Table 2.2.15 (continued)
LIST OF ASME CODE ALTERNATIVES FOR HI-STORM 100 SYSTEM

Component	Reference ASME Code Section/Article	Code Requirement	Alternative, Justification & Compensatory Measures
MPC Lid and Closure Ring Welds	NB-4243	Full penetration welds required for Category C Joints (flat head to main shell per NB-3352.3)	MPC lid and closure ring are not full penetration welds. They are welded independently to provide a redundant seal. Additionally, a weld efficiency factor of 0.45 has been applied to the analyses of these welds.
MPC Closure Ring, Vent and Drain Cover Plate Welds	NB-5230	Radiographic (RT) or ultrasonic (UT) examination required.	Root (if more than one weld pass is required) and final liquid penetrant examination to be performed in accordance with NB-5245. The closure ring provides independent redundant closure for vent and drain cover plates. Vent and drain port cover plate welds are helium leakage tested.
MPC Lid to Shell Weld	NB-5230	Radiographic (RT) or ultrasonic (UT) examination required.	Only UT or multi-layer liquid penetrant (PT) examination is permitted. If PT examination alone is used, at a minimum, it will include the root and final weld layers and each approx. 3/8" of weld depth.
MPC Enclosure Vessel and Lid	NB-6111	All completed pressure retaining systems shall be pressure tested.	The MPC vessel is seal welded in the field following fuel assembly loading. The MPC vessel shall then be pressure tested as defined in Chapter 9. Accessibility for leakage inspections precludes a Code compliant pressure test. Since the shell welds of the MPC cannot be checked for leakage during this pressure test, the shop leakage test to 10^{-7} ref cc/sec (as described in Chapter 9) provides reasonable assurance as to its leak tightness. All MPC vessel welds (except closure ring and vent/drain cover plate) are inspected by volumetric examination, except the MPC lid-to-shell weld shall be verified by volumetric or multi-layer PT examination. If PT alone is used, at a minimum, it must include the root and final layers and each approximately 3/8 inch of weld depth. For either UT or PT, the maximum undetectable flaw size must be demonstrated to be less than the critical flaw size. The critical flaw size must be determined in accordance with ASME Section XI methods. The critical flaw size shall not cause the primary stress limits

Table 2.III.3: BWR FUEL ASSEMBLY CHARACTERISTICS FOR LOADING IN MPC-68M (Note 1)

Fuel Assembly Array and Class	**10x10F**	**10x10G**	**10x10I** (Note 12)	**10x10J** (Note 13)	**11x11A** (Note 14)
Clad Material (Note 2)	Zr	Zr	Zr	Zr	Zr
Design Initial U (kg/assy.) (Note 3)	≤ 192	≤ 188	≤ 194	≤ 194	≤ 194
Maximum Planar-Average Initial Enrichment (wt.% ^{235}U) (Note 8, 9)	4.7 (Note 7)	4.75 (Note 10)	4.8	4.8	4.8
Maximum Planar-Average Initial Enrichment with Partial Gadolinium Credit (wt.%235U) (Note 11)	5.0	5.0	5.0	5.0	5.0
Initial Rod Maximum Enrichment (wt.% ^{235}U)	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
No. of Fuel Rod Locations	92/78 (Note 4)	96/84	91/79	96/80	112/92
Fuel Clad O.D. (in.)	≥ 0.4035	≥ 0.387	≥ 0.4047	≥0.3999	≥0.3701
Fuel Clad I.D. (in.)	≤ 0.3570	≤ 0.340	≤ 0.3559	≤ 0.3603	≤ 0.3252
Fuel Pellet Dia. (in.)	≤ 0.3500	≤ 0.334	≤ 0.3492	≤ 0.3531	≤ 0.3193
Fuel Rod Pitch (in.)	≤ 0.510	≤ 0.512	≤ 0.5100	≤ 0.5149	≤ 0.4705
Design Active Fuel Length (in.)	≤ 150	≤ 150	≤ 150	≤ 150	≤ 150
No. of Water Rods (Note 6)	2	5 (Note 5)	1	1	1
Water Rod Thickness (in.)	≥ 0.030	≥ 0.031	≥ 0.0315	≥ 0.0297	≥ 0.0340
Channel Thickness (in.)	≤ 0.120	≤ 0.060	≤ 0.100	≤ 0.0938	≤ 0.100

9.1.6 Thermal Acceptance Tests

The thermal performance of the HI-STORM 100 System, including the MPCs and HI-TRAC transfer casks, is demonstrated through analysis in Chapter 4 of the FSAR. Dimensional inspections to verify the item has been fabricated to the dimensions provided in the drawings shall be performed prior to system loading. Following the loading and placement on the storage pad of the first HI-STORM System placed in service, the operability of the natural convective cooling of the HI-STORM 100 System shall be verified by the performance of an air temperature rise test. A description of the test is described in FSAR Chapter 8.

In addition, the technical specifications require periodic surveillance of the overpack air inlet and outlet vents or, optionally, implementation of an overpack air temperature monitoring program to provide continued assurance of the operability of the HI-STORM 100 heat removal system.

9.1.6.1 Supplemental Cooling System Thermal Acceptance Testing

The following thermal acceptance testing shall be performed following fabrication and prior to the first implementation of the HI-DRIP and the Dry Ice Jacket Supplemental Cooling system. The thermal acceptance test will be performed and documented a single time for each method to validate the thermal analysis. (see also Section 2.2.1.7 and 2.2.1.8)

9.1.6.1.1 HI-DRIP Supplemental Cooling Thermal Acceptance Testing

[PROPIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

Testing shall be performed in accordance with written and approved procedures and documented.

9.1.6.1.2 Dry Ice Jacket Supplemental Cooling Thermal Acceptance Testing

[PROPIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

Testing shall be performed in accordance with written and approved procedures and documented.

9.1.7 Cask Identification

Each MPC, HI-STORM overpack, and HI-TRAC transfer cask shall be marked with a model number, identification number (to provide traceability back to documentation), and the empty weight of the item in accordance with the marking requirements specified in 10 CFR 72.236(k).

2.II.1.5.1 Design Heat Load

MPC-32M is designed for the uniform and regionalized fuel loading strategies as described in Subsection 2.0.1 and 2.1.9. The design basis uniform heat load defined in Section 2.1.9, Q_d, for MPC-32M is provided in Table 2.II.1.5. The regions for the MPC-32M are presented in Table 2.II.1.3. Additionally, two *discrete* heat load patterns have been defined for MPC-32M as shown in Figures 2.II.1.2 and 2.II.1.3. The quadrants for the MPC-32M are defined in Table 2.II.1.4 and the maximum quadrant decay heat loads are given in Table 2.II.1.5. The same fuel cladding temperature limits as those for the regionalized loading configuration apply to these heat load patterns.

The MPC-32M is designed to accommodate variable fuel heights. For fuel with a longer active fuel length that the reference fuel (144in), the total heat load, quadrant heat load limits and specific heat load limit in each cell may be increased by the ratio SQRT (L/144), where L is the active length of the fuel in inches. For fuel with a shorter active fuel length than the reference fuel (144in), the total heat load, quadrant heat load limits and specific heat load limit in each cell shall be reduced by the ratio L/144, where L is the active length of the fuel in inches.

2.II.1.5.2 Radiological Parameters for Spent Fuel and Non-Fuel Hardware

MPC-32M is authorized to store fuel and non-fuel hardware with burnup - cooling time combinations as given in Tables 2.II.1.2 and 2.II.1.6.

The burnup and cooling time for every fuel assembly loaded into the MPC-32M must satisfy the following equation:

$$Ct = A \cdot Bu^3 + B \cdot Bu^2 + C \cdot Bu + D$$

where,

Ct = Minimum cooling time (years),

Bu = Assembly-average burnup (MWd/mtU),

A, B, C, D = Polynomial coefficients listed in Table 2.II.1.6

The coefficients for above equation for the assembly in an individual cell depend on the heat load limit in that cell, Table 2.II.1.6 lists the coefficients for several heat load limit ranges. Note that the heat load limits are only used for the lookup of the coefficients in that table, and do not imply any equivalency. Specifically, meeting heat load limits is not a substitute for meeting burnup and cooling time limits, and vice versa.

2.II.1.5.3 Criticality Paramters

Table 2.II.1.7 contains the soluble boron requirements for wet loading and unloading operations for the MPC-32M.

Table 2.II.1.6

Burnup and Cooling Time Fuel Qualification Requirements for MPC-32M

Cell Decay Heat Load Limit (kW)	Polynomial Coefficients, see Paragraph 2.II.1.5.2			
	A	B	C	D
≤ 0.83	6.57083E-14	-4.02593E-09	1.47107E-04	8.01647E-01
0.83 < decay heat ≤ 1.25	4.11020E-14	-4.62813E-09	2.17444E-04	-5.55545E-01
1.25 < decay heat ≤ 1.46	1.21147E-14	-1.08013E-09	8.66361E-05	4.04455E-01
1.46 < decay heat ≤ 3.26	3.76103E-16	4.83486E-11	1.74805E-05	6.53455E-01

Table 3.II.2.3: HI-TRAC Version MS Weight and Dimension Data		
Item	Data (in inch or pounds)	Comment
Ref radial width of lead in the cask's annulus	4"	The data in this table corresponds to the Licensing drawing where the cask cavity height is set by the "reference PWR fuel". The radial thickness of lead and water jacket cavity are as listed in this table. These shielding material thicknesses may be adjusted to optimize shielding within the constraint of the cask laydown space in the Fuel Building and the capacity of the cask crane. The tornado missile analysis in Section 3.II.4 uses the reference data from this table.
Minimum thickness of lead in the cask's annulus	[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CR 2.390]	
Ref radial width of water jacket in the cask body	4 3/4"	
Minimum radial width of water jacket in the cask body	[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CR 2.390]	
Weight of empty cask with bottom lid attached (empty water jacket)	120,000	
Weight of Water in HI-TRAC Water Jacket	8,100	
HI-TRAC weight with MPC in the pool, water jacket *full* without accounting for buoyancy effects	230,000	
HI-TRAC weight with MPC in the pool, water jacket *empty* without accounting for buoyancy effects	222,000	
HI-TRAC weight with "loaded, welded and prepped" MPC (Includes 5% adder for fabrication tolerances)	215,000	

Table 3.II.2.4: Weight Data on HI-STORM 100S Version E Overpack			
Ref. Concrete density	Weight of cask body with MPC in kips (including lid)	Weight of top lid in kips	Comments
175 pcf	336,100	29,000	The weight data corresponds to the Licensing drawing
225 pcf	392,100	34,000	

SUPPLEMENT 5.II: SHIELDING EVALUATION

5.II.0 Introduction

This supplement is focused on providing a shielding evaluation of the HI-STORM 100 System with the following components: MPC-32 Version 1, MPC-68 Version 1, MPC-32M as well as the HI-STORM 100S Version E storage cask and the HI-TRAC Version MS transfer cask. The evaluation is performed pursuant to the guidelines in NUREG-1536.

