

**CERTIFICATE OF COMPLIANCE NO. 1014**

**APPENDIX B-100U**

**APPROVED CONTENTS AND DESIGN FEATURES**

**FOR THE HI-STORM 100 CASK SYSTEM**  
**(MODEL NO. 100U ADDITION)**

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## 1.0 Definitions

Refer to Appendix A for Definitions.

## 2.0 APPROVED CONTENTS

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### 2.1 Fuel Specifications and Loading Conditions

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

- a. INTACT FUEL ASSEMBLIES, and NON-FUEL HARDWARE meeting the limits specified in Table 2.1-1 and other referenced tables may be stored.
- 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 NON-FUEL HARDWARE specified in the CoC.

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(continued)

## 2.0 Approved Contents

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### 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-32, MPC-68 models, respectively<sup>1</sup>. 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

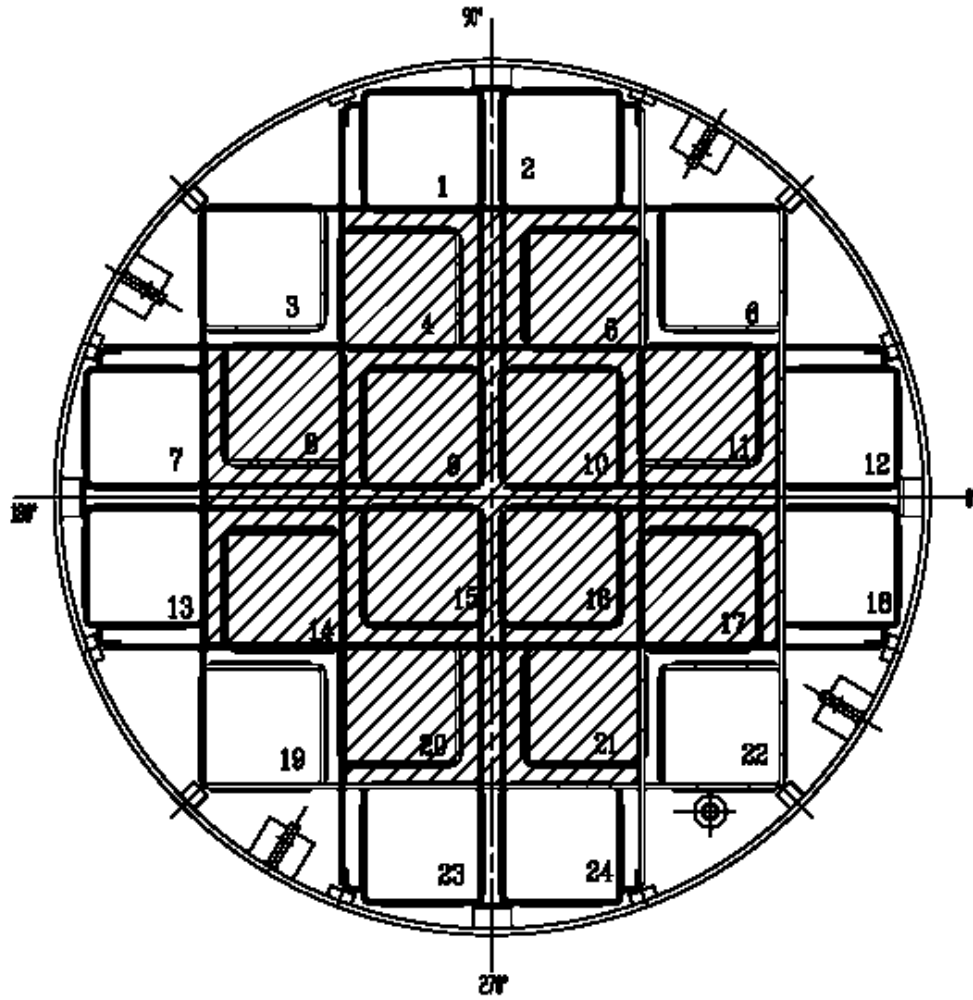
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<sup>1</sup> These figures are only intended to distinguish the fuel loading regions. Other details of the basket design are illustrative and may not reflect the actual basket design details. The design drawings should be consulted for basket design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

