1.0.3 Implementation of Topical Reports

1.0.3.1 Thermal Topical Report

The NRC has reviewed and approved Topical Report HI-2200343-A [1.0.7]. This report outlines a methodology for developing heat load patterns for each canister. Throughout this FSAR, the areas where the topical report can be applied are identified. However, since the topical report itself is specifically focused on the thermal methodology, this section provides an outline of the approach for implementing that methodology. For additional clarity, a flowchart of the process is included in Figure 1.0.1.

Change Control
The NRC's SER [1.0.8] explicitly lays out restrictions on the scope of the review for the topical report. Most notably, limitation 4.2 describes the model reviewed for the scope of the topical report as invariant. However, since this FSAR is subject to the provisions of 10CFR72.48, use of that topical report needs to address the change control process. Note that in all cases, the system being considered must be one of the models listed in Appendix 1 of [1.0.8]

The following explains the steps in the flow chart in Figure 1.0.1 for implementation of the topical report

- **Step 1**: Site decides the existing CoC heat load patterns do not meet their needs, and develops a new pattern that would meet fuel loading needs
- **Step 2**: Site / Holtec determine if the system being used matches the invariant model in the topical report
  - If yes, then proceed through the qualification process outlined in the typical report, ensure all topical report acceptance criteria are met, and rejoin at Step 3
  - If no, follow steps 2a through 2d
- **Step 2a**: Ensure that the variations from the topical report invariant model (identified in Step 2) are acceptable without prior NRC approval
  - This process is identical to Holtec's existing 72.48 program and should be documented accordingly, which develops a "72.48 model" for that variation
  - If the 72.48 process indicates that prior NRC approval is required, that application must be made prior to use of the system
- **Step 2b**: Once the variations have been determined to be acceptable without prior NRC approval under 72.48, the site's candidate heat load pattern should be evaluated in the "72.48 model"
  - The results of this calculation must show that all components have a lower temperature than the FSAR limits and pressures lower than the FSAR limits
  - The peak cladding temperature (PCT) from this analysis is then compared to the results from Step 2c
- **Step 2c**: The candidate heat load pattern is then fully qualified for use by evaluation in the Topical Report "invariant model"
  - This evaluation must show ALL Topical Report acceptance criteria are met
  - This evaluation must show a higher PCT than Step 2b

  - If either of these conditions is not met, the candidate heat load pattern must be revised and Steps 2b and 2c are repeated
- **Step 2d**: The temperature results from both Steps 2b and 2c are compared to the structural evaluations in the FSAR
  - If FSAR structural evaluations use temperatures that bound the calculated temperatures, no further structural evaluations are needed
  - IF FSAR structural evaluations use temperatures that do NOT bound the calculated temperatures, an additional 72.48 must be performed to demonstrate the new temperatures are acceptable without NRC approval
    - If the structural evaluation changes are not acceptable under 72.48 than either the candidate heat load pattern must be changed or application made to the NRC
- **Step 3**: Once all the items and acceptance criteria in Step 2a through 2d are satisfied – document the evaluation performed in Step 2c (candidate heat load pattern in invariant model) in site's qualification report and referenced as appropriate in the general licensee's 72.212 report.
- **Step 4:** Site chooses fuel to meet the qualified heat load pattern, confirming that the fuel also meets other CoC restrictions, such as (but not limited to) fuel types and FQTs (see below shielding discussion)
- **Step 5**: Site ensures loading procedures have the accurate restrictions for:
  - Helium Backfill – HI-2200343-A Section 2.3.6
  - Time to boil – HI-2200343-A Section 2.3.8
  - Duct Blockage allowable clearance time or temperature monitoring limit – HI-2200343-A Section 2.3.12

Shielding

The fuel qualification limits for burnups, enrichments and cooling times (BECTs) are independent of the fuel decay heat limits, and any assembly has to meet both the applicable BECT limits, and any decay heat limit developed through the application of the Topical Report. No changes are made for now to these BECT limits, and no additional dose calculations are needed for the existing limits. Hence there are no new shielding analyses needed as a consequence of introducing the Topical Report. For further discussions and explanations see the following paragraphs.

