HOLTEC
INTERNATIONAL

Holtec Center, 555 Lincoln Drive West, Marlton, NJ 08053
Telephone (856) 797-0900
Fax (856) 797-0909

April 17, 2013

John Goshen, P.E., Project Manager – Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety and Safeguards

ATTN: USNRC Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Docket No. 72-1014
Certificate of Compliance (CoC) No. 1014

Subject: Supplemental information for License Amendment Request #9 (LAR 1014-9) to HI-STORM 100 (TAC No. L24476)

References:
[1] Holtec Letter 5021011, dated April 3, 2013.
[2] Holtec Letter 5014705, dated September 10, 2010.
[3] Holtec Letter 5014708, dated October 1, 2010
[4] Holtec Letter 5014725, dated July 29, 2011.
[5] Holtec Letter 5014729, dated November 14, 2011.
[6] Holtec Letter 5014737, dated April 25, 2012.
[7] NRC public meeting minutes dated February 12, 2013.
[8] USNRC Docket No. 72-1014, TAC No. L24476

Dear Mr. Goshen:

Holtec International herein submits this supplement to the HI-STORM 100 Amendment 9 License Amendment Request (LAR) in response to the memorandum dated February 12, 2013 [7] detailing the meeting minutes from the NRC-Holtec public meeting on January 16, 2013.

The Final Safety Analysis Report (FSAR) changes that are part of this supplemental submission are based on HI-STORM 100 FSAR Rev. 10 which was submitted to NRC as a bi-annual update [6]. The CoC, and Appendices A & B changes are based on Amendment 8 CoC and Appendices A & B posted on ADAMS on November 23, 2012 [8]. All applicable changes to the CoC and Appendices A & B from the original Amendment 9 submittal [2], supplemental information [3],

NMSS24
NMSS26

HOLTEC
INTERNATIONAL

Holtec Center, 555 Lincoln Drive West, Marlton, NJ 08053

Telephone (856) 797-0900

Fax (856) 797-0909

RAI 1 [4] and RAI 2 [5] responses have been incorporated into the Amendment 9 CoC and Appendices A & B versions submitted with this supplement.

Attachment 1 is Holtec's response to NRC-Holtec Public Meeting memo dated February 12, 2013. Attachment 2 to this letter contains a summary of the proposed changes. Attachments 3 and 4 contain a summary of accompanying changes to the FSAR, CoC and TS A and B. Attachments 5, 6, 7 and 8 contain marked-up changes to the FSAR, Certificate of Compliance (CoC), and Technical Specifications (TS) A & B. Calculation Package Appendix N is in Attachments 9. Attachment 10 are the Thermal FLUENT Input/Output files, which are submitted on a hard drive. Attachment 11 is an affidavit written per 10 CFR 2.390 requesting that Attachments 9 and 10 be withheld from the public due to their proprietary nature.

Thermal Calculation Package Appendix O was previously submitted as Attachment 13 to Holtec Letter 5021011 [1] and is hereby incorporated by reference.

If you have any questions, then please contact me at (856)-797-0900 ext. 3659.

Sincerely,

P. Stefan Anton
Acting Licensing Manager
Holtec International

cc: (letter only w/o attachments)
Tony Hsia, USNRC
Michele Sampson, USNRC
Christian Araguas, USNRC
Jorge Solis, USNRC
Ghani Zigh, USNRC
Holtec Group 1 (via email)
HUG Licensing Subcommittee (via email)

HOLTEC INTERNATIONAL

Holtec Center, 555 Lincoln Drive West, Marlton, NJ 08053

Telephone (856) 797-0900

Fax (856) 797-0909

List of Attachments:

Attachment 1: Response to NRC-Holtec Public Meeting memo dated February 12, 2013. (5 pages)
Attachment 2: Summary of Proposed Changes for LAR Supplemental Submittal (4 pages)
Attachment 3: Summary of Proposed Changes to FSAR (3 pages)
Attachment 4: Summary of Proposed Changes to CoC, and TS A & B (2 pages)
Attachment 5: HI-STORM 100 FSAR, Rev. 10 proposed changes (70 pages)
Attachment 6: CoC No. 1014 proposed changes (5 pages)
Attachment 7: TS Appendix A/A-100U proposed changes (15 pages)
Attachment 8: TS Appendix B/B-100U proposed changes (7 pages)
Attachment 9: Holtec Report HI-2043317R19, Appendix N (Holtec Proprietary Information) (36 pages)
Attachment 10: Thermal FLUENT Input/Output files (Hard drive) (Holtec Proprietary Information)
Attachment 11: Affidavit per 10 CFR 2.390 (5 pages)

Response to NRC-Holtec Public Meeting Memo dated February 12, 2013

The staff identified some modeling issues associated with Holtec's thermal analysis of the transfer cask. The issues and their potential impact on the predicted peak cladding temperature are identified below.

1 **Representation of water density using Boussinesq approximation.** Real fluid property as function of temperature and pressure should be implemented for the running fluids to assess the use of Boussinesq approach on the final Computational Fluid Dynamics (CFD) results.

Holtec Response:

Holtec agrees with NRC staff on representing real fluid property as a function of temperature instead of using the Boussinesq approximation approach. The HI-TRAC thermal models were modified to model the water density in water jacket as a function of temperature.

2 **The representation of fuel rods using porous media and effective thermal conductivity.** In the porous media approximation, fuel rods were approximated hydraulically by using frictional and inertial resistance. Also effective thermal conductivity was used to model radiation and conduction heat transfer in the fuel assembly instead of representing the real geometry. Effective thermal conductivity was also used in the air gap between the MPC and the transfer cask. Calculations should be performed to assess the sensitivity on the final results (i.e., peak cladding temperature (PCT)) to possible changes in frictional losses, inertial losses, and use of effective thermal conductivity.

For example, the staff performed some sensitivity calculations in the use of effective thermal conductivity in the air gap between the MPC and the transfer cask. The FLUENT model provided by Holtec was modified to represent the air gap to allow air motion as well as heat transfer by conduction and radiation. The water density in the water jacket was represented by using water density as a function of temperature. With these changes, the staff obtained a peak cladding temperature of 745°F as compared to Holtec's result of 738°F for the bounding case (X=3) and an ambient temperature of 110°F. The PCT predicted by the staff is below the allowable limit but this result does not include the discretization error or the application error, as explained later.

In addition, the staff performed a FLUENT analysis of the thermal-hydraulic experiment performed at Sandia National Laboratory (SNL) for a 17X17 PWR fuel assembly. The SNL thermal-hydraulic experiment was performed for buoyancy driven flow. The analysis indicated that a viscous resistance factor of about a million would match the experimental data. Also, the staff performed a sensitivity calculation using a viscous

resistance factor similar to the value used in the FLUENT analysis of the SNL experiment for the same basket storage cell width and obtained a PCT of about 782°F. The validation against the SNL experiment for a similar fuel assembly type and same storage cell width indicates that a viscous resistance factor of about one million adequately captures the fuel assembly pressure drop, as measured in the SNL experiment. Holtec should consider how it will justify the viscous resistance factors used in their thermal analysis to properly capture the fuel assembly pressure drop since, as indicated earlier based on experimental data, the values currently used in the thermal model appears to be non-conservative.

As indicated earlier, the analysis provided by Holtec does not include the discretization and the application errors. These should be quantified to assess their impact on the predicted PCT. These errors are described below.

a Spatial discretization (numerical) errors. Discretized equations have a limited resolution in space. Increasing the number of cells will reduce the discretization error and therefore the results will be closer to the exact solution. Also, the higher the order of the scheme the closer the results will be to the exact solution. Grid Convergence Index method (ASME V&V 20-2009) can be used to assess the sensitivity of the solution to the grid density. Per ASME V&V 20-2009, when using the GCI method to estimate the discretization error, the following criteria should be met:

- The solution from the different grids used display monotonic convergence.
- The solution from the different grids used should be in the asymptotic range.

b Application uncertainties. Uncertainty in the applied boundary conditions may lead to errors and differences between the exact solution and the discretized equations. Calculations on the applied boundary conditions should be performed to assess their sensitivity to the predicted peak cladding temperature.

The applicant should provide the difference (to PCT) contributed by each uncertainty and provide the PCT for the bounding ambient temperatures (with and without insolation).

Holtec Response:

Flue Flow Resistance Comment:

NRC staffs provided Holtec the partial report for the thermal-hydraulic experiments performed at Sandia National Laboratory (SNL) and the validation FLUENT model performed by NRC staffs. In the validation FLUENT model, the fuel assembly located inside a single cell is modeled as the porous medium with the viscos factor at about 1 million. After reviewing the information from NRC, Holtec post-processed the FLUENT model provided by NRC and obtained the volumetric flow rate and the maximum cladding temperature at elevations of 136 and 142 inches.

The results predicted by the FLUENT model have a good agreement with the measurement results provided in the experimental report. Based on the above observation, Holtec agrees with NRC staff that a viscous resistance factor of one million adequately captures the flow character of the typical 17x17 PWR fuel assemble using in SNL experiment. Therefore, a viscous factor of 1×10^6 m^{-2} is used in all models submitted for this amendment request. The review of information provided by NRC is documented in the Appendix O of Holtec report HI-2043317R19 provided to NRC.

Air Gap Modeling Comment:

Holtec agrees with NRC staffs on explicitly modeling the annular air gap between the MPC shell and the HI-TRAC inner shell as fluid zone, instead of a solid zone having an effective thermal conductivity. The HI-TRAC thermal models were modified to model the annular gap explicitly.