MPC-32M is a new canister, that is the PWR counterpart of MPC-68M analyzed in Supplement 5.III. Also, slightly modified updates of the classical canisters, namely MPC-32 Version 1 and MPC-68 Version 1, are introduced in this supplement. The evaluation presented herein supplements the evaluations in the main body of Chapter 5 of this FSAR, and information in the main body of Chapter 5 that remains applicable is not repeated here. To aid the reader, the sections in this supplement are numbered in the same fashion as the corresponding sections in the main body of this chapter, i.e., Sections 5.II.1 through 5.II.6 correspond to Sections 5.1 through 5.6. Tables and figures in this supplement are labeled sequentially.

The design goal for the HI-STORM 100S Version E and HI-TRAC Version MS casks is to provide overall (not necessarily locally) the same or better performance as of the reference HI-STORM 100S Version B and 100-ton HI-TRAC casks, respectively, considering the design basis fuel loading Specifically, the design basis burnup-cooling time combinations for uniform loading patterns in Section 5.1 as well as the design basis loading curves (which specify burnup and cooling time combinations for all/specific cells in the cask) for the uniform, regionalized and discrete loading patterns, presented in Table 2.II.1.6 for MPC-32M, have been evaluated. The purpose of this supplement is simply to present the results of shielding analyses, which confirm that this design goal is met, hence the conclusions in the main body of this chapter remain fully applicable.

In addition, in order to simplify a fuel qualification procedure and present reasonably bounding dose rates for the HI-STORM 100S Version E and HI-TRAC Version MS casks, a modified approach is used to specify the MPC-32M basket content's burnup, enrichment and cooling time.

5.II.1 Discussion and Results

The HI-STORM 100S Version E cask is an enhanced version of HI-STORM 100S Version B with a number of improvements, such as a new design of the inlet and outlet vent systems, increased density of the shielding concrete in the overpack body and top lid, etc.

The HI-TRAC Version MS transfer cask is anatomically similar to HI-TRAC 100 and HI-TRAC 125 cask models analyzed in the main part of Chapter 5 of this FSAR. It is essentially a smaller diameter version of HI-TRAC VW Version V transfer cask in the HI-STORM FW FSAR [5.II.1]. The HI-TRAC Version MS (acronym for **m**aximum **s**hielding) cask is designed to provide maximum shielding to the plant personnel engaged in conducting short-term operations and facilitate ALARA transfer of a loaded MPC to or from the storage module. To optimize the shielding in the body of HI-TRAC Version MS, the thickness of the lead cylinder and the water jacket can be varied to meet the shielding demand of the MPCs being loaded.

The HI-STORM Version E and HI-TRAC Version MS casks can accept all MPC designs, considered in the main body of the FSAR, as well as MPC-32 Version 1, MPC-68 Version 1 and MPC-32M, introduced in this supplement. For additional details about the HI-STORM Version E and HI-TRAC Version MS casks, the reader is referred to Supplements 1.II and 2.II.

The modified updates of the classical canisters, namely MPC-32 and MPC-68, are introduced with the identifier "Version 1" appended to differentiate them from their base designs. The MPC Version 1 changes affecting shielding are a slightly reduced basket wall thickness, increased baseplate thickness, and basket shims. The studies, described in Section 5.4, show that the self-shielding of the fuel and basket for neutron radiation is low, while for photon radiation it is very high. The low neutron self-shielding means that the neutron doses are not significantly affected by the reduced basket weight, since the majority of the neutron shielding function is provided by the overpack around the MPC. The high self-shielding for photons means that only the outer basket panels are effective for gamma shielding. For the MPC Version 1, the shielding in this area is enhanced due to the presence of the basket shims, and therefore comparable to the absorption in the thicker basket walls of the classical MPC-32 and MPC-68 baskets. The baseplate thickness increase impacts the fuel assembly elevation and provides better shielding performance at the bottom of the overpack. In summary, based on the small effect of the design changes in MPC Version 1 on dose rates, those Version 1 MPCs are also qualified for all other overpacks evaluated in the main part of this chapter without any further analyses.

MPC-32M is a variation of the 32 cell PWR canister MPC-32 evaluated in the main part of this chapter, but with a basket design consisting of aluminum oxide and finely ground boron carbide dispersed in a metal matrix of pure aluminum. The boron carbide content is 10% (minimum) by weight. This results in a B-10 areal density that is slightly above that in MPC-32. The relevant differences between the baskets are listed below, and then discussed in respect to its effect on the photon and neutron dose rates.

Differences between MPC-32M compared to MPC-32, in respect to the characteristics important for the dose calculations, are as follows:

- MPC-32M has a slightly higher B-10 content;
- MPC-32M is lighter, since it consists of aluminum and boron carbide, but no steel;
- In the enclosure shell, MPC-32M is surrounded by aluminum basket shims.

To evaluate the effect of these differences, studies in the main part of Chapter 5 regarding dose contributions from a regionalized loading scheme are utilized. These studies, described in Section 5.4, show that the inner region of MPC-32 (12 assemblies = 38 % of the content) contributes about 21% of the neutron dose

rate, but only about 1 % of the photon dose rate. This means that the self-shielding of the fuel and basket for neutron radiation is low, while for photon radiation it is very high. The low neutron self-shielding means that the neutron doses are not significantly affected by the reduced basket weight, since the majority of the neutron shielding function is provided by the overpack around the MPC. Also, for MPCs filled with water, there is a further reduction in neutron dose due to the increased absorption of thermal neutrons from the increased B-10 loading. The high self-shielding for photons means that only the outer basket panels are effective for gamma shielding. For MPC-32M, the shielding in this area is enhanced due to the presence of the basket shims, and therefore comparable to the absorption in the steel basket walls. In summary, the effect of the design differences between MPC-32 and MPC-32M on dose rates is small. Therefore, the main body of this chapter (including the array classes qualified for loading into MPC-32) remains fully applicable for the HI-STORM 100 System using an MPC-32M. Nevertheless, the shielding analyses are explicitly performed for HI-STORM Version E with MPC-32M in this supplement and the highest dose rates are reported.

The shielding analyses in this supplement were performed with an updated version of MCNP (MCNP5-1.51) [5.II.2] developed by Los Alamos National Laboratory (LANL). The source terms for the design basis fuels were calculated using TRITON / ORIGAMI modules of the SCALE 6.2.1 code package [5.II.3] developed by Oak Ridge National Laboratory (ORNL). A detailed description of the MCNP models and the source term calculations are presented in Sections 5.II.3 and 5.II.2, respectively.

The same design basis zircaloy clad fuel assemblies used for calculating the dose rates presented in the main body of this chapter, namely B&W 15x15 and GE 7x7 (see Section 5.2), are used in this supplement for PWR and BWR fuel types, respectively.

From a thermal perspective, the MPC-32M basket can be loaded in uniform, regionalized or discrete fashion. For the uniform loading, all cells have the same heat load limit, whereas for the regionalized and discrete loading patterns, the heat load limits vary for different cells, according to the information in Table 2.II.1.5 and Figures 2.II.1-2 and 2.II.1-3. To prescribe radiological limits for the fuel to be loaded, loading curves are defined in Paragraph 2.II.1.5.2, where a loading curve specifies the minimum cooling time as a function of fuel burnup. Different loading curves are defined for the different heat load limits, so that the thermal and radiological requirements for the fuel in each cell are approximately aligned. However, it should be noted that thermal and radiological limits for each assembly are applied completely independent from each other. The loading curves for the uniform, regionalized and discrete loading patterns for the fuel to be loaded in the MPC-32M canister are discussed in Subsection 5.II.2.2.

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[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

Overall, the loading curves, established in Table 2.II.1.6 and evaluated in this supplement, produce the burnup and cooling time combinations that correspond to higher heat loads than permitted in Subsection 2.1.9 and Figures 2.II.1-2 and 2.II.1-3, hence the calculated and reported dose rates are bounding with respect to the dose rates from the fuel assemblies that can actually be loaded according to the thermal requirements.

Based on this approach, the source terms used in the analyses of MPC-32M are reasonably bounding for all realistically expected assemblies. All MPC-32M dose rates in this supplement are developed using this approach, unless noted otherwise. Also, as discussed in Section 5.II.4, the bounding BPRA activity at 1 year cooling time is considered for MPC-32M in this supplement.

5.II.1.1 Normal and Off-Normal Operations

As discussed in Subsection 5.1.1, none of the off-normal conditions have any impact on the shielding analysis. Therefore, off-normal and normal conditions are identical for the purpose of the shielding evaluation.

Tables 5.II.1.1 and 5.II.1.2 provide the maximum dose rates adjacent to and one meter from the HI-STORM 100S Version E overpack with MPC-32M during normal conditions, respectively.

Table 5.II.1.3 presents the annual dose to an individual from a single HI-STORM 100S Version E cask and various storage cask arrays, assuming an 8760 hour annual occupancy at the dose point location. The minimum distance required for the corresponding dose is also listed.

Table 5.II.1.4 provides dose rates adjacent to and one meter from the HI-TRAC Version MS with MPC-68M using the design basis loading pattern, in accordance with the analysis in the main part of Chapter 5. The dose rates correspond to the normal condition in which the MPC is dry and the HI-TRAC water jacket is filled with water.

The analyses summarized in this supplement demonstrate that the design basis goal is met and the HI-STORM 100S Version E and HI-TRAC Version MS casks provide for the most part the better performance in comparison with the reference HI-STORM 100S Version B and 100-ton HI-TRAC casks, respectively. The presented dose rates are reasonably bounding for all and any combination of the design basis content, authorized in Chapter 2. Hence the HI-STORM 100 System, including the HI-STORM Version E storage cask, the HI-TRAC Version MS transfer cask and MPC-32M, are in compliance with the 10CFR72.104 limits and ALARA practices.

5.II.1.2 Accident Conditions

The safety information in Subsection 5.1.2 remains fully applicable for the HI STORM 100 System components evaluated in this supplement, except if the lead thickness of the customized HI-TRAC Version MS cask is less than the lead thickness of the reference 100-ton HI-TRAC analyzed in the main body of Chapter 5. For this specific case, the additional site-specific shielding evaluation shall be performed to confirm the shielding performance of HI-TRAC Version MS under accident conditions.

To illustrate the impact of the design basis accident, Table 5.II.1.5 provides the dose rates at 1 and 100 meters from the HI-TRAC Version MS cask with the lower bound lead and water jacket thicknesses under accident conditions. Consistent with Subsection 5.1.2,

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The normal condition dose rates are provided for reference. The burnup and cooling time combinations used in Table 5.II.1.5 were the combinations that resulted in the highest post-accident condition dose rates at the respective locations. Note that these burnup and cooling time combinations do not necessarily correspond to the burnup and cooling time combinations that result in the highest dose rate during normal conditions. Further note that the dose rate at the controlled area boundary (100 meters from the HI-TRAC Version MS cask) for the design basis uniform loading pattern is bounded by the 100-ton HI-TRAC results in Table 5.1.10, showing that the design goal for the HI-TRAC Version MS cask is met. For additional discussion of the loss of the neutron shield (water), please see Section 5.II.4.

