

CERTIFICATE OF COMPLIANCE NO. 1014
APPENDIX B
APPROVED CONTENTS AND DESIGN FEATURES
FOR THE HI-STORM 100 CASK SYSTEM

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2.0 Approved Contents

2.1 Fuel Specifications and Loading Conditions (cont'd)

2.1.3 Regionalized Fuel Loading

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

2.2 Violations

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

- 2.2.1 The affected fuel assemblies shall be placed in a safe condition.
- 2.2.2 Within 24 hours, notify the NRC Operations Center.
- 2.2.3 Within 30 days, submit a special report which describes the cause of the violation, and actions taken to restore compliance and prevent recurrence.

2.3 Not Used

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

Table 2.1-1 (page 1 of 2930)
Fuel Assembly Limits

I. MPC MODEL: MPC-24

A. Allowable Contents

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

a. Cladding Type: ZR or Stainless Steel (SS) as specified in Table 2.1-2 for the applicable fuel assembly array/class.

b. Initial Enrichment: As specified in Table 2.1-2 for the applicable fuel assembly array/class.

c. Post-irradiation Cooling Time and Average Burnup Per Assembly:

i. Array/Classes
14x14D, 14x14E, and
15x15G Cooling time ≥ 8 years and an average burnup $\leq 40,000$ MWD/MTU.

ii. All Other Array/Classes Cooling time ≥ 3 years and average burnup $\leq 68,200$ MWD/MTU as specified in Section 2.4.

ii. NON-FUEL HARDWARE As specified in Table 2.1-8.

Table 2.1-1 (page 9 of 2930)
Fuel Assembly Limits

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

A. Allowable Contents (continued)

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

- | | |
|---|--|
| a. Cladding Type: | ZR |
| b. Composition: | 98.2 wt.% ThO_2 , 1.8 wt. % UO_2 with an enrichment of 93.5 wt. % ^{235}U

OR
98.5 wt.% ThO_2 , 1.5 wt.% UO_2 with an enrichment of 93.5 wt.% ^{235}U . |
| c. Number of Rods Per Thoria Rod Canister: | ≤ 18 |
| d. Decay Heat Per Thoria Rod Canister: | ≤ 115 Watts |
| e. Post-irradiation Fuel Cooling Time and Average Burnup Per Thoria Rod Canister: | A fuel post-irradiation cooling time ≥ 18 years and an average burnup $\leq 16,000$ MWD/MTIHM. |
| f. Initial Heavy Metal Weight: | ≤ 27 kg/canister |
| g. Fuel Cladding O.D.: | ≥ 0.412 inches |
| h. Fuel Cladding I.D.: | ≤ 0.362 inches |
| i. Fuel Pellet O.D.: | ≤ 0.358 inches |
| j. Active Fuel Length: | ≤ 111 inches |
| k. Canister Weight: | ≤ 550 lbs, including fuel |

Table 2.1-1 (page 11 of 2930)
Fuel Assembly Limits

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

A. Allowable Contents

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

- | | |
|--|---|
| a. Cladding Type: | ZR or Stainless Steel (SS) as specified in Table 2.1-3 for the applicable fuel assembly array/class |
| b. Maximum PLANAR-AVERAGE INITIAL ENRICHMENT: | As specified in Table 2.1-3 for the applicable fuel assembly array/class. |
| c. Initial Maximum Rod Enrichment | As specified in Table 2.1-3 for the applicable fuel assembly array/class. |
| 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 | Cooling time \geq 3 years and an average burnup \leq 65,000 MWD/MTUAs specified in Section 2.4. |