Ambient Air Temperature Comment:

HI-TRAC transfer cask was evaluated for both inside and outside building environmental conditions. The ambient conditions are listed in Table 2.2.2 of FSAR and given below:

HI-TRAC Transfer Cask	
Inside Building Short Term Operations (3-Day Average)	110°F with no insolation
Outside Building Short Term Operations (3-Day Average)	90°F with insolation

Discretization and Application Errors Analysis

(a) Spatial discretization (numerical) errors

To evaluate the spatial discretization error, a grid independence study was performed per ASME V&V 20-2009. The following table gives a brief summary of the different sets of grids evaluated along with the PCT results. As can be seen from this table, the finest mesh (Mesh 3) is 4.8 times the total mesh size of the baseline mesh (Mesh 1). Even with such a large mesh refinement, the change in PCT is small. The solutions from the different grids used are in the asymptotic range. The small PCT difference between the meshes is negligible compared to the available PCT safety margin. To provide further assurance of convergence, the sensitivity results are evaluated in accordance with the ASME V&V 20-2009. The apparent order is calculated as 1.5, which is close to the theoretical order of discretization scheme. The calculation of Grid Convergence Index (GCI), which is a measure of the solution uncertainty, is computed as 0.37%.

Mesh No	Total Cell Number	PCT °C (°F)
1	887640	391 (736)
2*	2026834	390 (734)
3	4264584	390 (734)
* Mesh 2 is reasonably converged and is adopted for all licensing basis calculations.		

(b) Application uncertainties

To evaluate the uncertainty in applied boundary conditions, the following sensitivity studies were performed:

(i) A sensitivity study was performed to study the effect of fuel thermal conductivity on PCT by reducing it by 10%.
(ii) A sensitivity study was performed to study the effect of cask external surface heat transfer coefficient (h) on PCT by reducing it by 10%.
(iii) A sensitivity study was performed to study the combination of the above two changes.

The PCT results for the above mentioned sensitivity studies are shown in the table below. These analyses were performed with the following input parameters:

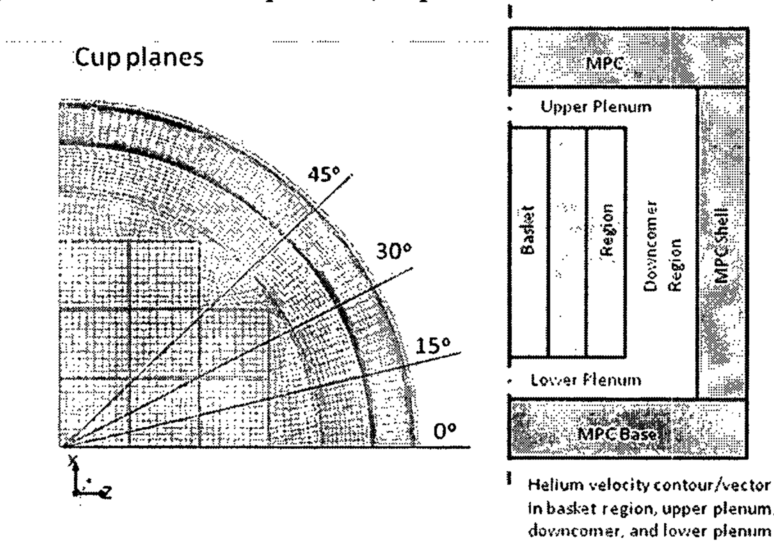
- Fuel viscous resistance factor of 1×10^6 m^{-2} for all three zones of fuel assembly
- 90% of design basis maximum heat load (Section 2.1.9 of HI-STORM 100 FSAR) and a regionalization parameter X=3;
- 90°F ambient temperature with 10CFR71 insolation level.

The results show that the PCT under the worst combination of both reduced fuel thermal conductivity and heat transfer coefficient is still below the fuel temperature limit.

	Model	Peak Clad Temperature °C (°F)
	Reference Fuel Conductivity, h=5.2 W/m^2-K	390 (734)
(i)	Reduced Fuel Conductivity, h=5.2 W/m^2-K	393 (739)
(ii)	Reference Fuel Conductivity, h=4.68 W/m^2-K	393 (739)
(iii)	Reduced Fuel Conductivity, h=4.68 W/m^2-K	395 (743)

All these evaluations are documented in the Holtec report HI-2043317R19 or LAR-9 Sections 4.5 and 4.6 provided to NRC.

3. Provide helium velocity profiles (contours/vectors) in basket region, upper plenum, downcomer and low plenum (cut planes are shown below).



Holtec Response:

The helium velocity profiles were added as Figures N.1 thru N.7 in Holtec report HI-2043317 revision 19. This report is provided for NRC staff's reference. The velocity vectors through these multiple planes clearly demonstrate thermosiphon action inside the MPC cavity.

Attachment 2 to Letter 5014750

Summary of Proposed Changes for LAR 1014-9 Supplemental Submittal

The purpose of this document is to provide supporting information for proposed changes requested with LAR 1014-9. Specifically, the change is to update the thermal model for the HI-TRAC transfer cask from a two dimensional thermal hydraulic model to a three dimensional thermal hydraulic model, and perform thermal evaluations with increased thermal resistance data obtained from the NRC. Information previously submitted regarding supplemental cooling or lack thereof shall be superseded by information in this submittal, and will be identified.

Proposed Changes

Table 1 below summarizes the conditions, sections and/or pages that have been revised, removed or added to the Certificate of Compliance (CoC), Technical Specification (TS) Appendices A, A-100U, B and B-100U due to modification of requirements for Supplemental Cooling and improvement in the thermal analysis methodology for the HI-STORM 100 and 100U storage systems during short term operations.

Table 1

CoC*	TS* A	TS A-100U	TS B	TS B-100U
Pages 1-5, Amd. Nos.	Table of Contents (Page i)	Table of Contents (Page i)	Table of Contents (Page i)	Table of Contents (Page i)
Condition 9 (Page 3)	LCO 3.1.1 (Page 3.1.1-1)	LCO 3.1.1 (Page 3.1.1-1)	Section 3.4 (Page 3-17)	Section 3.7 (Page 3-13)
	LCO 3.1.4 (Page 3.1.4-1)	LCO 3.1.4 (Page 3.1.4-1)	Section 3.7 (Page 3-23)	Section 3.11 (Page 3-18)
	Table 3-1 (Page 3.4-1)	Table 3-1 (Page 3.4-1)	Section 3.9 (Page 3-25)	
	Table 3-2 (Page 3.4-2)	Table 3-2 (Page 3.4-2)		
	Table 3-3 (Page 3.4-3)	Table 3-3 (Page 3.4-3)		
	Table 3-4 (Page 3.4-3)	Table 3-4 (Page 3.4-3)		
*CoC - Certificate of Compliance		*TS - Technical Specification		

Reason for Proposed Changes

The changes indicated above were proposed in order to simplify the requirements for short term operations using the HI-TRAC for the HI-STORM 100 or 100 U Systems so that the occupational dose, loading times, and crew safety are improved. This will be accomplished by utilizing a three dimensional thermal-hydraulic model of the HI-TRAC transfer.

Justification for Proposed Change

Holtec utilized Sandia National Labs (SNL) experimental data described in NRC memorandum of Holtec-NRC public meeting dated February 12, 2013 during the thermal analysis process to provide confirmation that Supplemental Cooling is required during HI-TRAC fuel transfer operations under specific conditions. The data was provided to Holtec by the NRC. As the supplemental cooling requirement is based on thermal loadings at threshold and ambient temperature conditions, other aspects of the system also needed evaluations. These included the MPC Helium backfill pressure, MPC cavity drying mechanisms, and MPC model. To that end evaluations were performed to ensure the system would continue to function in its entirety as required under normal, off-normal and accident conditions.

Per analyses, temperatures remained below the ISG-11 Revision 3 and HI-STORM 100 FSAR Rev. 10 Table 2.2.3 limits. MPC Helium backfill pressure remained within the designed pressure limit under all loading conditions, and the revised MPC cavity drying limits remained consistent with the design basis. Evaluations yielded similar results for all MPC models.

The proposed changes do not affect the structural changes to the 100U and the accompanying evaluations submitted with the original license Amendment # 9 dated September 10, 2010 (Holtec Letter No. 5014705), and accompanying documents in the supplemental letter and attachments dated October 1, 2010, RAI round 1 response letter and attachments dated July 29, 2011, and RAI round 2 response letter and attachments dated November 14, 2011. Those changes have been incorporated and will not be identified with a strikethrough, underline and/or a change bar on the side of the page. Please note that only thermal changes are identified in this submission, which is based on the approved Amendment 8 CoC, TS A & B. The original amendment 9 submission was based on the approved Amendment 7.

The change was evaluated via re-analysis of short-term operations involving the HI-TRAC transfer cask for the case of loadings with High Burn-up Fuel (HBF). These operations include drying of the MPC and on-site transport of the dried MPC. Per this submittal, use of a Supplemental Cooling System (SCS) will only be required under the following conditions:

1. For post-backfill HI-TRAC operations of an MPC containing one or more high burn-up (> 45, 000 MWD/MTU) fuel assemblies and storage cells heat loads in excess of 90% of the design basis storage cell heat loads defined in Appendix B, Section 2.4.2.
2. If following determination of three-day average ambient temperatures in excess of 90^0F inside and 110^0F outside operations building for intended short-term HI-TRAC operations dates, a site-specific evaluation performed using the loaded fuel determines the predicted cladding temperatures exceed the ISG-11 Rev. 3 limits for such operations.

The Final Safety Analysis Report (FSAR) part of this supplemental submission is based on Rev. 10 to the HI-STORM 100 FSAR (Docket 72-1014). The CoC, and TS Appendices A & B changes are based on Amendment 8 CoC and TS A & B posted on ADAMS on November 23, 2012. The CoC and TS A & B from the original Amendment 9 submittal as well as changes to each from RAI # 1 and RAI #2 responses have become incorporated into the current Amendment 9 CoC and TS A & B submitted with this supplement.