Table 5.II.1.1

DOSE RATES ADJACENT TO HI-STORM 100S VERSION E OVERPACK FOR NORMAL CONDITIONS MPC-32M

Dose Point[1] Location	Fuel Gammas[2] (mrem/hr)	^{60}Co Gammas (mrem/hr)	Neutrons (mrem/hr)	Totals (mrem/hr)	Totals with BPRAs (mrem/hr)
1	176.00	369.99	14.90	560.89	576.52
2	125.86	0.11	0.41	126.38	134.75
3	76.82	37.95	9.97	124.73	159.67
4	8.98	1.50	0.29	10.77	12.83

[1] Refer to Figures 5.II.3-1 AND 5.II.3-3.
[2] Gammas generated by neutron capture are included with fuel gammas.

Table 5.II.1.2

DOSE RATES AT ONE METER FROM HI-STORM 100S VERSION E OVERPACK FOR NORMAL CONDITIONS MPC-32M

Dose Point[1] Location	Fuel Gammas[2] (mrem/hr)	^{60}Co Gammas (mrem/hr)	Neutrons (mrem/hr)	Totals (mrem/hr)	Totals with BPRAs (mrem/hr)
1	44.24	6.26	0.27	50.77	53.40
2	58.26	21.70	0.77	80.73	85.33
3	19.34	5.76	1.14	26.24	32.10
4	2.80	0.54	0.14	3.48	4.12

[1] Refer to Figures 5.II.3-1 AND 5.II.3-3.

[2] Gammas generated by neutron capture are included with fuel gammas.

Table 5.II.1.3

DOSE RATES FOR ARRAYS OF HI-STORM 100S VERSION E CONTAINING MPC-32M

Array Configuration	1 cask	2x2	2x3	2x4	2x5
HI-STORM 100S Version E Overpack					
Annual Dose (mrem/year)[1]	15.43	13.70	20.55	10.62	13.28
Distance to Controlled Area Boundary (meters)[2]	300	400	400	500	500

[1] 8760 hr. annual occupancy is assumed.

[2] Dose location is at the center of the long side of the array.

Table 5.II.1.4

DOSE RATES FROM HI-TRAC VERSION MS
FOR NORMAL CONDITIONS
MPC-68M DESIGN BASIS ZIRCALOY CLAD FUEL AT
50,000 MWD/MTU AND 3-YEAR COOLING

Dose Point[1] Location	Fuel Gammas[2] (mrem/hr)	^{60}Co Gammas (mrem/hr)	Neutrons (mrem/hr)	Totals (mrem/hr)
ADJACENT TO HI-TRAC				
1	135.14	665.28	162.99	963.41
2	4987.76	2.99	363.95	5354.70
3	13.96	73.55	7.43	94.94
4	1149.86	2356.88	93.76	3600.50
5	644.12	5594.13	1454.18	7692.44
ONE METER FROM HI-TRAC				
1	527.99	382.33	57.82	968.14
2	1779.68	24.20	122.18	1926.05
3	149.02	315.44	14.31	478.77
4	144.72	514.01	40.51	699.24

[1] Refer to Figures 5.II.3-4.
[2] Gammas generated by neutron capture are included with fuel gammas.

Table 5.II.1.5

DOSE RATES FROM HI-TRAC VERSION MS FOR ACCIDENT CONDITIONS MPC-68M DESIGN BASIS ZIRCALOY CLAD FUEL

Dose Point[1] Location	Fuel Gammas[2] (mrem/hr)	^{60}Co Gammas (mrem/hr)	Neutrons (mrem/hr)	Totals (mrem/hr)
ONE METER FROM HI-TRAC (70,000 MWD/MTU AND 6-YEAR COOLING)				
2 (Accident Condition)	1218.13	32.50	3445.86	4696.49
2 (Normal Condition)	838.76	18.69	244.43	1101.89
100 METERS FROM HI-TRAC (50,000 MWD/MTU AND 3-YEAR COOLING)				
2 (Accident Condition)	1.18	0.24	0.62	2.04

[1] Refer to Figures 5.II.3-4.

[2] Gammas generated by neutron capture are included with fuel gammas.

5.II.2 Source Specification

The neutron and gamma source terms, and decay heat values were calculated with a fine mesh of enrichment, burnup and cooling time combinations using the TRITON / ORIGAMI modules of the SCALE 6.2.1 code package [5.II.3], which is consistent with other approved Holtec applications [5.II.4]. This is an improved method compared to the SAS2H / ORIGEN-S sequence from SCALE 4.3, using predefined libraries for a large number of standard fuel assemblies, based on updated data sets, using a 252-energy group structure. Unless otherwise noted in the following subsections, the discussions and conclusions in Section 5.2 remain applicable to the evaluations in this supplement.

5.II.2.1 Design Basis Assembly

In order to perform a bounding analysis, a design basis fuel assembly must be chosen. In accordance with the discussions in Subsection 5.2.5, the design basis zircaloy clad fuel assemblies B&W 15x15 and GE 7x7 are used for all PWR and BWR calculations, respectively. Tables 5.II.2.1 and 5.II.2.2 provide the gamma and neutron source term for the design basis fuel, calculated using the TRITON / ORIGAMI modules of the SCALE 6.2.1 code package. Table 5.II.2.3 shows the fuel hardware activation.

5.II.2.2 Design Basis Burnup and Cooling Times

This subsection is only for fuel to be loaded in MPC-32M. The design basis burnup-cooling time combinations for uniform loading patterns for other canisters are provided in Section 5.1.

For the fuel to be loaded into the MPC-32M canister, the design basis loading curves (which specify burnup and cooling time combinations for all/specific cells in the cask) for the uniform, regionalized and discrete loading patterns are provided in Table 2.II.1.6 using polynomial equation and corresponding polynomial coefficients.

In order to qualify the HI-STORM 100 System with MPC-32M and allowable burnup, cooling time combinations in Table 2.II.1.6, the considered range of burnup, enrichment and cooling time combinations is selected as follows:

- 5 GWD/MTU burnup and burnups from 10 GWD/MTU to 70 GWD/MTU, in increments of 10 GWD/MTU;
- The cooling time is calculated for each burnup using the equation and polynomial coefficients in Table 2.II.1.6. The determined cooling times are rounded down to the nearest available cooling time in the calculated source terms library, which provides a significant conservatism, especially, in the low cooling time area. The value of 1 year (minimum allowed cooling time) is used for all cooling times below 1 year;
- The appropriate burnup-specific lower bound enrichment is selected according to Table 5.II.2.4.

The final set of the burnup, enrichment and cooling time combinations is provided in Table 5.II.2.5. As discussed in Section 5.II.1, the burnup, enrichment and cooling time combinations, considered for the uniform and regionalized loading pattern in Table 5.II.2.5, provide the bounding source terms for all acceptable uniform and regionalized loading burnup levels and cooling times per Subsection 2.1.9.

5.II.2.3 Fuel Enrichment

This subsection is only for fuel to be loaded in MPC-32M.

As discussed in Subsection 5.2.2, enrichments have a significant impact on neutron dose rates, with lower enrichments resulting in higher dose rates at the same burnup. For assemblies with higher burnups (which result in high neutron source terms) and/or locations that are more neutron dominated, the enrichment would therefore be important in order to present dose rates in a conservative way. However, it would be impractical and excessively conservative to perform all calculations at bounding low enrichment, since low enrichments are generally only found in lower burned assemblies. Therefore, a conservatively low enrichment value is selected based on the burnup. Specifically, based on industry information on more than 130,000 PWR assemblies, the fuel assemblies are distributed over different burnup range bins (0 5, 5-10 … 70-75 GWd/mtU).

[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

For additional details the reader is referred to Reference [5.II.6]. The calculated and finally established lower bound enrichment values are provided in Figure 5.II.2-2, as well as summarized in Table 5.II.2.4.

Given that the considered baskets contain a relatively large number of available cells for fuel loading, selecting the minimum enrichment for all assemblies is considered reasonably conservative. The typical content of the basket would have most assemblies well above the lower bound enrichment assumed in the analyses, so even if a small number of assemblies would be below the assumed minimum, that would have a negligible effect or be essentially inconsequential for the dose rates around the cask. Furthermore, the site-specific shielding analysis shall consider actual or bounding fuel enrichment. Therefore, an explicit lower enrichment limit for the fuel assemblies is not considered necessary.

5.II.2.4 Non-Fuel Hardware

This subsection is only for non-fuel hardware to be loaded in MPC-32M. The non-fuel hardware in other canisters is discussed in Sections 5.2 and 5.4 of the main part of the chapter.

The same non-fuel hardware, discussed in Subsection 5.2.4, i.e. BPRAs, TPDs, CRAs, and APSRs, are permitted for storage in MPC-32M as an integral part of a PWR fuel assembly, following the requirements provided in Subsection 2.1.9 and Section 2.II.1.

Additionally, in order to qualify non-fuel hardware with the lower cooling time, the following conditions are considered:

- BPRA and TPD with the minimum cooling time of 1 year, independent of the burnup. Table 5.II.2.6 shows the ^{60}Co activities that were calculated for BPRAs and TPDs in each region of the fuel assembly (e.g. incore, plenum, top);
- CRA and APSR with the minimum cooling time of 2 years, independent of the burnup. Tables 5.II.2.7 and 5.II.2.8 present the source terms, including decay heat, that were calculated for the CRAs and APSRs, respectively. As discussed in Paragraph 5.2.4.2, the only significant source from the activation of inconel or steel is Co-60 and the other significant source is from the activation of AgInCd (0.3-1.0 MeV);
- NSAs with the minimum cooling time of 1 year are also permitted for storage in MPC-32M. As discussed in Paragraph 5.2.7.1, the total activation of steel and inconel in NSAs (^{60}Co source) is bounded by the total activation of a BPRA, while the neutron source itself is either very short-lived, which results in a complete decay by the time of storage, or long-lived, where the cooling time decrease to 1 year has a small effect. Hence the justification in Subsection 5.2.7 remains fully applicable.

Subsection 5.II.4.2 discusses the effect on dose rate of the insertion of non-fuel hardware with the lower cooling times into MPC-32M.

