 5	100888	-60277.7	24150.1	-142.541	7896.11	-3272.86	-232.197
≥ 6	124846	-102954	50350.8	-161.849	8350.16	-3163.44	-91.1396
≥ 7	143516	-140615	76456.5	-185.538	8833.04	-2949.38	-104.802
≥ 8	158218	-171718	99788.2	-196.315	9048.88	-2529.26	-259.929
≥ 9	172226	-204312	126620	-214.214	9511.56	-2459.19	-624.954
≥ 10	182700	-227938	146736	-215.793	9555.41	-1959.92	-830.943
≥ 11	190734	-246174	163557	-218.071	9649.43	-1647.5	-935.021
≥ 12	199997	-269577	186406	-223.975	9884.92	-1534.34	-1235.27
≥ 13	207414	-287446	204723	-228.808	10131.7	-1614.49	-1358.61
≥ 14	215263	-306131	223440	-220.919	9928.27	-988.276	-1638.05
≥ 15	221920	-321612	239503	-217.949	9839.02	-554.709	-1784.04
≥ 16	226532	-331778	252234	-216.189	9893.43	-442.149	-1754.72
≥ 17	232959	-348593	272609	-219.907	10126.3	-663.84	-1915.3
≥ 18	240810	-369085	296809	-219.729	10294.6	-859.302	-2218.87
≥ 19	244637	-375057	304456	-210.997	10077.8	-425.446	-2127.83
≥ 20	248112	-379262	309391	-204.191	9863.67	100.27	-2059.39

Table 2.4-4 (Page 5 of 10)

BWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 9x9B						
	A	B	C	D	E	F	G
≥ 3	30613.2	28985.3	-18371	-151.117	6321.55	-1881.28	988.92
≥ 4	71346.6	-15922.9	631.132	-128.876	7232.47	-2810.64	-471.737
≥ 5	102131	-60654.1	23762.7	-140.748	7881.6	-3156.38	-417.979
≥ 6	127187	-105842	51525.2	-162.228	8307.4	-2913.08	-342.13
≥ 7	146853	-145834	79146.5	-185.192	8718.74	-2529.57	-484.885
≥ 8	162013	-178244	103205	-197.825	8896.39	-1921.58	-584.013
≥ 9	176764	-212856	131577	-215.41	9328.18	-1737.12	-1041.11
≥ 10	186900	-235819	151238	-218.98	9388.08	-1179.87	-1202.83
≥ 11	196178	-257688	171031	-220.323	9408.47	-638.53	-1385.16
≥ 12	205366	-280266	192775	-223.715	9592.12	-472.261	-1661.6
≥ 13	215012	-306103	218866	-231.821	9853.37	-361.449	-1985.56
≥ 14	222368	-324558	238655	-228.062	9834.57	3.47358	-2178.84
≥ 15	226705	-332738	247316	-224.659	9696.59	632.172	-2090.75
≥ 16	233846	-349835	265676	-221.533	9649.93	913.747	-2243.34
≥ 17	243979	-379622	300077	-222.351	9792.17	1011.04	-2753.36
≥ 18	247774	-386203	308873	-220.306	9791.37	1164.58	-2612.25
≥ 19	254041	-401906	327901	-213.96	9645.47	1664.94	-2786.2
≥ 20	256003	-402034	330566	-215.242	9850.42	1359.46	-2550.06

Table 2.4-4 (Page 6 of 10)

BWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 9x9C/D						
	A	B	C	D	E	F	G
≥ 3	30051.6	29548.7	-18614.2	-148.276	6148.44	-1810.34	1006
≥ 4	70472.7	-14696.6	-233.567	-127.728	7008.69	-2634.22	-444.373
≥ 5	101298	-59638.9	23065.2	-138.523	7627.57	-2958.03	-377.965
≥ 6	125546	-102740	49217.4	-160.811	8096.34	-2798.88	-259.767
≥ 7	143887	-139261	74100.4	-184.302	8550.86	-2517.19	-275.151
≥ 8	159633	-172741	98641.4	-194.351	8636.89	-1838.81	-486.731
≥ 9	173517	-204709	124803	-212.604	9151.98	-1853.27	-887.137
≥ 10	182895	-225481	142362	-218.251	9262.59	-1408.25	-978.356
≥ 11	192530	-247839	162173	-217.381	9213.58	-818.676	-1222.12
≥ 12	201127	-268201	181030	-215.552	9147.44	-232.221	-1481.55
≥ 13	209538	-289761	203291	-225.092	9588.12	-574.227	-1749.35
≥ 14	216798	-306958	220468	-222.578	9518.22	-69.9307	-1919.71
≥ 15	223515	-323254	237933	-217.398	9366.52	475.506	-2012.93
≥ 16	228796	-334529	250541	-215.004	9369.33	662.325	-2122.75
≥ 17	237256	-356311	273419	-206.483	9029.55	1551.3	-2367.96
≥ 18	242778	-369493	290354	-215.557	9600.71	659.297	-2589.32
≥ 19	246704	-377971	302630	-210.768	9509.41	1025.34	-2476.06
≥ 20	249944	-382059	308281	-205.495	9362.63	1389.71	-2350.49

Table 2.4-4 (Page 7 of 10)

BWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 9x9E/F						
	A	B	C	D	E	F	G
≥ 3	30284.3	26949.5	-16926.4	-147.914	6017.02	-1854.81	1026.15
≥ 4	69727.4	-17117.2	1982.33	-127.983	6874.68	-2673.01	-359.962
≥ 5	98438.9	-58492	23382.2	-138.712	7513.55	-3038.23	-112.641
≥ 6	119765	-95024.1	45261	-159.669	8074.25	-3129.49	221.182
≥ 7	136740	-128219	67940.1	-182.439	8595.68	-3098.17	315.544
≥ 8	150745	-156607	88691.5	-193.941	8908.73	-2947.64	142.072
≥ 9	162915	-182667	109134	-198.37	8999.11	-2531	-93.4908
≥ 10	174000	-208668	131543	-210.777	9365.52	-2511.74	-445.876
≥ 11	181524	-224252	145280	-212.407	9489.67	-2387.49	-544.123
≥ 12	188946	-240952	160787	-210.65	9478.1	-2029.94	-652.339
≥ 13	193762	-250900	171363	-215.798	9742.31	-2179.24	-608.636
≥ 14	203288	-275191	196115	-218.113	9992.5	-2437.71	-1065.92
≥ 15	208108	-284395	205221	-213.956	9857.25	-1970.65	-1082.94
≥ 16	215093	-301828	224757	-209.736	9789.58	-1718.37	-1303.35
≥ 17	220056	-310906	234180	-201.494	9541.73	-1230.42	-1284.15
≥ 18	224545	-320969	247724	-206.807	9892.97	-1790.61	-1381.9
≥ 19	226901	-322168	250395	-204.073	9902.14	-1748.78	-1253.22
≥ 20	235561	-345414	276856	-198.306	9720.78	-1284.14	-1569.18

Table 2.4-4 (Page 8 of 10)

BWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 9x9G						
	A	B	C	D	E	F	G
≥ 3	35158.5	26918.5	-17976.7	-149.915	6787.19	-2154.29	836.894
≥ 4	77137.2	-19760.1	2371.28	-130.934	8015.43	-3512.38	-455.424
≥ 5	113405	-77931.2	35511.2	-150.637	8932.55	-4099.48	-629.806
≥ 6	139938	-128700	68698.3	-173.799	9451.22	-3847.83	-455.905
≥ 7	164267	-183309	109526	-193.952	9737.91	-3046.84	-737.992
≥ 8	182646	-227630	146275	-210.936	10092.3	-2489.3	-1066.96
≥ 9	199309	-270496	184230	-218.617	10124.3	-1453.81	-1381.41
≥ 10	213186	-308612	221699	-235.828	10703.2	-1483.31	-1821.73
≥ 11	225587	-342892	256242	-236.112	10658.5	-612.076	-2134.65
≥ 12	235725	-370471	285195	-234.378	10604.9	118.591	-2417.89
≥ 13	247043	-404028	323049	-245.79	11158.2	-281.813	-2869.82
≥ 14	253649	-421134	342682	-243.142	11082.3	400.019	-2903.88
≥ 15	262750	-448593	376340	-245.435	11241.2	581.355	-3125.07
≥ 16	270816	-470846	402249	-236.294	10845.4	1791.46	-3293.07
≥ 17	279840	-500272	441964	-241.324	11222.6	1455.84	-3528.25
≥ 18	284533	-511287	458538	-240.905	11367.2	1459.68	-3520.94
≥ 19	295787	-545885	501824	-235.685	11188.2	2082.21	-3954.2
≥ 20	300209	-556936	519174	-229.539	10956	2942.09	-3872.87