The following FSAR sections and other documents previously submitted are superseded by information in this submittal:

1. FSAR Section 4_5-R9B (superseded by 4_5-R10A)
2. FSAR Section 4_6-R9B (superseded by 4_6-R10A)
3. FSAR Section 4_8-R9A (superseded by 4_8-R10A)
4. FSAR Section Supp. 11_I-R9B (superseded by Supp. 11_I_R10A)
5. Holtec Report HI-2043317R10 Appendices C & D (superseded by HI-2043317R18 Appendices C, D & N) – Calculation Package
6. CoC (superseded by marked-up CoC in this package)
7. TS A (superseded by marked-up TS Appendix A in this package)
8. TS B (superseded by marked-up TS Appendix B in this package)

Attachment 2 to Letter 5014750

The following FSAR sections are being submitted as additions to the original submittal:

1. 1_2-R10A (editorial changes only)
2. 2_0-R10A
3. 2_1-R10A
4. 2_2-R10A
5. 2_C-R10A
6. 8_1-R10A (editorial changes only)
7. 8_3-R10A
8. 11_1-R10A
9. 12_2-R10A
10. 12_A_B3_1_1-R10A
11. 12_A_B3_1_4-R10A
12. Holtec Report (HI-2043317R18 Appendix N)

The following FSAR sections, reports and Request for Additional Information (RAI) responses previously submitted are not being resubmitted and will not be superseded by information in this submittal:

Amendment 9 request letter dated September 10, 2010 (Holtec Letter No. 5014705)

1. FSAR Sections Supplements 1_I-R9A and 10_I-R9A in attachment 3.

Amendment 9 supplemental letter dated October 1, 2010 (Holtec Letter No. 5014708)

1. Appendices C & D in attachment 1
2. Calculations 1A, 2A, 7A, 9A and 11A from Holtec Report (HI-2053389R9) in attachment 2
3. Holtec report HI-2104599R0

Holtec response to RAI letter dated July 29, 2011 (Holtec Letter No. 5014725)

1. Responses in RAIs in attachment 1
2. FSAR Section Supplement 2_I-R9B in attachment 3
3. Appendix F to Holtec Report (HI-2104599R1) in attachment 5
4. Holtec Position Paper DS 338Rev 1 in attachment 6
5. Holtec Drawing 4501R6 in attachment 7

Holtec response to 2nd RAI letter dated November 14, 2011 (Holtec Letter No. 5014729)

1. Response to 2nd round RAIs in attachment 1
2. FSAR Section Supplement 3_I-R9C
3. Appendix G, G1, G2 and G3 to Holtec Report (HI-2104599R2) in attachment 3

An NRC-Holtec public meeting was held on January 16, 2013. During the meeting NRC staff stated three thermal modeling issues that concerned them with Holtec's thermal analysis of the transfer cask. The issues were subsequently documented in a memorandum of the meeting minutes dated February 12, 2013. The issues are stated along with Holtec's response to each in Attachment 1 to this letter. Holtec re-performed the thermal analysis incorporating the following measures identified by the NRC:

- real fluid property as a function of temperature and pressure,
- modeled air gaps instead of a solid zone with an effective thermal conductivity,
- utilized viscous resistance factor of one million per experimental data from Sandia National Laboratory (SNL),
- determined monotonic convergence by varying the number of cells for each mesh,
- evaluated uncertainty in applied boundary conditions by varying thermal conductivities and heat transfer coefficients for inside and outside building conditions, and
- providing the requested helium velocity profiles of the indicated regions of the MPC. See Enclosure 1 for full response.

Holtec understands the importance of safety and supports studies such as the thermal-hydraulic experiment performed at SNL on the 17 x 17 PWR fuel assembly for buoyancy driven flow. The data obtained from that experiment referenced in NRC memorandum (February 12, 2013) of NRC-Holtec public meeting on January 16, 2013 has been incorporated into the thermal analysis in this package, and while the temperature margins to the regulatory limits were slightly reduced, they remained adequate. Holtec has responded to all issues identified by the NRC, and looks forward to a timely review and acceptance of the proposed changes.

Attachment 3 to Holtec Letter No. 5014750

Changes to HI-STORM 100 Final Safety Analysis Report (FSAR)

FSAR Section/Table/Figure Number	Description of Change
Subsection 1.2.2.2, Page 1.2-25	Supplemental Cooling System (SCS) requirement changed from temperature exceeding long-term limits to short-term limits in HI-TRAC.
Table 1.2.2	MPC Short-term operations pressure conditions added to table.
Subsection 2.0.1, Page 2.0-3	MPCs threshold heat loads for forced helium dehydration (FHD) drying of MPC cavity and SCS revised.
Subsection 2.0.3, Page 2.0-9	MPC threshold heat load for SCS revised for HI-TRAC short-term operations.
Subsection 2.1.9.1.5	Subsection discussing SCS threshold heat loads added to FSAR.
Table 2.1.30	Note 1 added to table to link cell heat loads and reduction factors mandating SCS operation.
Table 2.2.1	Short-term operations MPC Internal Pressure added to table.
Table 2.2.2	Indoors and outdoors 3-day temperature average for short-term operations added to table.
Subsection 2.C.2	SCS design criteria for ambient air temperature revised.
Section 4.5	See changes to Subsection 1.2.2.2 above.
Subsection 4.5.1	Methodology revised to adopt the 3D HI-TRAC thermal model and incorporation of high fluid resistance.
Subsection 4.5.3.1	Revised methodology to adopt the 3D thermal model for evaluating Vacuum Drying Operations.
Subsection 4.5.3.2	Table FHD requirement for heat loads deleted.
Subsection 4.5.4	Discussion on re-flooding operations added.
Subsection 4.5.5	Retitled. Revised discussion on maximum temperature.
Subsection 4.5.5.1	Retitled. Discussion revised.
Subsection 4.5.5.2	Title and discussion replaced.

Subsection 4.5.5.3	New Discussion.
Subsection 4.5.5.4	New Section.
Subsection 4.5.5.5	New Section.
Subsection 4.5.6	Revised discussion on MPC maximum internal pressure.
Table 4.5.1	Replaced.
Tables 4.5.4 – 4.5.8	Tables revised.
Table 4.5.9	New Table.
Subsection 4.6.2.1, Page 4.6-6	Revised discussion on HI-TRAC Fire.
Subsection 4.6.2.2	Revised discussion on Jacket Water Loss.
Table 4.6.2	Revised to include HI-TRAC Fire Accident pressure and recalculated HI-TRAC Jacket Water Loss.
Table 4.6.5	Modified for regionalized loadings.
Section 4.8, Page 4.8-3	Two references added.
Subsection 8.1.1 Page 8.1-1	Filled water jacket requirement added as foot note 1.
Subsection 8.1.1, Page 8.1-2	SCS helium backfill requirement revised.
Subsection 8.1.4, Page 8.1-20	Annulus water flushing requirement removed.
Subsection 8.1.6, Page 8.1-25	SCS time limits requirement revised.
Subsection 8.1.7, Page 8.1-27	SCS usage requirement revised.
Table 8.1.6, Page 8.1-40	Modified to include high decay heat loads.
Subsection 8.3.2, Page 8.3-4	Revised threshold heat load criteria.
Section 11.1	HI-TRAC Off-Normal Ambient Temperature section added.

Subsection 11.1.8	New subsection on HI-TRAC off-normal ambient temperatures.
Subsection 11.1.8.1	New subsection on cause of off-normal ambient temperatures.
Subsection 11.1.8.2	New subsection on detecting off-normal ambient temperatures.
Subsection 11.1.8.3	New subsection on effects of off-normal ambient temperatures.
Subsection 11.1.8.4	New subsection on corrective action for off-normal environmental temperatures.
Subsection 11.1.8.5	New subsection on radiological impact of off-normal environmental temperatures.
Subsection 12.2.11	Revision to recommendations for MPC drying.
Subsection B3.1.1, Page B3.1.1-4	B.1 Revised.
Subsection B3.1.1, Page B3.1.1-9	Reference removed.
Subsection B3.1.4, Page B3.1.4-2	Revised conditions for SCS operations, including when using high and lower helium backfills.
Subsection B3.1.4, Page B3.1.4-3	Revised texts to reference SCS design limits. Added ambient temperature requirements.
Subsection 11.I.1	Added HI-TRAC off-normal ambient temperatures to the list of off-normal events.
Subsection 11.I.1.9	New section.
Subsection 11.I.2.16	SCS condition evaluation.

Attachment 4 to Holtec Letter No. 5014750

Summary of Changes to HI-STORM 100 CoC, Appendix A & B

CoC, Appendix A and Appendix B Section/Table/Figure Number	Description of Change
Amend. No. changed to 9 throughout CoC	New amendment number.
CoC, Condition 9	Editorial Changes
Appendix A, Table Of Contents (TOC)	Added Tables 3-3 and 3-4 on Page 3.4-3
Appendix A, Subsection 3.1.1	LCO 3.1.1 MPC total decay heat thresholds revised.
Appendix A, Subsection 3.1.2	Updated to reference Tables 3-3 and 3-4 on pages 3.1.2-1 and 3.2.1-2
Appendix A, Subsection 3.1.4	LCO 3.1.4 revised SCS requirements.
Appendix A, Table 3-1	Modified MPC Heat Load requirements.
Appendix A, Table 3-2	Modified to include uniform and regionalized heat loads for various helium backfill pressures.
Appendix A, Table 3-3	Added to Appendix. Regionalized storage cell heat load limits.
Appendix A, Table 3-4	Added to Appendix. Uniform storage cell heat load limits.
Appendix A-100U, TOC	Added Tables 3-3 and 3-4 on Page 3.4-3
Appendix A-100U, Subsection 3.1.1	LCO 3.1.1 MPC total decay heat thresholds revised.
Appendix A-100U, Subsection 3.1.4	LCO 3.1.4 revised SCS requirements.
Appendix A-100U, Table 3-1	Modified MPC Heat Load requirements.
Appendix A-100U, Table 3-2	Modified to include uniform and regionalized heat loads for various helium backfill pressures.
Appendix A-100U, Table 3-3	Added to Appendix. Regionalized storage cell heat load limits.
Appendix A-100U, Table 3-4	Added to Appendix. Regionalized storage cell heat load limits.