Table 5.II.2.1

CALCULATED FUEL GAMMA SOURCE PER ASSEMBLY FOR DESIGN BASIS ZIRCALOY CLAD FUEL

Lower Energy	Upper Energy	MPC-32M	MPC-68M
		45,000 MWD/MTU 3 Year Cooling	50,000 MWD/MTU 3 Year Cooling
(MeV)	(MeV)	(Photons/s)	(Photons/s)
0.45	0.7	5.07E+15	2.09E+15
0.7	1.0	1.81E+15	7.36E+14
1.0	1.5	2.65E+14	1.02E+14
1.5	2.0	1.59E+13	5.72E+12
2.0	2.5	1.56E+13	4.96E+12
2.5	3.0	9.45E+11	3.33E+11
Total		7.18E+15	2.94E+15

Table 5.II.2.2

CALCULATED FUEL NEUTRON SOURCE PER ASSEMBLY FOR DESIGN BASIS ZIRCALOY CLAD FUEL

Lower Energy	Upper Energy	MPC-32M	MPC-68M
		45,000 MWD/MTU 3 Year Cooling	50,000 MWD/MTU 3 Year Cooling
(MeV)	(MeV)	(Neutrons/s)	(Neutrons/s)
1.0e-01	4.0e-01	3.30E+07	1.84E+07
4.0e-01	9.0e-01	7.21E+07	4.01E+07
9.0e-01	1.4	7.20E+07	4.01E+07
1.4	1.85	5.75E+07	3.20E+07
1.85	3.0	1.07E+08	5.93E+07
3.0	6.43	9.74E+07	5.42E+07
6.43	20.0	9.33E+06	5.22E+06
Total		4.48E+08	2.49E+08

Table 5.II.2.3

CALCULATED ^{60}Co SOURCE PER ASSEMBLY FOR DESIGN BASIS ZIRCALOY CLAD FUEL

Location	MPC-32M	MPC-68M
	45,000 MWD/MTU 3 Year Cooling	50,000 MWD/MTU 3 Year Cooling
	(curies)	(curies)
Lower End Fitting	196.77	90.32
Gas Plenum Springs	15.01	27.60
Gas Plenum Spacer	8.61	N/A
Expansion Springs	N/A	5.02
Incore Grid Spacers	509.60	41.40
Upper End Fitting	96.51	25.09
Handle	N/A	3.14

Table 5.II.2.4

LOWER BOUND ENRICHMENTS USED IN THE SOURCE TERM CALCULATIONS

Burnup Range[1] (MWD/MTU)	**Initial Enrichment for PWR Fuel (wt% ^{235}U)**
0,000-5,000	0.3
5,000-10,000	1.1
10,000-15,000	1.1
15,000-20,000	1.1
20,000-25,000	1.6
25,000-30,000	2.0
30,000-35,000	2.4
35,000-40,000	2.6
40,000-45,000	3.0
45,000-50,000	3.3
50,000-55,000	3.6
55,000-60,000	3.6
60,000-65,000	3.9
65,000-70,000	4.2
70,000-75,000	4.2

[1] Note: The burnup ranges do not overlap. Therefore, 20,000-25,000 MWD/MTU means 20,000-24,999.9 MWD/MTU, etc. This note does not apply to the maximum burnups of 75,000 MWD/MTU.

Table 5.II.2.5a

DESIGN BASIS BURNUP, ENRICHMENT AND COOLING TIMES COMBINATIONS CONSIDERED FOR MPC-32M

Region (Assemblies)	Burnup (MWd/mtU)	Enrichment (wt% ^{235}U)	Calculated Cooling Time[3] (years)	Cooling Time Assumed in Dose Analysis (years)	Decay Heat for Assumed Cooling Time (kW)	Reference Decay Heat (kW)
Uniform and Regionalized Loading						
All (32)	5000	1.1	0.42	1.0	1.3608	1.250
	10000	1.1	1.20	1.0	2.4177	
	20000	1.6	2.27	2.2	1.7275	
	30000	2.4	2.91	2.8	1.7504	
	40000	3.0	3.37	3.0	2.0787	
	50000	3.6	3.88	3.5	2.1566	
	60000	3.9	4.71	4.5	2.0683	
	70000	4.2	6.09	6.0	2.0008	

[3] Cooling times are calculated following the methodology in Paragraph 2.II.1.5.2 using the coefficients in Table 2.II.1.6.

Table 5.II.2.5b

DESIGN BASIS BURNUP, ENRICHMENT AND COOLING TIMES COMBINATIONS CONSIDERED FOR MPC-32M

Region[4] (Assemblies)	Burnup (MWd/mtU)	Enrichment (wt% ^{235}U)	Calculated Cooling Time[5] (years)	Cooling Time Assumed in Dose Analysis (years)	Decay Heat for Assumed Cooling Time (kW)	Reference Decay Heat[6] (kW)
Discrete Loading Pattern (see Paragraph 2.II.1.5.1)						
1 (4)	5000	1.1	0.81	1.0	1.3608	1.275, 1.455
	10000	1.1	1.17	1.0	2.4177	
	20000	1.6	1.80	1.8	2.2075	
	30000	2.4	2.36	2.2	2.3680	
	40000	3.0	2.92	2.8	2.2583	
	50000	3.6	3.55	3.5	2.1566	
	60000	3.9	4.33	4.0	2.3131	
	70000	4.2	5.33	5.0	2.2950	
2 (8)	Same as Region 1[7]					0.990, 1.070
3 (4)	5000	1.1	1.44	1.4	0.8726	0.375, 0.825
	10000	1.1	1.94	1.8	1.2255	
	20000	1.6	2.66	2.6	1.3809	
	30000	2.4	3.37	3.0	1.5991	
	40000	3.0	4.45	4.0	1.4748	
	50000	3.6	6.31	6.0	1.2823	
	60000	3.9	9.33	9.0	1.2766	
	70000	4.2	13.90	13.0	1.3477	
4 (8)	Same as Region 3[4]					0.745, 0.775
5 (8)	5000	1.1	0.74	1.0	1.3608	3.000, 3.255
	10000	1.1	0.83	1.0	2.4177	
	20000	1.6	1.03	1.0	4.0350	
	30000	2.4	1.23	1.2	4.4411	
	40000	3.0	1.45	1.4	4.7055	
	50000	3.6	1.70	1.6	4.8812	
	60000	3.9	1.96	1.8	5.1055	
	70000	4.2	2.24	2.2	4.8845	

[4] See Figure 5.II.2-1.
[5] Cooling times are calculated following the methodology in Paragraph 2.II.1.5.2 using the coefficients in Table 2.II.1.6.
[6] Cell heat load limit derived from the discrete loading patterns in Figures 2.II.1-2 and 2.II.1-3.
[7] Using Region 1 fuel conditions for Region 2 and Region 3 fuel conditions for Region 4 is conservative since it applies higher source terms to Region 2 and 4.

Table 5.II.2.6

COBALT-60 ACTIVITIES AND DECAY HEAT FOR BURNABLE POISON ROD ASSEMBLIES AND THIMBLE PLUG DEVICES AT 1-YEAR COOLING

Region	BPRA	TPD
Upper End Fitting (curies Co-60)	77	120
Gas Plenum Spacer (curies Co-60)	12	43
Gas Plenum Springs (curies Co-60)	21	75
In-core (curies Co-60)	2010	N/A
Total (curies Co-60)	2120	238
Decay Heat (Watts)	36.4	3.90

Table 5.II.2.7

SOURCE TERMS AT 2-YEARS COOLING FOR CONTROL ROD ASSEMBLY CONFIGURATIONS

Axial Dimensions Relative to Bottom of Active Fuel			**Photons/sec from AgInCd**					**Curies Co-60 from Inconel**
Start (in)	**Finish (in)**	**Length (in)**	**0.3-0.45 MeV**	**0.45-0.7 MeV**	**0.7-1.0 MeV**	**1.0-1.5 MeV**	**1.5-2.0 MeV**	
Configuration 1 - 10% Inserted – 468.6 watts decay heat								
0.0	15.0	15.0	1.95E+14	1.34E+15	1.41E+15	3.67E+14	6.19E+13	1649.23
15.0	18.8125	3.8125	9.90E+12	6.81E+13	7.16E+13	1.87E+13	3.14E+12	83.84
18.8125	28.25	9.4375	1.23E+13	8.43E+13	8.86E+13	2.31E+13	3.89E+12	103.76
Configuration 2 - Fully Removed – 47.9 watts decay heat								
0.0	3.8125	3.8125	9.90E+12	6.81E+13	7.16E+13	1.87E+13	3.14E+12	83.84
3.8125	13.25	9.4375	1.23E+13	8.43E+13	8.86E+13	2.31E+13	3.89E+12	103.76

Table 5.II.2.8

SOURCE TERMS AT 2-YEARS COOLING FOR AXIAL POWER SHAPING ROD CONFIGURATIONS

Axial Dimensions Relative to Bottom of Active Fuel			Curies of Co-60
Start (in)	Finish (in)	Length (in)	
Configuration 1 - 10% Inserted – 132.5 watts decay heat			
0.0	15.0	15.0	7678.04
15.0	18.8125	3.8125	390.30
18.8125	28.25	9.4375	483.08
Configuration 2 - Fully Removed – 13.5 watts decay heat			
0.0	3.8125	3.8125	390.30
3.8125	13.25	9.4375	483.08
Configuration 3 - Fully Inserted - 513 watts decay heat			
0.0	63.0	63.0	32247.75
63.0	66.8125	3.8125	390.30
66.8125	76.25	9.4375	483.08

