and aggregate requirements to allow the utilization of the temperature limits in Table 2.2.3. The allowable temperatures for the structural steel components are based on the maximum temperature for which material properties and allowable stresses are provided in Section II of the ASME Code. The specific allowable temperatures for the structural steel components of the overpack are provided in Table 2.2.3.

The overpack is designed for extreme cold conditions, as discussed in Section 2.2.2.2. The structural steel materials used for the storage cask that are susceptible to brittle fracture are discussed in Section 3.1.2.3.

The overpack is designed for the maximum allowable heat load for steady-state normal conditions, in accordance with Section 2.1.6. The thermal characteristics of the MPCs for which the overpack is designed are defined in Chapter 4.

Shielding

The off-site dose for normal operating conditions to a real individual beyond the controlled area boundary is limited by 10CFR72.104(a) to a maximum of 25 mrem/year whole body, 75 mrem/year thyroid, and 25 mrem/year for other critical organs, including contributions from all nuclear fuel cycle operations. Since these limits are dependent on plant operations as well as site-specific conditions (e.g., the ISFSI design and proximity to the controlled area boundary, and the number and arrangement of loaded storage casks on the ISFSI pad), the determination and comparison of ISFSI doses to this limit are necessarily site-specific. Dose rates for a single cask and a range of typical ISFSIs using the HI-STORM 100 System are provided in Chapter 5. The determination of site-specific ISFSI dose rates at the site boundary and demonstration of compliance with regulatory limits is to be performed by the licensee in accordance with 10CFR72.212.

The overpack is designed to limit the calculated surface dose rates on the cask for all MPCs as defined in Section 2.3.5. The overpack is also designed to maintain occupational exposures ALARA during MPC transfer operations, in accordance with 10CFR20. The calculated overpack dose rates are determined in Section 5.1. These dose rates are used to perform a generic occupational exposure estimate for MPC transfer operations and a dose assessment for a typical ISFSI, as described in Chapter 10.

Confinement

The overpack does not perform any confinement function. Confinement during storage is provided by the MPC and is addressed in Chapter 7. The overpack provides physical protection and biological shielding for the MPC confinement boundary during MPC dry storage operations.

Operations

There are no radioactive effluents that result from MPC transfer or storage operations using the overpack. Effluents generated during MPC loading and closure operations are handled by the plant's

Table 2.0.2 (continued)
HI-STORM 100 OVERPACK DESIGN CRITERIA SUMMARY

Type	Criteria	Basis	FSAR Reference
Response and Degradation Limits	Protect MPC from deformation	10CFR72.122(b) 10CFR72.122(c)	Sections 2.0.2 and 3.1
	Continued adequate performance of overpack	10CFR72.122(b) 10CFR72.122(c)	
	Retrieval of MPC	10CFR72.122(l)	
Thermal:			
Maximum Design Temperatures:			
Concrete			
Through-Thickness Section Average (Normal)	Table 2.2.3	ACI 349, Appendix A (Paragraph A.4.3)	Section 2.0.2, and Tables 1.D.1 and 2.2.3
Through-Thickness Section Average (Off-Normal and Accident)	Table 2.2.3		Section 2.0.2, and Tables 1.D.1 and 2.2.3
Steel Structure (other than lid bottom and top plates) Lid Bottom and Top Plates	350° F 450°F	ASME Code Section II, Part D	Table 2.2.3
Insolation:	Averaged Over 24 Hours	10CFR71.71	Section 4.4.1.1.8
Confinement:	None	10CFR72.128(a)(3) & 10CFR72.236(d) & (e)	N/A
Retrievability:			
Normal and Off-Normal	No damage that precludes Retrieval of MPC	10CFR72.122(f) & (l)	Section 3.4
Accident			Section 3.4
Criticality:	Protection of MPC and Fuel Assemblies	10CFR72.124 & 10CFR72.236(c)	Section 6.1
Radiation Protection/Shielding:		10CFR72.126 & 10CFR72.128(a)(2)	
Overpack (Normal/Off-Normal/Accident)			
Surface	ALARA	10CFR20	Chapters 5 and 10
Position	ALARA	10CFR20	Chapters 5 and 10

Non-fuel hardware, as defined in Table 1.0.1, has been evaluated and is authorized for storage in the PWR MPCs as specified in Section 2.1.9.

2.1.8 Criticality Parameters for Design Basis SNF

As discussed earlier, the MPC-68, MPC-68F, MPC-68FF, MPC-32 and MPC-32F feature a basket without flux traps. In the aforementioned baskets, there is one panel of neutron absorber between two adjacent fuel assemblies. The MPC-24, MPC-24E, and MPC-24EF employ a construction wherein two neighboring fuel assemblies are separated by two panels of neutron absorber with a water gap between them (flux trap construction).

The minimum ^{10}B areal density in the neutron absorber panels for each MPC model is shown in Table 2.1.15.

For all MPCs, the ^{10}B areal density used for the criticality analysis is conservatively established below the minimum values shown in Table 2.1.15. For Boral, the value used in the analysis is 75% of the minimum value, while for METAMIC, it is 90% of the minimum value. This is consistent with NUREG-1536 [2.1.5] which suggests a 25% reduction in ^{10}B areal density credit when subject to standard acceptance tests, and which allows a smaller reduction when more comprehensive tests of the areal density are performed.

The criticality analyses for the MPC-24, MPC-24E and MPC-24EF (all with higher enriched fuel) and for the MPC-32 and MPC-32F were performed with credit taken for soluble boron in the MPC water during wet loading and unloading operations. Table 2.1.14 and 2.1.16 provide the required soluble boron concentrations for these MPCs.

2.1.9 Summary of Authorized Contents

Tables 2.1.3, 2.1.4, 2.1.12, and 2.1.17 through 2.1.29 together specify the limits for spent fuel and non-fuel hardware authorized for storage in the HI-STORM 100 System. The limits in these tables are derived from the safety analyses described in the following chapters of this FSAR. Fuel classified as damaged fuel assemblies or fuel debris must be stored in damaged fuel containers for storage in the HI-STORM 100 System.

Tables 2.1.17 through 2.1.24 are the baseline tables that specify the fuel assembly limits for each of the MPC models, with appropriate references to the other tables in this section for certain other limits. Tables 2.1.17 through 2.1.24 refer to Section 2.1.9.1 for ZR-clad fuel limits on minimum cooling time, maximum decay heat, and maximum burnup for uniform and regionalized fuel loading.

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

Each ZR-clad fuel assembly and any PWR integral non-fuel hardware (NFH) to be stored in the HI-STORM 100 System must meet the following limits, in addition to meeting the physical limits specified elsewhere in this section, to be authorized for storage in the HI-STORM 100 System. The

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

The maximum allowable ZR-clad fuel assembly average burnup varies with the following parameters, based on the shielding analysis in Chapter 5:

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

The calculation described in this section is used to determine the maximum allowable fuel assembly burnup for minimum cooling times between 3 and 20 years, using maximum decay heat and minimum enrichment as input values. This calculation may be used to create multiple burnup versus cooling time tables for a particular fuel assembly array/class and different minimum enrichments. The allowable maximum burnup for a specific fuel assembly may be calculated based on the assembly's particular enrichment and cooling time.

(i) Choose a fuel assembly minimum enrichment, E_{235}.

(ii) Calculate the maximum allowable fuel assembly average burnup for a minimum cooling time between 3 and 20 years using the equation below:

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

Equation j

Where:

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

q = Maximum allowable decay heat per fuel storage location determined in Section 2.1.9.1.1 or 2.1.9.1.2 (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 2.1.28 or 2.1.29 for the applicable fuel assembly array/class and minimum cooling time.

2.1.9.1.4 Other Considerations

In computing the allowable maximum fuel storage location decay heats and fuel assembly average burnups, the following requirements apply:

- Calculated burnup limits shall be rounded down to the nearest integer

- Calculated burnup limits greater than 68,200 MWD/MTU for PWR fuel and 65,000 MWD/MTU for BWR fuel must be reduced to be equal to these values.

- 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 minimum cooling time of 4.5 years may be interpolated between those burnups calculated for 4 and 5 years.

- ZR-clad fuel assemblies must have a minimum enrichment, as defined in Table 1.0.1, greater than or equal to the value used in determining the maximum allowable burnup per Section 2.1.9.1.3 to be authorized for storage in the MPC.

- 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 PWR 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.

Section 12.2.10 provides a practical example of determining fuel storage location decay heat, burnup, and cooling time limits and verifying compliance for a set of example fuel assemblies.

2.1.9.1.5 Supplemental Cooling Threshold Heat Loads

Fuel loading operations involving the handling of High Burnup Fuel (HBF) in a dewatered MPC emplaced in a HI-TRAC transfer cask require additional cooling under certain thermal loads to address reduced heat dissipation relative to the normal storage condition. To address this requirement the Supplemental Cooling System (SCS) defined in Appendix 2.C is mandated under threshold heat loads defined in Section 4.5 and Table 2.1.30. The specific design of a SCS must accord with site-specific needs and resources, including the availability of plant utilities. However, a set of specifications to ensure that the performance objectives of the SCS are satisfied by plant-specific designs are set forth in Appendix 2.C.

Table 2.1.20

LIMITS FOR MATERIAL TO BE STORED IN MPC-24E AND MPC-24EF

PARAMETER	VALUE (Note 1)	
Fuel Type	Uranium oxide PWR intact fuel assemblies meeting the limits in Table 2.1.3 for the applicable array/class	Uranium oxide PWR damaged fuel assemblies and/or fuel debris meeting the limits in Table 2.1.3 for the applicable array/class, placed in a Damaged Fuel Container (DFC)
Cladding Type	ZR or Stainless Steel (SS) assemblies as specified in Table 2.1.3 for the applicable array/class	ZR or Stainless Steel (SS) assemblies as specified in Table 2.1.3 for the applicable array/class
Maximum Initial Enrichment per Assembly	As specified in Table 2.1.3 for the applicable array/class	As specified in Table 2.1.3 for the applicable array/class
Post-irradiation Cooling Time, and Average Burnup per Assembly	ZR clad: As specified in Section 2.1.9.1 SS clad: ≥ 8 yrs and ≤ 40,000 MWD/MTU	ZR clad: As specified in Section 2.1.9.1 SS clad: ≥ 8 yrs and ≤ 40,000 MWD/MTU
Decay Heat Per Fuel Storage Location	ZR clad: As specified in Section 2.1.9.1 SS clad: ≤ 710 Watts	ZR clad: As specified in Section 2.1.9.1 SS clad: ≤ 710 Watts
Non-fuel hardware post-irradiation Cooling Time and Burnup	As specified in Table 2.1.25	As specified in Table 2.1.25
Fuel Assembly Length	≤ 176.8 in. (nominal design)	≤ 176.8 in. (nominal design)
Fuel Assembly Width	≤ 8.54 in. (nominal design)	≤ 8.54 in. (nominal design)
Fuel Assembly Weight	≤ 1,720 lbs (including non-fuel hardware) for array/classes that do not require fuel spacers, otherwise ≤ 1680 lbs (including non-fuel hardware)	≤ 1,720 lbs (including DFC and non-fuel hardware) for array/classes that do not require fuel spacers, otherwise ≤ 1680 lbs (including DFC and non-fuel hardware)

Table 2.1.22

LIMITS FOR MATERIAL TO BE STORED IN MPC-68 AND MPC-68FF

PARAMETER	VALUE (Note 1)	
Fuel Type	Uranium oxide or MOX BWR intact fuel assemblies meeting the limits in Table 2.1.4 for the applicable array/class, with or without channels.	Uranium oxide or MOX BWR damaged fuel assemblies or fuel debris meeting the limits in Table 2.1.4 for the applicable array/class, with or without channels, in DFCs.
Cladding Type	ZR or Stainless Steel (SS) assemblies as specified in Table 2.1.4 for the applicable array/class	ZR or Stainless Steel (SS) assemblies as specified in Table 2.1.4 for the applicable array/class
Maximum Initial Planar Average Enrichment per Assembly and Rod Enrichment	As specified in Table 2.1.4 for the applicable fuel assembly array/class	Planar Average: ≤ 2.7 wt% ^{235}U for array/classes 6x6A, 6x6B, 6x6C, 7x7A, and 8x8A; ≤ 4.0 wt% ^{235}U for all other array/classes Rod: As specified in Table 2.1.4
Post-irradiation cooling time and average burnup per Assembly	ZR clad: As specified in Section 2.1.9.1; except as provided in Notes 2 and 3. SS clad: Note 4	ZR clad: As specified in Section 2.1.9.1; except as provided in Notes 2 and 3. SS clad: Note 4.
Decay Heat Per Fuel Storage Location	ZR clad: As specified in Section 2.1.9.1; except as provided in Notes 2 and 3. SS clad: ≤ 95 Watts	ZR clad: As specified in Section 2.1.9.1; except as provided in Notes 2 and 3. SS clad: ≤ 95 Watts
Fuel Assembly Length	Array/classes 6x6A, 6x6B, 6x6C, 7x7A, and 8x8A: ≤ 135.0 in. (nominal design) All Other array/classes: ≤ 176.5 in. (nominal design)	Array/classes 6x6A, 6x6B, 6x6C, 7x7A, and 8x8A: ≤ 135.0 in. (nominal design) All Other array/classes: ≤ 176.5 in. (nominal design)