Appendix B, Table of Contents (TOC)	Added section 3.9 on page 3-25. Editorial changes.
Appendix B, Section 3.4	Added ambient temperature HI-TRAC operations evaluation to design features.
Appendix B, Subsection 3.7.1	Revised SCS requirements.
Appendix B, Subsection 3.7.2	Changed ambient temperature design basis requirement for SCS.
Appendix B, Section 3.9	New section for environmental temperature requirement.
Appendix B-100U, TOC	Added section 3.11 on page 3-18.
Appendix B, Subsection 3.7.1	Revised SCS requirements.
Appendix B, Subsection 3.7.2	Changed ambient temperature design basis requirement for SCS.
Appendix B, Subsection 3.11	New section for environmental temperature requirement.

the cradle is equipped with rotation trunnions they are used to engage the HI-TRAC 100 or 125 pocket trunnions. While the loaded HI-TRAC is lifted by the lifting trunnions, the HI-TRAC is lowered onto the cradle rotation trunnions. Then, the crane lowers and the HI-TRAC pivots around the pocket trunnions and is placed in the horizontal position in the cradle.

The HI-TRAC 100D and 125D do not include pocket trunnions in their designs. Therefore, the user must downend the transfer cask onto the transport frame using appropriately designed rigging in accordance with the site's heavy load control program.

If the loaded HI-TRAC is transferred to the cask transfer facility in the horizontal orientation, the HI-TRAC transport frame and/or cradle are placed on a transport vehicle. The transport vehicle may be an air pad, railcar, heavy-haul trailer, dolly, etc. If the loaded HI-TRAC is transferred to the cask transfer facility in the vertical orientation, the HI-TRAC may be lifted by the lifting trunnions or seated on the transport vehicle. During the transport of the loaded HI-TRAC, standard plant heavy load handling practices shall be applied including administrative controls for the travel path and tie-down mechanisms.

For MPCs containing any HBF and a decay heat load that would yield a peak HBF cladding temperature above the ~~long~~short-term temperature limit, the Supplemental Cooling System (SCS) is required to be operational during the time the loaded and backfilled MPC is in HI-TRAC to ensure fuel cladding temperatures remain within limits. The SCS is discussed in detail in Section 4.5 and the design criteria for the system are provided in Appendix 2.C. The SCS is not required when the MPC is inside the HI-STORM overpack, regardless of decay heat load.

After the loaded HI-TRAC arrives at the cask transfer facility, the HI-TRAC is upended by a crane if the HI-TRAC is in a horizontal orientation. The loaded HI-TRAC is then placed, using the crane located in the transfer area, on top of HI-STORM, which has been inspected and staged with the lid removed, vent duct shield inserts installed, the alignment device positioned, and the mating device installed, as applicable.

After the HI-TRAC is positioned atop the HI-STORM or the mating device, the MPC is raised slightly. In the standard design, the transfer lid door locking pins are removed and the doors are opened. With the HI-TRAC 100D and 125D, the pool lid is removed using the mating device. The MPC is lowered into HI-STORM. Following verification that the MPC is fully lowered, slings are disconnected and lowered onto the MPC lid. For the HI-STORM 100, the doors are closed and HI-TRAC is removed from on top of HI-STORM or disconnected from the mating device, as applicable. For the HI-STORM 100S and the HI-STORM 100S Version B, the standard design HI-TRAC may need to be lifted above the overpack to a height sufficient to allow closure of the transfer lid doors without interfering with the MPC lift cleats. The HI-TRAC is then removed and placed in its designated storage location. The MPC lift cleats and slings are removed from atop the MPC. The alignment device, vent duct shield inserts, and mating device is/are removed, as applicable. The pool lid is removed from the mating device and re-attached to the HI-TRAC 100D or 125D prior to its next use. The HI-STORM lid is installed, and the upper vent screens and gamma shield cross plates are installed. The HI-STORM lid studs and nuts are installed.

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.

iv. For High Burnup Fuel (HBF), operating restrictions are imposed to limit the maximum temperature excursion during short-term operations to 65°C (117°F).

To achieve compliance with the above criteria, certain design and operational changes are necessary, as summarized below.

i. The peak fuel cladding temperature limit (PCT) for long term storage operations and short term operations is generally set at 400°C (752°F). However, for MPCs containing <u>all</u> moderate burnup fuel, the fuel cladding temperature limit for short-term operations is set at 570°C (1058°F) because fuel cladding stress is shown to be less than approximately 90 MPa per Reference [2.0.9]. Appropriate analyses have been performed as discussed in Chapter 4 and operating restrictions added to ensure these limits are met (see Section 4.5).

ii. For MPCs containing at least one high burnup fuel (HBF) assembly or if the MPC heat load is greater than ~~28.74 kW~~ the threshold heat load defined in ~~(See Section~~Table 4.5.~~3.2)~~1, the forced helium dehydration (FHD) method of MPC cavity drying must be used to meet the normal operations PCT limit and satisfy the 65°C temperature excursion criterion for HBF.

iii. The off-normal and accident condition PCT limit remains unchanged (1058°F).

iv. For MPCs loaded with one or more high burnup fuel assemblies ~~or if~~and the MPC heat load is greater than ~~28.74 kW(~~threshold heat load defined in Table ~~See Section~~ 4.5.4~~5.1)~~, the Supplemental Cooling System (SCS) is required to ensure fuel cladding temperatures remain below the applicable temperature limit (see Section 4.5). The design criteria for the SCS are provided in Appendix 2.C.

The MPC cavity is dried using either a vacuum drying system, or a forced helium dehydration system (see Appendix 2.B). The MPC is backfilled with 99.995% pure helium in accordance with the limits in Table 1.2.2 during canister sealing operations to promote heat transfer and prevent cladding degradation.

The normal condition design temperatures for the structural steel components of the MPC are based on the temperature limits provided in ASME Section II, Part D, tables referenced in ASME Section III, Subsection NB and NG, for those load conditions under which material properties are relied on for a structural load combination. The specific design temperatures for the components of the MPC are provided in Table 2.2.3.

The MPCs are designed for a bounding thermal source term, as described in Section 2.1.6. The maximum allowable fuel assembly heat load for each MPC is limited as specified in Section 2.1.9.

Each MPC model, except MPC-68F, allows for two fuel loading strategies. The first is uniform fuel loading, wherein any authorized fuel assembly may be stored in any fuel storage location up to a maximum specific heat emission rate, subject to other restrictions, such as location

MPC for which the HI-TRAC is designed are defined in Chapter 1.

Thermal

The allowable temperatures for the HI-TRAC transfer cask structural steel components are based on the maximum temperature for material properties and allowable stress values provided in Section II of the ASME Code. The top lids of the HI-TRAC 125 and HI-TRAC 125D incorporate Holtite-A shielding material. This material has a maximum allowable temperature in accordance with the manufacturer's test data. The specific allowable temperatures for the structural steel and shielding components of the HI-TRAC are provided in Table 2.2.3. The HI-TRAC is designed for off-normal environmental cold conditions, as discussed in Section 2.2.2.2. The structural steel materials susceptible to brittle fracture are discussed in Section 3.1.2.3.

The HI-TRAC is designed for the maximum heat load analyzed for storage operations. When the MPC contains any high burnup fuel assemblies ~~or if~~and the MPC decay heat is greater than ~~28.74 kW (See Section~~the threshold heat load defined in Table 4.5.~~5.14)~~, the Supplemental Cooling System (SCS) will be required for certain time periods while the MPC is inside the HI-TRAC transfer cask (see Section 4.5). The design criteria for the SCS are provided in Appendix 2.C. The HI-TRAC water jacket maximum allowable temperature is a function of the internal pressure. To preclude over pressurization of the water jacket due to boiling of the neutron shield liquid (water), the maximum temperature of the water is limited to less than the saturation temperature at the shell design pressure. In addition, the water is precluded from freezing during off-normal cold conditions by limiting the minimum allowable temperature and adding ethylene glycol. The thermal characteristics of the fuel for each MPC for which the transfer cask is designed are defined in Section 2.1.6. The working area ambient temperature limit for loading operations is limited in accordance with the design criteria established for the transfer cask.

Shielding

The HI-TRAC transfer cask provides shielding to maintain occupational exposures ALARA in accordance with 10CFR20, while also maintaining the maximum load on the plant's crane hook to below either 125 tons or 100 tons, or less, depending on whether the HI-TRAC 125 or HI-TRAC 100 transfer cask is utilized. The HI-TRAC calculated dose rates are reported in Section 5.1. These dose rates are used to perform a generic occupational exposure estimate for MPC loading, closure, and transfer operations, as described in Chapter 10. A postulated HI-TRAC accident condition, which includes the loss of the liquid neutron shield (water), is also evaluated in Section 5.1.2. In addition,

HI-TRAC dose rates are controlled in accordance with plant-specific procedures and ALARA requirements (discussed in Chapter 10).

The HI-TRAC 125 and 125D provide better shielding than the HI-TRAC 100 or 100D. Provided the licensee is capable of utilizing the 125-ton HI-TRAC, ALARA considerations would normally dictate that the 125-ton HI-TRAC should be used. However, sites may not be capable of utilizing the 125-ton HI-TRAC due to crane capacity limitations, floor loading limits, or other site-specific

2.1.9.1.4 Other Considerations

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

- Calculated burnup limits shall be rounded down to the nearest integer
- Calculated burnup limits greater than 68,200 MWD/MTU for PWR fuel and 65,000 MWD/MTU for BWR fuel must be reduced to be equal to these values.
- Linear interpolation of calculated burnups between cooling times for a given fuel assembly maximum decay heat and minimum enrichment is permitted. For example, the allowable burnup for a minimum cooling time of 4.5 years may be interpolated between those burnups calculated for 4 and 5 years.
- ZR-clad fuel assemblies must have a minimum enrichment, as defined in Table 1.0.1, greater than or equal to the value used in determining the maximum allowable burnup per Section 2.1.9.1.3 to be authorized for storage in the MPC.
- When complying with the maximum fuel storage location decay heat limits, users must account for the decay heat from both the fuel assembly and any PWR non-fuel hardware, as applicable for the particular fuel storage location, to ensure the decay heat emitted by all contents in a storage location does not exceed the limit.