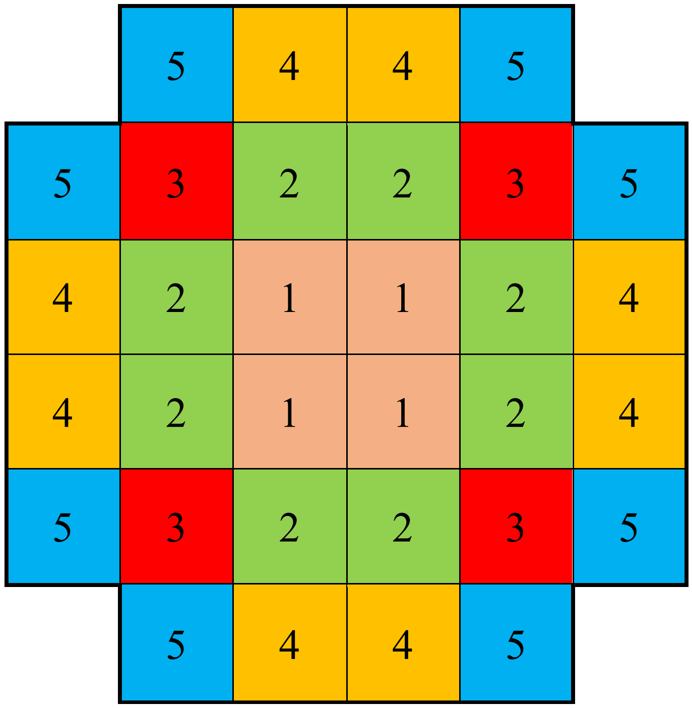


FIGURE 5.II.2-1 5-REGION LOADING CONFIGURATION FOR DISCRETE LOADING PATTERN OF THE MPC-32M BASKET

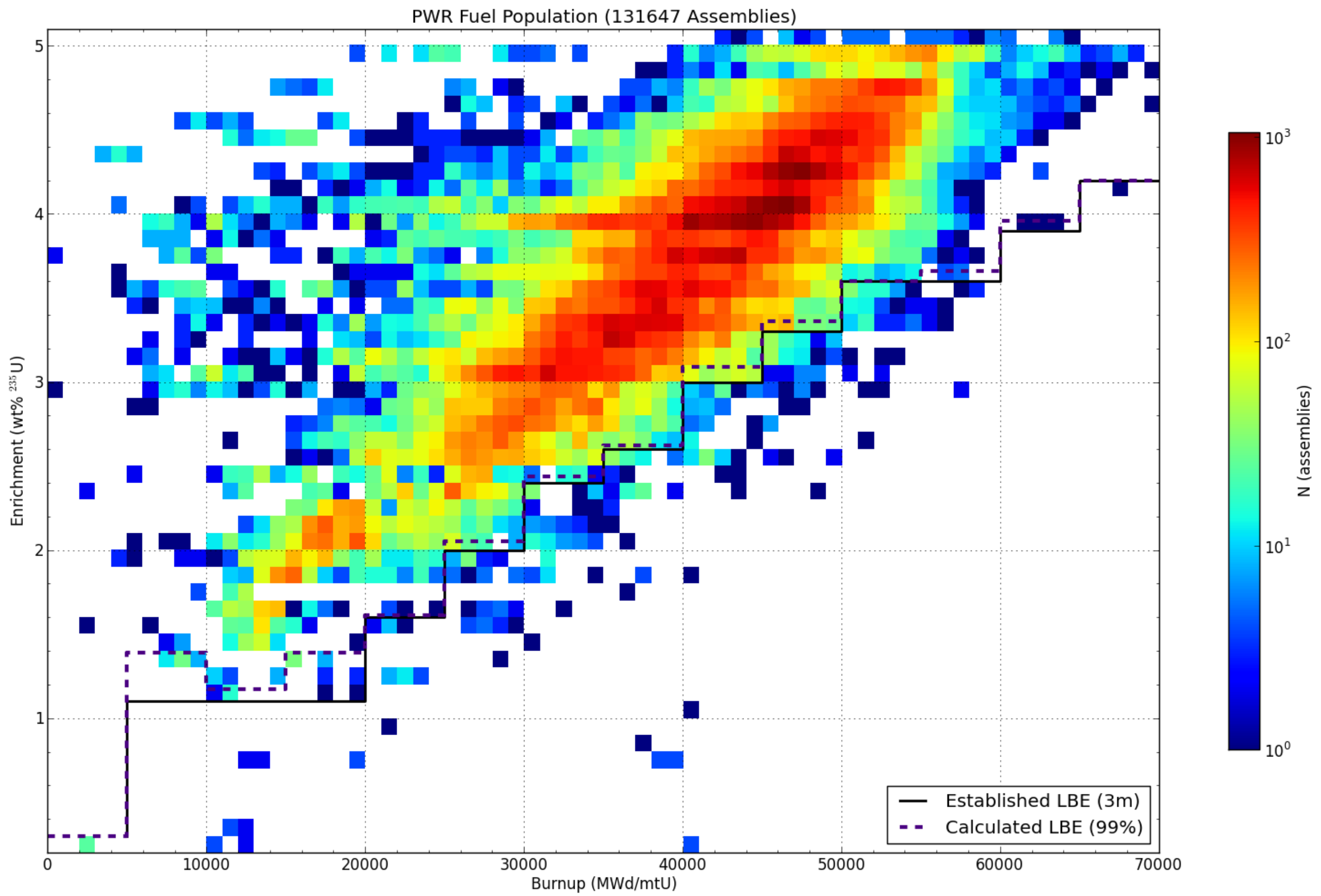


FIGURE 5.II.2-2 LOWER BOUND INITIAL ENRICHMENT BASED ON PWR FUEL DATA

5.II.3 Model Specifications

All shielding analyses of the HI-STORM 100 System in this supplement were performed with MCNP5-1.51 [5.II.2], which has been already used for evaluation of the HI-STORM 100 System with MPC-68M in Supplement 5.III. The results of the calculations in Supplement 5.III show no significant differences in the dose rates between the two MCNP versions.

Generally, the model specification of the fuel assemblies, MPCs, radiation sources, etc. is the same as in Section 5.3 of the main body of this chapter, unless otherwise noted in the following subsections.

5.II.3.1 Description of the Radial and Axial Shielding Configuration

Full three-dimensional calculational models were used in the shielding analysis. The MPC and casks input data used in the MCNP models are based on the drawings listed in Chapter 1. Nominal dimensions are used in the models consistent with the main part of Chapter 5, unless stated otherwise. This is considered sufficient for the purpose of this supplement to demonstrate reasonable assurance of an adequate level of safety. However, as discussed in Supplement 1.II, some parameters may be customized for the host site of a spent fuel storage system to optimize the shielding performance. In order to maintain the appropriate level of safety, the potential effect of such updated parameters on the dose rates shall be assessed. The additional site-specific shielding evaluations will be considered to confirm that the shielding performance of the customized HI-STORM 100 System is appropriate. The site-specific assessment should also verify that the fuel assembly design and assembly characteristics used in the calculations are appropriate.

The calculational models explicitly define the fuel basket walls, basket shims, MPC enclosure and overpack components. As described in the the main part of this chapter, the active fuel region is modeled as a homogenous material of fresh UO_2 fuel and hardware. The end fittings and the plenum regions are also modeled as homogenous regions of steel. The axial model dimensions are determined following the guidance in Section 3.II.2.

Figures 5.II.3-1 through 5.II.3-3 show representative cross sections of the MCNP model for the HI-STORM Version E cask with the MPC-32M basket. The ribs, bolt recesses as well as the inlet and outlet vents are modeled explicitly, therefore, streaming through these components is accounted for in the dose rate calculations.

Figures 5.II.3-4 and 5.II.3-5 show representative cross sections of the MCNP model for the HI-TRAC Version MS cask with the MPC-68M basket. The ribs and bolt recesses are modeled explicitly, therefore, streaming through these components is accounted for in the dose rate calculations. In order to account for ground scatter, the calculational model simulates the HI-TRAC Version MS cask at a height of 6 inches (the typical cask carry height) above the concrete floor. As a result of such modeling, the dose rate at 1 meter from the pool lid is not calculated.

Several conservative assumptions and approximations were made in modeling the MPC. The conservative approximations are listed below.

- For both MPC-32M and MPC-68M baskets, the basket flow holes at the base of the basket are modeled as a complete loss of basket material between the bottom and top edge of the flow hole. The basket shim flow holes are modeled as a complete loss of shim material below the top edge of the flow hole. This is conservative since more material is neglected than actually superseded by the flow holes. The reader is referred to Figures 5.II.3-1 and 5.II.3-4 for details;

- For both MPC-32M and MPC-68M baskets, no elevation of the fuel assemblies above the MPC baseplate is assumed. This is conservative since the bottom nozzle is located adjacent to the flow holes as well as closer to the bottom vent ducts and bottom cask surface;
- The MPC-32M baseplate can be made with the optionally increased thickness. Nonetheless, a baseplate with a lowest nominal thickness is conservatively considered in the calculations;
- Several simplifications are made in the model of the MPC-32M and/or MPC-68M basket shims. Specifically,
    - The rounding of the shim corners is neglected. Since the amount of extra material is roughly compensated by the amount of lost material due to these simplifications, a small (if any) net effect on results is expected;
    - The potential tiny gaps between the basket shims and basket/enclosure are not modeled since an insignificant impact on results is expected;
    - For MPC-32M, in the overlap of the peripheral shim walls and the basket corners (enriched with B_4C), the basket material is conservatively neglected (see Figure 5.II.3-2).

To ensure that the bounding dose rates are provided for HI-TRAC Version MS, the evaluations are performed for HI-TRAC Version MS with the lower bound lead and water jacket thicknesses, listed in Table 3.II.2.3. The results of the calculations for the HI-TRAC Version MS cask with the lower bound lead and water jacket thicknesses are provided in Tables 5.II.1.4, 5.II.1.5 and 5.II.4.9. The results of the calculations for HI-TRAC Version MS with the reference dimensions are provided Tables 5.II.4.4 (for a discussion, see Section 5.II.4).

5.II.3.2 Regional Densities

In addition to the composition and densities of the various materials used in the HI-STORM 100 System shielding analyses and presented in Table 5.3.2, the shielding models of HI-STORM Version E and HI-TRAC Version MS casks employ the materials provided in Table 5.II.3.1.

The concrete density shown in Table 5.II.3.1 represents the minimum concrete density in the body and lid of HI-STORM Version E overpack.

Both the MPC-32M and MPC-68M baskets are manufactured using the Metamic-HT panels, made of aluminum and B_4C powder. The B_4C content of 9 wt% is conservatively used in the Metamic-HT fixed neutron absorber material.

Table 5.II.3.1

COMPOSITION OF THE MATERIALS IN THE HI-STORM 100 SYSTEM

Component	Density (g/cm^3)	Elements	Mass Fraction (%)
Metamic-HT	[PROPRIETARY INFORMATION WITHHELD PER 10CFR2.390]		
Aluminum	2.7	Al	100
Carbon Steel	7.82	C	1
		Fe	99
Air	1.17e-3	N	78 (atomic fraction %)
		O	22 (atomic fraction %)
Concrete	2.723	H	1
		O	53.2
		Si	33.7
		Al	3.4
		Na	2.9
		Ca	4.4
		Fe	1.4