**LEGEND:**


**REGION 1:** 

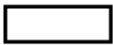
**REGION 2:** 

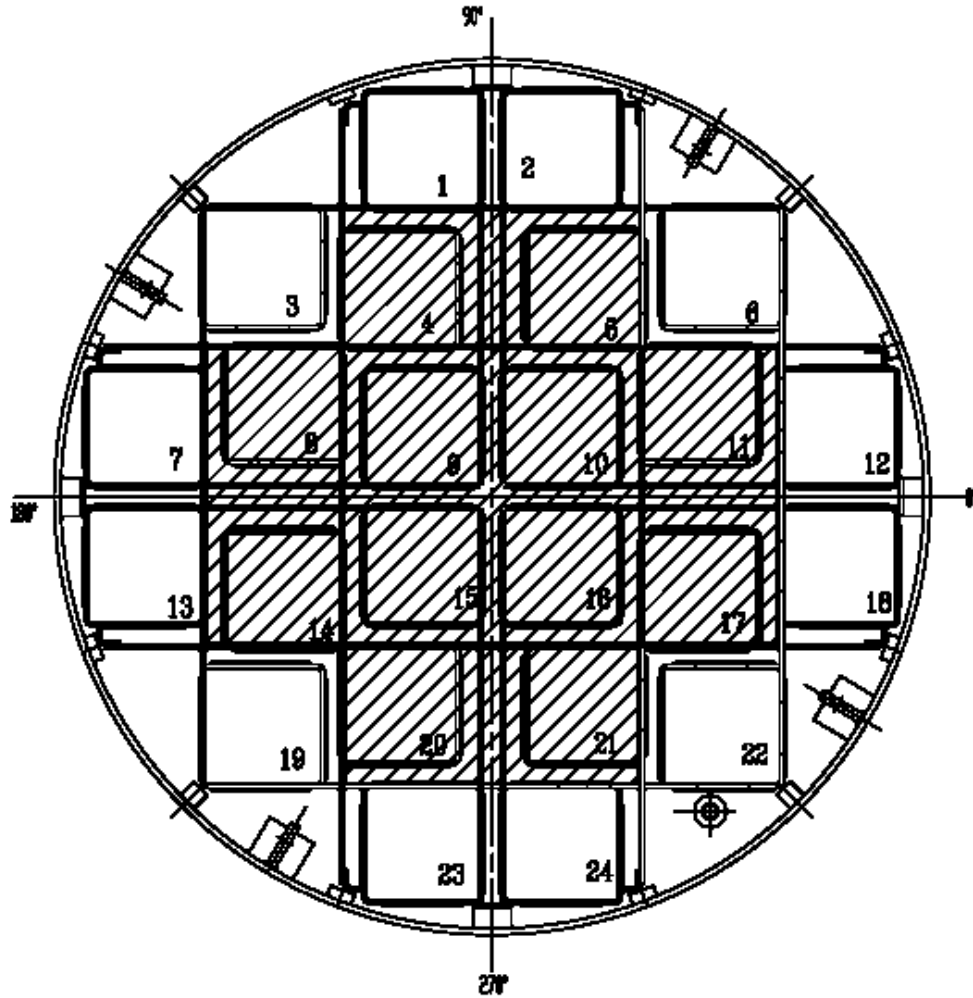


**Figure 2.1-1  
Fuel Loading Regions - MPC-24**

**LEGEND:**


**REGION 1:** 

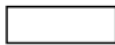
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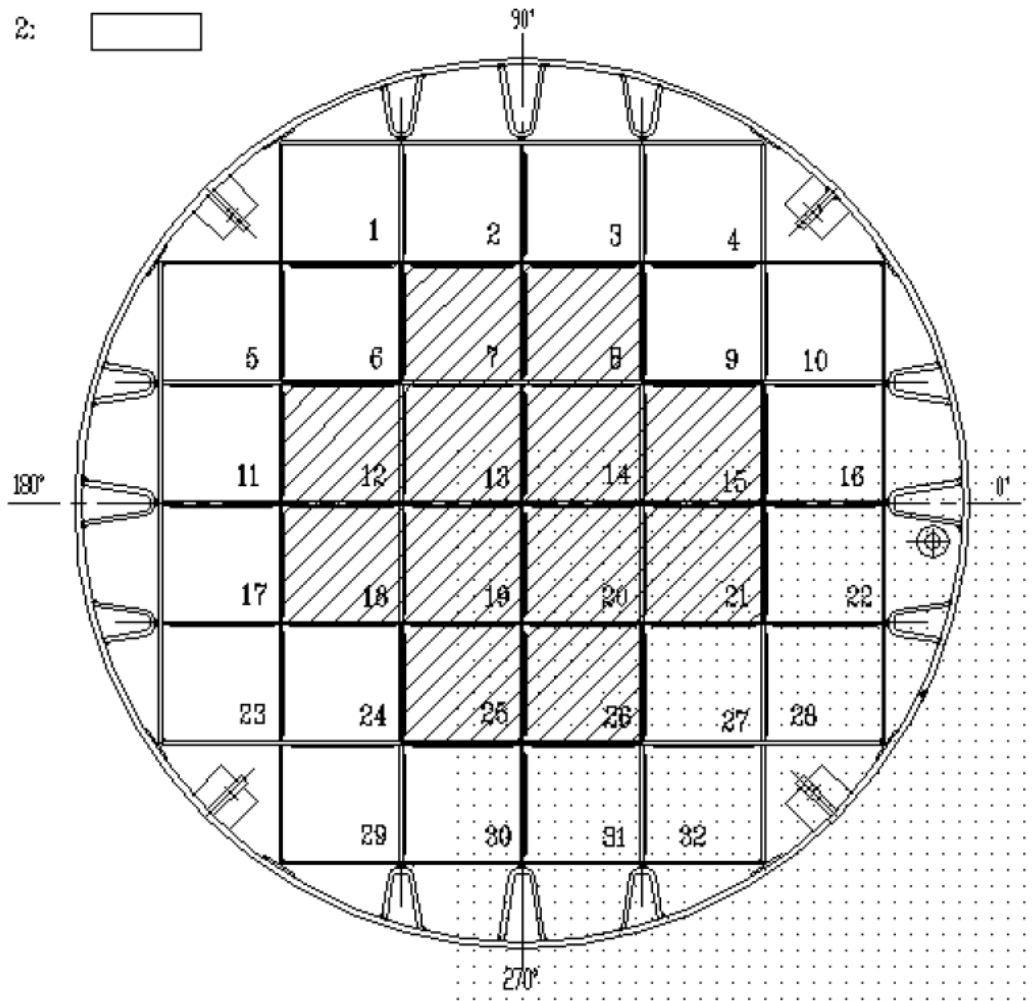


**Figure 2.1-2  
Fuel Loading Regions - MPC-24E**

LEGEND:

REGION 1: 

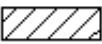
REGION 2: 




**Figure 2.1-3**  
**Fuel Loading Regions - MPC-32**



LEGEND:

REGION 1: 

REGION 2: 