Independence of BECTs and decay heat limits

Earlier revisions of this FSAR included an explicit link between BECTs and decay heat limits, and this also impacted the way the dose analyses were performed. The link was specified in the form of polynomials, where the burnup limit was established from the decay heat limit, enrichment and cooling time of an assembly. Due to the complications this created in the qualification process for fuel assemblies, and since both decay heat and burnup of any assembly are independently verified anyhow, this link was removed in a recent revision of the FSAR. Instead, a fixed set of BECTs was established that is independent of the decay heat limit. The dose analyses were updated to account for this more generic approach. Details are presented in Section 5.4.11 of the FSAR. The BECTs that were established are listed in Tables 2.1.28 and 2.1.29.

Having these limits as independent means that meeting the BECT limits does not imply the decay heat limit are met, and vice versa. This could result a situation where an assembly meets the BECT but not the decay heat limit, or meet the decay heat but not the BECT limits. In both cases, the assembly would not be qualified for loading.

Note these BECTs are only applicable to the MPC-24/32/68/68M that were previously covered by the explicit link between decay heat limits and BECTs. They are not applicable to the MPC-68M patterns analyzed in Supplement 5.II or 5.III, and also not to the MPC-32M analyzed in Supplement 5.II. This is consistent with the applicability of the Topical Report.

It is noted that in some situations the BECTs are developed as polynomials, where the set of coefficients depend on the decay heat limit of the cell location in the basket. See for example Table 2.II.1.6. However, this just uses the decay heat limit as a convenient reference to certain cell location, and decay heat limits and BECT limits still have to be met independent of each other. Expressed differently, meeting the BECT limits does not in any way imply that the corresponding decay heat limit is met, and meeting the decay heat limit does not in any way imply that the BECT limits are met.

No changes to BECT limits.
This FSAR revision focuses solely on the introduction of the Topical report to allow increased flexibility in the thermal loading pattern. To keep this focus, no changes are introduced to the previously established BECTs. It is understood that this may lead to situations where an assembly may meet the decay heat limit, but not the BECT limits. In that case, the assembly would not be qualified for storage. Future revision of the FSAR may introduce changes to the BECT limits to avoid this, which then would require appropriate justification from a dose perspective

No changes to Dose Analyses.
The dose analyses in Section 5.4.11 to support the BECT limits in Tables 2.1.28 and 2.1.29 are performed in a bounding fashion, i.e. using uniform loading of the baskets with any of the BECT combinations and determining the maximum dose rates. They therefore support the BECTs for any assembly in any location of the basket, and there are no restrictions on fuel placements implied or specified from these analyses. Any flexible placement permitted for fuel assemblies based on the Topical Report is therefore covered by these analyses, and no further dose analyses are needed.

This also includes any consideration for Non-Fuel Hardware (NFH). From a thermal perspective, the decay heat value of any NFH present in the fuel assembly must be included before comparing the decay heat with the limit, regardless of the position in the basket. From a dose perspective, the contribution of the NFH, as previously established, is included in the analyses described in Section 5.4.11 in support of the BECTs. The introduction of the TR with its potentially more flexible assembly location is therefore fully covered by the dose analyses that include the NFH, and hence no further dose analyses are needed.