[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

FIGURE 5.II.3-1

[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

FIGURE 5.II.3-2

[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

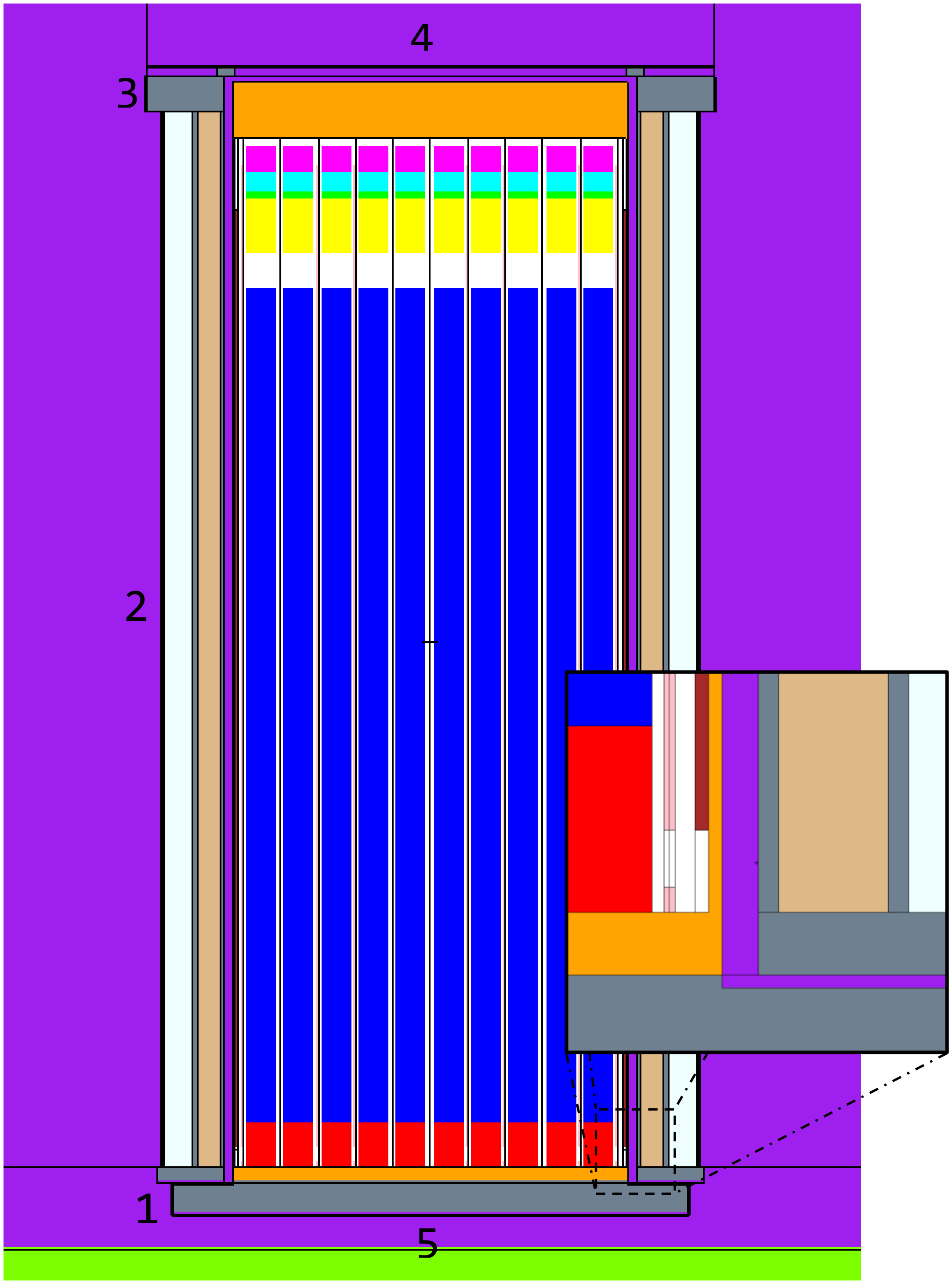
FIGURE 5.II.3-3

[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

FIGURE 5.II.3-4

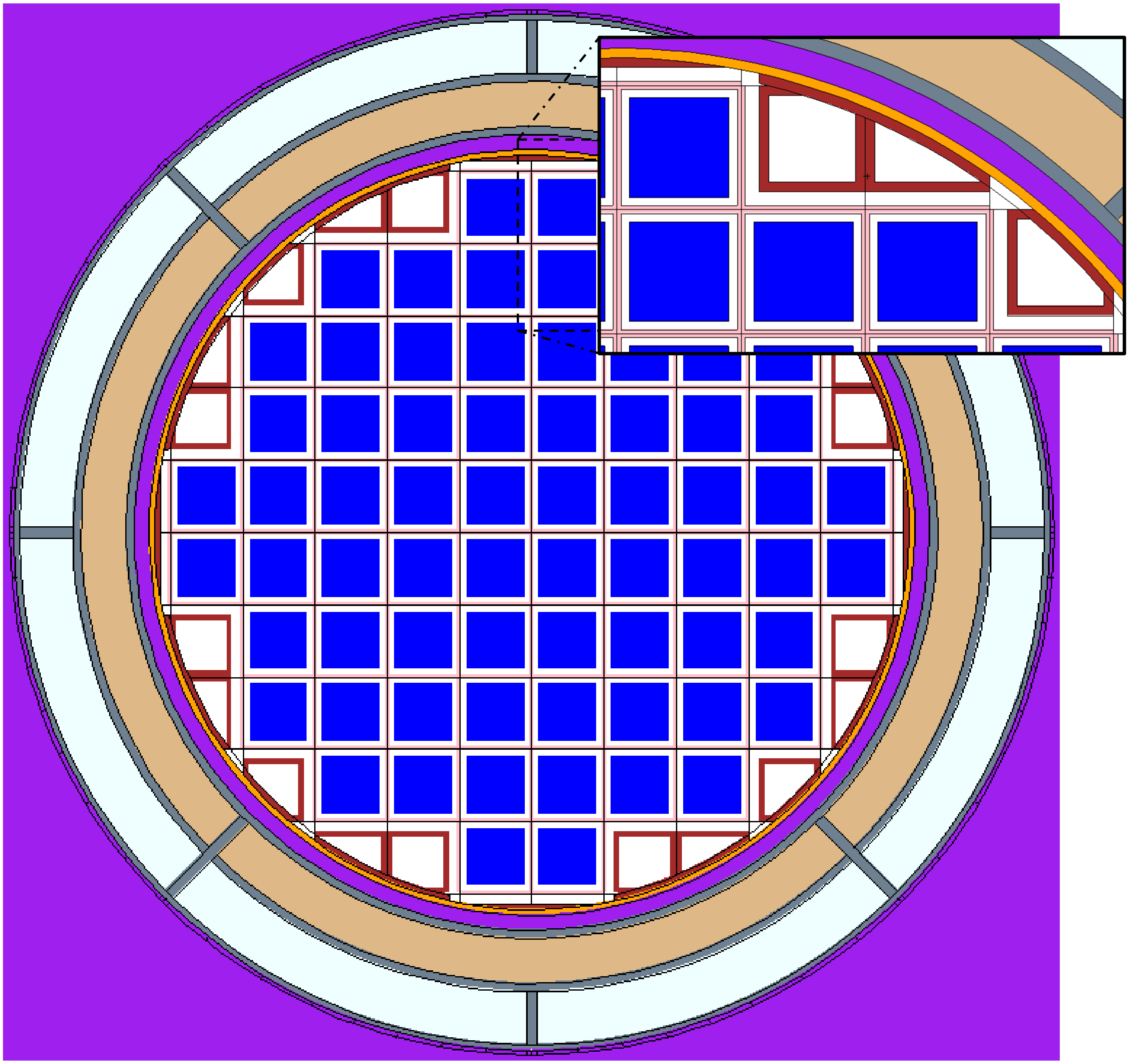
[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

FIGURE 5.II.3-5



Note: Figure is generated directly from MCNP input file using the MCNP visual editor.

FIGURE 5.II.3-4 CALCULATIONAL MODEL (AXIAL CROSS-SECTION) OF HI-TRAC VERSION MS WITH MPC-68M



Note: Figure is generated directly from MCNP input file using the MCNP visual editor.

FIGURE 5.II.3-5 CALCULATIONAL MODEL (RADIAL CROSS-SECTION) OF HI-TRAC VERSION MS WITH MPC-68M

5.II.4 Shielding Evaluation

Generally, the same methodology is used as described in Section 5.4 of the main body of this chapter for the dose rate calculations, unless otherwise noted in the following subsections. However, the MCNP5-1.51 code was used instead of MCNP-4A, as discussed in Section 5.II.3, for all of the shielding analyses.

The analysis of HI-STORM Version E with MPC-32 under the normal condition has been performed in order to compare the shielding performance of the reference HI-STORM 100S Version B and HI-STORM 100S Version E overpacks. Two design basis uniform loading patterns and ^{60}Co activity (BPRA) already considered in the main body of Chapter 5 have been used. Additionally, a uniform pattern with a low burnup and short cooling time is used in the comparison, which results in more gamma-dominated dose rates. The results of the calculations presented in Table 5.II.4.1 show an increase of the maximum dose rate in the areas adjacent to the inlet and outlet vents. However, due to high-density concrete in the HI-STORM Version E body/lid, the dose rates at all other surfaces and 1 m distance points are two times lower or even less. This confirms an improvement of HI-STORM Version E shielding performance in comparison with the reference HI-STORM 100S Version B cask and associated reduction of occupational exposure and the dose rates at the controlled area boundary.

Tables 5.II.4.2 and 5.II.4.3 provide the maximum dose rates for the HI-STORM Version E with MPC-32M under the normal condition for both the design basis BPRA activity and the BPRA activity at 1 year cooling time discussed in Subsection 5.II.2.4. It should be noted that the total dose rates (and component-specific dose rates) may be slightly different between these tables, depending on the maximum dose rate location for the total dose rate with BPRA. The results in Tables 5.II.4.1 and 5.II.4.2 confirm that the dose rates for HI-STORM Version E with MPC-32 and MPC-32M with the same BPRA activity are essentially similar. The only significant outlier is the bottom vents surface location, where the maximum dose rate is increased due to a conservative assumption of zero fuel assembly elevation in MPC-32M (see Subsection 5.II.3.1). Therefore, the conclusions in the main body of Chapter 5 remain fully applicable, and MPC-32M is approved for storage in HI-STORM Version E and transfer in all HI-TRAC casks. As expected, the effect of the increased BPRA activity at 1 year cooling time on the dose rates is substantial, hence this BPRA activity is considered in all design basis calculations for MPC-32M, unless noted otherwise.

The analysis of HI-TRAC Version MS with MPC-68M under the normal condition with a dry MPC cavity has been performed in order to compare the shielding performance of the of the 100-ton HI-TRAC and HI-TRAC Version MS overpacks with the nominal and reference dimensions, respectively. Two design basis uniform loading patterns already considered in the main body of Chapter 5 have been used. As for the comparison for HI-STORM discussed above, an additional uniform pattern with a low burnup and short cooling time is used, which results in more gamma-dominated dose rates. The results of the calculations presented in Table 5.II.4.4 show an increase of the maximum dose rate at the top surface and 1 m distance from the top surface of the cask, which is due to the increased cask cavity ID and consequently a larger annular gap between the cask and MPC. However, all the other locations show a substantial reduction of the dose rates, which confirms an improvement of HI-TRAC Version MS shielding performance and associated reduction of occupational exposure. Such results are expected since a layer of lead in the reference HI-TRAC Version MS cask wall is much thicker than in the 100-ton HI-TRAC. The additional site-specific shielding evaluations shall be performed to confirm the shielding performance of HI-TRAC Version MS, if the lead thickness of the customized HI-TRAC Version MS cask is less than the lead thickness of the reference 100-ton HI-TRAC, analyzed in the main body of Chapter 5. Nonetheless, to ensure that the bounding dose rates are provided in Section 5.II.1, the evaluations are performed for HI-TRAC Version MS with the lower bound lead and water jacket thicknesses, as discussed in Subsection 5.II.3.1.

5.II.4.1 Site Boundary Evaluation

The methodology of calculating the dose from a single HI-STORM overpack loaded with an MPC and various arrays of loaded HI-STORMs at distances equal to and greater than 100 meters is described in Chapter 5. The same back row factor of 0.20 is utilized herein to calculate dose value C below, based on the results that the dose from the side of the back row of casks is approximately 16 % of the total dose. The bounding source terms based on the loading curves (see Section 5.II.2) are used in order to provide the reasonably highest dose rates.