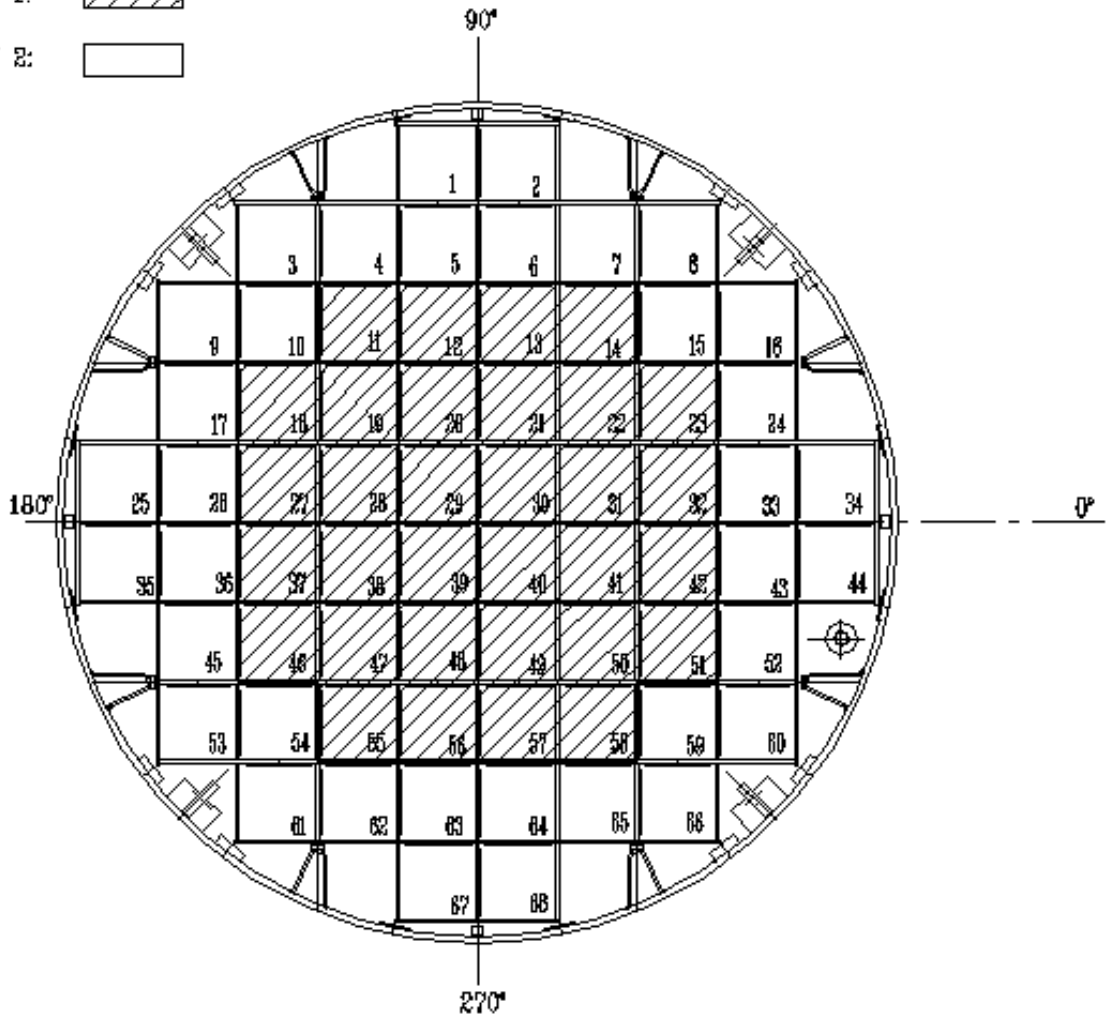


Figure 2.1-4  
Fuel Loading Regions - MPC-68

Table 2.1-1 (page 1 of 8)  
Fuel Assembly Limits

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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.
  - ii. NON-FUEL HARDWARE As specified in Table 2.1-4.

Table 2.1-1 (page 2 of 8)  
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  $\leq 710$  Watts

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

e. Fuel Assembly Length:  $\leq 176.8$  inches (nominal design)

f. Fuel Assembly Width:  $\leq 8.54$  inches (nominal design)

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

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

C. 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 3 of 8)  
Fuel Assembly Limits

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II. MPC MODEL: MPC-68

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.                           |
| d. 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 MWD/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 4 of 8)  
Fuel Assembly Limits

II. MPC MODEL: MPC-68 (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 ≤ 400 lbs, including channels
- ii. All Other Array/Classes ≤ 730 lbs, including channels

B. Quantity per MPC: Up to 68 fuel assemblies.

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 5 of 8)  
Fuel Assembly Limits

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III. MPC MODEL: MPC-24E

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 2.1-4.  |

Table 2.1-1 (page 6 of 8)  
Fuel Assembly Limits

III. MPC MODEL: MPC-24E (continued)

A. Allowable Contents (continued)

d. Decay Heat Per Fuel Storage Location:

i. Array/Classes 14x14D, 14x14E, and 15x15G  $\leq 710$  Watts.

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

e. Fuel Assembly Length:  $\leq 176.8$  inches (nominal design)

f. Fuel Assembly Width:  $\leq 8.54$  inches (nominal design)

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

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

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 7 of 8)  
Fuel Assembly Limits

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IV. MPC MODEL: MPC-32

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 2.1-4.   |



Table 2.1-1 (page 8 of 8)  
Fuel Assembly Limits

IV. MPC MODEL: MPC-32 (continued)

A. Allowable Contents (continued)

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 ≤ 1,720 lbs (including NON-FUEL HARDWARE) for assemblies that do not require fuel spacers, otherwise, ≤ 1,680 lbs (including NON-FUEL HARDWARE)