Table 2.1.24

LIMITS FOR MATERIAL TO BE STORED IN MPC-32 AND MPC-32F

PARAMETER	VALUE (Note 1)	
Fuel Type	Uranium oxide, PWR intact fuel assemblies meeting the limits in Table 2.1.3 for the applicable fuel assembly array/class	Uranium oxide, PWR damaged fuel assemblies and fuel debris in DFCs meeting the limits in Table 2.1.3 for the applicable fuel assembly array/class
Cladding Type	ZR or Stainless Steel (SS) as specified in Table 2.1.3 for the applicable fuel assembly array/class	ZR or Stainless Steel (SS) as specified in Table 2.1.3 for the applicable fuel assembly array/class
Maximum Initial Enrichment per Assembly	As specified in Table 2.1.3	As specified in Table 2.1.3
Post-irradiation Cooling Time and Average Burnup per Assembly	*ZR clad:* As specified in Section 2.1.9.1 SS clad: ≥ 9 years and ≤ 30,000 MWD/MTU or ≥ 20 years and ≤ 40,000MWD/MTU	*ZR clad:* As specified in Section 2.1.9.1 SS clad: ≥ 9 years and ≤ 30,000 MWD/MTU or ≥ 20 years and ≤ 40,000MWD/MTU
Decay Heat Per Fuel Storage Location	ZR clad: As specified in Section 2.1.9.1 SS clad: ≤ 500 Watts	ZR clad: As specified in Section 2.1.9.1 SS clad: ≤ 500 Watts
Non-fuel hardware post-irradiation Cooling Time and Burnup	As specified in Table 2.1.25	As specified in Table 2.1.25
Fuel Assembly Length	≤ 176.8 in. (nominal design)	≤ 176.8 in. (nominal design)
Fuel Assembly Width	≤ 8.54 in. (nominal design)	≤ 8.54 in. (nominal design)
Fuel Assembly Weight	≤ 1,720 lbs (including non-fuel hardware) for array/classes that do not require fuel spacers, otherwise ≤ 1,680 lbs (including non-fuel hardware)	≤ 1,720 lbs (including DFC and non-fuel hardware) for array/classes that do not require fuel spacers, otherwise ≤ 1,680 lbs (including DFC and non-fuel hardware)

Table 2.1.28
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 2.1.28 (cont'd)

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 2.1.28 (cont'd)

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 2.1.28 (cont'd)

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 2.1.28 (cont'd)

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 2.1.28 (cont'd)

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 2.1.28 (cont'd)

PWR FUEL ASSEMBLY COOLING TIME-DEPENDENT COEFFICIENTS
(ZR-CLAD FUEL)

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

Table 2.1.28 (cont'd)

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 2.1.29

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 2.1.29 (cont'd)

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 2.1.29 (cont'd)

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 2.1.29 (cont'd)

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 2.1.29 (cont'd)

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 2.1.29 (cont'd)

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 2.1.29 (cont'd)

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 2.1.29 (cont'd)

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 2.1.29 (cont'd)

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 2.1.29 (cont'd)

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

Table 2.2.3

DESIGN TEMPERATURES

HI-STORM 100 Component	Long Term, Normal Condition Design Temperature Limits (Long-Term Events) (° F)	Off-Normal and Accident Condition Temperature Limits (Short-Term Events)† (° F)	30-Day Accident Condition Temperature Limit (° F)*
MPC shell	500	775	572
MPC basket	725	950	752
MPC Neutron Absorber	800	1000	752
MPC lid	550	775	572
MPC closure ring	400	775	572
MPC baseplate	400	775	572
HI-TRAC inner shell	400	800	-
HI-TRAC pool lid/transfer lid	350	800	-
HI-TRAC top lid	400	800	-
HI-TRAC top flange	400	700	-
HI-TRAC pool lid seals	350	N/A	-
HI-TRAC bottom lid bolts	350	800	-
HI-TRAC bottom flange	350	800	-
HI-TRAC top lid neutron shielding	300	350	-
HI-TRAC radial neutron shield	307	N/A	-
HI-TRAC radial lead gamma shield	350	600	-
Remainder of HI-TRAC	350	800	-
Fuel Cladding	752	752 or 1058 (Short Term Operations)†† 1058 (Off-Normal and Accident Conditions)	752
Overpack concrete	300	572 (local temperature	450 (local temperature)
Overpack Lid Top and Bottom Plate	450	800	450
Remainder of overpack steel structure	350	800	450

† For accident conditions that involve heating of the steel structures and no mechanical loading (such as the blocked air duct accident), the permissible metal temperature of the steel parts is defined by Table 1A of ASME Section II (Part D) for Section III, Class 3 materials as 700°F. For the ISFSI fire event, the maximum temperature limit for ASME Section 1 equipment is appropriate (850°F in Code Table 1A).

* 30-day accident event is defined as a 100% blocked vent condition at threshold heat loads defined in Section 4.6.

†† Normal short term operations includes MPC drying and onsite transport per Reference [2.0.8]. The 1058°F temperature limit applies to MPCs containing all moderate burnup fuel as discussed in Reference [2.0.9]. The limit for MPCs containing one or more high burnup fuel assemblies is 752°F. See also Section 4.3.

additional stability margin.

The penetration potential of the missile strikes (Load Case 04 in Table 3.1.5) is examined first. The detailed calculations show that there will be no penetration through the concrete surrounding the inner shell of the storage overpack or penetration of the top closure plate. Therefore, there will be no impairment to the confinement boundary due to missile strikes during a tornado. Since the inner shell is not compromised by the missile strike, there will be no permanent deformation of the inner shell. Therefore, ready retrievability is assured after the missile strike. The following paragraphs summarize the analysis work for the HI-STORM 100.

a. The small missile will dent any surface it impacts, but no significant puncture force is generated. The 1" missile can enter the air ducts, but geometry prevents a direct impact with the MPC.

b. The following table summarizes the denting and penetration analysis performed for the intermediate missile. Denting is used to connote a local deformation mode encompassing material beyond the impacting missile envelope, while penetration is used to connote a plug type failure mechanism involving only the target material immediately under the impacting missile. The results are applicable to the HI-STORM 100 and to the HI-STORM 100S. The HI-STORM 100S version B has a thicker outer shell than the classic HI-STORM 100, and a lid configuration that consists of a 1" lid cover plate backed by concrete and a 3" thick lid vent shield plate that acts as a barrier to a top lid missile strike. Therefore, the tabular results presented below are bounding for the HI-STORM 100S Version B.

Location	Denting (in.)	Thru-Thickness Penetration
Storage overpack outer Shell	13.75†	Yes (>0.75 in.)
Radial Concrete	18.54††	No (<27.25 in.)
Storage overpack Top Lid	< 2.0	No (<4 in.)

† Based on minimum outer shell thickness of 3/4". Penetration is less for HI-STORM 100 and 100S overpacks with 1" thick outer shell.

†† Based on concrete compressive strength equal to 50% of minimum value specified in Table 3.3.5 to account for exposure to high temperatures resulting from blocked duct accident.

The primary stresses that arise due to an intermediate missile strike on the side of the storage overpack and in the center of the storage overpack top lid are determined next. The analysis of the storage lid for the HI-STORM 100 bounds that for the HI-STORM 100S; because of the additional energy absorbing material (concrete) in the direct path of a potential missile strike on the top lid of the HI-STORM 100S lid, the energy absorbing requirements of the circular plate structure are much reduced. The analysis demonstrates that Level D stress limits are not exceeded in either the overpack outer shell or the top lid. The safety factor in the storage overpack, considered as a cantilever beam under tip load, is computed, as is the safety factor in the top lids, considered as two centrally loaded plates. The applied load, in each case, is the missile impact load. Similar calculations are performed for the HI-STORM 100S Version B using the same model and methodology. A summary of the results for axial stress in the storage overpack is given in the table below with numbers in parentheses representing the results of calculations for the geometry of the HI-STORM 100S Version B:

HI-STORM 100 MISSILE IMPACT - Global Axial Stress Results			
Item	**Value (ksi)**	**Allowable (ksi)**	**Safety Factor**
Outer Shell – Side Strike	14.35†(15.17)	37.95	2.64†(2.50)
Top Lid - End Strike	44.14(47.57)	57.0 (50.65)	1.29(1.065)

† Based on HI-STORM 100 overpack with inner and outer shell thicknesses of 1-1/4” and 3/4”, respectively. Result is bounding for HI-STORM 100 overpacks made with 1” thick inner and outer shells because the section modulus of the steel structure is greater.

To demonstrate ready retrievability of the MPC, we must show that the storage overpack suffers no permanent deformation of the inner shell that would prevent removal of the MPC after the missile strike. To demonstrate ready retrievability (for both HI-STORM 100 and for HI-STORM 100S) a conservative evaluation of the circumferential stress and deformation state due to the missile strike on the outer shell is performed. A conservative estimate for the 8” diameter missile impact force, “Pi”, on the side of the storage overpack is calculated as:

Pi = 843,000 lb.

This force is conservative in that the target overpack is assumed rigid; any elasticity serves to reduce the peak magnitude of the force and increase the duration of the impact. The use of the upper bound value is the primary reason for the high axial stresses resulting from this force. To demonstrate continued ability to retrieve the MPC subsequent to the strike, circumferential stress and deformation that occurs locally in the ring section near the location of the missile strike are investigated.

Subsection 3.4.7 presents stress and displacement results for a composite ring of unit width consisting of the inner and outer shells of the storage overpack. The solution assumes that the net loading is 56,184 lb. applied on the 1” wide ring (equivalent to a 45g deceleration applied uniformly along the height on a storage overpack weight of 270,000 lb.). This solution can be applied directly to evaluate the circumferential stress and deformation caused by a tornado missile strike on the outer shell. Using the results for the 45g tipover event, an attenuation factor to adjust the results is developed that reflects the difference in load magnitude and the width of

The allowable stress for the above calculation is the Level D membrane stress intensity limit from Table 3.1.12 at 450°F. This is a conservative result since the stress intensity is localized and need not be compared to primary membrane stress intensity. Even with the overestimate of impact strike force used in the calculations here, the stresses remain elastic and the calculated diameter changes are small and do not prevent ready retrievability of the MPC. Note that because the stresses remain in the elastic range, there will be no post-strike permanent deformation of the inner shell.

The above calculations remain valid for the HI-STORM 100S, Version B using normal weight concrete and are bounding for the case where densified concrete is used.

3.4.8.2 HI-TRAC Transfer Cask

3.4.8.2.1 Intermediate Missile Strike

HI-TRAC is always held by the handling system while in a vertical orientation completely outside of the fuel building (see Chapter 2 and Chapter 8). Therefore, considerations of instability due to a tornado missile strike are not applicable. However, the structural implications of a missile strike require consideration.

The penetration potential of the 8" missile strike on HI-TRAC (Load Case 04 in Table 3.1.5) is examined at two locations:

1. the lead backed outer shell of HI-TRAC.
2. the flat transfer lid consisting of multiple steel plates with a layer of lead backing.

In each case, it is shown that there is no penetration consequence that would lead to a radiological release. The following paragraphs summarize the analysis results.

a. The small missile will dent any surface it impacts, but no significant puncture force is generated.

b. The following table summarizes the denting and penetration analysis performed for the intermediate missile. Denting connotes a local deformation mode encompassing material beyond the impacting missile envelope, while penetration connotes a plug type failure mechanism involving only the target material immediately under the impacting missile. Where there is through-thickness penetration, the lead and the inner plate absorb any residual energy remaining after penetration of the outer plate in the 100 Ton HI-TRAC transfer lid. The table summarizes the bounding results for both transfer casks.

TABLE 3.4.9
SAFETY FACTORS FROM SUPPLEMENTARY CALCULATIONS

Item	Loading	Safety Factor	FSAR Location Where Details are Provided
HI-STORM Top Lid Weld Shear	Tipover	3.22	3.4.4.3.2.2
HI-STORM Lid Bottom Plate	End Drop	9.777	3.4.4.3.2.3
HI-STORM Lid Bottom Plate Welds	End Drop	2.695	3.4.4.3.2.3
Pedestal Shield Compression	End Drop	1.011	3.4.4.3.2.3
HI-STORM Inlet Vent Plate Bending Stress	End Drop	1.271	3.4.4.3.2.3
HI-STORM Lid Top Plate Bending	End Drop –100 100S	5.208 1.357	3.4.4.3.2.3
HI-TRAC Pocket Trunnion Weld	HI-TRAC Rotation	2.92	3.4.4.3.3.1
HI-TRAC 100 Optional Bolts - Tension	HI-TRAC Rotation	1.11	3.4.4.3.3.1
HI-STORM 100 Shell	Seismic Event	14.6	3.4.7
HI-TRAC Transfer Lid Door Lock Bolts	Side Drop	2.387	3.4.4.3.3.3
HI-TRAC Transfer Lid Separation	Side Drop	1.159	3.4.4.3.3.3
HI-STORM 100 Top Lid	Missile Impact	1.065	3.4.8.1
HI-STORM 100 Shell	Missile Impact	2.50	3.4.8.1
HI-TRAC Water Jacket –Enclosure Shell Bending	Pressure	1.85	3.4.4.3.3.4
HI-TRAC Water Jacket – Enclosure Shell Bending	Pressure plus Handling	1.80	3.4.4.3.3.1
HI-TRAC Water Jacket – Bottom Flange Bending	Pressure	1.39	3.4.4.3.3.4
HI-TRAC Water Jacket – Weld	Pressure	1.42	3.4.4.3.3.4
Fuel Basket Support Plate Bending	Side Drop	1.82	3.4.4.3.1.8
Fuel Basket Support Leg Stability	Side Drop	4.07	3.4.4.3.1.8
Fuel Basket Support Welds	Side Drop	1.35	3.4.4.3.1.8
MPC Cover Plates in MPC Lid	Normal Condition Internal Pressure	1.81	3.4.4.3.1.8
MPC Cover Plate Weld	Accident Condition Internal Pressure	2.52	3.4.4.3.1.8
HI-STORM Storage Overpack	External Pressure	2.88	3.4.4.5.2
HI-STORM Storage Overpack Circumferential Stress	Missile Strike	2.60	3.4.8.1
HI-TRAC Transfer Cask Circumferential Stress	Missile Strike	2.61	3.4.8.2
HI-TRAC Transfer Cask Axial Membrane Stress	Side Drop	1.52	3.4.9.3

the 0º orientation (which is why it is chosen for detailed analysis). It is also noted that the 90º corners where the basket panels intersect do not provide any additional moment resistance because of the slotted joint construction (see Figure 1.III.1); therefore, the 45º orientation (or any other orientation between 0º and 45º) does not give rise to any prying loads at the cell corners. Finally, to ensure that the analysis for the 0º orientation is conservative and bounds all other basket orientations, the analysis is performed based on a lateral impact deceleration of 60g even though, according to the results presented in Section 3.III.4.10, the maximum impact deceleration due to the non-mechanistic tip over event (measured at the top of the overpack lid) is less than 45g.