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Figure 1.0.1: Thermal Topical Report Implementation

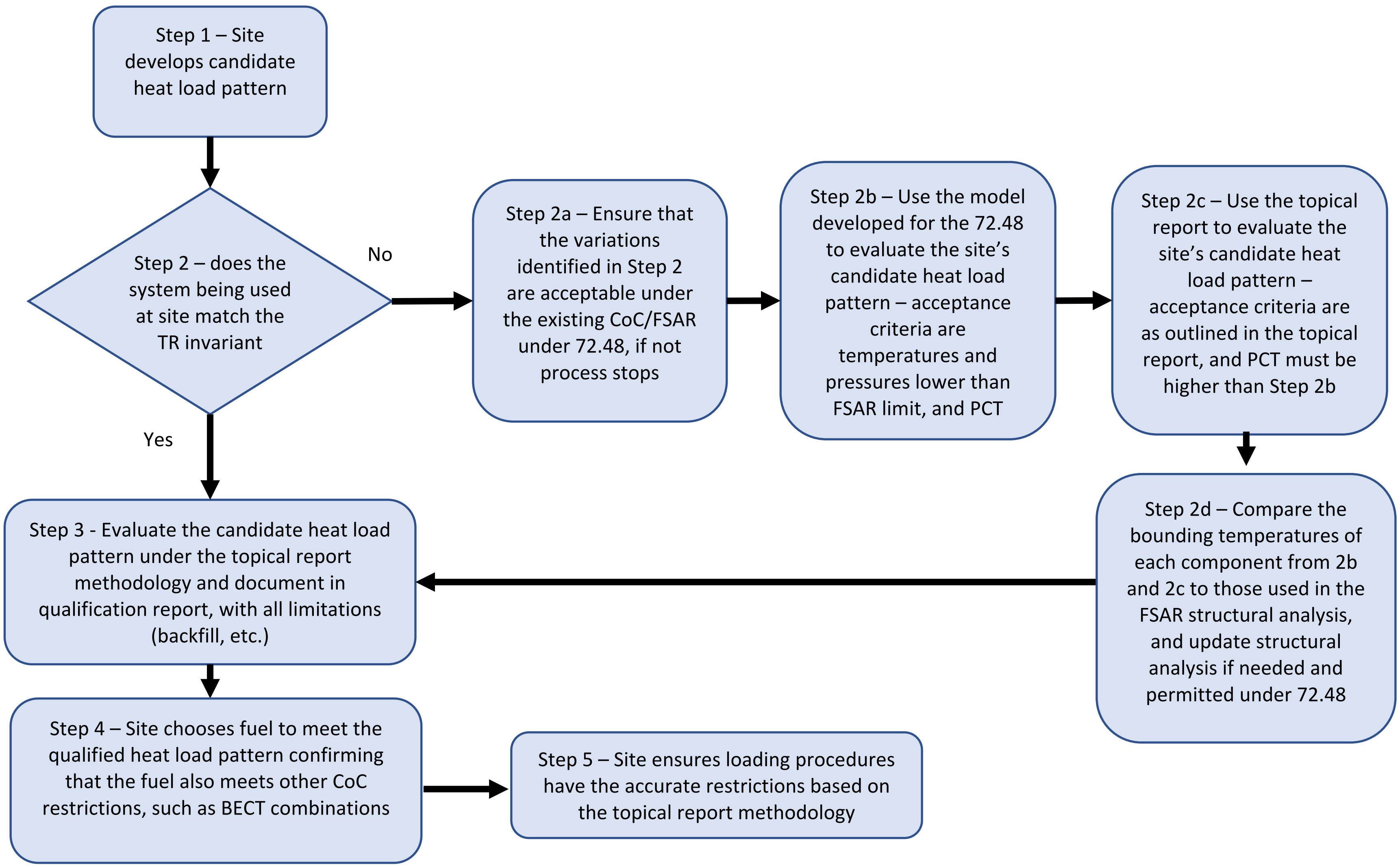

Table 1.2.2

KEY PARAMETERS FOR HI-STORM 100 MULTI-PURPOSE CANISTERS

	PWR	BWR
Pre-disposal service life (years)	40	40
Design temperature, max./min. (°F)	725°† /-40°††	725°† /-40°††
Design internal pressure (psig) Normal conditions Off-normal/Short-term conditions Accident Conditions	 100 110 200	 100 110 200
Total heat load, max. (kW)††††	36.9	36.9
Maximum permissible peak fuel cladding temperature: Long Term Normal (°F) Short Term Operations (°F) Off-normal and Accident (°F)	 752 752 or 1058††† 1058	 752 752 or 1058††† 1058

† Maximum normal condition design temperatures for the MPC fuel basket. A complete listing of design temperatures for all components is provided in Table 2.2.3.