B. Quantity per MPC: Up to 32 fuel assemblies.

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 5)  
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 and 24E without soluble boron credit) (wt % <sup>235</sup> U)                | ≤ 4.6 (24)<br>≤ 5.0 (24E) | ≤ 4.6 (24)<br>≤ 5.0 (24E) | ≤ 4.6 (24)<br>≤ 5.0 (24E) | ≤ 4.0 (24)<br>≤ 5.0 (24E) | ≤ 5.0 (24)<br>≤ 5.0 (24E) |
| Initial Enrichment (MPC-24, 24E, or 32, with soluble boron credit - see Note 5) (wt % <sup>235</sup> 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 7)  | ≤ 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 5)  
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 and 24E without soluble boron credit) (wt % <sup>235</sup> U)              | ≤ 4.1 (24)  | ≤ 4.1 (24)  | ≤ 4.1 (24)  | ≤ 4.1 (24)  | ≤ 4.1 (24)  | ≤ 4.1 (24)  |
|   | ≤ 4.5 (24E) | ≤ 4.5 (24E) | ≤ 4.5 (24E) | ≤ 4.5 (24E) | ≤ 4.5 (24E) | ≤ 4.5 (24E) |
| Initial Enrichment (MPC-24, 24E, or 32 with soluble boron credit - see Note 5)(wt % <sup>235</sup> 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 7)   | ≤ 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 5)  
PWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

| Fuel Assembly Array/ Class   | 15x15G                    | 15x15H                    | 16x16A                    | 16x16B                         | 16x16C                         |
|--|---------------------------|---------------------------|---------------------------|--------------------------------|--------------------------------|
| Clad Material  | SS                        | ZR                        | ZR                        | ZR                             | ZR                             |
| Design Initial U (kg/assy.)(Note 3)  | ≤ 420                     | ≤ 495                     | ≤ 448                     | ≤ 427                          | ≤ 426                          |
| Initial Enrichment (MPC-24 and 24E without soluble boron credit) (wt % <sup>235</sup> U)               | ≤ 4.0 (24)<br>≤ 4.5 (24E) | ≤ 3.8 (24)<br>≤ 4.2 (24E) | ≤ 4.6 (24)<br>≤ 5.0 (24E) | ≤ 4.6 (24)<br>≤ 5.0 (24E/24EF) | ≤ 4.6 (24)<br>≤ 5.0 (24E/24EF) |
| Initial Enrichment (MPC-24, 24E, or 32 with soluble boron credit - see Note 5) (wt % <sup>235</sup> U) | ≤ 5.0                     | ≤ 5.0                     | ≤ 5.0                     | ≤ 5.0                          | ≤ 5.0                          |
| No. of Fuel Rod Locations  | 204                       | 208                       | 236                       | 236                            | 235                            |
| Fuel Rod Clad O.D. (in.)   | ≥ 0.422                   | ≥ 0.414                   | ≥ 0.382                   | ≥ 0.374                        | ≥ 0.374                        |
| Fuel Rod Clad I.D. (in.)   | ≤ 0.3890                  | ≤ 0.3700                  | ≤ 0.3350                  | ≤ 0.3290                       | ≤ 0.3290                       |
| Fuel Pellet Dia. (in.) (Note 7)  | ≤ 0.3825                  | ≤ 0.3622                  | ≤ 0.3255                  | ≤ 0.3225                       | ≤ 0.3225                       |
| Fuel Rod Pitch (in.)   | ≤ 0.563                   | ≤ 0.568                   | ≤ 0.506                   | ≤ 0.506                        | ≤ 0.485                        |
| Active Fuel Length (in.)   | ≤ 144                     | ≤ 150                     | ≤ 150                     | ≤ 150                          | ≤ 150                          |
| No. of Guide and/or Instrument Tubes   | 21                        | 17                        | 5 (Note 4)                | 5 (Note 4)                     | 21                             |
| Guide/Instrument Tube Thickness (in.)  | ≥ 0.0145                  | ≥ 0.0140                  | ≥ 0.0350                  | ≥ 0.0400                       | ≥ 0.0157                       |

Table 2.1-2 (page 4 of 5)  
PWR FUEL ASSEMBLY CHARACTERISTICS (Note 1)

| Fuel Assembly Array/ Class   | 17x17A                    | 17x17B                    | 17x17C                    |
|--|---------------------------|---------------------------|---------------------------|
| Clad Material  | ZR                        | ZR                        | ZR                        |
| Design Initial U (kg/assy.)(Note 3)  | ≤ 433                     | ≤ 474                     | ≤ 480                     |
| Initial Enrichment (MPC-24 and 24E without soluble boron credit) (wt % <sup>235</sup> U)               | ≤ 4.0 (24)<br>≤ 4.4 (24E) | ≤ 4.0 (24)<br>≤ 4.4 (24E) | ≤ 4.0 (24)<br>≤ 4.4 (24E) |
| Initial Enrichment (MPC-24, 24E, or 32 with soluble boron credit - see Note 5) (wt % <sup>235</sup> U) | ≤ 5.0                     | ≤ 5.0                     | ≤ 5.0                     |
| No. of Fuel Rod Locations  | 264                       | 264                       | 264                       |
| Fuel Rod Clad O.D. (in.)   | ≥ 0.360                   | ≥ 0.372                   | ≥ 0.377                   |
| Fuel Rod Clad I.D. (in.)   | ≤ 0.3150                  | ≤ 0.3310                  | ≤ 0.3330                  |
| Fuel Pellet Dia. (in.) (Note 7)  | ≤ 0.3088                  | ≤ 0.3232                  | ≤ 0.3252                  |
| Fuel Rod Pitch (in.)   | ≤ 0.496                   | ≤ 0.496                   | ≤ 0.502                   |
| Active Fuel Length (in.)   | ≤ 150                     | ≤ 150                     | ≤ 150                     |
| No. of Guide and/or Instrument Tubes   | 25                        | 25                        | 25                        |
| Guide/Instrument Tube Thickness (in.)  | ≥ 0.016                   | ≥ 0.014                   | ≥ 0.020                   |