The stress and strain distributions in the fuel basket panels at 60g are shown in Figures 3.III.2 and 3.III.3, respectively. These figures show that the state of stress in the fuel basket panels is primarily elastic. The fuel basket displacements are plotted in Figure 3.III.4. Table 3.III.4 compares the maximum lateral displacement in a fuel basket panel (relative to its end supports) with the deflection limit specified in Subsection 2.III.0.1.

Per the licensing drawing, the nominal width of fuel basket panels in the vertical direction may be increased or decreased provided that the length of the panel slots is increased or decreased proportionally. This means that the fixed-height fuel basket may be assembled using more (or fewer) panels than the number depicted on the licensing drawing. The results of the ANSYS static analysis for the fuel basket presented herein are valid for any panel width since (a) the lateral load on the fuel basket per unit (vertical) length remains the same and (b) the length of the slots measured as a percentage of the panel width remains the same.

Finally, to evaluate the potential for crack propagation and growth for the MPC-68M fuel basket under the non-mechanistic tipover event, a crack propagation analysis is carried out for the MPC-68M fuel basket using the same methodology utilized in Attachment D of [1.III.A.3] to evaluate the HI-STAR 180 F-37 fuel basket in support of the HI-STAR 180 Transport Package [2.III.6.2].

The crack propagation analysis is informed by the results from the ANSYS finite element analysis of the MPC-68M fuel basket under a bounding load of 60g, which is described above. In particular, the stress distribution in the Metamic-HT basket panels, as determined by ANSYS, is shown in Figure 3.III.2. The maximum stress occurs at one of the basket notches, which are conservatively modeled as sharp (90 degree) corners in the finite element model. This peak stress is used as input to the following crack propagation analysis.

The critical stress intensity factor of Metamic-HT panels is estimated to be

$$K_{IC} = 15 \text{ ksi}\sqrt{\text{in}}$$

The estimated value is conservatively chosen to be lower than the typical range for aluminum alloys, which is 20 to 50 $MPa\sqrt{m}$ or 18.2 to 45 $ksi\sqrt{in}$ per Table 3 of [3.III.4]. Next the minimum crack size, a_{min}, for crack propagation to occur is calculated below using the formula for a through-thickness edge crack given in [3.1.5]. Although the formula is derived for a straight-edge specimen, the use of the peak stress, σ_{max}, at a notch in the fuel basket panel (instead of the average stress in the panel as required by the formula) essentially compensates for the geometric difference between the basket panel and the specimen. Moreover, the maximum size of a pre-existing crack (1/16") in the fuel basket panel is less than 1/6th of the basket panel thickness (0.40"). Thus, the assumption of a through-thickness edge crack is very conservative. The result is

$$a_{min} = \frac{\left(\frac{K_{IC}}{1.12\sigma_{max}}\right)^2}{\pi} = \frac{\left[\frac{15ksi\sqrt{in}}{1.12(12.78ksi)}\right]^2}{\pi} = 0.35in$$

and the safety factor against crack propagation (based on a 1/16" minimum detectable flaw size) is

$$SF = \frac{a_{min}}{a_{det}} = \frac{0.35in}{0.0625in} = 5.59$$

The calculated minimum crack size is five times greater than the maximum possible pre-existing crack size in the fuel basket (based on 100% surface inspection of each panel). The large safety factor ensures that crack propagation in the MPC-68M fuel basket will not occur due to the non-mechanistic tipover event.

3.III.4.4.3.2 Elastic Stability and Yielding of the MPC-68M Fuel Basket under Compression Loads (Load Case F3 in Table 3.1.3)

Under certain conditions, the fuel basket plates may be under direct compressive load. Although the finite element simulations can predict the onset of an instability and post-instability behavior, the computation in this subsection uses (the more conservative) classical instability formulations to demonstrate that an elastic instability of the basket plates is not credible.

A solution for the stability of the fuel basket plate is obtained using the classical formula for buckling of a wide bar [3.III.1]. Material properties are selected corresponding to a metal temperature of 325ºC, which bounds the computed metal temperatures anywhere in the fuel basket (see Table 4.III.3). The critical buckling stress for a pin-ended bar is:

$$\sigma_{cr} = (\pi)^2 \frac{E}{12(1-\nu^2)}\left(\frac{h}{a}\right)^2$$

where h is the plate thickness, a is the unsupported plate length, E is the Young's Modulus of Metamic-HT at 325ºC, ν is Poisson's Ratio (use 0.3 for this calculation)

From the drawings in Section 1.5, h = 0.40 in, a = 6.05 in, and E = 8,050 ksi (Table 1.III.A.1). Then, the classical critical buckling stress is computed as 31.8 ksi, which exceeds the yield be impervious to air. Using this model, a transient thermal solution of the HI-STORM 100 System starting from normal storage conditions is obtained. The results of the blocked ducts transient analysis are presented in Table 4.6.5 and confirmed to be below the accident temperature limits (Table 2.2.3). The co-incident MPC pressure is also computed and compared with the accident design pressure (Table 2.2.1). The result (Table 4.6.2) is confirmed to be below the limit.

For MPC heat loads which meet the values in Table 4.5.7 or 4.5.8, the results of the transient analysis that support the required action completion times for clearing the inlets are presented in Table 4.6.7 and confirm all temperatures are below the accident temperature limits (Table 2.2.3).

30-Day 100% Vent Blockage Accident

As noted above, the fuel and component temperatures rise due to complete blockage of HI-STORM vents. This temperature rise is small for casks where heat loads are much lower than design basis heat loads. A threshold heat load is defined for all MPCs in Table 4.6.8 at or below which fuel and component temperatures remain below their respective 30-day accident temperature limits (Table 2.2.3) under steady state conditions. A steady state evaluation of a complete vent blockage at threshold heat loads is performed for both MPC-32 and MPC-68. Steady state temperature and MPC cavity pressure results are presented in Table 4.6.9. The results demonstrate that the fuel and component temperatures remain below their respective 30-day accident temperature limits defined in the Design Criteria Chapter 2 with robust margins. MPC cavity pressure is also below the accident design limit with robust margins. Thermal performance of MPC-68 bounds all types of MPC-68 and MPC-24. Therefore, the threshold total decay heat for MPC-68 is also adopted for all other variants of MPC-68 and MPC-24 canisters. To identify and clear any blockages mandatory surveillance is defined in Chapter 11.

Since the mandatory surveillance frequency for MPCs at or below threshold decay heat is substantial, the following evaluations are performed to demonstrate that the MPCs are safe at off-normal and accident conditions. Thermal off-normal and design basis events or accident conditions defined in Chapter 4 of the FSAR are concurrently evaluated with the 100% vent blockage event at threshold heat load:

(a) Pressure (fuel rod rupture): There is no credible event to cause fuel rods to rupture during a 100% vent blockage event because of the following reasons:

- The computed PCT under 100% vent blockage accident condition (Table 4.6.9) is below the ISG-11 Rev 3 long-term normal temperature limit, and
- there is no credible loading on the fuel assemblies to cause fuel rods to rupture during a 100% vent blockage event.

Accordingly, the computed cavity pressures under 30-day vent blockage event evaluated herein is not affected.

(b) Off-Normal Ambient Temperatures: This event is defined in Section 4.6.1.2 as an ambient temperature of 100^{o}F for a 3-day period. The results of off-normal environmental temperatures coincident with 100% vent blockage event are summarized in Table 4.6.12. Component temperatures are obtained by adding the off-normal-to-normal ambient temperature difference of 20°F (11.1°C) to temperatures computed for MPCs at threshold decay heat (Table 4.6.9). The results are below the off-normal limits (Table 2.2.3) with substantial margins.

(c) Partial Blockage of Air Inlets: This condition is already covered by the postulated event wherein all the HI-STORM vents are assumed blocked.

(d) Fire: During transfer operations at the ISFSI, there is a possibility of a fire accident event to occur coincident with a 100% vent blockage event. The impact of fire on the MPC and fuel temperatures is extremely small (approximately 1°F). Overpack temperatures are primarily impacted due to heat input from the fire which is considerably larger than the SNF decay heat. Therefore, as evaluated in Section 4.6.2.1(a), the overpack components and concrete temperatures remain below their respective accident temperature limits. Therefore, this accident event coincident with a 100% vent blockage event does not challenge the HI-STORM 100 System safety limits.

(e) Extreme Environment Temperature: This event is defined in Section 4.6.2.3 as an ambient temperature of 125°F for a 3-day period. The results of extreme environmental temperatures coincident with 100% vent blockage event are summarized in Table 4.6.13. Component temperatures are obtained by adding the extreme-to-normal ambient temperature difference of 45°F (25°C) to temperatures computed for MPCs at threshold decay heat (Table 4.6.9). The results are below the accident limits (Table 2.2.3) with substantial margins.

(f) Burial under Debris: This accident event is evaluated in Section 4.6.2.5. Since the threshold decay heat is substantially lower than the maximum design basis heat load and cask initial temperatures (Table 4.6.9) are similar for 100% vent blockage event and that evaluated in Table 4.6.6, the evaluation in Section 4.6.2.5 remains bounding.

In this manner the above evaluations reasonably assure that the HI-STORM 100 system containing MPCs are safe under off-normal and accident conditions coincident with 30-day 100% blocked vents under the threshold heat load.

4.6.2.5 Burial Under Debris

Burial of the HI-STORM 100 System under debris is not a credible accident. During storage at the ISFSI there are no structures over the casks. Minimum regulatory distances from the ISFSI to the nearest ISFSI security fence precludes the close proximity of substantial amount of vegetation. There is no credible mechanism for the HI-STORM 100 System to become completely buried under debris. However, for conservatism, complete burial under debris is considered.

To demonstrate the inherent safety of the HI-STORM 100 System, a bounding analysis that considers the debris to act as a perfect insulator is considered. Under this scenario, the contents of the HI-STORM 100 System will undergo a transient heat up under adiabatic conditions. The

Table 4.6.8

THRESHOLD DECAY HEAT FOR 100% VENT BLOCKAGE

MPC Type	Threshold Decay Heat, kW	Per Storage Cell Decay Hear Limit, kW
MPC-24/24E/EF	18	0.75
MPC-68/68F/68FF/68M	18	0.264
MPC-32/32F	16	0.5

Table 4.6.9

STEADY STATE MAXIMUM HI-STORM TEMPERATURES AND MPC CAVITY PRESSURE AT THRESHOLD HEAT LOAD UNDER 100% VENT BLOCKAGE

Component	**MPC-32 Temperatures (°F)**	**MPC-68 Temperatures (°F)**
Fuel Cladding	714	730
MPC Basket	712	727
MPC Shell	471	502
MPC Lid (Note 1)	495	522
MPC Closure Ring	453	486
MPC Baseplate (Note 1)	327	342
Overpack Inner Shell (Note 2)	403	430
Overpack Concrete	401	426
Overpack Lid Concrete Bottom Plate	372	396
Overpack Lid Concrete Top Plate	221	225
Overpack Lid Concrete	372	396
MPC Cavity Pressure, psig (Note 3)		
No Rod Rupture With 1% Rod Rupture	102.6 103.6	104.7 105.2

Note 1: Thru-thickness section average temperature is reported.

Note 2: The overpack inner shell maximum temperature bounds the temperature of the remaining overpack steel structure.

Note 3: Although the CFD evaluations have been performed with an operating temperature corresponding to minimum initial helium backfill specification of 29.3 psig at 70°F reference temperature, maximum initial helium backfill pressure of 48.5 psig is adopted to compute MPC cavity pressure. In reality, the actual MPC cavity pressure will be lower than that reported above.

Table 4.6.12

STEADY STATE HI-STORM TEMPERATURES WITH MPCs AT THRESHOLD HEAT LOAD UNDER 100% VENT BLOCKAGE AND COINCIDENT OFF-NORMAL ENVIRONMENTAL TEMPERATURE

Component	**MPC-32 Temperatures** Note 1 **(°F)**	**MPC-68 Temperatures** Note 1 **(°F)**
Fuel Cladding	734	750
MPC Basket	732	747
MPC Shell	491	522
MPC Lid (Note 2)	515	542
MPC Closure Ring	473	506
MPC Baseplate (Note 2)	347	362
Overpack Inner Shell (Note 3)	423	450
Overpack Body Concrete	421	446
Overpack Lid Bottom Plate	392	416
Overpack Lid Top Plate	241	245
Overpack Lid Concrete	392	416
MPC Cavity Pressure, psig		
With 1% Rod Rupture	106.0	107.6

Note 1: Unless otherwise specified, all the reported temperatures are peak maximum values.
Note 2: Maximum through thickness average temperature at the hottest location is reported for structural thick components.
Note 3: The overpack inner shell maximum temperature bounds the temperature of the remaining overpack steel structure.

Table 4.6.13

STEADY STATE HI-STORM TEMPERATURES WITH MPCs AT THRESHOLD HEAT LOAD UNDER 100% VENT BLOCKAGE AND COINCIDENT EXTREME ENVIRONMENTAL TEMPERATURE

Component	**MPC-32 Temperatures** Note 1 **(°F)**	**MPC-68 Temperatures** Note 1 **(°F)**
Fuel Cladding	759	775
MPC Basket	757	772
MPC Shell	516	547
MPC Lid (Note 2)	540	567
MPC Closure Ring	498	531
MPC Baseplate (Note 2)	372	387
Overpack Inner Shell (Note 3)	448	475
Overpack Body Concrete	446	471
Overpack Lid Bottom Plate	417	441
Overpack Lid Top Plate	266	270
Overpack Lid Concrete	417	441
MPC Cavity Pressure, psig		
With 1% Rod Rupture	109.0	110.6

Note 1: Unless otherwise specified, all the reported temperatures are peak maximum values.
Note 2: Maximum through thickness average temperature at the hottest location is reported for structural thick components.
Note 3: The overpack inner shell maximum temperature bounds the temperature of the remaining overpack steel structure.