Table 2.1-1 (page 13 of 2930)
Fuel Assembly Limits

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

A. Allowable Contents (continued)

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

- | | |
|---|---|
| a. Cladding Type: | ZR or Stainless Steel (SS) in accordance with Table 2.1-3 for the applicable fuel assembly array/class. |
| b. Maximum PLANAR-AVERAGE INITIAL ENRICHMENT: | |
| i. Array/Classes 6x6A, 6x6B, 6x6C, 7x7A, and 8x8A. | As specified in Table 2.1-3 for the applicable fuel assembly array/class. |
| ii. All Other Array Classes | ≤ 4.0 wt.% ^{235}U . |
| c. Initial Maximum Rod Enrichment | As specified in Table 2.1-3 for the applicable fuel assembly array/class. |
| d. Post-irradiation Cooling Time and Average Burnup Per Assembly: | |
| i. Array/Class 6x6A, 6x6B, 6x6C, 7x7A, or 8x8A | Cooling time ≥ 18 years and an average burnup $\leq 30,000$ MWD/MTU (or MWD/MTIHM). |
| ii. Array/Class 8x8F | Cooling time ≥ 10 years and an average burnup $\leq 27,500$ MWD/MTU. |
| iii. Array/Class 10x10D and 10x10E | Cooling time ≥ 10 years and an average burnup $\leq 22,500$ MWD/MTU. |
| iv. All Other Array/Classes | Cooling time ≥ 3 years and an average burnup $\leq 65,000$ MWD/MTUAs specified in Section 2.4. |

Table 2.1-1 (page 14 of 2930)
Fuel Assembly Limits

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

A. Allowable Contents (continued)

e. Decay Heat Per Assembly

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

f. Fuel Assembly Length

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

g. Fuel Assembly Width

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

h. Fuel Assembly Weight

- | | |
|---|--|
| i. Array/Class 6x6A, 6x6B,
6x6C, 7x7A, or 8x8A | ≤ 550 lbs, including channels and DFC |
| ii. All Other Array/Classes | ≤ 7830 lbs, including channels and DFC |

Table 2.1-1 (page 15 of 2930)
Fuel Assembly limits

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

A. Allowable Contents (continued)

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

a. Cladding type	ZR
b. Composition	98.2 wt.% ThO_2 , 1.8 wt.% UO_2 with an enrichment of 93.5 wt.% ^{235}U OR 98.5 wt.% ThO_2 , 1.5 wt.% UO_2 with an enrichment of 93.5% wt.% ^{235}U .
c. Number of Rods per Thoria Rod Canister:	≤ 18
d. Decay Heat Per Thoria Rod Canister:	≤ 115 Watts
e. Post-irradiation Fuel Cooling Time and Average Burnup per Thoria Rod Canister:	A fuel post-irradiation cooling time ≥ 18 years and an average burnup $\leq 16,000$ MWD/MTIHM
f. Initial Heavy Metal Weight:	≤ 27 kg/canister
g. Fuel Cladding O.D.:	≥ 0.412 inches
h. Fuel Cladding I.D.:	≤ 0.362 inches
i. Fuel Pellet O.D.:	≤ 0.358 inches
j. Active Fuel Length:	≤ 111 inches
k. Canister Weight:	≤ 550 lbs, including fuel

Table 2.1-1 (page 17 of 2930)
Fuel Assembly Limits

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

A. Allowable Contents

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

- | | |
|---|---|
| a. Cladding Type: | ZR or Stainless Steel (SS) as specified in Table 2.1-2 for the applicable fuel assembly array/class |
| b. Initial Enrichment: | As specified in Table 2.1-2 for the applicable fuel assembly array/class. |
| c. Post-irradiation Cooling Time and Average Burnup Per Assembly: | |
| i. Array/Classes 14x14D, 14x14E, and 15x15G | Cooling time \geq 8 years and an average burnup \leq 40,000 MWD/MTU. |
| ii. All Other Array/Classes | Cooling time \geq 3 years and an average burnup \leq 68,200 MWD/MTUAs specified in Section 2.4. |
| iii. NON-FUEL HARDWARE | As specified in Table 2.1-8. |