Table 2.1-2 (page 5 of 5)  
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 of Appendix A-100U.
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. 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.% <sup>235</sup> U) | ≤ 2.7    | ≤ 2.7 for the UO <sub>2</sub> rods. See Note 4 for MOX rods | ≤ 2.7    | ≤ 2.7    | ≤ 4.2    | ≤ 2.7    |
| Initial Maximum Rod Enrichment (wt.% <sup>235</sup> 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.% <sup>235</sup> U) | ≤ 4.2    | ≤ 4.2    | ≤ 4.2          | ≤ 4.2    | ≤ 4.0         | ≤ 4.2          |
| Initial Maximum Rod Enrichment (wt.% <sup>235</sup> 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.% <sup>235</sup> U) | ≤ 4.2      | ≤ 4.2    | ≤ 4.2    | ≤ 4.0          | ≤ 4.0          | ≤ 4.2      |
| Initial Maximum Rod Enrichment (wt.% <sup>235</sup> 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)

| <b>Fuel Assembly Array/Class</b>                                     | <b>10x10A</b>     | <b>10x10B</b>     | <b>10x10C</b> | <b>10x10D</b> | <b>10x10E</b> |
|--|-------------------|-------------------|---------------|---------------|---------------|
| Clad Material  | ZR                | ZR                | ZR            | SS            | SS            |
| Design Initial U (kg/assy.)<br>(Note 3)                              | ≤ 188             | ≤ 188             | ≤ 179         | ≤ 125         | ≤ 125         |
| Maximum PLANAR-AVERAGE INITIAL ENRICHMENT<br>(wt.% <sup>235</sup> U) | ≤ 4.2             | ≤ 4.2             | ≤ 4.2         | ≤ 4.0         | ≤ 4.0         |
| Initial Maximum Rod Enrichment (wt.% <sup>235</sup> U)               | ≤ 5.0             | ≤ 5.0             | ≤ 5.0         | ≤ 5.0         | ≤ 5.0         |
| No. of Fuel Rod Locations  | 92/78<br>(Note 8) | 91/83<br>(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. Not Used.
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.  $\leq 0.635$  wt. %  $^{235}\text{U}$  and  $\leq 1.578$  wt. % total fissile plutonium ( $^{239}\text{Pu}$  and  $^{241}\text{Pu}$ ), (wt. % of total fuel weight, i.e.,  $\text{UO}_2$  plus  $\text{PuO}_2$ ).
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.

Table 2.1-4  
NON-FUEL HARDWARE COOLING AND AVERAGE BURNUP (Notes 1, 2, 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 Model 100U. 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)

| <b>MPC Model</b> | <b>Decay Heat per Fuel Storage Location (kW)</b> |
|------------------|--|
|                  | Intact Fuel Assemblies                           |
| MPC-24           | $\leq 1.266$                                     |
| MPC-24E          | $\leq 1.266$                                     |
| MPC-32           | $\leq 0.949$                                     |
| MPC-68           | $\leq 0.447$                                     |

2.4.2 Regionalized Fuel Loading Decay Heat Limits for ZR-Clad Fuel (INTACT FUEL only)

The maximum allowable decay heat per fuel storage location for fuel in regionalized loading is determined using the following equations:

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

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

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

$$q_1 = q_2 \times X$$

Where:

$Q_0$  = Maximum uniform storage MPC decay heat (34 kW)

$\alpha$  = Penalty Factor (0.894)

$X$  = 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 | 12   | 12   |
| MPC-32             | 12   | 20   |
| MPC-68             | 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

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. %  $^{235}\text{U}$ ) (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/16x16B/C |          |          |          |         |          |          |
|----------------------|-----------------------------|----------|----------|----------|---------|----------|----------|
|                      | 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 |

### 3.0 DESIGN FEATURES

#### 3.1 Site

##### 3.1.1 Site Location

The HI-STORM 100 Cask System is authorized for general use by 10 CFR Part 50 license holders at various site locations under the provisions of 10 CFR 72, Subpart K.

#### 3.2 Design Features Important for Criticality Control

##### 3.2.1 MPC-24

1. Flux trap size:  $\geq 1.09$  in.
2.  $^{10}\text{B}$  loading in the neutron absorbers:  $\geq 0.0267$  g/cm<sup>2</sup> (Boral) and  $\geq 0.0223$  g/cm<sup>2</sup> (METAMIC)

##### 3.2.2 MPC-68

1. Fuel cell pitch:  $\geq 6.43$  in.
2.  $^{10}\text{B}$  loading in the neutron absorbers:  $\geq 0.0372$  g/cm<sup>2</sup> (Boral) and  $\geq 0.0310$  g/cm<sup>2</sup> (METAMIC)

##### 3.2.3 MPC-24E

1. Flux trap size:
  - i. Cells 3, 6, 19, and 22:  $\geq 0.776$  inch
  - ii. All Other Cells:  $\geq 1.076$  inches
2.  $^{10}\text{B}$  loading in the neutron absorbers:  $\geq 0.0372$  g/cm<sup>2</sup> (Boral) and  $\geq 0.0310$  g/cm<sup>2</sup> (METAMIC)

##### 3.2.4 MPC-32

1. Fuel cell pitch:  $\geq 9.158$  inches
2.  $^{10}\text{B}$  loading in the neutron absorbers:  $\geq 0.0372$  g/cm<sup>2</sup> (Boral) and  $\geq 0.0310$  g/cm<sup>2</sup> (METAMIC)

##### 3.2.5 Not Used

## DESIGN FEATURES

### 3.2 Design features Important for Criticality Control (cont'd)

- 3.2.6 Fuel spacers shall be sized to ensure that the active fuel region of intact fuel assemblies remains within the neutron poison region of the MPC basket with water in the MPC.
- 3.2.7 The B<sub>4</sub>C content in METAMIC shall be ≤ 33.0 wt.%.
- 3.2.8 Neutron Absorber Tests

Section 9.1.5.3 of the HI-STORM 100 FSAR is hereby incorporated by reference into the HI-STORM 100 CoC. The minimum <sup>10</sup>B for the neutron absorber shall meet the minimum requirements for each MPC model specified in Sections 3.2.1 through 3.2.4 above.