The MPC-24, MPC-24E, MPC-24EF, MPC-32, MPC-32F, MPC-68, and MPC-68FF are qualified for storage of SNF with different combinations of maximum burnup levels and minimum cooling times. Section 2.1.9 specifies the acceptable maximum burnup levels and minimum cooling times for storage of zircaloy clad fuel in these MPCs. Section 2.1.9 also specifies the acceptable maximum burnup levels and minimum cooling times for storage of stainless steel clad fuel. The burnup and cooling time values in Section 2.1.9, which differ by array class, were chosen based on an analysis of the maximum decay heat load that could be accommodated within each MPC. Section 5.2 of this chapter describes the choice of the design basis fuel assembly based on a comparison of source terms and also provides a description of how the allowable burnup and cooling times were derived. Since for a given cooling time, different array classes have different allowable burnups in Section 2.1.9, burnup and cooling times that bound array classes 14x14A and 9x9G were used for the analysis in this chapter since these array class burnup and cooling time combinations bound the combinations from the other PWR and BWR array classes. Section 5.2.5 describes how this results in a conservative estimate of the maximum dose rates.

Section 2.1.9 specifies that the maximum assembly average burnup for PWR and BWR fuel is 68,200 and 65,000 MWD/MTU, respectively. The analysis in this chapter conservatively considers burnups up to 75,000 and 70,000 MWD/MTU for PWR and BWR fuel, respectively.

The burnup and cooling time combinations listed below bound all acceptable uniform and regionalized loading burnup levels and cooling times from Section 2.1.9. All combinations were analyzed in the HI-STORM overpack and HI-TRAC transfer casks.

Zircaloy Clad Fuel		
MPC-24	**MPC-32**	**MPC-68**
60,000 MWD/MTU 3 year cooling	45,000 MWD/MTU 3 year cooling	50,000 MWD/MTU 3 year cooling
69,000 MWD/MTU 4 year cooling	60,000 MWD/MTU 4 year cooling	62,000 MWD/MTU 4 year cooling
75,000 MWD/MTU 5 year cooling	69,000 MWD/MTU 5 year cooling	65,000 MWD/MTU 5 year cooling
		70,000 MWD/MTU 6 year cooling

B&W15 is an additional 17% higher for consistency with previous revisions of the FSAR which also used this assembly as the design basis assembly.

The Haddam Neck and San Onofre 1 classes are shorter stainless steel clad versions of the WE 15x15 and WE 14x14 classes, respectively. Since these assemblies have stainless steel clad, they were analyzed separately as discussed in Section 5.2.3. Based on the results in Table 5.2.27, which show that the WE 15x15 assembly class has a higher source term than the WE 14x14 assembly class, the Haddam Neck, WE 15x15, fuel assembly was analyzed as the bounding PWR stainless steel clad fuel assembly. The Indian Point 1 fuel assembly is a unique 14x14 design with a smaller mass of fuel and clad than the WE14x14. Therefore, it is also bounded by the WE 15x15 stainless steel fuel assembly.

As discussed below in Section 5.2.5.3, the allowable burnup limits in Section 2.1.9 were calculated for different array classes rather than using the design basis assembly to calculate the allowable burnups for all array classes. As mentioned above, the design basis assembly has the highest neutron and gamma source term of the various array classes for the same burnup and cooling time. In order to account for the fact that different array classes have different allowable burnups for the same cooling time, burnups which bound the 14x14A array class were used with the design basis assembly for the analysis in this chapter because those burnups bound the burnups from all other PWR array classes. This approach assures that the calculated source terms and dose rates will be conservative.

5.2.5.2 BWR Design Basis Assembly

Table 2.1.2 lists the BWR fuel assembly classes that were evaluated to determine the design basis BWR fuel assembly. Since there are minor differences between the array types in the GE BWR/2-3 and GE BWR/4-6 assembly classes, these assembly classes were not considered individually but rather as a single class. Within that class, the array types, 7x7, 8x8, 9x9, and 10x10 were analyzed to determine the bounding BWR fuel assembly. Since the Humboldt Bay 7x7 and Dresden 1 8x8 are smaller versions of the 7x7 and 8x8 assemblies they are bounded by the 7x7 and 8x8 assemblies in the GE BWR/2-3 and GE BWR/4-6 classes. Within each array type, the fuel assembly with the highest UO_2 mass was analyzed. Since the variations of fuel assemblies within an array type are very minor, it is conservative to choose the assembly with the highest UO_2 mass. For a given array type of assemblies, the one with the highest UO_2 mass will produce the highest radiation source because, for a given burnup (MWD/MTU) and enrichment, it will have produced the most energy and therefore the most fission products. The Humboldt Bay 6x6, Dresden 1 6x6, and LaCrosse assembly classes were not considered in the determination of the bounding fuel assembly. However, these assemblies were analyzed explicitly as discussed below.

Table 5.2.26 presents the characteristics of the fuel assemblies analyzed to determine the design basis zircaloy clad BWR fuel assembly. The corresponding fuel assembly array class from Section 2.1.9 is also listed in the table. The fuel assembly listed for each array type is the assembly that has the highest UO_2 mass. All fuel assemblies in Table 5.2.26 were analyzed at the same burnup and cooling time. The initial enrichment used in these analyses is consistent with Table 5.2.24. The results of the comparison are provided in Table 5.2.28. These results indicate that the 7x7 fuel assembly has the highest radiation source term of the zircaloy clad fuel assembly classes considered in Table 2.1.2. This fuel assembly also has the highest UO_2 mass which confirms that, for a given initial enrichment, burnup, and cooling time, the assembly with the highest UO_2 mass produces the highest radiation source term. According to Reference [5.2.6], the last discharge of a 7x7 assembly was in 1985 and the maximum average burnup for a 7x7 during their operation was 29,000 MWD/MTU. This clearly indicates that the existing 7x7 assemblies have an average burnup and minimum cooling time that is well within the burnup and cooling time limits in Section 2.1.9. Therefore, the 7x7 assembly has never reached the burnup level analyzed in this chapter. However, in the interest of conservatism the 7x7 was chosen as the bounding fuel assembly array type. The power/assembly values used in Table 5.2.26 were calculated by dividing 120% of the thermal power for commercial BWR reactors by the number of assemblies in the core. The higher thermal power, 120%, was used to account for potential power uprates. The power level used for the 7x7 is an additional 4% higher for consistency with previous revisions of the FSAR which also used this assembly as the design basis assembly.

Since the LaCrosse fuel assembly type is a stainless steel clad 10x10 assembly it was analyzed separately. The maximum burnup and minimum cooling time for this assembly are limited to 22,500 MWD/MTU and 10-year cooling as specified in Section 2.1.9. This assembly type is discussed further in Section 5.2.3.

The Humboldt Bay 6x6 and Dresden 1 6x6 fuel are older and shorter fuel than the other array types analyzed and therefore are considered separately. The Dresden 1 6x6 was chosen as the design basis fuel assembly for the Humboldt Bay 6x6 and Dresden 1 6x6 fuel assembly classes because it has the higher UO_2 mass. Dresden 1 also contains a few 6x6 MOX fuel assemblies, which were explicitly analyzed as well.

Reference [5.2.6] indicates that the Dresden 1 6x6 fuel assembly has a higher UO_2 mass than the Dresden 1 8x8 or the Humboldt Bay fuel (6x6 and 7x7). Therefore, the Dresden 1 6x6 fuel assembly was also chosen as the bounding assembly for damaged fuel and fuel debris for the Humboldt Bay and Dresden 1 fuel assembly classes.

Since the design basis 6x6 fuel assembly can be intact or damaged, the analysis presented in Section 5.4.2 for the damaged 6x6 fuel assembly also demonstrates the acceptability of storing intact 6x6 fuel assemblies from the Dresden 1 and Humboldt Bay fuel assembly classes.

As discussed below in Section 5.2.5.3, the allowable burnup limits in Section 2.1.9 were calculated for different array classes rather than using the design basis assembly to calculate the allowable burnups for all array classes. As mentioned above, the design basis assembly has the highest neutron and gamma source term of the various array classes for the same burnup and cooling time. In order to account for the fact that different array classes have different allowable burnups for the same cooling time, burnups which bound the 9x9G array class were used with the design basis assembly for the analysis in this chapter because those burnups bound the burnups from all other BWR array classes. This approach assures that the calculated source terms and dose rates will be conservative.

5.2.5.3 Decay Heat Loads and Allowable Burnup and Cooling Times

Section 2.1.6 describes the calculation of the MPC maximum decay heat limits per assembly. These limits, which differ for uniform and regionalized loading, are presented in Section 2.1.9. The allowable burnup and cooling time limits are derived based on the allowable decay heat limits. Since the decay heat of an assembly will vary slightly with enrichment for a fixed burnup and cooling time, an equation is used to represent burnup as a function of decay heat and enrichment. This equation is of the form:

$$B_u = A * q + B * q^2 + C * q^3 + D * {E_{235}}^2 + E * E_{235} * q + F * E_{235} * q^2 + G$$

where:
B_u = Burnup in MWD/MTU
q = assembly decay heat (kW)
E_{235} = wt.% ^{235}U

The coefficients for this equation were developed by fitting ORIGEN-S calculated data for a specific cooling time using GNUPLOT [5.2.16]. ORIGEN-S calculations were performed for enrichments ranging from 0.7 to 5.0 wt.% ^{235}U and burnups from 10,000 to 65,000 MWD/MTU for BWRs and 10,000 to 70,000 MWD/MTU for PWRs. The burnups were increased in 2,500 MWD/MTU increments. Using the ORIGEN-S data, the coefficients A through G were determined and then the constant, G, was adjusted so that all data points were bounded (i.e. calculated burnup less than or equal to ORIGEN-S value) by the fit. The coefficients were calculated using ORIGEN-S data for cooling times from 3 years to 20 years. As a result, Section 2.1.9 provides different equation coefficients for each cooling time from 3 to 20 years. Additional discussion on the determination of the equation coefficients is provided in Appendix 5.F. Since the decay heat increases as the enrichment decreases, the allowable burnup will decrease as the enrichment decreases. Therefore, the enrichment used to calculated the allowable burnups becomes a minimum enrichment value and assemblies with an enrichment higher than the value used in the equation are acceptable for storage assuming they also meet the corresponding burnup and decay heat requirements. Even though the lower limit of 0.7 wt.% ^{235}U was used in developing the coefficients, these equations are valid for the few assemblies that might exist with enrichments below 0.7 wt.% ^{235}U. This is because the curve fit is very well behaved in the enrichment range from 0.7 to 5.0 wt.% ^{235}U and, therefore, it is expected that the curve fit will remain accurate for enrichments below 0.7 wt.% ^{235}U.

Different array classes or combinations of classes were analyzed separately to determine the allowable burnup as a function of cooling time for the specified allowable decay heat limits. Calculating allowable burnups for individual array classes is appropriate because even two assemblies with the same MTU may have a different allowable burnup for the same allowable cooling time and permissible decay heat. The heavy metal mass specified in Table 5.2.25 and

5.2.26 and Section 2.1.9 for the various array classes is the value that was used in the determination of the coefficients as a function of cooling time and is the maximum for the respective assembly class. Equation coefficients for each array class listed in Tables 5.2.25 and 5.2.26 were developed. In the end, the equation for the 17x17B and 17x17C array classes resulted in almost identical burnups. Therefore, in Section 2.1.9 these array classes were combined and the coefficients for the 17x17C array class were used since these coefficients produce slightly lower allowable burnups.

There is some uncertainty associated with the ORIGEN-S calculations due to uncertainty in the physics data (e.g. cross sections, decay constants, etc.) and the modeling techniques. To estimate this uncertainty, an approach similar to the one in Reference [5.2.14] was used. As a result, the potential error in the ORIGEN-S decay heat calculations was estimated to be in the range of 3.5 to 5.5% at 3 year cooling time and 1.5 to 3.5% at 20 year cooling. The difference is due to the change in isotopes important to decay heat as a function of cooling time. In order to be conservative in the derivation of the coefficients for the burnup equation, a 5% decay heat penalty was applied for both the PWR and BWR array classes.

As a demonstration that the decay heat values used to determine the allowable burnups are conservative, a comparison between these calculated decay heats and the decay heats reported in Reference [5.2.7] are presented in Table 5.2.29. This comparison is made for a burnup of 30,000 MWD/MTU and a cooling time of 5 years. The burnup was chosen based on the limited burnup data available in Reference [5.2.7].

As mentioned above, the fuel assembly burnup and cooling times in Section 2.1.9 were calculated using the decay heat limits which are also stipulated in Section 2.1.9. The burnup and cooling times for the non-fuel hardware, in Section 2.1.9, were chosen based on the radiation source term calculations discussed previously. The fuel assembly burnup, decay heat, and enrichment equations were derived without consideration for the decay heat from BPRAs, TPDs, CRAs, or APSRs. This is acceptable since the user of the HI-STORM 100 system is required to demonstrate compliance with the assembly decay heat limits in Section 2.1.9 regardless of the heat source (assembly or non-fuel hardware) and the actual decay heat from the non-fuel hardware is expected to be minimal. In addition, the shielding analysis presented in this chapter conservatively calculates the dose rates using both the burnup and cooling times for the fuel assemblies and non-fuel hardware. Therefore, the safety of the HI-STORM 100 system is guaranteed through the bounding analysis in this chapter, represented by the burnup and cooling time limits in the CoC, and the bounding thermal analysis in Chapter 4, represented by the decay heat limits in the CoC.