Table 2.1-1 (page 19 of 2930)
Fuel Assembly Limits

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

A. Allowable Contents (continued)

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

- | | |
|---|---|
| a. Cladding Type: | ZR or Stainless Steel (SS) as specified in Table 2.1-2 for the applicable fuel assembly array/class |
| b. Initial Enrichment: | As specified in Table 2.1-2 for the applicable fuel assembly array/class. |
| c. Post-irradiation Cooling Time and Average Burnup Per Assembly: | |
| i. Array/Classes 14x14D, 14x14E, and 15x15G | Cooling time \geq 8 years and an average burnup \leq 40,000 MWD/MTU. |
| ii. All Other Array/Classes | Cooling time \geq 3 years and an average burnup \leq 68,200 MWD/MTUAs specified in Section 2.4. |
| iii. NON-FUEL HARDWARE | As specified in Table 2.1-8. |

Table 2.1-1 (page 21 of 2930)
Fuel Assembly Limits

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

A. Allowable Contents

1. Uranium oxide, PWR INTACT FUEL ASSEMBLIES listed in Table 2.1-2, with or without NON-FUEL HARDWARE and meeting the following specifications (Note 1):
 - a. Cladding Type: ZR or Stainless Steel (SS) as specified in Table 2.1-2 for the applicable fuel assembly array/class
 - b. Initial Enrichment: As specified in Table 2.1-2 for the applicable fuel assembly array/class.
 - c. Post-irradiation Cooling Time and Average Burnup Per Assembly:
 - i. Array/Classes 14x14D, 14x14E, and 15x15G
Cooling time \geq 9 years and an average burnup \leq 30,000 MWD/MTU or cooling time \geq 20 years and an average burnup \leq 40,000 MWD/MTU.
 - ii. All Other Array/Classes
Cooling time \geq 3 years and an average burnup \leq 68,200 MWD/MTU as specified in Section 2.4.
 - iii. NON-FUEL HARDWARE
As specified in Table 2.1-8.

Table 2.1-1 (page 23 of 2930)
Fuel Assembly Limits

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

A. Allowable Contents (cont'd)

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

- | | |
|---|--|
| a. Cladding Type: | ZR or Stainless Steel (SS) as specified in Table 2.1-2 for the applicable fuel assembly array/class |
| b. Initial Enrichment: | As specified in Table 2.1-2 for the applicable fuel assembly array/class. |
| c. Post-irradiation Cooling Time and Average Burnup Per Assembly: | |
| i. Array/Classes 14x14D, 14x14E, and 15x15G | Cooling time \geq 9 years and an average burnup \leq 30,000 MWD/MTU or cooling time \geq 20 years and an average burnup \leq 40,000 MWD/MTU. |
| ii. All Other Array/Classes | Cooling time \geq 3 years and an average burnup \leq 68,200 MWD/MTUs specified in Section 2.4. |
| iii. NON-FUEL HARDWARE | As specified in Table 2.1-8. |

Table 2.1-1 (page 25 of 2930)
Fuel Assembly Limits

VI. MPC MODEL: MPC-68M

A. Allowable Contents

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

- | | |
|--|---|
| a. Cladding Type: | ZR |
| b. Maximum PLANAR-AVERAGE INITIAL ENRICHMENT: | As specified in Table 2.1-3 for the applicable fuel assembly array/class. |
| c. Initial Maximum Rod Enrichment | As specified in Table 2.1-3 for the applicable fuel assembly array/class. |
| d. Post-irradiation Cooling Time and Average Burnup Per Assembly | |
| i. Array/Class 8x8F | Cooling time \geq 10 years and an average burnup \leq 27,500 MWD/MTU. |
| ii. All Other Array/Classes | Cooling time \geq 3 years and an average burnup \leq 65,000 MWD/MTUs specified in Section 2.4. |

Table 2.1-1 (page 27 of 2930)
Fuel Assembly Limits

VI. MPC MODEL: MPC-68M (continued)

A. Allowable Contents (continued)

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

- | | |
|---|---|
| a. Cladding Type: | ZR |
| 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/Class 8x8F | Cooling time \geq 10 years and an average burnup \leq 27,500 MWD/MTU. |
| ii. All Other Array/Classes | Cooling time \geq 3 years and an average burnup \leq 65,000 MWD/MTUs as specified in Section 2.4. |