†† Temperature based on off-normal minimum environmental temperatures specified in Section 2.2.2.2 and no fuel decay heat load.

††† See Section 4.5 for discussion of the applicability of the 1058°F temperature limit during MPC drying.

†††† Maximum heat load shown is for regionalized loading. This maximum heat load does not apply to patterns developed according to Topical Report HI-2200343-A

Table 1.2.2 (cont'd)

KEY PARAMETERS FOR HI-STORM 100 MULTI-PURPOSE CANISTERS

	PWR	BWR
MPC internal environment Helium fill (99.995% fill helium purity) (See Note 2) MPC-24 Note 3 (heat load ≤ 27.77 kW, see Table 2.1.31) (heat load > 27.77 kW) MPC-24E/24EF Note 3 (heat load ≤ 28.17 kW, see Table 2.1.31) (heat load > 28.17 kW) MPC-68/68F/68FF Note 3 (heat load ≤ 28.19 kW, see Table 2.1.31) (heat load >28.19 kW) MPC-32/32F Note 3 (heat load ≤ 28.74 kW, see Table 2.1.31) (heat load >28.74 kW)	(all pressure ranges are at a reference temperature of 70°F) ≥ 29.3 psig and ≤ 48.5 psig OR 0.1212 +/-10% g-moles/liter ≥ 45.5 psig and ≤ 48.5 psig ≥ 29.3 psig and ≤ 48.5 psig OR 0.1212 +/-10% g-moles/liter ≥ 45.5 psig and ≤ 48.5 psig ≥ 29.3 psig and ≤ 48.5 psig ≥ 45.5 psig and ≤ 48.5 psig	(all pressure ranges are at a reference temperature of 70°F) ≥ 29.3 psig and ≤ 48.5 psig OR 0.1218 +/-10% g-moles/liter ≥ 45.5 psig and ≤ 48.5 psig
Maximum permissible multiplication factor (k_{eff}) including all uncertainties and biases	< 0.95	< 0.95
Fixed Neutron Absorber ^{10}B Areal Density (g/cm^2) Boral/Metamic	0.0267/0.0223 (MPC-24) 0.0372/0.0310 (MPC-24E, MPC-24EF MPC-32 & MPC-32F)	0.0372/0.0310 (MPC-68 & MPC-68FF) 0.01/NA (MPC-68F) (See Note 1)
End closure(s)	Welded	Welded
Fuel handling	Opening compatible with standard grapples	Opening compatible with standard grapples
Heat dissipation	Passive	Passive

NOTE:

1. All MPC-68F canisters are equipped with Boral neutron absorber.
2. Refer to Section 4.4.5.1 for detailed information on heat load values.
3. For patterns developed in accordance with Topical Report HI-2200343-A, these backfill ranges may be modified

1.6 REFERENCES

[1.0.1] 10CFR Part 72, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation", Title 10 of the Code of Federal Regulations, 1998 Edition, Office of the Federal Register, Washington, D.C.

[1.0.2] Regulatory Guide 3.61 (Task CE306-4) "Standard Format for a Topical Safety Analysis Report for a Spent Fuel Storage Cask", USNRC, February 1989.

[1.0.3] NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems", U.S. Nuclear Regulatory Commission, January 1997.

[1.0.4] American Concrete Institute, "Code Requirements for Nuclear Safety Related Concrete Structures", ACI 349-85, ACI, Detroit, Michigan.†

[1.0.5] American Concrete Institute, "Building Code Requirements for Structural Plain Concrete (ACI 318.1-89) (Revised 1992) and Commentary - ACI 318.1R-89 (Revised 1992)".