5.2.5.4 Burnup, Enrichment and Cooling time values for Site Specific Dose Analyses

As discussed earlier in this Chapter, site-specific dose evaluations are required to show compliance with the regulatory requirements, and those need to consider the types, burnups, enrichments and cooling times of the fuel to be stored. Since it is impractical to evaluate every fuel assembly individually, a bounding approach is typically used where assemblies are grouped

APPENDIX 5.F

Additional Information on the Burnup Versus Decay Heat and Enrichment Equation

The equation in Section 5.2.5.3 was determined to be the best equation capable of reproducing the burnup versus enrichment and decay heat data calculated with ORIGEN-S. As an example, Figure 5.F.1 graphically presents ORIGEN-S burnup versus decay heat data for various enrichments for the 9x9C/D fuel assembly array/classes with a 20- year cooling time. This data could also be represented graphically as a surface on a three dimensional plot. However, the 2D plot is easier to visualize. Additional enrichments were used in the ORIGEN-S calculations and have been omitted for clarity.

Figures 5.F.2 through 5.F.4 show ORIGEN-S burnup versus decay heat data for specific enrichments. In addition to the ORIGEN-S data, these figures present the results of the original curve fit and the adjusted curve fit. Table 5.F.1 below shows the equation coefficients used for both curve fits. As these figures indicate, the curve fit faithfully reproduces the ORIGEN-S data.

Figure 5.F.5 provides a different representation of the curve fit versus ORIGEN-S comparison. This figure was generated by taking the ORIGEN-S enrichment and decay heat data from Figure 5.F.1 for a constant burnup of 30,000 MWD/MTU and calculating the burnup using the fitted equation with coefficients from Table 5.F.1. The resulting burnup versus enrichment is plotted. Table 5.F.2 presents the ORIGEN-S and curve fit data in tabular form used to generate Figure 5.F.5. Since the ORIGEN-S calculations were performed for a specific burnup of 30,000 MWD/MTU, the ORIGEN-S data is represented as a straight line. Figures 5.F.6 and 5.F.7 provide the same representation for burnups of 45,000 and 65,000 MWD/MTU. These results also indicate that the non-adjusted curve fit provides a very good representation of the ORIGEN-S data. It is also clear that the adjusted curve fit always bounds the ORIGEN-S data by predicting a lower burnup which results in a more restrictive and conservative limit for the user.

Table 5.F.1

COEFFICIENTS FOR EQUATION IN SECTION 5.2.5.3 FOR THE 9X9C/D FUEL ASSEMBLY ARRAY/CLASSES WITH A COOLING TIME OF 20 YEARS

Coefficient	**Original Curve Fit**	**Adjusted Curve Fit**
A	249944	249944
B	-382059	-382059
C	308281	308281
D	-205.495	-205.495
E	9362.63	9362.63
F	1389.71	1389.71
G	-1995.54	-2350.49

Table 5.F.2

ORIGEN-S AND CURVE FIT DATA FOR THE 9X9C/D FUEL ASSEMBLY ARRAY/CLASSES WITH A COOLING TIME OF 20 YEARS

Specified Enrichment	**ORIGEN-S calculated decay heat per assembly (kw)**	**ORIGEN-S calculated burnup (MWD/MTU)**	**Burnup calculated with original curve fit (MWD/MTU)**	**Burnup calculated with adjusted curve fit (MWD/MTU)**
0.7	1.55E-01	30000	29700.69	29345.74
1	1.53E-01	30000	29715.24	29360.29
1.35	1.52E-01	30000	29759.8	29404.85
1.7	1.50E-01	30000	29849.09	29494.14
2	1.50E-01	30000	29997.43	29642.48
2.3	1.49E-01	30000	30050.56	29695.61
2.6	1.49E-01	30000	30120.16	29765.21
2.9	1.49E-01	30000	30228.56	29873.61
3.2	1.50E-01	30000	30340.01	29985.06
3.4	1.50E-01	30000	30354.95	30000
3.6	1.49E-01	30000	30172.21	29817.26
3.9	1.48E-01	30000	30095.41	29740.46
4.2	1.48E-01	30000	30001.17	29646.22
4.5	1.48E-01	30000	29890.42	29535.47
4.8	1.48E-01	30000	29764.09	29409.14
5	1.49E-01	30000	29731.66	29376.71

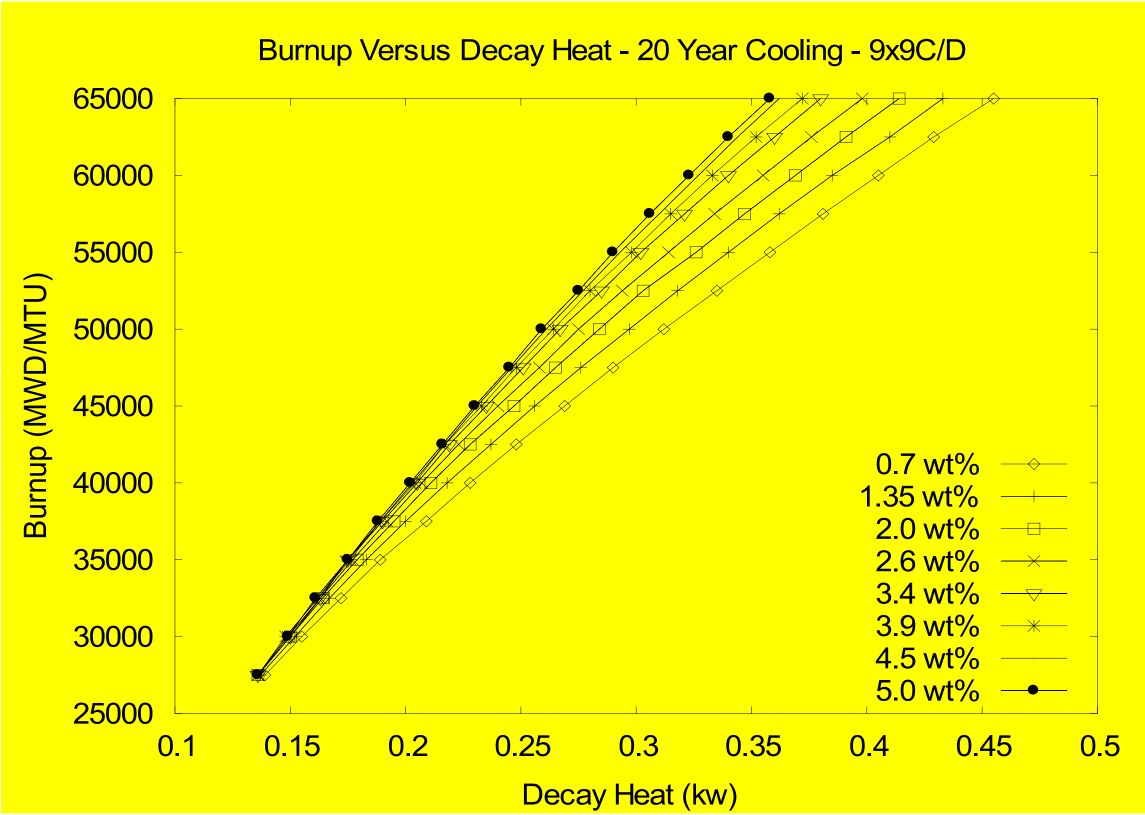

FIGURE 5.F.1; ORIGEN-S CALCULATED BURNUP VERSUS DECAY HEAT FOR VARIOUS ENRICHMENTS

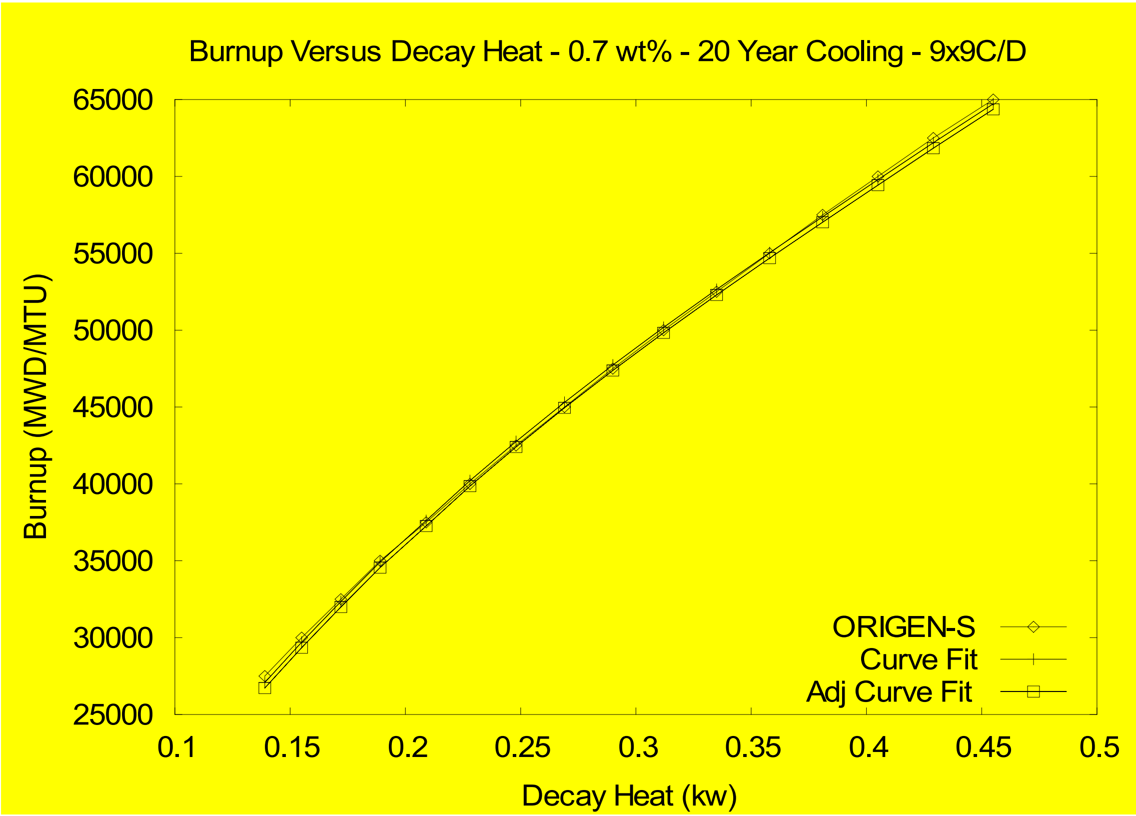

FIGURE 5.F.2; A COMPARISON OF THE BURNUP VERSUS DECAY HEAT CALCULATIONS FROM ORIGEN-S, THE ORIGINAL CURVE FIT, AND THE ADJUSTED CURVE FIT FOR AN ENRICHMENT OF 0.7 WT.% ^{235}U.

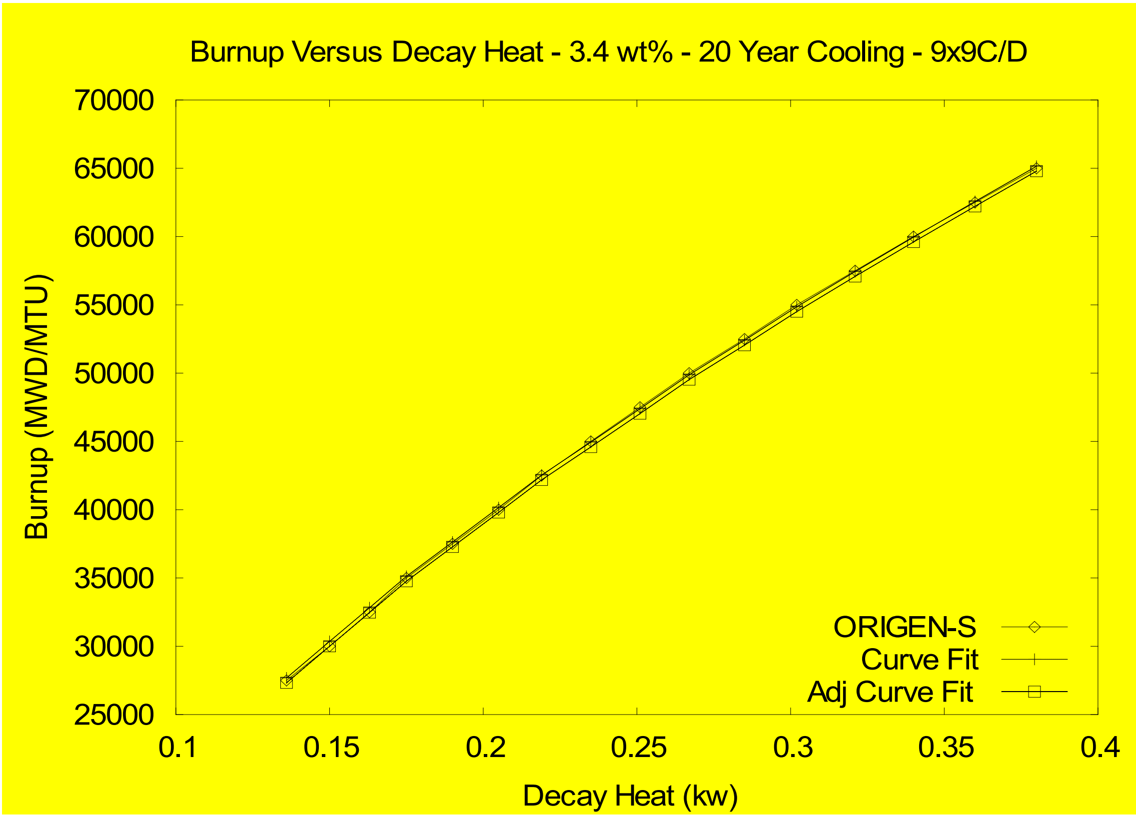

FIGURE 5.F.3; A COMPARISON OF THE BURNUP VERSUS DECAY HEAT CALCULATIONS FROM ORIGEN-S, THE ORIGINAL CURVE FIT, AND THE ADJUSTED CURVE FIT FOR AN ENRICHMENT OF 3.4 WT.% ^{235}U.