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

2.1.9.1.5 Supplemental Cooling Threshold Heat Loads

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

Table 2.1.30

MPC Regionalized Loading Heat Load Limits (q_1 and q_2)[1] for Discrete Values of X

X	MPC-24		MPC-32		MPC-68	
	q_1 (kW)	q_2 (kW)	q_1 (kW)	q_2 (kW)	q_1 (kW)	q_2 (kW)
0.5	1.025	2.050	0.710	1.419	0.354	0.710
0.6	1.128	1.880	0.796	1.327	0.392	0.653
0.7	1.216	1.737	0.873	1.248	0.424	0.606
0.8	1.292	1.615	0.943	1.178	0.453	0.566
0.9	1.358	1.509	1.005	1.117	0.478	0.531
1	1.416	1.416	1.062	1.062	0.500	0.500
1.1	1.468	1.334	1.114	1.012	0.519	0.472
1.2	1.513	1.261	1.161	0.968	0.537	0.447
1.3	1.554	1.195	1.205	0.926	0.552	0.425
1.4	1.590	1.136	1.245	0.889	0.567	0.405
1.5	1.623	1.082	1.282	0.854	0.579	0.386
1.6	1.653	1.033	1.316	0.822	0.591	0.369
1.7	1.680	0.988	1.347	0.792	0.602	0.354
1.8	1.705	0.947	1.377	0.765	0.612	0.340
1.9	1.728	0.909	1.405	0.739	0.621	0.326
2	1.748	0.874	1.430	0.715	0.629	0.314
2.1	1.767	0.841	1.454	0.692	0.637	0.303
2.2	1.785	0.811	1.477	0.671	0.644	0.292
2.3	1.801	0.783	1.498	0.651	0.650	0.282
2.4	1.816	0.756	1.518	0.632	0.656	0.273
2.5	1.829	0.731	1.537	0.614	0.662	0.265
2.6	1.842	0.708	1.554	0.597	0.667	0.256
2.7	1.854	0.686	1.571	0.581	0.672	0.249
2.8	1.865	0.666	1.587	0.566	0.677	0.241
2.9	1.875	0.646	1.602	0.552	0.681	0.235
3	1.885	0.628	1.616	0.538	0.685	0.228

*See Table 2.1.27 for the number of storage cells (n) in each region for the specific MPC type listed.

1 Under SCS mandatory conditions evaluated in HI-TRAC operations Section 4.5, the storage cell heat loads tabulated herein are limited by the heat load reduction factor defined in Table 4.5.4.

Table 2.2.1

DESIGN PRESSURES

Pressure Location	Condition	Pressure (psig)
MPC Internal Pressure	Normal	100
	Off-Normal/Short-Term	110
	Accident	200
MPC External Pressure	Normal	(0) Ambient
	Off-Normal	(0) Ambient
	Accident	60
Overpack External Pressure	Normal	(0) Ambient
	Off-Normal	(0) Ambient
	Accident	10 (differential pressure for 1 second maximum)* or 5 (differential pressure steady state)
HI-TRAC Water Jacket	Normal	60
	Off-normal	60
	Accident	N/A (Under accident conditions, the water jacket is assumed to have lost all water thru the pressure relief valves)

* The overpack is also qualified to sustain without tip-over a lateral impulse load of 60 psi (differential pressure for 85 milliseconds maximum) [3.4.5].

Table 2.2.2

ENVIRONMENTAL TEMPERATURES

Condition	Temperature (°F)	Comments
HI-STORM 100 Overpack		
Normal Ambient (Bounding Annual Average)	80	
Normal Soil Temperature (Bounding Annual Average)	77	
Off-Normal Ambient (3-Day Average)	-40 and 100	-40°F with no insolation 100°F with insolation
Extreme Accident Level Ambient (3-Day Average)	125	125°F with insolation starting at steady-state off-normal high environment temperature
HI-TRAC Transfer Cask		
~~Normal (Bounding Annual Average)~~ Inside Building Short Term Operations (3-Day Average)	110~~80~~	110°F with no insolation
Outside Building Short Term Operations (3-Day Average)	90	90°F with insolation

Note:

1. Handling operations with the loaded HI-STORM overpack and HI-TRAC transfer cask are limited to working area ambient temperatures greater than or equal to 0°F as specified in Subsection 2.2.1.2.

Appendix 2.C

The Supplemental Cooling System

2.C.1 Purpose

The Supplemental Cooling System (SCS) will be utilized, as necessary, to maintain the peak fuel cladding temperature below the limit set forth in Chapter 2 of the FSAR during normal short-term operations (as defined in Section 2.2).

2.C.2 General Description and Requirements

The SCS is a system for cooling the MPC inside the HI-TRAC transfer cask during on-site transport. During normal SCS operation, heat is removed by a coolant from the HI-TRAC annulus and rejected to the heat sink (ambient air). The SCS shall be designed to meet the following criteria:

(i) If the system uses water as the coolant, the system is sized to limit the coolant temperature to below 180°F under steady-state conditions for the design basis heat load at an ambient air temperature of 1~~0~~10°F. Active components (i.e., pump or air-cooler fan) are powered by electric motors with a backup power supply for uninterrupted operation.

(ii) The system will utilize a contamination-free fluid medium in contact with the external surfaces of the MPC and inside surfaces of the HI -TRAC transfer cask to minimize corrosion. Figure 2.C.1 shows a typical P&ID for a SCS.

(iii) The number of active components in the SCS will be minimized.

(iv) All passive components such as tubular heat exchangers, manually operated valves and fittings shall be designed to applicable standards (TEMA, ANSI).

2.C.3 Thermal/Hydraulic Design Criteria

(i) The heat dissipation capacity of the SCS shall be equal to or greater than the minimum necessary to ensure that the peak cladding temperature of High-Burnup fuel assemblies is below the ISG-11, Rev. 3 limit of 400°C (752°F). All heat transfer surfaces in any heat exchangers shall be assumed to be fouled to the maximum limits specified in a widely used heat exchange equipment standard such as the Standards of Tubular Exchanger Manufacturers Association.

(ii) The coolant utilized to extract heat from the MPC shall be either high purity water or air. Anti-freeze may be used to prevent water from freezing if warranted by operating conditions.

4.5 THERMAL EVALUATION OF SHORT TERM OPERATIONS

Prior to placement in a HI-STORM overpack, an MPC must be loaded with fuel, outfitted with closures, dewatered, dried, backfilled with helium and transported to the HI-STORM module. In the unlikely event that the fuel needs to be returned to the spent fuel pool, these steps must be performed in reverse. Finally, if required, transfer of a loaded MPC between HI-STORM overpacks or between a HI-STAR transport overpack and a HI-STORM storage overpack must be carried out in an assuredly safe manner. All of the above operations, henceforth referred to as "short term operations", are short duration events that would likely occur no more than once or twice for an individual MPC.

The device central to all of the above operations is the HI-TRAC transfer cask that, as stated in Chapter 1, is available in two anatomically similar weight ratings (100- and 125-ton). Two different versions of the 100 ton and the 125 ton HI-TRAC, the classical version and the version D, are available for use during fuel transfer operations. The HI-TRAC transfer cask is a short-term host for the MPC; therefore it is necessary to establish that, during all thermally challenging operation events involving either the 100-ton or 125-ton versions of the HI-TRAC, the permissible temperature limits presented in Section 4.3 are not exceeded. The following discrete thermal scenarios, all of short duration, involving the HI-TRAC transfer cask, have been identified as warranting thermal analysis.

i. Post-Loading Wet Transfer Operations
ii. MPC Cavity Vacuum Drying
iii. Normal Onsite Transport in a Vertical Orientation
iv. MPC Cooldown and Reflood for Unloading Operations

Onsite transport of the MPC occurs with the HI-TRAC in the vertical orientation, which preserves the thermosiphon action within the MPC. To avoid excessive temperatures, transport with the HI-TRAC in the horizontal condition is generally not permitted. However, it is recognized that an occasional downending of a HI-TRAC may become necessary to clear an obstruction such as a low egress bay door opening. In such a case the operational imperative for HI-TRAC downending must be ascertained and the permissible duration of horizontal configuration must be established on a site-specific basis and compliance with the thermal limits of ISG-11 [4.1.4] must be demonstrated as a part of the site-specific safety evaluation.

The fuel handling operations listed above place a certain level of constraint on the dissipation of heat from the MPC relative to the normal storage condition. Consequently, for some scenarios, it is necessary to provide additional cooling when decay heat loads are such that ~~long~~short-term cladding temperature limits would be exceeded. For such situations, the Supplemental Cooling System (SCS) is required to provide additional cooling during short term operations. The SCS is required by the CoC for any MPC ~~carrying one or more fuel assemblies with high burnup or~~ when the MPC heat load is such that ~~long~~short-term cladding temperature limits would be exceeded. The specific design of an SCS must accord with site-specific needs and resources, including the availability of plant utilities. However, a set of specifications to ensure that the performance objectives of the SCS are satisfied by plant-specific designs are set forth in Appendix 2.C.

4.5.1 HI-TRAC Thermal Model

The HI-TRAC transfer cask is used to load and unload the HI-STORM concrete storage overpack, including onsite transport of the MPCs from the loading facility to an ISFSI pad. Section views of the HI-TRAC have been presented in Chapter 1. Within a loaded HI-TRAC, heat generated in the MPC is transported from the contained fuel assemblies to the MPC in the manner described in Section 4.4~~shell through the fuel basket and the basket-to-shell gaps via conduction and thermal radiation~~. From the outer surface of the MPC to the ambient air, heat is transported by a combination of conduction, thermal radiation and natural convection.~~ Analytical modeling details of all the various thermal transport mechanisms are provided in the following subsection~~ For evaluation of the thermal state of a loaded canister during all short-term operations, the three dimensional (3D) thermal model of the MPC described in Section 4.4 is utilized.

All FLUENT thermal analyses to establish margins of safety are carried out for the MPC model that yields the highest peak cladding temperature and MPC cavity pressure under the long term storage condition. The above criterion identifies MPC-32 under regionalized fuel loading with X = 0.5 and X=3 as the governing cases.