[1.0.6] "Spent Nuclear Fuel Effective Thermal Conductivity Report," U.S. Department of Energy Document Identifier BBA000000-01717-5705-00010, Rev. 00, Tables S-1 through S-4.

[1.0.7] "Topical Report for Allowance of Heat Load Patterns in HI-STORM 100 and HI-STORM FW Systems," HI-2200343-A, Holtec International

[1.0.8] Final Safety Evaluation Report for the Holtec International Topical Report for Allowance of Heat Load Patterns in HI-STORM 100 and HI-STORM FW Systems," US NRC, ML21125A191

[1.1.1] ASME Boiler & Pressure Vessel Code, Section III, Subsection NB, American Society of Mechanical Engineers, 1995 with Addenda through 1997.

[1.1.2] USNRC Docket No. 72-1008, Final Safety Analysis Report for the (Holtec International Storage, Transport, and Repository) HI-STAR System, latest revision.

[1.1.3] USNRC Docket No. 71-9261, Safety Analysis Report for Packaging for the (Holtec International Storage, Transport, and Repository) HI-STAR System, latest revision.

[1.1.4] 10CFR Part 50, "Domestic Licensing of Production and Utilization Facilities", Title 10 of the Code of Federal Regulations, 1998 Edition, Office of the Federal

† The 1997 edition of ACI-349 is specified for embedment design for deployment of the anchored HI-STORM 100A and HI-STORM 100SA.

Register, Washington, D.C.

[1.1.5] Deleted.

[1.2.1] U.S. NRC Information Notice 96-34, "Hydrogen Gas Ignition During Closure Welding of a VSC-24 Multi-Assembly Sealed Basket".

[1.2.2] Directory of Nuclear Reactors, Vol. II, Research, Test & Experimental Reactors, International Atomic Energy Agency, Vienna, 1959.

[1.2.3] V.L. McKinney and T. Rockwell III, "Boral: A New Thermal-Neutron Shield", USAEC Report AECD-3625, August 29, 1949.

[1.2.4] Reactor Shielding Design Manual, USAEC Report TID-7004, March 1956.

[1.2.5] "Safety Analysis Report for the NAC Storable Transport Cask", Revision 8, September 1994, Nuclear Assurance Corporation (USNRC Docket No. 71-9235).

[1.2.6] Deleted.

[1.2.7] Materials Handbook, 13th Edition, Brady, G.S. and H.R. Clauser, McGraw-Hill, 1991, Page 310.

[1.2.8] Deleted.

[1.2.9] Deleted.

[1.2.10] Deleted.

[1.2.11] "Qualification of METAMIC® for Spent Fuel Storage Application," EPRI, 1003137, Final Report, October 2001.

[1.2.12] "Safety Evaluation by the Office of Nuclear Reactor Regulation Related to Holtec International Report HI-2022871 Regarding Use of Metamic in Fuel Pool Applications," Facility Operating License Nos. DPR-51 and NPF-6, Entergy Operations, Inc., Docket No. 50-313 and 50-368, USNRC, June 2003.

[1.2.13] "Metamic 6061+40% Boron Carbide Metal Matrix Composite Test", California Consolidated Tech. Inc. Report dated August 21, 2001 to NAC International.

[1.2.14] "Recommendations for Preparing the Criticality Safety Evaluation for Transportation Packages," NUREG/CR-5661, USNRC, Dyer and Parks, ORNL.