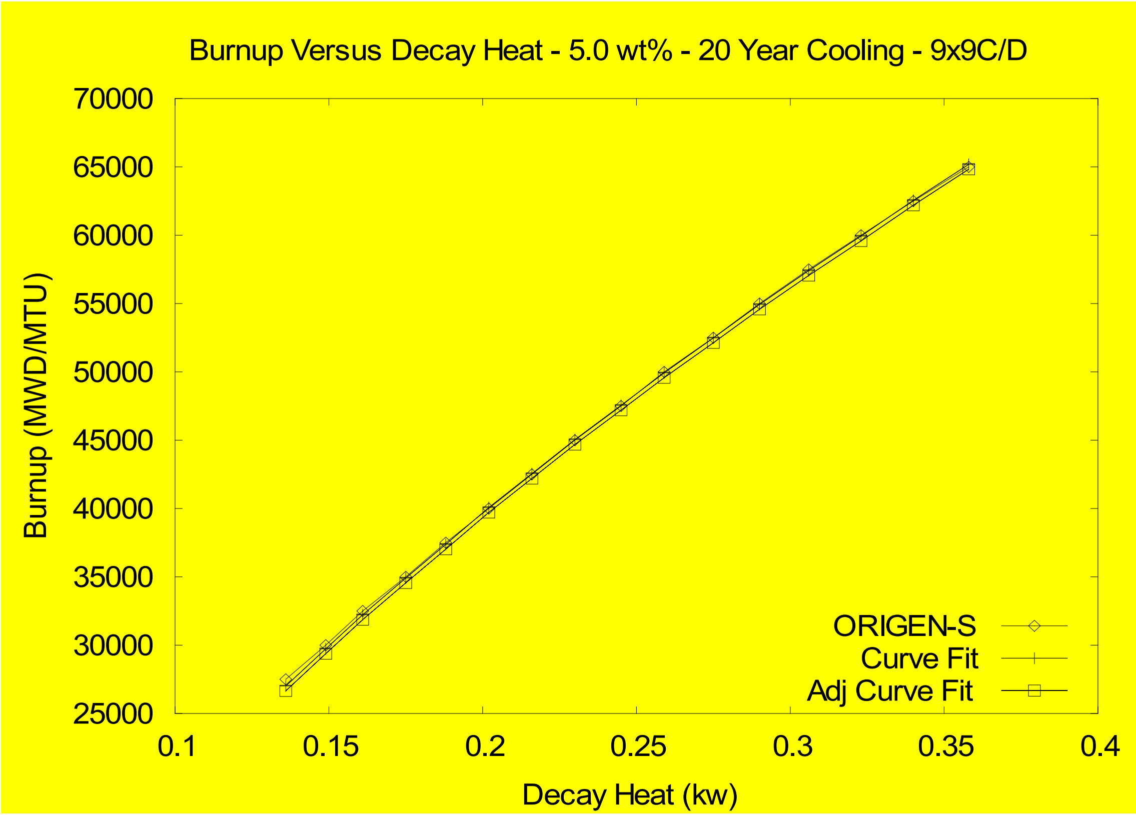

FIGURE 5.F.4; A COMPARISON OF THE BURNUP VERSUS DECAY HEAT CALCULATIONS FROM ORIGEN-S, THE ORIGINAL CURVE FIT, AND THE ADJUSTED CURVE FIT FOR AN ENRICHMENT OF 5.0 WT.% ^{235}U.

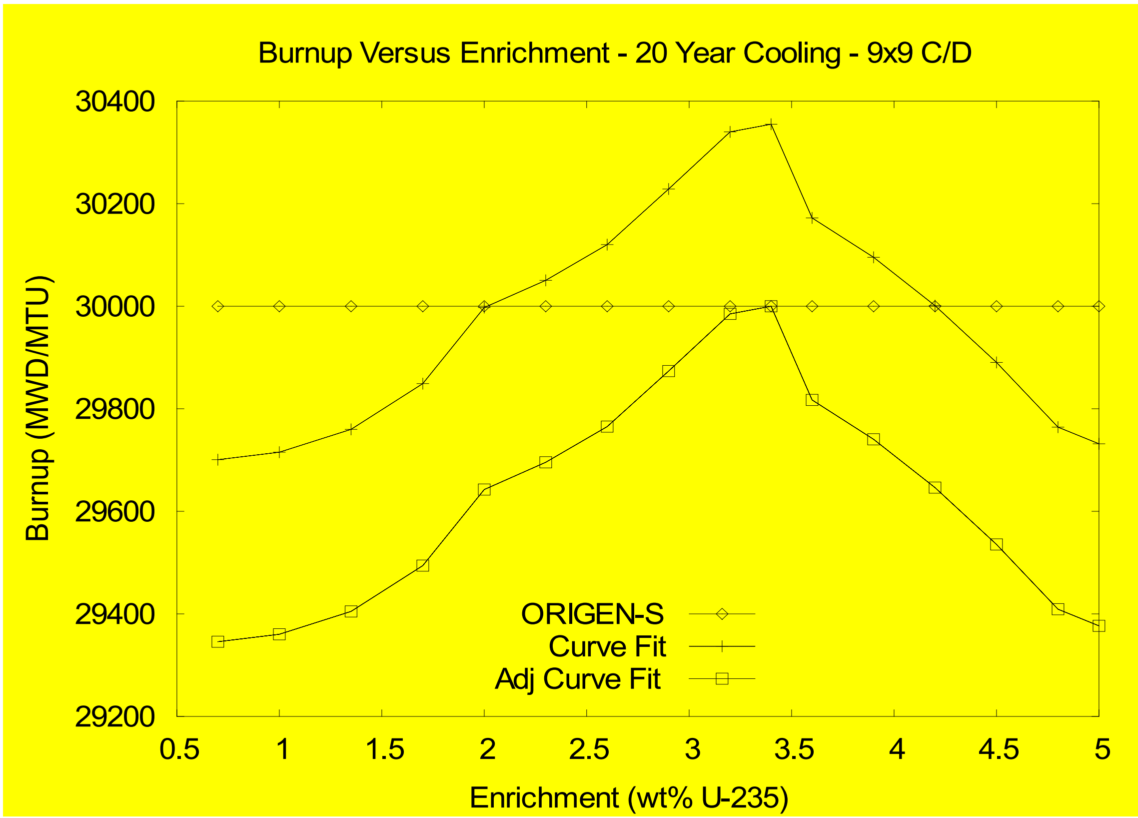

FIGURE 5.F.5; A COMPARISON OF THE CALCULATED BURNUPS USING THE CURVE FIT AND THE ADJUSTED CURVE FIT FOR VARIOUS ENRICHMENTS. ALL ORIGEN-S CALCULATIONS YIELDED A BURNUP OF 30,000 MWD/MTU.

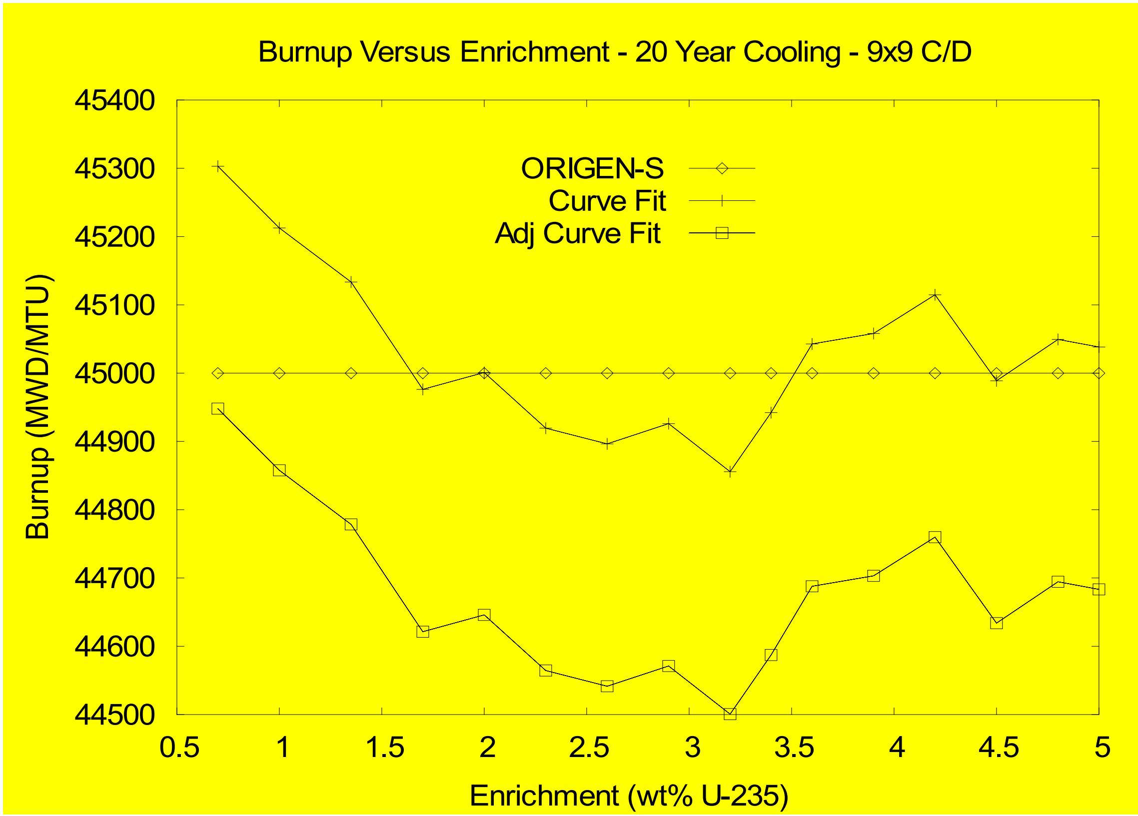

FIGURE 5.F.6; A COMPARISON OF THE CALCULATED BURNUPS USING THE CURVE FIT AND THE ADJUSTED CURVE FIT FOR VARIOUS ENRICHMENTS. ALL ORIGEN-S CALCULATIONS YIELDED A BURNUP OF 45,000 MWD/MTU.

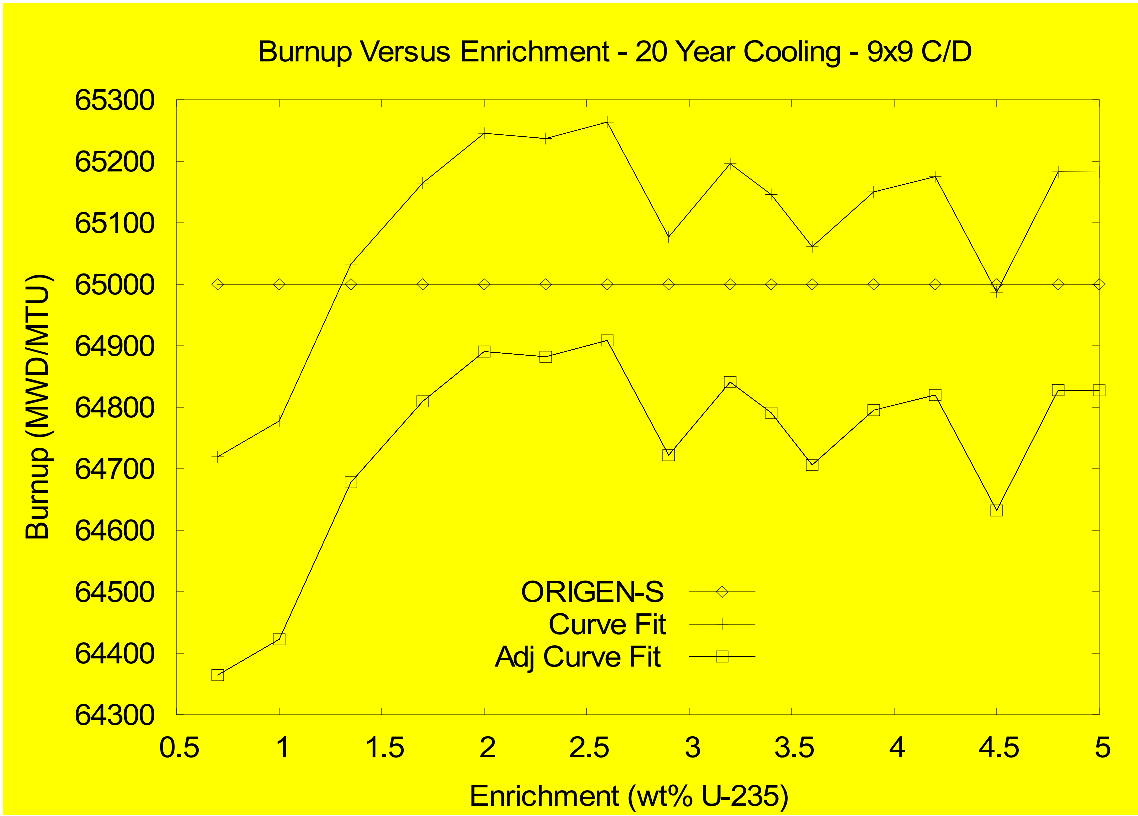

FIGURE 5.F.7; A COMPARISON OF THE CALCULATED BURNUPS USING THE CURVE FIT AND THE ADJUSTED CURVE FIT FOR VARIOUS ENRICHMENTS. ALL ORIGEN-S CALCULATIONS YIELDED A BURNUP OF 65,000 MWD/MTU.