Table 2.4-4 (Page 9 of 10)

BWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 10x10A/B						
	A	B	C	D	E	F	G
≥ 3	29285.4	27562.2	-16985	-148.415	5960.56	-1810.79	1001.45
≥ 4	67844.9	-14383	395.619	-127.723	6754.56	-2547.96	-369.267
≥ 5	96660.5	-55383.8	21180.4	-137.17	7296.6	-2793.58	-192.85
≥ 6	118098	-91995	42958	-162.985	7931.44	-2940.84	60.9197
≥ 7	135115	-123721	63588.9	-171.747	8060.23	-2485.59	73.6219
≥ 8	148721	-151690	84143.9	-190.26	8515.81	-2444.25	-63.4649
≥ 9	160770	-177397	104069	-197.534	8673.6	-2101.25	-331.046
≥ 10	170331	-198419	121817	-213.692	9178.33	-2351.54	-472.844
≥ 11	179130	-217799	138652	-209.75	9095.43	-1842.88	-705.254
≥ 12	186070	-232389	151792	-208.946	9104.52	-1565.11	-822.73
≥ 13	192407	-246005	164928	-209.696	9234.7	-1541.54	-979.245
≥ 14	200493	-265596	183851	-207.639	9159.83	-1095.72	-1240.61
≥ 15	205594	-276161	195760	-213.491	9564.23	-1672.22	-1333.64
≥ 16	209386	-282942	204110	-209.322	9515.83	-1506.86	-1286.82
≥ 17	214972	-295149	217095	-202.445	9292.34	-893.6	-1364.97
≥ 18	219312	-302748	225826	-198.667	9272.27	-878.536	-1379.58
≥ 19	223481	-310663	235908	-194.825	9252.9	-785.066	-1379.62
≥ 20	227628	-319115	247597	-199.194	9509.02	-1135.23	-1386.19

Table 2.4-4 (Page 10 of 10)

BWR Fuel Assembly Cooling Time-Dependent Coefficients
(ZR-Clad Fuel)

Cooling Time (years)	Array/Class 10x10C						
	A	B	C	D	E	F	G
≥ 3	31425.3	27358.9	-17413.3	-152.096	6367.53	-1967.91	925.763
≥ 4	71804	-16964.1	1000.4	-129.299	7227.18	-2806.44	-416.92
≥ 5	102685	-62383.3	24971.2	-142.316	7961	-3290.98	-354.784
≥ 6	126962	-105802	51444.6	-164.283	8421.44	-3104.21	-186.615
≥ 7	146284	-145608	79275.5	-188.967	8927.23	-2859.08	-251.163
≥ 8	162748	-181259	105859	-199.122	9052.91	-2206.31	-554.124
≥ 9	176612	-214183	133261	-217.56	9492.17	-1999.28	-860.669
≥ 10	187756	-239944	155315	-219.56	9532.45	-1470.9	-1113.42
≥ 11	196580	-260941	174536	-222.457	9591.64	-944.473	-1225.79
≥ 12	208017	-291492	204805	-233.488	10058.3	-1217.01	-1749.84
≥ 13	214920	-307772	221158	-234.747	10137.1	-897.23	-1868.04
≥ 14	222562	-326471	240234	-228.569	9929.34	-183.47	-2016.12
≥ 15	228844	-342382	258347	-226.944	9936.76	117.061	-2106.05
≥ 16	233907	-353008	270390	-223.179	9910.72	360.39	-2105.23
≥ 17	244153	-383017	304819	-227.266	10103.2	380.393	-2633.23
≥ 18	249240	-395456	321452	-226.989	10284.1	169.947	-2623.67
≥ 19	254343	-406555	335240	-220.569	10070.5	764.689	-2640.2
≥ 20	260202	-421069	354249	-216.255	10069.9	854.497	-2732.77