Two HI-TRAC transfer cask designs, namely, the 125-ton and the 100-ton versions, are developed for onsite handling and transport, as discussed in Chapter 1. The two designs are principally different in terms of lead thickness and the thickness and number of the heat dissipating ribs (radial connectors) in the water jacket region. The aggregate heat dissipation by the ribs is defined by the product of the number of radial ribs, N and thickness, t_r. The numerical model developed for HI-TRAC thermal characterization conservatively accounts for these differences by applying the higher lead thickness and constructing the water jacket region having the lowest product of N and t_r. In this manner, the HI-TRAC thru-wall resistance to heat transfer is overestimated, yielding higher MPC internal and fuel cladding temperatures.

Transport of heat within HI-TRAC occurs through multiple concentric layers of air, steel and shielding materials. A small gap exists between the outer surface of the MPC and the inner surface of the HI-TRAC overpack. Heat is transported across this gap by the parallel mechanisms of natural convection, conduction and thermal radiation. Assuming that the MPC is centered and does not contact the transfer cask walls conservatively minimizes heat transport across this gap. Heat is transported through the cylindrical wall of the HI-TRAC transfer cask by conduction through successive layers of steel, lead, and steel. A water jacket, which provides neutron shielding for the HI-TRAC transfer cask, surrounds the cylindrical steel wall. The water jacket is essentially an array of carbon steel radial ribs with welded, connecting enclosure plates. Heat is dissipated by conduction and natural convection in the water cavities and by conduction in the radial ribs. Heat is passively rejected to the ambient from the outer surface of the HI-TRAC transfer cask by natural convection and thermal radiation.

The HI-TRAC transfer cask thermal analysis is based on a 3D FLUENT model that incorporates several conservative features, namely:

i. A constant solar flux is assumed with maximum permissible heat load and asymptotic steady state conditions to yield the most adverse temperature field in the cask. A theoretically bounding solar absorbtivity of 1.0 is applied to all exposed surfaces.

ii. Air motion in the HI-TRAC annulus is explicitly modeled. The MPC is assumed to be concentrically aligned with the cask cavity and the annulus is filled with air.

iii. Although the HI-TRAC transfer cask baseplate is in contact with supporting surfaces, for conservatism, an insulated boundary condition is applied to the HI-TRAC baseplate.

iv. The HI-TRAC transfer cask fluid columns in the water jacket and the open air volume above the MPC are conservatively assumed to remain in the laminar flow regime.

v. The HI-TRAC transfer cask/ MPC annular gap shrinks under heat up to operating temperatures. The enhancement of heat transfer due to the gap reduction is conservatively neglected.

vi. Buoyancy driven motion of air above the MPC is included in the thermal model.

vii. Radiation heat transfer is simulated by the more robust Discrete Ordinates (DO) model deployed in the HI-STAR 180 (Docket 71-9325) and HI-STORM FW (72-1032) in lieu of the DTRM model.

viii. The rodded zone, which contains the spent fuel assemblies, is modeled as a homogeneous porous media using the flow resistance properties based on extensive CFD simulations [4.4.2] performed in the HI-STORM 100 docket and used in subsequent safety evaluations in both HI-STORM 100(Docket 72-1014) and HI-STORM FW dockets (Docket 72-1032). A recent experimental work by the Sandia National Laboratory (SNL), however, indicates that the axial flow resistance in the PWR fuel may be somewhat greater [4.5.1]. ~~Even~~ Although the ~~QA provenance of the SNL work is not yet clear and a regulatory appraisal of the veracity of the~~ SNL experimental data is not yet published by the NRC as of this writing (April 05, 2013), in the interest of conservatism, the higher flow resistance, 1×10^6 m^{-2} for all three zones of fuel assembly, indicated by their work has been used in all of the thermal simulations for HI-TRAC. [4.5.1]

The computational fluid dynamics model of the HI-TRAC transfer cask captures all essential details of the cask body including the radial ribs, lead, steel shells and the water jacket. Figures 4.5.1 show the discretization of the cask and its enclosed MPC for FLUENT implementation.
~~All HI-TRAC transfer cask designs are developed for onsite handling and transport, as discussed in Chapter 1. The designs are principally different in terms of lead thickness and the thickness of radial connectors in the water jacket region. The analytical model developed for HI-TRAC thermal characterization conservatively accounts for these differences by applying the higher shell and lead thicknesses, lowest number of radial connectors, and thinner radial connectors' thickness to the~~

~~model. In this manner, the HI-TRAC overpack resistance to heat transfer is overestimated, resulting in higher predicted MPC internals and fuel cladding temperature levels.~~

~~4.5.1.1 Analytical Model~~

~~From the outer surface of the MPC to the ambient atmosphere, heat is transported within HI-TRAC through multiple concentric layers of air, steel and shielding materials. Heat must be transported across a total of six concentric layers, representing the air gap, the HI-TRAC inner shell, the lead shielding, the HI-TRAC outer shell, the water jacket and the enclosure shell. From the surface of the enclosure shell heat is rejected to the atmosphere by natural convection and radiation.~~

~~A small diametral air gap exists between the outer surface of the MPC and the inner surface of the HI-TRAC overpack. Heat is transported across this gap by the parallel mechanisms of conduction and thermal radiation. Assuming that the MPC is centered and does not contact the transfer overpack walls conservatively minimizes heat transport across this gap. Additionally, thermal expansion that would minimize the gap is conservatively neglected. Heat is transported through the cylindrical wall of the HI-TRAC transfer overpack by conduction through successive layers of steel, lead and steel. A water jacket, which provides neutron shielding for the HI-TRAC overpack, surrounds the cylindrical steel wall. The water jacket is composed of carbon steel channels with welded, connecting enclosure plates. Conduction heat transfer occurs through both the water cavities and the channels. While the water jacket channels are sufficiently large for natural convection loops to form, this mechanism is conservatively neglected. Heat is passively rejected to the ambient from the outer surface of the HI-TRAC transfer overpack by natural convection and thermal radiation.~~

~~In the vertical position, the bottom face of the HI-TRAC is in contact with a supporting surface. This face is conservatively modeled as an insulated surface. Because the HI-TRAC is not used for long-term storage in an array, radiative blocking does not need to be considered. The HI-TRAC top lid is modeled as a surface with convection, radiative heat exchange with air and a constant maximum incident solar heat flux load. Insolation on cylindrical surfaces is conservatively based on 12-hour levels prescribed in 10CFR71 averaged on a 24-hour basis. Concise descriptions of these models are given below.~~

~~4.5.1.1.1 Effective Thermal Conductivity of Water Jacket~~

~~The classical version HI-TRAC water jackets are composed of an array of radial ribs equispaced along the circumference of the HI-TRAC and welded along their length to the HI-TRAC outer shell. Enclosure plates are welded to these ribs, creating an array of water compartments. The version D HI-TRAC water jackets also have an array of radial ribs connected to enclosure plates with an array of plug welds to form multiple compartments. Holes in the radial ribs connect all the individual compartments in the water jacket. Any combination of rib number and thickness that yields an equal or larger heat transfer area is bounded by the calculation. Thus, the annular region between the HI-TRAC outer shell and the enclosure shell can be considered as an array of steel ribs and water spaces.~~

The effective radial thermal conductivity of this array of steel ribs and water spaces is determined by combining the heat transfer resistance of individual components in a parallel network. A bounding calculation is assured by using the minimum number of ribs and rib thickness as input values. The thermal conductivity of the parallel steel ribs and water spaces is given by the following formula:

$$K_{ne} = \frac{K_r N_r t_r \ln\left(\frac{r_o}{r_i}\right)}{2\pi L_R} + \frac{K_w N_r t_w \ln\left(\frac{r_o}{r_i}\right)}{2\pi L_R}$$

where:

K_{ne} = effective radial thermal conductivity of water jacket

r_i = inner radius of water spaces

r_o = outer radius of water spaces

K_r = thermal conductivity of carbon steel ribs

N_r = minimum number of radial ribs (equal to number of water spaces)

t_r = minimum (nominal) rib thickness (lower of 125-ton and 100-ton designs)

L_R = effective radial heat transport length through water spaces

K_w = thermal conductivity of water

t_w = water space width (between two carbon steel ribs)

Figure 4.5.1 depicts the resistance network to combine the resistances to determine an effective conductivity of the water jacket. The effective thermal conductivity is computed in the manner of the foregoing, and is provided in Table 4.5.1.

4.5.1.1.2 Heat Rejection from Overpack Exterior Surfaces

The following relationship for the surface heat flux from the outer surface of an isolated cask to the environment is applied to the thermal model:

$$q_s = 0.19\,(T_s - T_A)^{4/3} + 0.1714\varepsilon\left[\left(\frac{T_s + 460}{100}\right)^4 - \left(\frac{T_A + 460}{100}\right)^4\right]$$

where:

T_S = cask surface temperatures (°F)

T_A = ambient atmospheric temperature (°F)

q_s = surface heat flux (Btu/ft^2×hr)

ε = surface emissivity

The second term in this equation the Stefan-Boltzmann formula for thermal radiation from an exposed surface to ambient. The first term is the natural convection heat transfer correlation recommended by Jacob and Hawkins [4.2.9]. This correlation is appropriate for turbulent natural convection from vertical surfaces, such as the vertical overpack wall. Although the ambient air is conservatively assumed to be quiescent, the natural convection is nevertheless turbulent.