11.2.13 100% Blockage of Air Inlets

11.2.13.1 Cause of 100% Blockage of Air Inlets

This event is defined as a complete blockage of all four bottom inlets. Such blockage of the inlets may be postulated to occur as a result of a flood, blizzard snow accumulation, tornado debris, or volcanic activity.

11.2.13.2 100% Blockage of Air Inlets Analysis

The immediate consequence of a complete blockage of the air inlet ducts is that the normal circulation of air for cooling the MPC is stopped. An amount of heat will continue to be removed by localized air circulation patterns in the overpack annulus and outlet ducts, and the MPC will continue to radiate heat to the relatively cooler storage overpack. As the temperatures of the MPC and its contents rise, the rate of heat rejection will increase correspondingly. Under this condition, the temperatures of the overpack, the MPC and the stored fuel assemblies will rise as a function of time.

As a result of the large mass, and correspondingly large thermal capacity of the storage overpack, it is expected that a significant temperature rise is only possible if the blocked condition is allowed to persist for a number of days. This accident condition is, however, a short duration event that will be identified and corrected by scheduled periodic surveillance at the ISFSI site depending on the cask heat load at the time of inspection. The temperature rise due to this accident event is small for heat loads much lower than design maximum heat load even if the condition persists for a substantial number of days. As evaluated in Sub-section 4.6.2.4, mandatory 30-day surveillance of casks is required under heat loads less than or equal to the threshold heat load specified in Table 4.6.8 at the time of inspection.

Structural

There are no structural consequences as a result of this event. However, since the mandatory surveillance frequency for MPCs at or below threshold decay heat is substantial, structural evaluation of a missile impact coincident with the 100% vent blockage event is evaluated in Section 3.4.8.1 to demonstrate safety of the system.

Thermal

A thermal analysis is performed in Subsection 4.6.2 to determine the effect of a complete blockage of all inlets for an extended duration. For this event, both the fuel cladding and component temperatures remain below their temperature limits. The MPC internal pressure for this event is evaluated in Subsection 4.6.2 and is bounded by the design basis internal pressure for accident conditions (Table 2.2.1).

Since the mandatory surveillance frequency for MPCs at or below threshold decay heat is substantial, additional thermal evaluations are performed in Section 4.6.2.5 to demonstrate that the

MPCs are safe at off-normal and accident conditions coincident with the 100% vent blockage event at threshold heat load.

Shielding

There is no effect on the shielding performance of the system as a result of this event, since the concrete temperatures do not exceed the short-term condition design temperature provided in Table 2.2.3.

Criticality

There is no effect on the criticality control features of the system as a result of this event.

Confinement

There is no effect on the confinement function of the MPC as a result of this event.

Radiation Protection

Since there is no degradation in shielding or confinement capabilities as discussed above, there is no effect on occupational or public exposures as a result of this event.

Based on this evaluation, it is concluded that the 100% blockage of air inlets accident does not affect the safe operation of the HI-STORM 100 System, if the blockage is removed in the specified time period.

11.2.13.3 100% Blockage of Air Inlets Dose Calculations

As shown in the analysis of the 100% blockage of air inlets accident, the shielding capabilities of the HI-STORM 100 System are unchanged because the peak concrete temperature does not exceed its short-term condition design temperature. The elevated temperatures will not cause the breach of the confinement system and the short term fuel cladding temperature limit is not exceeded. Therefore, there is no radiological impact.

11.2.13.4 100% Blockage of Air Inlets Accident Corrective Action

Analysis of the 100% blockage of air inlet accident shows that the temperatures for cask system components and fuel cladding are within the accident temperature limits if the blockage is cleared within 32 hours for cask heat loads greater than that specified in Table 4.6.8 at the time of inspection. For cask containing MPCs with total heat load and per cell decay heat less than or equal to threshold heat load (Table 4.6.8), blockage is cleared within 30 days. Upon detection of the complete blockage of the air inlet ducts, the ISFSI operator shall assign personnel to clear the blockage with mechanical and manual means as necessary. After clearing the overpack ducts, the overpack shall be visually and radiologically inspected for any damage. If exit air temperature monitoring is performed in lieu of direct visual inspections, the difference between the ambient air

b. Canister material mechanical properties for structural integrity of the confinement boundary.

c. Canister and basket material thermal properties and dimensions for heat transfer control.

d. Canister and basket material composition and dimensions for dose rate control.

12.2.9 HI-STORM Overpack/VVM

a HI-STORM overpack/VVM material mechanical properties and dimensions for structural integrity to provide protection of the MPC and shielding of the spent nuclear fuel assemblies during loading, unloading and handling operations, as applicable.

b. HI-STORM overpack/VVM material thermal properties and dimensions for heat transfer control.

c. HI-STORM overpack/VVM material composition and dimensions for dose rate control.

12.2.10 Verifying Compliance with Fuel Assembly Decay Heat, Burnup, and Cooling Time Limits

The examples below execute the approach and equations described in Section 2.1.9.1 for determining allowable decay heat per storage location, burnup, and cooling time for the approved cask contents.

Example 1

In this example, a demonstration of the use of burnup versus cooling time tables for regionalized fuel loading is provided. In this example it will be assumed that the MPC-32 is being loaded with array/class 16x16A fuel in a regionalized loading pattern and will be stored in an aboveground HI-STORM system.

Step 1: Pick a value of X between 0.5 and 3. For this example X will be 2.8.

Step 2: Calculate $q_{Region2}$ as described in Section 2.1.9.1.2:

$$q_{Region2} = (2 \text{ x } 34)/[(1 + (2.8)^{0.2075}) \text{ x } ((12 \text{ x } 2.8) + 20)] = 0.5668 \text{ kW}^{\dagger}$$

Step 3: Calculate $q_{Region1}$ as described in Section 2.1.9.1.2:

$$q_{Region1} = X \text{ x } q_{Region2} = 2.8 \text{ x } 0.5668 = 1.5871 \text{ kW}$$

† Results are arbitrarily rounded to four decimal places.

Step 4: Develop a burnup versus cooling time table. Since this table is enrichment dependent, it is permitted and advisable to create multiple tables for different enrichments. In this example, two enrichments will be used: 3.1 and 4.185. Tables 12.2.1 and 12.2.2 show the burnup versus cooling time tables calculated for these enrichments for Region 1 and Region 2 as described in Section 2.1.9.1.3.

Table 12.2.3 provides three hypothetical fuel assemblies in the 16x16A array/class that will be evaluated for acceptability for loading in the MPC-32 example above. The decay heat values in Table 12.2.3 are calculated by the user. The other information is taken from the fuel assembly and reactor operating records.

Fuel Assembly Number 1 is not acceptable for storage because its enrichment is lower than that used to determine the allowable burnups in Table 12.2.1 and 12.1.2. The solution is to develop another table using an enrichment of 3.0 wt.% ^{235}U or less to determine this fuel assembly's suitability for loading in this MPC-32.

Fuel Assembly Number 2 is not acceptable for loading unless a unique maximum allowable burnup for a cooling time of 3.3 years is calculated by linear interpolation between the values in Table 12.2.1 for 3 years and 4 years of cooling. Linear interpolation yields a maximum burnup of 36,497 MWD/MTU (rounded down from 36,497.2), making Fuel Assembly Number 2 acceptable for loading only in Region 1 due to decay heat limitations.

Fuel Assembly Number 3 is acceptable for loading based on the higher allowable burnups in Table 12.2.2, which were calculated using a higher minimum enrichment that those in Table 12.2.1, which is still below the actual initial enrichment of Fuel Assembly Number 3. Due to its relatively low total decay heat of 0.5 kW (fuel: 0.4, non-fuel hardware: 0.1), Fuel Assembly Number 3 may be stored in Region 1 or Region 2.

Example 2

In this example, each fuel assembly in Table 12.2.3 will be evaluated to determine whether it may be stored in the same hypothetical MPC-32 in a regionalized storage pattern in an aboveground system. Assuming the same value 'X', the same maximum fuel storage location decay heats are calculated. The equation in Section 2.1.9.1.3 is executed for each fuel assembly using its exact initial enrichment to determine its maximum allowable burnup. Linear interpolation is used to further refine the maximum allowable burnup value between cooling times, if necessary.

Fuel Assembly Number 1: The calculated allowable burnup for 3.0 wt.% ^{235}U and a decay heat value of 1.5871 kW ($q_{region1}$) is 44,905 MWD/MTU at 4 years minimum cooling. Its decay heat is too high for loading in Region 2. Comparing the fuel assembly burnup and total decay heat of the contents† (fuel (1.01 kW) plus non-fuel hardware (0.5 kW)) to the calculated limits indicates that the fuel assembly, including the non-fuel hardware, is acceptable for storage in Region 1.

Fuel Assembly Number 2: The calculated allowable burnup for 3.2 wt.% ^{235}U and a decay heat value of 1.5871 kW ($q_{region1}$) is 32,989 MWD/MTU for 3 years cooling and 45,382 MWD/MTU for 4 years cooling. Linearly interpolating between these values for a cooling time of 3.3 years yields a maximum allowable burnup of 36,706 MWD/MTU and, therefore, the assembly is acceptable for storage in Region 1. This fuel assembly's decay heat is also too high for loading in Region 2.

Fuel Assembly Number 3: The calculated allowable maximum burnup for 4.3 wt.% ^{235}U and a decay heat value of 0.5668 ($q_{Region2}$) is 41,693 MWD/MTU for 18 years cooling. Comparing the fuel assembly burnup and total decay heat of the contents (fuel plus non-fuel hardware) against the calculated limits indicates that the fuel assembly and non-fuel hardware are acceptable for storage. Therefore, the assembly is acceptable for storage in Region 2. This fuel assembly would also be acceptable for loading in Region 1 (this conclusion is inferred, but not demonstrated).

Example 3

In this example, a demonstration of the use of burnup versus cooling time tables for uniform fuel loading is provided. In this example it will be assumed that the MPC-68 is being loaded with array/class 9x9A fuel and will be stored in an aboveground HI-STORM system.

Step 1: CoC TS Appendix B Table 2.4-1 provides the heat load limit on each storage location (q_{max}). For MPC-68 this is 0.5 kW.

Step 2: Develop a burnup versus cooling time table. Since this table is enrichment dependent, it is permitted and advisable to create multiple tables for different enrichments if the fuel being loaded varies significantly in initial enrichment. It is conservative to choose the lowest value of initial enrichment to generate the table.

In this example, two enrichments will be used: 3.0 and 4.5. Tables 12.2.4 and 12.2.5 show the burnup versus cooling time tables calculated for these enrichments for the respective q_{max}.

Table 12.2.6 provides three hypothetical fuel assemblies in the 9x9A array/class that will be evaluated for acceptability for loading in the MPC-68 example above. The decay heat values in Table 12.2.6 would be calculated by the user. The other information would be taken from the fuel assembly and reactor operating records.

All of the assemblies meet the per cell heat load limit of 0.5 kW.

† The assumption is made that the non-fuel hardware meets burnup and cooling time limits in Table 2.1.25.

Fuel Assembly Number 1 is acceptable for storage because its enrichment is lower than that used to determine the allowable burnups in Table 12.2.4 and the burnup is lower than that allowed for the cooling time of the assembly.

Fuel Assembly Number 2 is not acceptable for loading based on the current tables. The fuel assembly burnup is greater than allowed by Table 12.2.4, even with linear interpolation (30978 MWD/MTU). Fuel Assembly Number 2 may be acceptable for loading if a new table is created specifically for an initial enrichment of 3.5 wt% and the allowable burnup is greater than 35250.

Fuel Assembly Number 3 is acceptable for loading based on the allowable burnups in Table 12.2.5.

12.2.11 Verifying Compliance with Total MPC Heat Load

Some operational steps and/or use of particular equipment are required if Q_{CoC} is above a certain value, e.g. 28.74 kW in the MPC-32. These include supplemental cooling, forced helium dehydration, helium backfill pressure, and surveillance requirements for LCO 3.1.2. These examples demonstrate the logic behind the decisions for these operational steps. Time to boil limits and vacuum drying are also considered in these examples.

Example 1:

Table 12.2.7 contains a proposed heat load pattern for loading a MPC-68 into an aboveground HI-STORM 100 System. The table provides the decay heat of each storage location. It is assumed that each of these assemblies meets the burnup, cooling time and enrichment criteria for loading as described in the previous examples in Section 12.2.10.

General observations on this loading plan:

1. The heat loads in all cells meet the CoC limits for Uniform Loading, i.e. all cells are ≤ 0.50 kW (See Table 2.1.26).
2. The MPC is loaded preferentially for ALARA considerations, i.e. the assemblies with the lower heat loads are in the peripheral cells.
3. The aggregate MPC heat load, as defined in Section 2.1.9.1.2 as the simple summation of the assemblies in the MPC, is 18.917 kW.
4. The maximum heat load in any cell is 0.460 kW.
5. $Q_{CoC,}$ as defined in Section 2.1.9.1.2 equation c is 31.280 kW.

Recommendations based on the general observations <u>without further site-specific analysis</u>:

1. Vacuum drying: The MPC *cannot* be dried using vacuum drying because the Q_{CoC} heat load is greater than 30 kW (See FSAR Table 4.5.1).
2. Forced Helium Dehydration: The MPC should be dried using forced helium

dehydration since the Q_{CoC} heat load exceeds the vacuum drying threshold heat loads (See FSAR Table 4.5.1).

3. Helium Backfill Pressure Range: The MPC should be backfilled to the higher pressure range given in the TS because the Q_{CoC} heat load exceeds the threshold heat loads in FSAR Table 1.2.2.
4. Supplemental Cooling System: A supplemental cooling system would be required for on-site transport of High Burnup Fuel in the HI-TRAC after the MPC is dried, backfilled and sealed because the Q_{CoC} heat load exceeds the 90% design basis threshold heat load in FSAR Table 4.5.4.
5. Heat Removal Surveillance (LCO 3.1.2): The user has 24 hours to clear blockage on the system containing this MPC since the Q_{CoC} heat load (assuming the pattern is at the time of inspection) exceeds the 28.152 kW (=0.414 kW*68) threshold heat load in LCO 3.1.2.
6. Time to boil determination: The user can calculate the time to boil limit based on the aggregate MPC heat load of 18.917 kW since this is a bulk adiabatic heat up calculation strictly based on the aggregate heat in the MPC.
7. Air mass flow rate test requirements per Condition 9 of the CoC: The user can determine if this test needs to be performed based on the aggregate MPC heat load of 18.917 kW since the air flow on the outside of the MPC is strictly based on the aggregate heat in the MPC.