Table 1.III.1
Key Parameters for MPC-68M

	BWR
MPC internal environment Helium fill (99.995% fill helium purity) (heat load ≤ 28.19 kW) (heat load >28.19 kW) Quarter Symmetric Heat Load (QSHL, Figure 2.III.1) QSHL patterns in Figures 2.III.2 through 2.III.4	(all pressure ranges are at a reference temperature of 70ºF) > 29.3 psig and < 48.5 psig OR 0.1218 +/-10% g-moles/liter > 45.5 psig and < 48.5 psig ≥ 43.5 psig and ≤ 46.5 psig > 45.5 psig and < 48.5 psig (Note 1)
B_4C content in Metamic-HT (wt. %)	As specified on drawing in Section 1.5

Notes:

1. For patterns developed in accordance with Topical Report HI-2200343-A [1.0.7], these backfill ranges may be modified

methodology described in Section 2.1.9.1.1 or 2.1.9.1.2 depending on whether uniform fuel loading or regionalized fuel loading is being implemented†. The total permissible MPC heat load, for both uniform and regionalized loading, is determined in the following two subsections 2.1.9.1.1 and 2.1.9.1.2. Total MPC heat load and individual cell limits may also be determined using the methodology outlined in Topical Report HI-2200343-A. These fuel assemblies must still meet the fuel qualification requirements based on burnup, enrichment, and cooling time outlined in Paragraph 2.1.9.1.3. The decay heat limits are independent of burnup, cooling time, or enrichment and are based strictly on the thermal analysis described in Chapter 4 or the topical report [1.0.7] referenced above . Decay heat limits must be met for all contents in a fuel storage location (i.e., fuel and PWR non-fuel hardware, as applicable).

2.1.9.1.1 Uniform Fuel Loading Decay Heat Limits for ZR-Clad Fuel

Table 2.1.26 provides the maximum allowable decay heat per fuel storage location for ZR-clad fuel in uniform fuel loading for each MPC model in aboveground storage*. Even if the limits in Table 2.1.26 are met, the user must follow the instructions in the next section to calculate Q_{CoC} to determine if certain operational steps are required per the CoC. If the user needs to load fuel assemblies with a decay heat higher than the limits in Table 2.1.26, a regionalized loading pattern discussed in the next section may be considered.

2.1.9.1.2 Design Heat Load for ZR-Clad Fuel

The discussion in this section provides the approach to determine the maximum permitted per cell heat load for long term-storage in a regionalized pattern. In addition, this section also provides the approach to determine the allowed per cell heat load for those operations that are dependent on the total MPC heat load. These include helium backfill pressure, supplemental cooling, drying method, and time requirements for clearing blockage on HI-STORM inlet vents.

The Design Basis heat load for the aboveground HI-STORM System, Q_d, is 34 kW. Q_d is based on the assumption that every storage cell in the MPC is generating an equal amount of heat. In other words, the specific heat generation rate, q, of each storage location is considered equal. Thus, in an MPC with n storage locations,

$$Q_d = n\,q \qquad \text{Equation a}$$

In reality, however, the population of SNF and associated NFH loaded in the MPC invariably has unequal decay heat. If we consider the loaded decay heat in a cell as r, and r_i denotes the loaded decay heat in location i, then the aggregate MPC heat load, Q_t, is given by a simple summation, i.e.,

† Note that the stainless steel-clad fuel decay heat limits apply to all fuel in the MPC, if a mixture of stainless steel and ZR-clad fuel is stored in the same MPC. The stainless steel-clad fuel assembly decay heat limits may be found in Table 2.1.17 through 2.1.24

* Maximum allowable heat loads in 100U underground storage are defined in Supplement 2.I; however the discussion in Section 2.1.9.1 also applies to the 100U.

non-mechanistic). The basis for the lateral deflection limit in the active fuel region, θ, is provided in [2.III.6.1] as

$$\theta = \frac{\delta}{w}$$

where δ is defined as the maximum total deflection sustained by the basket panels under the loading event and *w* is the nominal inside (width) dimension of the storage cell. The limiting value of θ is provided in Table 2.III.4. The above deflection-based criterion has been used previously in the HI-STAR 180 Transportation Package [2.III.6.2] to qualify similar Metamic-HT fuel baskets.

ii. Thermal

The design and operation of the HI-STORM 100 System with the MPC-68M must meet the intent of the review guidance contained in ISG-11, Revision 3 [2.0.8] as described in Subsection 2.0.1.