~~Turbulent natural convection correlations are suitable for use when the product of the Grashof and Prandtl (Gr×Pr) numbers exceeds 10^9. This product can be expressed as $L^3 \times \Delta T \times Z$, where L is the characteristic length, ΔT is the surface-to-ambient temperature difference, and Z is a function of the surface temperature. The characteristic length of a vertically oriented HI-TRAC is its height of approximately 17 feet. The value of Z, conservatively taken at a surface temperature of 340°F, is 2.6×10^5. Solving for the value of ΔT that satisfies the equivalence $L^3 \times \Delta T \times Z = 10^9$ yields ΔT = 0.78°F. For a horizontally oriented HI-TRAC the characteristic length is the diameter of approximately 7.6 feet (minimum of 100- and 125-ton designs), yielding ΔT = 8.76°F. The natural convection will be turbulent, therefore, provided the surface to air temperature difference is greater than or equal to 0.78°F for a vertical orientation and 8.76°F for a horizontal orientation.~~

~~4.5.1.1.3 Determination of Solar Heat Input~~

~~The intensity of solar radiation incident on an exposed surface depends on a number of time varying terms. A twelve-hour averaged insolation level is prescribed in 10CFR71 for curved surfaces. The HI-TRAC cask, however, possesses a considerable thermal inertia. This large thermal inertia precludes the HI-TRAC from reaching a steady-state thermal condition during a twelve-hour period. Thus, it is considered appropriate to use the 24-hour averaged insolation level.~~

4.5.2 Maximum Time Limit During Wet Transfer Operations

In accordance with NUREG-1536, water inside the MPC cavity during wet transfer operations is not permitted to boil. Consequently, uncontrolled pressures in the de-watering, purging, and recharging system that may result from two-phase conditions are completely avoided. This requirement is accomplished by imposing a limit on the maximum allowable time duration for fuel to be submerged in water after a loaded HI-TRAC cask is removed from the pool and prior to the start of vacuum drying operations.

Fuel loading operations are typically conducted with the HI-TRAC and the contents (water filled MPC) submerged in pool water. Under these conditions, the HI-TRAC is essentially at the pool water temperature. When the HI-TRAC transfer cask and the loaded MPC under water-flooded conditions is removed from the pool, the water, fuel, MPC and HI-TRAC metal absorb the decay heat emitted by the fuel assemblies. This results in a slow temperature rise of the HI-TRAC with time, starting from an initial (pool water) temperature. The rate of temperature rise is limited by the thermal inertia of the HI-TRAC system. To enable a bounding heat-up rate determination, the following conservative assumptions are utilized:

i. Heat loss by natural convection and radiation from the exposed HI-TRAC surfaces to ambient air is neglected (i.e., an adiabatic heat-up calculation is performed).

ii. Design maximum decay heat input from the loaded fuel assemblies is assumed.

T_{max} = maximum MPC cavity water mass temperature
T_{in} = temperature of pool water supply to MPC

With the MPC cavity water temperature limited to 150°F, MPC inlet water maximum temperature equal to 125°F and at the design basis maximum heat load, the water flow rate is determined to be 5210 lb/hr (10.5 gpm).

The user can determine the maximum allowed time limit for wet transfer or "time to boil limit" using equations 4.5.2.1 and 4.5.2.2 and substituting the total MPC heat load for Q. The total MPC heat load can be calculated by summing the individual, as-loaded, heat loads in all the storage cells. Similarly, the user can determine M_W using equation 4.5.2.3 and substituting the as-loaded MPC heat load for Q and the temperature of the pool water supply for T_{in}.

4.5.3 MPC Temperatures During Moisture Removal Operations

4.5.3.1 Vacuum Drying Operation

~~After loading SNF into the MPC in a spent fuel pool, the pool water within the MPC must be drained. This can be accomplished using either nitrogen or helium. After draining, the MPC is dried, using either vacuum drying or forced helium dehydration, and filled with helium for storage. For MPCs containing moderate burnup fuel assemblies only, drying may be carried out using the conventional vacuum drying approach. In this method, removal of the last traces of residual moisture from the MPC cavity is accomplished by evacuating the MPC for a short time after draining the MPC. Vacuum drying may not be performed on MPCs containing high burnup fuel assemblies or on MPCs with a decay heat load above a threshold level (see Subsection 4.5.5.2). High burnup or high decay heat fuel drying is performed by a forced flow helium drying process as described in Section 4.5.3.2 and Appendix 2.B.~~

~~If the vacuum drying method is used, the heat dissipation capability of the canister is progressively reduced as the gas/vapor mixture is withdrawn from the canister. Therefore, the most adverse thermal condition for the fuel cladding is reached at the end of the vacuum drying process when the pressure in the canister is at its minimum.~~

~~Both helium and nitrogen are inert gases whose use during the blow-down operation poses no long term risk to the integrity of the fuel cladding [4.1.5]. For long term storage, however, this FSAR limits the canister fill gas to helium only.~~

~~Prior to the start of the MPC draining operation, both the HI-TRAC annulus and the MPC are full of water. The presence of water in the MPC ensures that the fuel cladding temperatures are lower than design basis limits by large margins. As the heat generating active fuel length is uncovered during the draining operation, the fuel and basket mass will undergo a gradual heat up from the initially cold conditions when the heated surfaces were submerged under water.~~

The vacuum condition effective fuel assembly conductivity is determined by procedures discussed earlier (Section 4.4) after setting the thermal conductivity of the gaseous medium to a small fraction (one part in one thousand) of helium conductivity. The MPC basket cross sectional effective conductivity is determined for vacuum conditions using a finite-element procedure. Basket periphery-to-MPC shell heat transfer occurs through conduction and radiation.

4.5.3.1.1 Vacuum Drying Model

An axisymmetric FLUENT thermal model of the MPC is constructed, employing the MPC in-plane conductivity as an isotropic fuel basket conductivity (i.e. conductivity in the basket radial and axial directions is equal), to determine peak cladding temperature at design basis heat loads. To avoid excessive conservatism in the computed FLUENT solution, for higher heat loads partial recognition for higher axial heat dissipation is adopted in the peak cladding calculations[+]. The boundary conditions applied to this evaluation are:

i. A bounding steady-state analysis is performed with the total MPC decay heat load set equal to the largest decay heat load for which vacuum drying is permitted, with the heat load equally distributed in the cells. As discussed below, there are two different total heat load scenarios analyzed for the MPC-24 and MPC-68 designs.

ii. The conductivity of the gas in the MPC open spaces is grossly understated.

iii. The outer surface of the MPC shell is postulated to be at a bounding maximum temperature of either 232°F or 125°F, as discussed below.

iv. The top and bottom surfaces of the MPC are adiabatic.

Results of vacuum condition analyses are provided in Subsection 4.5.5.2.

4.5.3.1.2 Vacuum Drying without Annulus Flushing

For MPC total decay heat loads up to those listed in the table below, vacuum drying of the MPC is performed with the annular gap between the MPC and the HI-TRAC filled with water; i.e. annulus flushing is not required. The presence of water in this annular gap will maintain the MPC shell temperature approximately equal to the saturation temperature of the water in the annulus. The thermal analysis of the MPC during vacuum drying for these conditions is performed with cooling of the MPC shell with water at a bounding maximum temperature of 232°F and with the heat loads in each cell as indicated in the table below.

[+] Although partial recognition for higher axial heat dissipation is considered for steady-state analysis (during vacuum drying under the flushing condition) and is reflected in the temperatures reported in Table 4.5.5, it is not credited in the safety analysis to meet ISG-11 Rev. 3 limits since vacuum drying of an MPC with a heat load greater than 23 kW is limited to 40 hours.

MPC Model	Assumed Heat Load in Individual Cells (kW)	Maximum MPC Heat Load (kW)
MPC-24	0.870	20.88
MPC-68	0.316	21.52
MPC-32	Not Permitted	
MPC-24E	Not Permitted	

4.5.3.1.3 Vacuum Drying with Annulus Flushing

For MPC decay heat loads up to those listed in the table below, vacuum drying of the MPC must be performed with the annular gap between the MPC and the HI-TRAC continuously flushed with water. The water movement in this annular gap will maintain the MPC shell temperature at about the temperature of flowing water. The thermal analysis of the MPC during vacuum drying for these conditions assumes the water is cooling of the MPC shell at a bounding maximum temperature of 125 °F and with the heat loads in each cell as indicated in the table below. Users must ensure that water exiting the annulus gap is maintained at or below 125 °F.

MPC Model	Assumed Heat Load in Individual Cells (kW)	Heat Load per MPC for Vacuum Drying (kW)†
MPC-24	1.157	27.77 ‡
MPC-68	0.414	28.19 ‡
MPC-32	0.898	28.74 ‡
MPC-24E	1.173	28.17 ‡
† A vacuum drying time limit of 40 hours is imposed for an MPC with an aggregate heat load greater than 23 kW.		
‡ These values are the product of the heat load per individual cell and the number of cells in the MPC consistent with the thermal analysis. Technical Specifications limit vacuum drying of MPC-68 and MPC-32 to aggregate heat loads not exceeding 26 kW.		

The initial loading of SNF in the MPC requires that the water within the MPC be drained, fuel dried and the water replaced with helium. Vacuum drying of fuel is conducted by evacuating the MPC after completion of MPC draining operation. For MPCs containing Moderate Burnup Fuel (MBF) assemblies only, this operation may be carried out using the vacuum drying method up to the threshold heat loads defined in Table 4.5.1. In this Table threshold heat loads Q1 and Q2 are defined wherein Q1 is the threshold heat load for vacuum drying operations without time limits and Q2 is the threshold heat load for time-limited vacuum drying. The requirements and limits for moisture removal are provided in LCO 3.1.1 and are specific to the amendment to which the HI-STORM 100 System is being loaded.

Vacuum drying of MPCs containing High Burnup Fuel (HBF) is not permitted. High burnup fuel drying must be conducted by using a forced helium drying (FHD) process as discussed in Section 4.5.3.2. To minimize fuel temperatures during vacuum drying operations the HI-TRAC annulus must be water filled.