Example 2

Table 12.2.8 contains a proposed heat load pattern for loading a MPC-32. The table provides the decay heat of each storage location. It is assumed that each of these assemblies meets the burnup, cooling time and enrichment criteria for loading as described in the previous examples in Section 12.2.10.

General observations on this loading plan:

1. The heat loads in all cells meet the CoC limits for Uniform Loading, i.e. all cells are ≤ 1.062 kW (See Table 2.1.26).
2. The MPC is loaded preferentially for ALARA considerations, i.e. the assemblies with the lower heat loads are in the peripheral cells.
3. The aggregate MPC heat load, as defined in Section 2.1.9.1.2 as the simple summation of the assemblies in the MPC, is 17.471 kW.
4. The maximum heat load in any cell is 0.826 kW.
5. $Q_{CoC,}$ as defined in Section 2.1.9.1.2 equation c is 26.432 kW.

Recommendations based on the general observations <u>without further site-specific analysis</u>:

1. Vacuum drying: The MPC can be dried using vacuum drying since the Q_{CoC} heat load is bounded by the threshold heat load Q2 in FSAR Table 4.5.1. The vacuum

drying is time limited as Q_{CoC} exceeds threshold heat load Q1 in FSAR Table 4.5.1.

2. Forced Helium Dehydration: The MPC can be dried using forced helium dehydration but it is not required.
3. Helium Backfill Pressure Range: The MPC may be backfilled to either pressure range given in the TS because the Q_{CoC} heat load is bounded by the threshold heat load in FSAR Table 1.2.2.
4. Supplemental Cooling System: A supplemental cooling system would NOT be required for on-site transport in the HI-TRAC after the MPC is dried, backfilled and sealed because the Q_{CoC} heat load is bounded by the 90% design basis threshold heat load in FSAR Table 4.5.4.
5. Heat Removal Surveillance (LCO 3.1.2): The user has 64 hours to clear blockage on the system containing this MPC since the Q_{CoC} heat load(assuming the pattern is at the time of inspection) is bounded by the 28.74 kW threshold heat load in LCO 3.1.2.
6. Time to boil determination: The user can calculate the time to boil limit based on the aggregate MPC heat load of 17.471 kW since this is a bulk adiabatic heat up calculation strictly based on the aggregate heat in the MPC.
7. Air mass flow rate test requirements per Condition 9 of the CoC: The user can determine if this test needs to be performed based on the aggregate MPC heat load of 17.471 kW since the air flow on the outside of the MPC is strictly based on the aggregate heat in the MPC.

Example 3

Table 12.2.9 contains a proposed heat load pattern for loading a MPC-32. The table provides the decay heat of each storage location. It is assumed that each of these assemblies meets the burnup, cooling time and enrichment criteria for loading as described in the previous examples in Section 12.2.10.

General observations on this loading plan:

1. The heat loads do not meet the CoC limits for Uniform Loading, i.e. some cells are ≥ 1.0625 kW (See Table 2.1.26).
2. The X value that most closely meets this pattern (See Table 2.1.30) is 1.5 which means the inner locations cannot have a total decay heat greater than 1.282 kW and the outer locations cannot have a total decay heat greater than 0.855 kW. Note that the pattern also meets the criteria for any X value ≥ 1.5.
3. The aggregate MPC heat load, as defined in Section 2.1.9.1.2 as the simple summation of the assemblies in the MPC, is 20.697 kW.
4. The maximum heat load in any cell is 1.273 kW.
5. Since this MPC is loaded in a regionalized pattern, $Q_{CoC,}$ as defined in Section 2.1.9.1.2 equation e is 32.484 kW. (12*1.282+20*0.855)

Recommendations based on the general observations without further site-specific analysis:

1. Vacuum drying: The MPC *cannot* be dried using vacuum drying since the Q_{CoC} heat load under uniform loading (1.273 kWx32 equals 40.736 kW) exceeds the threshold heat loads in FSAR Table 4.5.1.
2. Forced Helium Dehydration: The MPC must be dried using forced helium dehydration only because vacuum drying is not permitted (see above) and regionalized loading Q_{CoC} is bounded by the design basis heat load in FSAR Table 4.5.1.
3. Helium Backfill Pressure Range: The MPC must be backfilled to the higher pressure range given in the TS because the uniform loading Q_{CoC} heat load exceeds the threshold heat load in FSAR Table 1.2.2.
4. Supplemental Cooling System: A supplemental cooling system is required for on-site transport of High Burnup Fuel in the HI-TRAC after the MPC is dried, backfilled and sealed because both uniform loading Q_{CoC} and storage cell heat loads under regionalized storage exceed the 90% design basis threshold heat load in FSAR Table 4.5.4.
5. Heat Removal Surveillance (LCO 3.1.2): The user has 24 hours to clear blockage on the system containing this MPC since the uniform loading Q_{CoC} heat load (assuming the pattern is at the time of inspection) exceeds the 28.74 kW threshold heat load in LCO 3.1.2.
6. Time to boil determination: The user can calculate the time to boil limit based on the aggregate MPC heat load of 20.697 kW since this is a bulk adiabatic heat up calculation strictly based on the aggregate heat in the MPC.
7. Air mass flow rate test requirements per Condition 9 of the CoC: The user can determine if this test needs to be performed based on the aggregate MPC heat load of 20.697 kW since the air flow on the outside of the MPC is strictly based on the aggregate heat in the MPC.

Table 12.2.1

EXAMPLE BURNUP VERSUS COOLING TIME LIMITS FOR REGIONALIZED LOADING
(MPC-32, Array/Class 16x16A, X = 2.8, and Enrichment = 3.1 wt.% ^{235}U)
($q_{Region\ 1}$ = 1.5871 kW, $q_{Region\ 2}$ = 0.5668 kW)

MINIMUM COOLING TIME (years)	**MAXIMUM ALLOWABLE BURNUP IN REGION 1 (MWD/MTU)**	**MAXIMUM ALLOWABLE BURNUP IN REGION 2 (MWD/MTU)**
≥3	32791	10896
≥4	45145	17370
≥5	53769	22697
≥6	59699	26615
≥7	63971	29386
≥8	67343	31437
≥9	68200	33000
≥10	68200	34271
≥11	68200	35384
≥12	68200	36322
≥13	68200	37189
≥14	68200	37980
≥15	68200	38773
≥16	68200	39512
≥17	68200	40234
≥18	68200	40908
≥19	68200	41620
≥20	68200	42324

Table 12.2.2

EXAMPLE BURNUP VERSUS COOLING TIME LIMITS FOR REGIONALIZED LOADING
(MPC-32, Array/Class 16x16A, X = 2.8, and Enrichment =4.185 wt.% ^{235}U)
($q_{Region\ 1}$ = 1.5871 kW, $q_{Region\ 2}$ = 0.5668 kW)

MINIMUM COOLING TIME (years)	MAXIMUM ALLOWABLE BURNUP IN REGION 1 (MWD/MTU)	MAXIMUM ALLOWABLE BURNUP IN REGION 2 (MWD/MTU)
≥3	34797	11101
≥4	47590	17870
≥5	56438	23272
≥6	62533	27157
≥7	66963	29907
≥8	68200	31935
≥9	68200	33510
≥10	68200	34785
≥11	68200	35927
≥12	68200	36894
≥13	68200	37790
≥14	68200	38593
≥15	68200	39419
≥16	68200	40191
≥17	68200	40937
≥18	68200	41643
≥19	68200	42363
≥20	68200	43094

Table 12.2.3

SAMPLE CONTENTS TO DETERMINE ACCEPTABILITY FOR STORAGE
(Array/Class 16x16A)

FUEL ASSEMBLY NUMBER	**ENRICHMENT (wt. % ^{235}U)**	**FUEL ASSEMBLY BURNUP (MWD/MTU)**	**FUEL ASSEMBLY COOLING TIME (years)**	**FUEL ASSEMBLY DECAY HEAT (kW)**	**NON-FUEL HARDWARE STORED WITH ASSEMBLY**	**NFH DECAY HEAT (kW)**
1	3.0	37100	4.7	1.01	BPRA	0.5
2	3.2	35250	3.3	1.45	NA	NA
3	4.3	41276	18.2	0.4	BPRA	0.1

Table 12.2.4

EXAMPLE BURNUP VERSUS COOLING TIME LIMITS FOR REGIONALIZED LOADING
(MPC-68, Array/Class 9x9A, and Enrichment = 3.0 wt.% ^{235}U)
(q_{max} = 0.5 kW)

MINIMUM COOLING TIME (years)	**MAXIMUM ALLOWABLE BURNUP (MWD/MTU)**
≥3	27739
≥4	38536
≥5	46268
≥6	51583
≥7	55424
≥8	58303
≥9	60733
≥10	62798
≥11	64609
≥12	66331
≥13	68005
≥14	68200
≥15	68200
≥16	68200
≥17	68200
≥18	68200
≥19	68200
≥20	68200

Table 12.2.5

EXAMPLE BURNUP VERSUS COOLING TIME LIMITS FOR REGIONALIZED LOADING
(MPC-68, Array/Class 9x9A, and Enrichment =4.5 wt.% ^{235}U)
(q_{max} = 0.5 kW)

MINIMUM COOLING TIME (years)	**MAXIMUM ALLOWABLE BURNUP (MWD/MTU)**
≥3	30017
≥4	41399
≥5	49359
≥6	54839
≥7	58856
≥8	61932
≥9	64534
≥10	66802
≥11	68200
≥12	68200
≥13	68200
≥14	68200
≥15	68200
≥16	68200
≥17	68200
≥18	68200
≥19	68200
≥20	68200

Table 12.2.6

SAMPLE CONTENTS TO DETERMINE ACCEPTABILITY FOR STORAGE
(Array/Class 9x9A)

FUEL ASSEMBLY NUMBER	**ENRICHMENT (wt. % ^{235}U)**	**FUEL ASSEMBLY BURNUP (MWD/MTU)**	**FUEL ASSEMBLY COOLING TIME (years)**	**FUEL ASSEMBLY DECAY HEAT (kW)**
1	3.0	37100	4.7	0.3
2	3.5	35250	3.3	0.495
3	4.5	41276	18.2	0.2

BASES

ACTIONS (continued)

B.1

If the heat removal system has been determined to be inoperable, it must be restored to operable status within eight hours for OVERPACKS containing MPCs with heat loads in excess of the heat loads in Table B.1-1 (below) at the time of inspection. Eight hours is a reasonable period of time (typically, one operating shift) to take action to remove the obstructions in the air flow path.

Table B.1-1
(Threshold* heat loads for HI-STORM 100 System Surveillance Frequency and Completion Time to restore heat removal system to operable status)

MPC Model(s)	**Threshold Heat Load (per canister)**	**Threshold Heat Load (per assembly)**
24 (all variants)	18 kW	0.75 kW
68 (all variants)	18 kW	0..264 kW
32 (all variants)	16 kW	0.5 kW

Alternatively, for OVERPACKS containing MPCs heat loads up to the thresholds in Table B.1-1 at the time of inspection, the system must be restored to operable status within twenty four hours. Twenty four hours is a reasonable period of time for these lower heat load systems since the temperature limits of the system components and fuel cladding are not exceeded and the event is not time limiting.

(continued)

BASES

ACTIONS

C.2.1 (continued)

This Required Action must be complete in 64 hours (after entering Condition C) for an aboveground system with an MPC decay heat load of 28.74 kW or less, in 24 hours (after entering Condition C) for an aboveground system with an MPC decay heat load greater than 28.74 kW, and in 16 hours for an underground system. These Completion Times are consistent with the thermal analyses of this event, which show that all component temperatures remain below their short-term temperature limits up to 72, 32 or 24 hours after event initiation, respectively. For MPC heat loads up to the thresholds in Table B.1-1, system components temperatures do not exceed their 30 day accident temperature limits.

The Completion Time reflects the 8 or 24 hours to complete Required Action B.1 and the appropriate balance of time consistent with the applicable analysis results. The event is assumed to begin at the time the SFSC heat removal system is declared inoperable. This is reasonable considering the low probability of all air ducts becoming simultaneously blocked by trash or debris.

C.2.2

In lieu of implementing Required Action C.2.1, transfer of the MPC into a TRANSFER CASK will place the MPC in an analyzed condition and ensure adequate fuel cooling until actions to correct the heat removal system inoperability can be completed. Transfer of the MPC into a TRANSFER CASK removes the SFSC from the LCO Applicability since STORAGE OPERATIONS does not include times when the MPC resides in the TRANSFER CASK. In this case, the requirements of CoC Appendix A, LCO 3.1.4 apply.

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.1.2 (continued)

The Frequency of 24 hours for aboveground systems with heat loads that exceed the thresholds in Table B.1-1 at the time of inspection, and 16 hours for underground systems is reasonable based on the time necessary for SFSC components to heat up to unacceptable temperatures assuming design basis heat loads, and allowing for corrective actions to take place upon discovery of blockage of air ducts. For aboveground systems containing MPCs with heat loads less than or equal to the threshold heat loads in Table B.1-1 at the time of inspection, the surveillance frequency of 30 days is appropriate, since the system components and peak cladding temperature limits for 30 day accident are not exceeded and the event is not time limiting.

REFERENCES

1. FSAR Chapter 4
2. FSAR Sections 11.2.13 and 11.2.14
3. ANSI/ANS 57.9-1992