The annual dose to an individual from a single HI-STORM Version E cask and various storage cask arrays, assuming 100% occupancy (8760 hours) and top surface contribution of 10% was calculated in three steps, as described in Subsection 5.4.3. The annual dose at 300 meters from a single HI-STORM Version E cask and the dose rates calculated for cask arrays are presented in Tables 5.II.4.5 and 5.II.4.6, respectively. Comparing the annual dose versus distance values with the design basis results for HI-STORM 100S Version B provided in Tables 5.4.6 and 5.4.7 in the main body of Chapter 5 shows that they are well bounded. This indicates an increase of shielding performance for HI-STORM Version E, which is mainly rendered by a concrete material with increased density.

5.II.4.2 Non-Fuel Hardware

The results of the evaluations of the non-fuel hardware devices, documented in Subsection 5.4.6, show that the dose rates on the side of the cask, which is the dominant contributor to the site boundary dose rates, containing BPRAs are much larger than the dose rates on the side of the cask containing TPDs, CRAs or APSRs. It was concluded that while other non-fuel hardware types may produce a local increase in dose near the top of the cask (TPD) or near the bottom (CRA and APSRs), using BPRAs with all burnable poison rods in the analyses that demonstrate compliance with the site boundary dose limits is bounding. Therefore, the design basis ^{60}Co activity of 895 Ci, used as the activity limit for BPRAs in Subsection 5.4.6, and the ^{60}Co activity of BPRA with 1 year cooling (see Subsection 5.II.2.4) have been explicitly evaluated in this supplement and the reasonably highest dose rates are reported.

The acceptability of loading of the other non-fuel hardware with the reduced cooling time, such as TPD, CRA and APSR, provided in Subsection 5.II.2.4, was determined by comparing the source terms with the reference activities in Section 5.2.4. Specifically, Table 5.II.4.7 presents the calculated ratios of the increased activities due to reduced cooling time and the reference activities provided in Tables 5.II.2.6, 5.II.2.7, 5.II.2.8 and Tables 5.2.31, 5.2.34, 5.2.35, respectively. The results show that most of the increased ^{60}Co activities are well bounded by the activity increase of BPRA with 1 year cooling time, which is used in the dose rate calculations. The activity increase for CRAs and APSRs is higher, but according to the results provided in Subsection 5.4.6, the dose rates on the radial surface and at a distance from the overpack due to the storage of these devices is at least 16 times less than the dose rate from BPRAs, and the dose rate out the top of the overpack is essentially 0. Hence the ^{60}Co activity BPRA with 1 year cooling time is considered bounding and used in the dose rate calculations in this supplement.

It should be noted that the dose rate out the bottom of the overpack is substantial due to these devices. However, the conclusions made in Subsection 5.4.6, that these dose rates occur in an area which is not normally occupied and, therefore, they do not pose a risk from an operations perspective, are still applicable.

5.II.4.3 Generic PWR Damaged Fuel

Nonetheless, in order to demonstrate that fuel debris under normal or accident conditions, or damaged fuel in a post-accident configuration, will not result in a significant increase in the dose rates around the cask,

the additional calculations for HI-STORM Version E and HI-TRAC Version MS with the lower bound lead and water jacket thicknesses, loaded with MPC-32M (16 peripheral locations with fuel debris) are performed in accordance with the analysis in Paragraph 5.4.2.2.

The results of the calculations for HI-STORM Version E (with excluded BPRA) are presented in Table 5.II.4.8.

[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

As concluded in Paragraph 5.4.2.2, the potential effect on the dose rate is not significant for the storage of damaged fuel and/or fuel debris, hence the results and conclusions in Paragraph 5.4.2.2 remain applicable to the evaluations in this supplement.

A higher dose rate increase is observed at 1 m distance from the outlet vents (~60%), however such fuel reconfiguration to the top portion of the cask is unlikely. Also, the dose rates from the vents provide a smaller contribution to the dose rates at the controlled area boundary due to a low surface area. Therefore, a small change of the dose versus distance results is expected for HI-STORM Version E with damaged fuel. In summary, the dose rates at the controlled area boundary would remain bounded by the design basis calculations in main body of Chapter 5.

The results of the calculations for HI-TRAC Version MS (with excluded BPRA) are presented in Table 5.II.4.9. A comparison of these results to the calculations of MPC-32M with the undamaged fuel assemblies only confirm the conclusions made in Paragraph 5.4.2.2.

[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

Hence this confirms that the potential effect of storage of damaged fuel and/or fuel debris on shielding performance is not significant. This conclusion is further reinforced by the fact that the majority of the significantly damaged fuel assemblies in the spent fuel inventories are older assemblies from the earlier days of nuclear plant operations. Therefore, these assemblies will have a considerably lower burnup and longer cooling times than the design basis assemblies analyzed in this supplement.

Finally, the assumption of such a significant fuel debris compression is considered extremely conservative, since it's very unlikely to compress large sections of a fuel assembly to such extent. Also, the assumption of fuel compression over the entire active fuel length, basically, implies twice the amount of fuel that is permitted in all peripheral storage cells. Therefore, all the potential dose rate increases provided in Tables 5.II.4.8 and 5.II.4.9 cannot occur simultaneously.

5.II.4.4 Stainless Steel Clad Fuel Source

The stainless steel clad (SS-clad) fuel properties that have been already qualified for loading into the MPC-32 basket are provided in Chapter 2. The same burnup and cooling time requirements are applied for loading of stainless steel clad fuel assemblies into MPC-32M (see Table 2.II.1.1) without any changes. Comparing the gamma sources in all 7 energy groups for the bounding SS-clad fuel with those provided in Table 5.II.2.1 for the design basis zircaloy clad fuel shows that they are bounded with a significant margin. This margin is sufficient to offset a potential change of the self-shielding properties of the SS-clad fuel assemblies. Hence the dose rates for the HI STORM 100 System with MPC-32M and the allowable stainless steel clad fuel are less than those of design basis zircaloy clad fuel, and no further analyses are needed for stainless steel clad fuel in MPC-32M.

Table 5.II.4.1

DOSE RATES COMPARISON BETWEEN HI-STORM 100S VERSION B AND HI-STORM 100S VERSION E FOR NORMAL CONDITIONS MPC-32 DESIGN BASIS ZIRCALOY CLAD FUEL

Totals with BPRA (mrem/hr)									
Dose Point Location[8]	20,000 MWd/mtU, 2.3%, 1.8 years			45,000 MWd/mtU, 3.6%, 3.0 years			60,000 MWd/mtU, 4.5%, 4.0 years		
	HI-STORM Version B[9] (Reference)	HI-STORM Version E	Ratio	HI-STORM Version B (Reference)	HI-STORM Version E	Ratio	HI-STORM Version B (Reference)	HI-STORM Version E	Ratio
	ADJACENT TO HI-STORM								
1	76.91	244.19	3.2	111.08	312.04	2.8	123.75	308.91	2.5
2	349.41	99.61	0.3	287.91	73.58	0.3	231.71	54.32	0.2
3	32.32	71.32	2.2	46.12	97.32	2.1	52.14	102.16	2.0
4	17.00	9.01	0.5	22.37	10.10	0.5	25.27	9.76	0.4
	ONE METER FROM HI-STORM								
1	51.38	36.66	0.7	50.09	29.29	0.6	46.04	22.95	0.5
2	183.18	56.65	0.3	149.19	48.34	0.3	118.59	39.43	0.3
3	29.97	14.90	0.5	29.86	18.33	0.6	27.25	18.16	0.7
4	4.36	2.33	0.5	6.02	2.65	0.4	7.52	2.63	0.4

[8] Refer to Figures 5.II.3-1 AND 5.II.3-3.
[9] The reference results calculated in [5.II.5] were reprocessed using the SCALE 6.2.1 source terms.

Table 5.II.4.2

DOSE RATES FOR HI-STORM 100S VERSION E WITH THE DESIGN BASIS BPRA FOR NORMAL CONDITIONS MPC-32M DESIGN BASIS ZIRCALOY CLAD FUEL AT 45,000 MWD/MTU AND 3-YEAR COOLING

Dose Point[10] Location	Fuel Gammas[11] (mrem/hr)	^{60}Co Gammas (mrem/hr)	Neutrons (mrem/hr)	Totals (mrem/hr)	Totals with BPRAs (mrem/hr)
ADJACENT TO HI-STORM					
1	121.35	306.73	5.76	433.84	440.45
2	53.39	0.18	0.41	53.97	57.17
3	53.17	29.63	3.31	86.11	99.93
4	5.07	1.16	0.13	6.36	7.23
ONE METER FROM HI-STORM					
1	20.78	7.25	0.22	28.25	29.38
2	29.84	20.94	0.44	51.22	53.16
3	11.59	4.79	0.49	16.88	19.35
4	1.59	0.43	0.05	2.08	2.35

[10] Refer to Figures 5.II.3-1 AND 5.II.3-3.

[11] Gammas generated by neutron capture are included with fuel gammas.

Table 5.II.4.3

DOSE RATES FOR HI-STORM 100S VERSION E WITH THE BPRA AT 1-YEAR COOLING FOR NORMAL CONDITIONS MPC-32M DESIGN BASIS ZIRCALOY CLAD FUEL AT 45,000 MWD/MTU AND 3-YEAR COOLING

Dose Point[12] Location	Fuel Gammas[13] (mrem/hr)	^{60}Co Gammas (mrem/hr)	Neutrons (mrem/hr)	Totals (mrem/hr)	Totals with BPRAs (mrem/hr)
ADJACENT TO HI-STORM					
1	121.35	306.73	5.76	433.84	449.48
2	52.51	0.39	0.39	53.29	61.97
3	51.14	29.85	3.36	84.34	119.28
4	5.07	1.16	0.13	6.36	8.42
ONE METER FROM HI-STORM					
1	20.78	7.25	0.22	28.25	30.91
2	29.84	20.94	0.44	51.22	55.82
3	11.59	4.79	0.49	16.88	22.74
4	1.59	0.43	0.05	2.08	2.72

[12] Refer to Figures 5.II.3-1 AND 5.II.3-3.
[13] Gammas generated by neutron capture are included with fuel gammas.

Table 5.II.4.4

DOSE RATES COMPARISON BETWEEN 100-TON HI-TRAC AND HI-TRAC VERSION MS (REFERENCE DIMENSIONS) FOR NORMAL CONDITIONS MPC-68M DESIGN BASIS ZIRCALOY CLAD FUEL

Totals (mrem/hr)									
Dose Point Location[14]	20,000 MWd/mtU, 2.1%, 1.6 years			50,000 MWd/mtU, 3.6%, 3.0 years			70,000 MWd/mtU, 4.8%, 6.0 years		
	100-ton[15] HI-TRAC (Reference)	HI-TRAC Version MS	Ratio	100-ton HI-TRAC (Reference)	HI-TRAC Version MS	Ratio	100-ton HI-TRAC (Reference)	HI-TRAC Version MS	Ratio
	ADJACENT TO HI-TRAC								
1	1312.00	557.49	0.4	2047.54	968.28	0.5	1903.47	972.40	0.5
2	3633.36	1002.60	0.3	3004.33	959.67	0.3	1736.88	852.14	0.5
3	1671.03	9.62	<0.1	2490.55	18.21	<0.1	2069.79	21.51	<0.1
4	855.20	2405.61	2.8	1260.91	3564.92	2.8	1026.39	2721.33	2.7
5	5041.08	4724.56	0.9	8448.41	7722.27	0.9	8748.98	7643.30	0.9
	ONE METER FROM HI-TRAC								
1	572.54	218.90	0.4	544.38	282.51	0.5	376.70	249.93	0.7
2	1419.96	382.10	0.3	1154.08	340.90	0.3	653.90	277.82	0.4
3	399.57	58.04	0.1	446.26	71.73	0.2	318.65	62.58	0.2
4	316.35	472.54	1.5	457.30	696.46	1.5	367.92	568.97	1.5

[14] Refer to Figures 5.II.3-4.
[15] The reference results calculated in [5.II.5] were reprocessed using the SCALE 6.2.1 source terms.