Table 2.1-1 (page 28 of 2930)
Fuel Assembly Limits

VI. MPC MODEL: MPC-68M (continued)

A. Allowable Contents (continued)

e. Decay Heat Per Assembly

i. Array/Class 8x8F ≤ 183.5 Watts

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

f. Fuel Assembly Length ≤ 176.5 inches (nominal design)g. Fuel Assembly Width ≤ 5.85 inches (nominal design)h. Fuel Assembly Weight ≤ 7830 lbs, including channels and DFC

Table 2.1-1 (page 29 of 2930)
Fuel Assembly Limits

VI. MPC MODEL: MPC-68M (continued)

A. Allowable Contents (continued)

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

a. Cladding type	ZR
b. Composition	98.2 wt.% ThO_2 , 1.8 wt.% UO_2 with an enrichment of 93.5 wt.% ^{235}U OR 98.5 wt.% ThO_2 , 1.5 wt.% UO_2 with an enrichment of 93.5% wt.% ^{235}U
c. Number of Rods per Thoria Rod Canister:	≤ 18
d. Decay Heat Per Thoria Rod Canister:	≤ 115 Watts
e. Post-irradiation Fuel Cooling Time and Average Burnup per Thoria Rod Canister:	A fuel post-irradiation cooling time ≥ 18 years and an average burnup $\leq 16,000$ MWD/MTIHM
f. Initial Heavy Metal Weight:	≤ 27 kg/canister
g. Fuel Cladding O.D.:	≥ 0.412 inches
h. Fuel Cladding I.D.:	≤ 0.362 inches
i. Fuel Pellet O.D.:	≤ 0.358 inches
j. Active Fuel Length:	≤ 111 inches
k. Canister Weight:	≤ 550 lbs, including fuel

Table 2.1-1 (page 30 of 30)
Fuel Assembly Limits

VI. MPC MODEL: MPC-68M (continued)

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

1. Up to sixteen (16) DFCs containing BWR DAMAGED FUEL ASSEMBLIES and/or up to eight (8) DFCs containing FUEL DEBRIS. DFCs shall be located only in fuel storage locations 1, 2, 3, 8, 9, 16, 25, 34, 35, 44, 53, 60, 61, 66, 67, and/or 68. The remaining fuel storage locations may be filled with Uranium Oxide BWR UNDAMAGED FUEL ASSEMBLIES.
2. Up to one (1) Dresden Unit 1 Thoria Rod Canister

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

Fuel Assembly Array/Class	10x10A	10x10B	10x10C	10x10D	10x10E	10x10F	10x10G
Clad Material	ZR	ZR	ZR	SS	SS	ZR	ZR
Design Initial U (kg/assy.) (Note 3)	≤ 188	≤ 188	≤ 179	≤ 125	≤ 125	≤ 192	≤ 188
Maximum PLANAR-AVERAGE INITIAL ENRICHMENT(MPC-68, 68F, and 68FF) (wt.% ²³⁵ U) (Note 14)	≤ 4.2	≤ 4.2	≤ 4.2	≤ 4.0	≤ 4.0	Note 17	Note 17
Maximum PLANAR-AVERAGE INITIAL ENRICHMENT (MPC-68M) (wt.% ²³⁵ U) (Note 16, 19)	≤ 4.8	≤ 4.8	≤ 4.8	Note 18	Note 18	≤ 4.7 (Note 15)	≤ 4.675 (Note 15)
Initial Maximum Rod Enrichment (wt.% ²³⁵ U)	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
No. of Fuel Rod Locations	92/78 (Note 8)	91/83 (Note 9)	96	100	96	92/78 (Note 8)	96/84
Fuel Rod Clad O.D. (in.)	≥ 0.4040	≥ 0.3957	≥ 0.3780	≥ 0.3960	≥ 0.3940	≥ 0.4035	≥ 0.387
Fuel Rod Clad I.D. (in.)	≤ 0.3520	≤ 0.3480	≤ 0.3294	≤ 0.3560	≤ 0.3500	≤ 0.3570	≤ 0.340
Fuel Pellet Dia. (in.)	≤ 0.3455	≤ 0.3420	≤ 0.3224	≤ 0.3500	≤ 0.3430	≤ 0.3500	≤ 0.334
Fuel Rod Pitch (in.)	≤ 0.510	≤ 0.510	≤ 0.488	≤ 0.565	≤ 0.557	≤ 0.510	≤ 0.512
Design Active Fuel Length (in.)	≤ 150	≤ 150	≤ 150	≤ 83	≤ 83	≤ 150	≤ 150
No. of Water Rods (Note 11)	2	1 (Note 6)	5 (Note 10)	0	4	2	5 (Note 10)
Water Rod Thickness (in.)	≥ 0.030	> 0.00	≥ 0.031	N/A	≥ 0.022	≥ 0.030	≥ 0.031
Channel Thickness (in.)	≤ 0.120	≤ 0.120	≤ 0.055	≤ 0.080	≤ 0.080	≤ 0.120	≤ 0.060