### 3.3 Codes and Standards

The American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), 1995 Edition with Addenda through 1997, is the governing Code for the HI-STORM 100 System MPCs, OVERPACKs, and TRANSFER CASKs, as clarified in Specification 3.3.1 below, except for Code Sections V and IX. The ASME Code paragraphs applicable to the 100U VVM are listed in Table 3-2. The latest effective editions of ASME Code Sections V and IX, including addenda, may be used for activities governed by those sections, provided a written reconciliation of the later edition against the 1995 Edition, including addenda, is performed by the certificate holder. American Concrete Institute (ACI) 349-85 is the governing Code for plain concrete as clarified in Appendix 1.D of the Final Safety Analysis Report for the HI-STORM 100 Cask System.

#### 3.3.1 Alternatives to Codes, Standards, and Criteria

Table 3-1 of Appendix B to CoC-1014 lists approved alternatives to the ASME Code for the design of the MPCs and TRANSFER CASKs of the HI-STORM 100U System.

#### 3.3.2 Construction/Fabrication Alternatives to Codes, Standards, and Criteria

Proposed alternatives to the ASME Code, Section III, 1995 Edition with Addenda through 1997 including modifications to the alternatives allowed by Specification 3.3.1 may be used on a case-specific basis when authorized by the Director of the Office of Nuclear Material Safety and Safeguards or designee. The request for such alternative should demonstrate that:

1. The proposed alternatives would provide an acceptable level of quality and safety, or

(continued)

DESIGN FEATURES

3.3.2 Construction/Fabrication Alternatives to Codes, Standards, and Criteria  
(cont'd)

2. Compliance with the specified requirements of the ASME Code, Section III, 1995 Edition with Addenda through 1997, would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Requests for alternatives shall be submitted in accordance with 10 CFR 72.4.

(continued)

DESIGN FEATURES

Table 3-1: Not Used

**Table 3-2  
Applicable Code Paragraphs for Underground VVMs**

|     | <b>Item</b>                                 | <b>Code Paragraph<sup>†</sup></b>        | <b>Explanation and Applicability</b>   |
|-----|---|--|--|
| 1.  | Definition of primary and secondary members | NF-1215                                  |  |
| 2.  | Jurisdictional boundary                     | NF-1133                                  | The “intervening elements” are termed interfacing SSCs in this FSAR.   |
| 3.  | Certification of Material                   | NF-2130(b) and (c)                       | Materials shall be certified to the applicable Section II of the ASME Code or equivalent ASTM Specification.   |
| 4.  | Heat treatment of material                  | NF-2170 and NF-2180                      |  |
| 5.  | Storage of welding material                 | NF-2400                                  |  |
| 6.  | Structural Analysis of Interfacing SSCs     | ACI 318-05                               | The VVM Interface Pad and Support Foundation are reinforced concrete structures. Loadings come from the external environment and from the VVM. Sections of the Code that may reasonably be applied to subterranean application are applicable. |
| 7.  | Welding procedure                           | Section IX                               |  |
| 8.  | Welding material                            | Section II                               |  |
| 9.  | Loading conditions                          | NF-3111                                  |  |
| 10. | Allowable stress values                     | NF-3112.3                                |  |
| 11. | Rolling and sliding supports                | NF-3424                                  |  |
| 12. | Differential thermal expansion              | NF-3127                                  |  |
| 13. | Stress analysis                             | NF-3143<br>NF-3380<br>NF-3522<br>NF-3523 | Provisions for stress analysis for Class 3 plate and shell supports and for linear supports are applicable for CEC shells and CLOSURE LID.   |
| 14. | Cutting of plate stock                      | NF-4211<br>NF-4211.1                     |  |
| 15. | Forming                                     | NF-4212                                  |  |
| 16. | Forming tolerance                           | NF-4221                                  | Applies to the CEC Divider Shell and CEC Container Shell   |
| 17. | Fitting and Aligning Tack Welds             | NF-4231<br>NF-4231.1                     |  |
| 18. | Alignment                                   | NF-4232                                  |  |
| 19. | Storage of Welding Materials                | NF-4411                                  |  |
| 20. | Cleanliness of Weld Surfaces                | NF-4412                                  | Applies to structural and non-structural welds   |

**Table 3-2 (continued)**  
**Applicable Code Paragraphs for Underground VVMs**

|     | <b>Item</b>                           | <b>Code Paragraph†</b>        | <b>Explanation and Applicability</b>           |
|-----|---------------------------------------|-------------------------------|--|
| 21. | Backing Strips, Peening               | NF-4421<br>NF-4422            | Applies to structural and non-structural welds |
| 22. | Pre-heating and Interpass Temperature | NF-4611<br>NF-4612<br>NF-4613 | Applies to structural and non-structural welds |
| 23. | Non-Destructive Examination           | NF-5360                       | Invokes Section V                              |
| 24. | NDE Personnel Certification           | NF-5522<br>NF-5523<br>NF-5530 | -  |

† All references to the ASME Code refer to applicable sections of the 1995 edition with addenda through 1997, except for Code Sections V and IX, where the latest effective editions of ASME Code Sections V and IX, including addenda, may be used, provided a written reconciliation of the later edition against the 1995 Edition, including addenda, is performed by the certificate holder.