Table 5.II.4.5

ANNUAL DOSE AT 300 METERS FROM A SINGLE HI-STORM 100S VERSION E OVERPACK WITH MPC-32M[16]

Dose Component	Annual Dose (mrem/yr)
Fuel gammas[17]	13.63
^{60}Co Gammas	0.84
Neutrons	0.12
BPRA	0.83
Total	15.43

[16] 8760 hour annual occupancy is assumed.

[17] Gammas generated by neutron capture are included with fuel gammas.

Table 5.II.4.6

DOSE VALUES USED IN CALCULATING ANNUAL DOSE FROM VARIOUS HI-STORM 100S VERSION E ISFSI CONFIGURATIONS[18]

Distance	A Side of Overpack (mrem/yr)	B Top of Overpack (mrem/yr)	C Side of Shielded Overpack (mrem/yr)
100 meters	337.41	37.49	67.48
200 meters	51.87	5.76	10.37
300 meters	13.89	1.54	2.78
400 meters	4.82	0.54	0.96
500 meters	1.87	0.21	0.37
600 meters	0.77	0.09	0.15

[18] 8760 hour annual occupancy is assumed.

Table 5.II.4.7

SOURCE TERMS INCREASE FOR NON-FUEL HARDWARE

Non-fuel Hardware	Radiation Source	Activity Increase Ratio[19]
BPRA	^{60}Co	2.4
TPD	^{60}Co	1.7
CRA	AgInCd, 0.3-0.45 MeV	1.0
	AgInCd, 0.45-0.7 MeV	7.5
	AgInCd, 0.7-1.0 MeV	9.9
	^{60}Co	1.5
APSR	^{60}Co	2.9

[19] Source activity at the reduced cooling time (see Subsection 5.II.2.4) divided by the reference source activity (see Subsection 5.2.4).

Table 5.II.4.8

DOSE RATES FOR HI-STORM 100S VERSION E FOR NORMAL CONDITIONS WITH 16 DAMAGED FUEL CONTAINERS MPC-32M DESIGN BASIS ZIRCALOY CLAD FUEL AT 45,000 MWD/MTU AND 3-YEAR COOLING

Dose Point Location[20]	Totals without BPRA (mrem/hr)		Ratio
	Undamaged Fuel (Reference)	Undamaged Fuel and Fuel Debris	
ADJACENT TO HI-STORM			
1	433.84	517.05	1.2
2	53.29	56.89	1.1
3	84.34	144.43	1.7
4	6.36	7.43	1.2
ONE METER FROM HI-STORM			
1	28.25	30.99	1.1
2	51.22	56.35	1.1
3	16.88	26.77	1.6
4	2.08	3.07	1.5

[20] Refer to Figures 5.II.3-1 AND 5.II.3-3.

Table 5.II.4.9

DOSE RATES FOR HI-TRAC VERSION MS FOR NORMAL CONDITIONS WITH 16 DAMAGED FUEL CONTAINERS MPC-32M DESIGN BASIS ZIRCALOY CLAD FUEL AT 45,000 MWD/MTU AND 3-YEAR COOLING

Dose Point Location[21]	Totals without BPRA (mrem/hr)		Ratio
	Undamaged Fuel (Reference)	Undamaged Fuel and Fuel Debris	
ADJACENT TO HI-TRAC			
1	1017.96	1306.28	1.3
2	5331.72	5178.54	1.0
3	98.04	119.67	1.2
4	3955.79	5846.56	1.5
5	8904.50	9732.08	1.1
ONE METER FROM HI-TRAC			
1	1094.13	1268.80	1.2
2	1962.16	1930.26	1.0
3	536.13	641.64	1.2
4	836.75	1137.13	1.4

[21] Refer to Figures 5.II.3-4.

5.II.5 Regulatory Requirements

In summary it can be concluded that the reasonably highest dose rates from the HI-STORM 100S Version E and HI-TRAC Version MS casks are bounded by the dose rates reported in the main body of Chapter 5. Hence these overpacks are in compliance with 10CFR72.

5.II.6 References

[5.II.1] Final Safety Analysis Report on the HI-STORM FW System, Holtec International Report HI-2114830, Revision 5, USNRC Docket No 72-1032, Washington, DC.

[5.II.2] X-5 Monte Carlo Team, MCNP - A General Monte Carlo N-Particle Transport Code, Version 5, LA-UR-03-1987, Los Alamos National Laboratory, April 2003 (Revised 2/1/2008).

[5.II.3] B. T. Rearden and M. A. Jessee, Eds., SCALE Code System, ORNL/TM-2005/39, Version 6.2.1, Oak Ridge National Laboratory, Oak Ridge, Tennessee (2016).

[5.II.4] Safety Analysis Report on the HI-STAR 190 Package, Holtec International Report HI-2146214, Revision 3, USNRC Docket No 71-9373, Washington, DC.

[5.II.5] HI-STORM 100 System Additional Shielding Calculations, Holtec International Report HI-2012702, Revision 15.

[5.II.6] Lower Bound Fuel Enrichment Based on Industry Data, Holtec International Report HI-2188480, Revision 0.

SUPPLEMENT 9.II: ACCEPTANCE CRITERIA AND MAINTENANCE PROGRAM

The acceptance criteria and maintenance program for the storage over pack, the transfer cask and the Alloy X MPCs set down in the main body of this FSAR remain applicable for the Version E overpack, the HI-TRAC MS transfer cask and the versions of Alloy X MPCs introduced in this Supplement II. The exceptions are listed below with section numbering based upon the main body section. Likewise, the material on MPC-68M provided in Supplement 9.III (previously reviewed by the NRC) applies in total to MPC-32M, the new Metamic- HT canister introduced in this Rev 17 of the FSAR.

9. II.1.2 Structural and Pressure Tests

9. II.1.2.1 HI-TRAC MS Lifting Locations

The lifting of HI-TRAC MS is engineered to occur though threaded couplings integral to the strongest part in the component and a lifting block. As shown in the HI-TRAC MS drawing (Section 1.II.5) the threaded connection is located in the top forging. These lift locations are accordingly referred to as tapped anchor locations (TAL).

Because the TALs are integral to the component, they possess high ductility and shall meet the requirements as shown in Paragraph 3.II.4.3 and Section 2.II.2.7.

Table 3.II.2.6 (4) provides the design load for the HI-TRAC MS (TALs).

In order to ensure that the HI-TRAC TALs do not have any hidden material flaws, the locations shall be tested at 300% of the maximum design (service) lifting load applied for a minimum of 10 minutes. The HI-TRAC tapped anchor locations (TAL) threads shall then be visually examined to verify no deformation, distortion, or cracking occurred. Any evidence of deformation, distortion or cracking of the HI-TRAC tapped anchor locations (TAL) threads shall require repair of the HI-TRAC cask. Following any repair, the load testing shall be performed and the components re-examined in accordance with the original procedure and acceptance criteria. Testing shall be performed in accordance with written and approved procedures. Test results shall be documented. The documentation shall become part of the final quality documentation package.

The acceptance testing of the HI-TRAC TAL(s) in the manner described above will provide adequate assurance against handling accidents.

SUPPLEMENT 10.II: RADIATION PROTECTION

10.II.0 Introduction

The safety information in the main body of this chapter remains fully applicable for the HI-STORM 100 System using the MPCs introduced in Revision 17 of this FSAR, namely MPC-32 Version 1, MPC-68 Version 1, MPC-32M as well as the HI-STORM 100S Version E storage cask and the HI-TRAC Version MS transfer cask. The analyses summarized in Supplement 5.II demonstrate that the HI-STORM 100S Version E and HI-TRAC Version MS cask designs provide overall the same or better shielding performance in comparison with the reference HI-STORM 100 System, evaluated in the main part of Chapter 5. The same observation is documented in Supplement 10.III which dealt with MPC-68M certified through an earlier CoC amendment.

Like the MPC-68M basket, MPC-32M basket is lighter than its Alloy X counterpart. This is due to the lower density of the Metamic-HT panels as compared to stainless steel. The reduction in weight provides the user more flexibility to add shielding in the cask to improve ALARA. For example, additional auxiliary/temporary shielding, such as listed in Table 10.1.1, may be used to further reduce the dose rates around the HI-TRAC when performing short term operations.

Nonetheless, in order to illustrate that the 10CFR20 standards for radiation protection are met, the occupational dose assessment during the loading operations of HI-STORM 100S Version E using the HI-TRAC Version MS transfer cask with the minimum lead and water jacket thicknesses as well as the collective dose assessment has been performed and documented in this supplement.

10.II.1 Ensuring that Occupational Radiation Exposures are As-Low-As-Reasonably-Achievable (ALARA)

Since the loading operations procedure and the temporary shield requirements for the Version E and Version MS casks are the same as for the reference Version B and 100-ton HI-TRAC, evaluated in the main body of this chapter, the discussions in Section 10.1 are directly applicable.

Particularly, the HI-STORM 100 auxiliary and temporary shielding described in Table 10.1.1 and shown on Figure 10.1.1 may be used to reduce the dose rates. Table 10.II.1.1 provides the minimum requirements for use of the temporary shielding with the Version MS transfer cask indicating optional and required shielding. Additional supplemental shielding such as lead blankets and bricks or other embodiments of the temporary shielding may be used to help reduce the dose rates. Users shall evaluate the need for auxiliary and temporary shielding and use of special tooling to reduce the overall exposure based on an ALARA review of cask loading operations and the MPC contents.

Table 10.II.1.1

[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

10.II.2 Radiation Protection Design Features

Same as Section 10.2.

10.II.3 Estimated On-Site Collective Dose Assessment

Since the loading operations procedure and the temporary shield requirements for the Version E and Version MS casks are the same as for the reference Version B and 100-ton HI-TRAC, evaluated in the main body of this chapter, the operational exposures during the loading operations for Version E and Version MS have been calculated using the original results presented in Table 10.3.1b. Specifically, for each loading operation the dose rate at operator location has been scaled, as discussed below.

[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

10.II.4 Estimated Collective Dose Assessment

The discussions in Section 10.4 are directly applicable the Version E and Version MS casks.

[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

Table 10.II.4.1

[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]

Table 10.II.4.2

[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10 CFR 2.390]