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

Notes:

1. All dimensions are design nominal values. Maximum and minimum dimensions are specified to bound variations in design nominal values among fuel assemblies within a given array/class.
2. Deleted.
3. Design initial uranium weight is the nominal uranium weight specified for each assembly by the fuel manufacturer or reactor user. For each BWR fuel assembly, the total uranium weight limit specified in this table may be increased up to 1.5 percent for comparison with users' fuel records to account for manufacturer tolerances.
4. ≤ 0.635 wt. % ^{235}U and ≤ 1.578 wt. % total fissile plutonium (^{239}Pu and ^{241}Pu), (wt. % of total fuel weight, i.e., UO_2 plus PuO_2).
5. This assembly class contains 74 total rods; 66 full length rods and 8 partial length rods.
6. Square, replacing nine fuel rods.
7. Variable.
8. This assembly contains 92 total fuel rods; 78 full length rods and 14 partial length rods.
9. This assembly class contains 91 total fuel rods; 83 full length rods and 8 partial length rods.
10. One diamond-shaped water rod replacing the four center fuel rods and four rectangular water rods dividing the assembly into four quadrants.
11. These rods may also be sealed at both ends and contain Zr material in lieu of water.
12. This assembly is known as "QUAD+." It has four rectangular water cross segments dividing the assembly into four quadrants.
13. For the SPC 9x9-5 fuel assembly, each fuel rod must meet either the 9x9E or the 9x9F set of limits for clad O.D., clad I.D., and pellet diameter.
14. For MPC-68, 68F, and 68FF loaded with both INTACT FUEL ASSEMBLIES and DAMAGED FUEL ASSEMBLIES or FUEL DEBRIS, the maximum PLANAR AVERAGE INITIAL ENRICHMENT for the INTACT FUEL ASSEMBLIES is limited to 3.7 wt.% ^{235}U , as applicable.
15. Fuel assemblies classified as damaged fuel assemblies are limited to 4.6 wt.% ^{235}U for the 10x10F and 10x10G arrays/classes and 4.0 wt.% ^{235}U for the 8x8F, 9x9E, and 9x9F and 10x10G arrays/classes.
16. For MPC-68M loaded with both UNDAMAGED FUEL ASSEMBLIES and DAMAGED FUEL ASSEMBLIES or FUEL DEBRIS, the maximum PLANAR AVERAGE INITIAL ENRICHMENT for the UNDAMAGED FUEL ASSEMBLIES is limited to the enrichment limit of the damaged assembly.
17. This fuel assembly array/class is not allowable contents in MPC-68, 68F, or 68FF.
18. This fuel assembly array/class is not allowable contents in MPC-68M.
19. In accordance with the definition of UNDAMAGED FUEL ASSEMBLY, certain assemblies may be limited to up to 3.3 wt.% U-235. When loading these fuel

assemblies, all other undamaged fuel assemblies in the MPC are limited to ~~3.3~~ **3.3** wt% U-235 enrichments as specified in this table.