## DESIGN FEATURES (continued)

### 3.4 Site-Specific Parameters and Analyses

Site-specific parameters and analyses that will require verification by the system user are, as a minimum, as follows:

1. The temperature of 80° F is the maximum average yearly temperature.
2. The allowed temperature extremes, averaged over a 3-day period, shall be greater than -40° F and less than 125° F.
3. The analyzed flood condition of 15 fps water velocity and a height of 125 feet of water (full submergence of the loaded cask) are not exceeded.
4. The potential for fire and explosion shall be addressed, based on site-specific considerations. The user shall demonstrate that the site-specific potential for fire is bounded by the fire conditions analyzed by the Certificate Holder, or an analysis of the site-specific fire considerations shall be performed.
5. The resultant zero period acceleration at the top of the grade and at the elevation of the Support Foundation Pad (SFP) at the host site (computed by the Newmark's rule as the sum of  $A+0.4*B+0.4*C$ , where A, B, C denote the free field ZPA's in the three orthogonal directions in decreasing magnitude, i.e.,  $A \geq B \geq C$ ) shall be less than or equal to 1.3 and 1.228, respectively.
6.
  - a. The criteria used to qualify the protection of the reactor building base mat foundation at the nuclear plant shall also be used to insure that sub-grade supporting the SFP shall not violate the plant's acceptance criteria for the potential of liquefaction.
  - b. The depth averaged densities and strain compatible shear wave velocities in the different regions of the subgrade shall meet the minimum requirements of Table 3-4.
7. The moment and shear capacities of the ISFSI Structures shall meet the structural requirements under the load combinations in Table 3-3.
8. Radiation Protection Space (RPS) as defined in Subsection 5.7.9 of Appendix A-100U, is intended to ensure that the subgrade material in and around the lateral space occupied by the VVMs remains essentially intact under all service conditions including during an excavation activity adjacent to the RPS.
9. The Support Foundation Pad (mat) for a VVM array established in any one construction campaign shall be of monolithic construction, to the extent practicable, to maximize the physical stability of the underground installation.

(continued)

| <b>TABLE 3-3<br/>LOAD COMBINATIONS FOR THE TOP SURFACE PAD, VVM INTERFACE PAD,<br/>SUPPORT FOUNDATION PAD, AND THE RETAINING WALL PER<br/>ACI-318 (2005)</b> |              |
|--|--------------|
| Load Combination   |              |
| LC-1   | 1.4D         |
| LC-2   | 1.2D + 1.6L  |
| LC-3   | 1.2D + E + L |
| where:<br>D: Dead Load including long-term differential settlement effects.<br>L: Live Load<br>E: DBE for the Site   |              |

| <b>Table 3-4<br/>Values of Principal Design Parameters for the Underground ISFSI</b>       |                                    |
|--|------------------------------------|
| Thickness of the Support Foundation Pad, inch (nominal)                                    | ≥33                                |
| Thickness of the VVM Interface Pad, inch (nominal)   | ≥34                                |
| Thickness of the Top Surface Pad, inch (nominal)   | ≥30                                |
| Thickness of Retaining Wall, inch (nominal)  | ≥24                                |
| Rebar Size* (min.) and Layout* (max)   | #11 @ 9" each face, each direction |
| Rebar Concrete Cover (top and bottom)*, inch   | per 7.7.1 of ACI 318 (2005)        |
| Compressive Strength of Concrete*, psi   | ≥4500                              |
| Shear Wave Velocity in the Subgrade lateral to the VVM, fps (nominal)                      | ≥500                               |
| Shear Wave Velocity in the Subgrade Below the Support Foundation Pad, fps (nominal)        | ≥485                               |
| * Applies to Support Foundation Pad, VVM Interface Pad, Top Surface Pad and Retaining Wall |                                    |

(continued)

## DESIGN FEATURES (continued)

## 3.4 Site-Specific Parameters and Analyses (continued)

10. Prior to an excavation activity contiguous to an RPS, a seismic qualification of the ISFSI in the structurally most vulnerable configuration (i.e., maximum amount of earth removed) shall be performed to verify that the stability of the SFP, the TSP and the shielding material within the RPS, with or without the Retaining Wall, is maintained. If a Retaining Wall is not installed in any side of the ISFSI then an Excavation Exclusion Zone shall be established inside which excavation is prohibited by performing an appropriate SSI analysis.
11. In cases where engineered features (i.e., berms and shield walls) are used to ensure that the requirements of 10 CFR 72.104(a) are met, such features are to be considered important to safety and must be evaluated to determine the applicable quality assurance category.
12. LOADING OPERATIONS, TRANSPORT OPERATIONS, and UNLOADING OPERATIONS shall only be conducted with working area ambient temperatures  $\geq 0^{\circ}$  F.
13. For those users whose site-specific design basis includes an event or events (e.g., flood) that result in the blockage of any VVM inlet or outlet air ducts for an extended period of time (i.e, longer than the total Completion Time of LCO 3.1.2), an analysis or evaluation may be performed to demonstrate adequate heat removal is available for the duration of the event. Adequate heat removal is defined as fuel cladding temperatures remaining below the short term temperature limit. If the analysis or evaluation is not performed, or if fuel cladding temperature limits are unable to be demonstrated by analysis or evaluation to remain below the short term temperature limit for the duration of the event, provisions shall be established to provide alternate means of cooling to accomplish this objective.
14. Users shall establish procedural and/or mechanical barriers to ensure that during LOADING OPERATIONS and UNLOADING OPERATIONS, either the fuel cladding is covered by water, or the MPC is filled with an inert gas.

DESIGN FEATURES (continued)

3.5 Not Used

(continued)

## DESIGN FEATURES (continued)

## 3.6 Forced Helium Dehydration System

## 3.6.1 System Description

Use of a forced helium dehydration (FHD) system, (a closed-loop system) is an alternative to vacuum drying the MPC for moderate burnup fuel ( $\leq 45,000$  MWD/MTU) with lower MPC heat load and mandatory for drying MPCs containing one or more high burnup fuel assemblies or higher MPC heat load as indicated in Appendix A-100U Table 3-1. The FHD system shall be designed for normal operation (i.e., excluding startup and shutdown ramps) in accordance with the criteria in Section 3.6.2.