All applicable material design temperature limits in Section 2.2 and 4.3 continue to apply to the MPC-68M. Temperature limits of MPC-68M fuel basket and basket shim materials are specified in Table 4.III.2.

The MPC-68M is designed for both uniform and regionalized fuel loading strategies as described in Subsection 2.0.1. The regions for the MPC-68M are given in Table 2.III.1. Additionally, four quarter-symmetric heat load patterns have been defined for MPC-68M as shown in Figures 2.III.1 through 2.III.4. The same temperature limits apply to these configurations. Alternative heat load patterns may be developed following the methodology in the Topical Report HI-2200343-A [1.0.7].

iii. Shielding

Same as Subsection 2.0.1.

iv. Criticality

Same as Subsection 2.0.1 with the clarifications herein.

Criticality control is maintained by the geometric spacing of the fuel assemblies and spatially distributed B-10 isotope in the Metamic-HT. No soluble boron is required in the MPC-68M water. The minimum specified boron concentration in the Metamic-HT purchasing specification must be met in every lot of the material manufactured. No credit is taken for burnup. Enrichment limits are delineated in Table 2.III.2.

v. Confinement

Same as Subsection 2.0.1

BASES

SURVEILLANCE REQUIREMENTS

SR 3.1.1.1, SR 3.1.1.2 , and SR 3.1.1.3 (continued)

of Appendix A to the CoC and the storage cell heat loads are less than or equal to the limits in either Table 3-3 of Appendix A to the CoC (regionalized) or Table 3-4 of Appendix A to the CoC (uniform), then the lower helium backfill pressure range in Table 3-2 item (i) can be used. The higher backfill pressure range in Table 3-2 item (ii) must be used if the cask heat load is greater than the value in Table 3-2 and the storage cell heat load is greater than the value in either Table 3-3 or Table 3-4. Note that the higher backfill pressure range in Table 3-2 item (ii) is just a subset of the wider range in item (i), and therefore can always be used as an option. The storage cell heat load limits specified in Table 3-3 and Table 3-4 for MPC-68/68F/68FF are also applicable to the MPC-68M, consistent with the analyses in the FSAR. Alternatively, the quantity of helium can be calculated based on the methodology in Topical Report HI-2200343-A

Meeting the helium leak rate limit ensures there is adequate helium in the MPC for long term storage and that there is no credible effluent dose from the cask.

All of these surveillances must be successfully performed once, prior to TRANSPORT OPERATIONS to ensure that the conditions are established for SFSC storage which preserve the analysis basis supporting the cask design.

REFERENCES

1. FSAR Sections 1.2, 4.4, 4.5, 7.2, 7.3 and 8.1
2. Interim Staff Guidance Document 11
3. Interim Staff Guidance Document 18
4. Deleted

BASES

ACTIONS (continued)

B.1

If the heat removal system has been determined to be inoperable, it must be restored to operable status within the Completion Time per the Table in the CoC for OVERPACKS containing MPCs with heat loads in excess of the heat loads in Table B.1-1 (below) at the time of inspection. This is a reasonable period of time 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 with 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.

Note that topical report HI-2200343 provides an optional method for calculating completion time for all the actions in this LCO.

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.1.2 (continued)

As an alternative, for OVERPACKs with air temperature monitoring instrumentation installed in the air outlets, the temperature rise between ambient and the OVERPACK air outlet may be monitored to verify operability of the heat removal system. Blocked air ducts will reduce air flow and increase the temperature rise experienced by the air as it removes heat from the MPC. Based on the analyses, provided the air temperature rise is less than the limit stated in the SR (or calculated using topical report HI-2200343-A), adequate air flow and, therefore, adequate heat transfer is occurring to provide assurance of long term fuel cladding integrity. The reference ambient temperature used to perform this Surveillance shall be measured at the ISFSI facility.

The Frequency for aboveground systems per the Completion Time Table in the CoC 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