Table 2.1-8
NON-FUEL HARDWARE COOLING AND AVERAGE BURNUP (Notes 1, 2, 3, and 7)

Post-irradiation Cooling Time (years)	NSA with NFH INSERTS (Note 4) BURNUP (MWD/MTU)	NSA without NFH, GUIDE TUBE HARDWARE, or CONTROL COMPONENT (Note 5) BURNUP (MWD/MTU)	APSR BURNUP (MWD/MTU)
≥ 3	≤ 24,635	NA (Note 6)	NA
≥ 4	≤ 30,000	NA	NA
≥ 5	≤ 36,748	≤ 630,000	≤ 45,000
≥ 6	≤ 44,102	-	≤ 54,500
≥ 7	≤ 52,900	-	≤ 68,000
≥ 8	≤ 60,000	-	≤ 83,000
≥ 9	≤ 79,784-	-	≤ 111,000
≥ 10	≤ 101,826-	-	≤ 180,000
≥ 11	≤ 141,982-	-	≤ 630,000
≥ 12	≤ 360,000	-	=

- 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 APSR burnups > 180,000 MWD/MTU and ≤ 630,000 MWD/MTU must be cooled ≥ 11 years.
 3. Applicable to uniform loading and regionalized loading.
 4. Includes Burnable Poison Rod Assemblies (BPRAs), Wet Annular Burnable Absorbers (WABAs), ~~and~~ vibration suppressor inserts ~~and~~ Neutron Source Assemblies (NSAs) in combination with other control components (i.e. BPRAs, TPDs, and/or RCCAs).
 5. Includes Thimble Plug Devices (TPDs), water displacement guide tube plugs, orifice rod assemblies, Control Rod Assemblies (CRAs), Control Element Assemblies (CEAs), ~~and~~ Rod Cluster Control Assemblies (RCCAs) ~~and~~ NSAs without other forms of control components.
 6. NA means not authorized for loading at this cooling time.
 7. 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. ~~Burnup and cooling time limits on ZR-clad fuel are provided in Table 2.1-1. The method to calculate the limits and verify compliance, including examples, is provided in Chapter 12 of the HI-STORM 100 FSAR.~~

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

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

Table 2.4-1
Maximum Allowable Decay Heat per Fuel Storage Location
(Uniform Loading, ZR-Clad)

MPC Model	Decay Heat per Fuel Storage Location (kW)	
	Intact or Undamaged Fuel Assemblies	Damaged Fuel Assemblies and Fuel Debris
MPC-24	≤ 1.416	Not Permitted
MPC-24E/24EF	≤ 1.416	≤ 1.114
MPC-32/32F	≤ 1.062	≤ 0.718
MPC-68/68FF/68M	≤ 0.500	≤ 0.393

2.4.3 Deleted 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}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-Glad 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	851.124	-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	11064	-228.2	5141.35	-1102.05	338.294
≥ 10	82939.8	-45575.6	13320.2	-233.694	5266.25	-1095.94	-73.3159
≥ 11	86544	-49289.6	14921.7	-242.092	5444.54	-1141.6	-83.0603
≥ 12	91383	-54456.7	17107	-242.884	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	24830.4	-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	-2474.04

Table 2.4-3 (Page 2 of 8)

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

Cooling Time (years)	Array/Class 14x14C						
	A	B	C	D	E	F	G
≥ 3	18263.7	174.164	-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-Glad 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-Glad Fuel)

Cooling Time (years)	Array/Class 15x15D/E/F/H/I						
	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-Glad 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-Glad 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-Glad 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-Glad Fuel)

Cooling Time (years)	Array/Class 7x7B & 10x10F						
	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	139184	-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-Glad 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-Glad 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-Glad 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-Glad 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-Glad 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-Glad 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	45264	-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-Glad 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-Glad Fuel)

Cooling Time (years)	Array/Class 10x10A/B/G						
	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-Glad 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	7964	-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	117.064	-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

DESIGN FEATURES

3.3.1 Alternatives to Codes, Standards, and Criteria

Table 3-1 lists approved alternatives to the ASME Code for the design of the MPCs, OVERPACKs, and TRANSFER CASKs of the HI-STORM 100 Cask System.