## 3.6.2 Design Criteria

- 3.6.2.1 The temperature of the helium gas in the MPC shall be at least 15°F higher than the saturation temperature at coincident pressure.
- 3.6.2.2 The pressure in the MPC cavity space shall be  $\leq 60.3$  psig (75 psia) during drying. Backfill pressures shall be as described in Appendix A.
- 3.6.2.3 The hourly recirculation rate of helium shall be  $\geq 10$  times the nominal helium mass backfilled into the MPC for fuel storage operations.
- 3.6.2.4 The partial pressure of the water vapor in the MPC cavity will not exceed 3 torr. The limit is met if the gas temperature at the demister outlet is verified by measurement to remain  $\leq 21^\circ\text{F}$  for a period of 30 minutes or if the dew point of the gas exiting the MPC is verified by measurement to remain  $\leq 22.9^\circ\text{F}$  for  $\geq 30$  minutes.
- 3.6.2.5 The condensing module shall be designed to de-vaporize the recirculating helium gas to a dew point  $\leq 120^\circ\text{F}$ .
- 3.6.2.6 The demister module shall be configured to be introduced into its helium conditioning function after the condensing module has been operated for the required length of time to assure that the bulk moisture vaporization in the MPC (defined as Phase 1 in FSAR Appendix 2.B) has been completed.
- 3.6.2.7 The helium circulator shall be sized to effect the minimum flow rate of circulation required by these design criteria.
- 3.6.2.8 The pre-heater module shall be engineered to ensure that the temperature of the helium gas in the MPC meets these design criteria.

## DESIGN FEATURES (continued)

## 3.6 Forced Helium Dehydration System (continued)

## 3.6.3 Fuel Cladding Temperature

A steady-state thermal analysis of the MPC under the forced helium flow scenario shall be performed using the methodology described in HI-STORM 100 FSAR Section 4.4, with due recognition of the forced convection process during FHD system operation. This analysis shall demonstrate that the peak temperature of the fuel cladding, under the most adverse condition of FHD system operation, is below the peak cladding temperature limit for normal conditions of storage for the applicable fuel type (PWR or BWR) and cooling time at the start of dry storage.

## 3.6.4 Pressure Monitoring During FHD Malfunction

During an FHD malfunction event, described in HI-STORM 100 FSAR Chapter 11 as a loss of helium circulation, the system pressure must be monitored to ensure that the conditions listed therein are met.

DESIGN FEATURES (continued)

3.7 Deleted

DESIGN FEATURES (continued)

3.8 Combustible Gas Monitoring During MPC Lid Welding and Cutting

During MPC lid-to-shell welding and cutting operations, combustible gas monitoring of the space under the MPC lid is required, to ensure that there is no combustible mixture present.



DESIGN FEATURES (continued)

3.9 Corrosion Mitigation Measures

The HI-STORM 100U VVM CEC Container Shell and Bottom Plate shall be protected from corrosion damage due to the corrosivity of the surrounding environment using the following means:

**Implementation and Requirements of Corrosion Mitigation Measures**

| <b>Surrounding Environment's Corrosivity</b><br><br>(see note iv) | <b>Corrosion Mitigation Measures</b> |  |   |
|---|--------------------------------------|--|---|
|   | Coating<br><br>(see note i)          | Concrete Encasement<br><br>(see note ii)                             | Cathodic Protection<br><br>(see note iii) |
| <b>Mild</b>   | Required                             | Choice of either concrete encasement or cathodic protection; or both |   |
| <b>Aggressive</b>   | Required                             | Optional   | Required                                  |

Notes:

- i. An exterior surface preservative (coating) applied on the CEC in accordance with the acceptance criteria set forth in the FSAR.
- ii. Concrete encasement of the CEC external surfaces to establish a high pH buffer around the CEC metal mass in accordance with the requirements set forth in the FSAR.
- iii. An impressed current cathodic protection system (ICCP) in accordance with the design criteria set forth in the FSAR.
- iv. Surrounding environment corrosivity is categorized as either mild or aggressive in accordance with the requirements set forth in the FSAR.

## DESIGN FEATURES (continued)

### 3.10 Periodic Corrosion Inspections for Underground Systems

HI-STORM 100U VVM ISFSIs not employing an impressed current cathodic protection system shall be subject to visual and UT inspection of at least one representative VVM to check for significant corrosion of the CEC Container Shell and Bottom Plate at an interval not to exceed 20 years. The VVM chosen for inspection is not required to be in use or to have previously contained a loaded MPC. The VVM considered to be most vulnerable to corrosion degradation shall be selected for inspection. If significant corrosion is identified, either an evaluation to demonstrate sufficient continued structural integrity (sufficient for at least the remainder of the licensing period) shall be performed or the affected VVM shall be promptly scheduled for repair or decommissioning. Through wall corrosion shall not be permitted without promptly scheduling for repair or decommissioning. Promptness of repair or decommissioning shall be commensurate with the extent of degradation of the VVM but shall not exceed 3 years from the date of inspection.

If the representative VVM is determined to require repair or decommissioning, the next most vulnerable VVM shall be selected for inspection. This inspection process shall conclude when a VVM is found that does not require repair or decommissioning. Since the last VVM inspected is considered more prone to corrosion than the remaining un-inspected VVMs, the last VVM inspected becomes the representative VVM for the remaining VVMs.

#### Inspections

**Visual Inspection:** Visual inspection of the inner surfaces of the CEC Container Shell and Bottom Plate for indications of significant or through wall corrosion (i.e., holes).

**UT Inspection:** The UT inspection is performed on the inside surfaces of the CEC. A minimum of 16 data points shall be obtained, 4 near the top, 4 near the mid-height and 4 near the bottom of the CEC Container Shell all approximately 0, 90, 180, and 270 degrees apart; and 4 on the CEC Bottom Plate near the CEC Container Shell approximately 0, 90, 180, and 270 degrees apart. Locations where visual inspection has identified potentially significant corrosion shall also receive UT inspection. Locations suspected of significant corrosion may receive further UT inspection to determine the extent of corrosion.

#### Inspection Criteria

General wall thinning exceeding 1/8" in depth and local pitting exceeding 1/4" in depth are conditions of significant corrosion.