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

Proposed alternatives to the ASME Code, Sections II and 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
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)

<p>MPC Enclosure Vessel and Lid</p>	<p>NB-6111</p>	<p>All completed pressure retaining systems shall be pressure tested.</p>	<p>The MPC enclosure vessel is seal welded in the field following fuel assembly loading. The MPC enclosure vessel shall then be pressure tested as defined in Chapter 9. Pressure tests will not be performed because lack of Accessibility for leakage inspections precludes a Codemeaningful compliant pressure test. Additionally, dose to the crew and far more effective tests (a and b below) performed on the MPC confinement boundary render the pressure test unnecessary. Since the shell welds of the MPC cannot be checked for leakage during this pressure test, the shop leakage test to 10⁻⁷ ref-cc/sec provides reasonable assurance as to its leak tightness.</p> <p>a. All MPC enclosure vessel welds (except closure ring and vent/drain cover plate) are inspected by volumetric examination, except the MPC lid-to-shell weld shall be verified by volumetric or multi-layer PT examination. If PT alone is used, at a minimum, it must include the root and final layers and each approximately 3/8 inch of weld depth. For either UT or PT, the maximum undetectable flaw size must be demonstrated to be less than the critical flaw size. The critical flaw size must be determined in accordance with ASME Section XI methods. The critical flaw size shall not cause the primary stress limits of NB-3000 to be exceeded.</p> <p>b. Fabrication (shop) leakage test to 10⁻⁷ ref cc/sec is performed (as described in Chapter 9 of the FSAR) to provide reasonable assurance as to the leak tightness of the MPC.</p> <p>The inspection results, including relevant findings (indications), shall be made a permanent part of the user's records by video, photographic, or other means which provide an equivalent retrievable record of weld integrity. The video or photographic records should be taken during the final interpretation period described in ASME Section V, Article 6, T-676. The vent/drain cover plate and the closure ring welds are confirmed by liquid penetrant examination. The inspection of the weld must be performed by qualified personnel and shall meet the acceptance requirements of ASME Code Section III, NB-5350 for PT or NB-5332 for UT.</p>
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DESIGN FEATURES (continued)

3.4 Site-Specific Parameters and Analyses (continued)

NOTE: The above anchorage specifications are required for the seismic spectra defined in item 3.4.3.c.i. Users may use fewer studs or those of different diameter to account for site-specific seismic spectra less severe than those specified above. The embedment design shall comply with Appendix B of ACI-349-97. A later edition of this Code may be used, provided a written reconciliation is performed.

- iii. Embedment Concrete Compressive Strength: $\geq 4,000$ psi at 28 days
- 4. 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.
- 5. The potential for fire and explosion while handling a loaded OVERPACK or TRANSFER CASK 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.
- 6.
 - a. For freestanding casks, the ISFSI pad shall be verified by analysis to limit cask deceleration during design basis drop and non-mechanistic tip-over events to ≤ 45 g's at the top of the MPC fuel basket. Analyses shall be performed using methodologies consistent with those described in the HI-STORM 100 FSAR. A restriction on the lift and/or drop height is not required if the cask is lifted with a device designed in accordance with **applicable stress limits from ANSI N14.6, and/or NUREG-0612**, and has redundant drop protection features.
 - b. For anchored casks, the ISFSI pad shall be designed to meet the embedment requirements of the anchorage design. A cask tip-over event for an anchored cask is not credible. The ISFSI pad shall be verified by analysis to limit cask deceleration during a design basis drop event to ≤ 45 g's at the top of the MPC fuel basket, except as provided for in this paragraph below. Analyses shall be performed using methodologies consistent with those described in the HI-STORM 100 FSAR. A restriction on the lift and/or drop height is not required to be established if the cask is lifted with a device designed in accordance with **applicable stress limits from ANSI N14.6, and/or NUREG-0612**, and has redundant drop protection features.

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