A 3-D FLUENT thermal model of the MPC is constructed in the same manner as described in Section 4.4. The principal input to this model is the effective conductivity of fuel under vacuum drying operations. To reasonably bound vacuum drying operations the effective conductivity of fuel is computed assuming the MPC is filled with water vapor at a very low pressure (1 torr) for the entire duration of vacuum drying[2]. The methodology for computing the effective conductivity is given in Section 4.4.1. To ensure a conservative evaluation the thermal model is incorporated with the following assumptions:

i. Threshold heat load Q1, defined in Table 4.5.1, is assumed and steady-state condition reached under Q1 results in vacuum drying without time limits.
ii. Threshold heat load Q2, defined in Table 4.5.1, is assumed and a transient calculation is performed to determine the permissible vacuum drying time under Q2. The transient calculation is started assuming the MPC has reached 212°F boiling temperature in the operational step preceding vacuum drying (i.e. water blow down operations). The vacuum drying clock starts when the MPC is drained.
iii. The external surface of the MPC shell is postulated to vary linearly from 100°C (212°F) normal boiling temperature of water at the top to 111°C (231°F) elevated pressure boiling temperature at the bottom to account for the hydrostatic head.
iv. The bottom surface of the MPC is insulated.
v. MPC internal convection heat transfer is suppressed.
vi. Top surface of the MPC is in communicative contact with air. Natural convection and radiation cooling from the MPC top is included in the thermal model.

The principle objective of the vacuum drying analysis is to ensure that fuel temperatures are below ISG-11, Rev. 3 temperature limits (See Table 4.3.1). Under threshold heat load Q1 the results and margins are tabulated in Table 4.5.5. Under the time limited threshold heat load Q2 the peak cladding temperature plot is shown in Figure 4.5.2. The results under the scenarios Q1 and Q2 (with appropriate time limit) show that ISG-11, Rev. 3 limits are met with ample margins.

4.5.3.2 <u>Forced Helium Dehydration</u>

To dry the MPC cavity using a Forced Helium Dehydration (FHD) system, a conventional, closed loop dehumidification system consisting of a condenser, a demoisturizer, a compressor, and a pre-heater is utilized to extract moisture from the MPC cavity through repeated displacement of its contained helium, accompanied by vigorous flow turbulation. A vapor pressure of 3 torr or less is assured by verifying that the helium temperature exiting the demoisturizer is maintained at or below the psychrometric threshold of 21°F for a minimum of 30 minutes. See Appendix 2.B for detailed discussion of the design criteria and operation of the FHD system.

2 This is very conservative as the MPC pressure is progressively lowered below ambient pressure to facilitate moisture removal. Near the end of the vacuum drying operation the pressure is substantially lowered to approximately 1 torr to facilitate the 30-minute 3-torr vacuum rebound test followed by backfilling of the MPC with helium.

~~FHD can be used on any MPC but is required under certain conditions as indicated in the following table.~~

~~Condition*~~	~~Fuel in MPC~~	~~MPC Heat Load (kW)**~~	~~FHD Required~~
~~1*~~	~~All MBF~~	~~≤27.77 (MPC-24)~~ ~~≤28.17 (MPC-24E)~~ ~~≤26 (MPC-32/68)~~	~~NO~~
~~2*~~	~~All MBF~~	~~>27.77 (MPC-24)~~ ~~>28.17 MPC-24E)~~ ~~>26 (MPC-32/68)~~	~~YES~~
~~3~~	~~One or more HBF~~	~~any~~	~~YES~~
~~* A summation of the as-loaded heat loads in the individual storage cells shall be compared to this limit.~~ ~~** See Tables 4.5.7 and 4.5.8 for heat load in each storage location which supports the total MPC heat load.~~			

The FHD system provides concurrent fuel cooling during the moisture removal process through forced convective heat transfer. The attendant forced convection-aided heat transfer occurring during operation of the FHD system ensures that the fuel cladding temperature will remain below the applicable peak cladding temperature limit for normal conditions of storage, which is well below the high burnup cladding temperature limit 752°F (400°C) for all combinations of SNF type, burnup, decay heat, and cooling time. Because the FHD operation induces a state of forced convection heat transfer in the MPC, (in contrast to the quiescent mode of natural convection in long term storage), it is readily concluded that the peak fuel cladding temperature under the latter condition will be greater than that during the FHD operation phase. In the event that the FHD system malfunctions, the forced convection state will degenerate to natural convection, which corresponds to the conditions of normal onsite transport. As a result, the peak fuel cladding temperatures will approximate the values reached during normal onsite transport as described elsewhere in this chapter.

4.5.4 Cask Cooldown and Reflood Analysis During Fuel Unloading Operation

NUREG-1536 requires an evaluation of cask cooldown and reflood procedures to support fuel unloading from a dry condition. Past industry experience generally supports cooldown of cask internals and fuel from hot storage conditions by direct water quenching. Direct MPC cooldown is effectuated by introducing water through the lid drain line. From the drain line, water enters the MPC cavity near the MPC baseplate. Steam produced during the direct quenching process will be vented from the MPC cavity through the lid vent port. To maximize venting capacity, both vent port RVOA connections must remain open for the duration of the fuel unloading operations. As direct water

quenching of hot fuel results in steam generation, it is necessary to limit the rate of water addition to avoid MPC overpressurization. For example, steam flow calculations using bounding assumptions (100% steam production and MPC at design pressure) show that the MPC is adequately protected upto a reflood rate of 3715 lb/hr. Limiting the water reflood rate to this amount or less would prevent exceeding the MPC design pressure.

During direct reflood operations the fuel cladding is subject to high temperature gradients and concomitant thermal stresses. The integrity of fuel under direct quenching is evaluated in a generic manner in the HI-STORM FW SAR (Docket No. 72-1032, Ref. [4.5.2]). To define a bounding scenario at time t = 0 sec, a uniformly bounding temperature throughout the entire fuel rod is set at 752°F (400°C), which is the temperature limit of fuel cladding. At time t = 0.1 sec, a reasonably bounding 80°F quench water temperature is assigned to the lower half of the fuel rod to simulate a thermal shock with a large step change in the cladding temperature. The resulting transient stress and strain distributions in the fuel rod are evaluated with finite element ANSYS models. The results show that the maximum stress and strain values remain within the elastic range and remain well within failure strain limit (a factor of 6 against failure strain). This safety analysis documented in the Section 3.4.4.1.11 of HI-STORM FW FSAR provides the assurance that the MPC reflood event will not cause a breach of fuel cladding.

4.5.5 Maximum Temperatures under Onsite Transport ConditionsMandatory Limits for Short Term Operations

4.5.5.1 HI-TRAC Transport in a Vertical OrientationOutside of Fuel Loading Building

The requirements and limits are listed in the following table:

Condition*	Fuel in MPC	MPC Heat Load (kW)**	SCS Required
1	All MBF	≤ 28.74	NO
2	All MBF	> 28.74	YES
3	One or more HBF	any	YES

* The highest temperatures are reached under Condition 1. Under the other conditions the mandatory use of the Supplemental Cooling System, sized to extract 36.9 kW from the MPC, will lower the fuel temperatures significantly assuring ISG-11, Rev. 3 compliance with large margins.

** See Tables 4.5.7 and 4.5.8 for heat load in each storage location which supports the total MPC heat load.

Condition 2 mandates the use of the SCS at heat loads greater than 28.74 kW for MBF. This will assure that cladding temperature limits are met at these higher heat loads. See Appendix 2.C for the SCS requirements.

It is recognized that, due to increased thermosiphon action, the temperature in the MPC under 7 atmospheres internal pressure (required for heat loads > 28.74 kW) will be lower than that for the conservative 5 atmospheres case on which Condition 1 is based. Therefore, there is an additional implicit margin in the fuel cladding temperatures incorporated in the short term operations for heat loads > 28.74 kW.

An axisymmetric FLUENT thermal model of an MPC inside a HI-TRAC transfer cask was developed to evaluate temperature distributions for onsite transport conditions. A bounding steady-state analysis of the HI-TRAC transfer cask has been performed using the hottest MPC, the highest decay heat load for which SCS is not required, and design-basis insolation levels. While the duration of onsite transport may be short enough to preclude the MPC and HI-TRAC from obtaining a steady-state, a steady-state analysis is conservative.

A converged temperature contour plot is provided in Figure 4.5.2. Maximum fuel clad temperatures are listed in Table 4.5.4, which also summarizes maximum calculated temperatures in different parts of the HI-TRAC transfer cask and MPC. As described in Subsection 4.4.4.1, the FLUENT calculated peak temperature in Table 4.5.4 is actually the peak pellet centerline temperature, which bounds the peak cladding temperature. We conservatively assume that the peak clad temperature is equal to the peak pellet centerline temperature.

The maximum computed temperatures listed in Table 4.5.4 are based on the HI-TRAC cask at the maximum heat load that can be handled in HI-TRAC without needing the Supplemental Cooling System (see table above), passively rejecting heat by natural convection and radiation to a hot ambient environment at 100°F in still air in a vertical orientation. In this orientation, there is apt to be less metal-to-metal contact between the physically distinct entitities, viz., fuel, fuel basket, MPC shell and HI-TRAC cask. For this reason, the gaps resistance between these parts is higher than in a horizontally oriented HI-TRAC. To bound gaps resistance, the various parts are postulated to be in a centered configuration. MPC internal convection at a postulated low cavity pressure of 5 atm is included in the thermal model. The peak cladding temperature computed under these adverse Ultimate Heat Sink (UHS) assumptions is 872°F which is substantially lower than the temperature limit of 1058°F for moderate burnup fuel (MBF). Consequently, cladding integrity assurance is

~~provided by large safety margins (in excess of 100°F) during onsite transfer of an MPC containing MBF emplaced in a HI-TRAC cask.~~

~~As a defense-in-depth measure, cladding integrity is demonstrated for a theoretical bounding scenario. For this scenario, all means of convective heat dissipation within the canister are neglected in addition to the bounding relative configuration for the fuel, basket, MPC shell and HI-TRAC overpack assumption stated earlier for the vertical orientation. This means that the fuel is centered in the basket cells, the basket is centered in the MPC shell and the MPC shell is centered in the HI-TRAC overpack to maximize gaps thermal resistance. The peak cladding temperature computed for this scenario (1025°F) is below the short-term limit of 1058°F.~~

~~For high burnup fuel (HBF), however, the maximum computed fuel cladding temperature reported in Table 4.5.4 is significantly greater than the temperature limit of 752°F for HBF. Consequently, it is necessary to utilize the SCS described at the beginning of this section and in Appendix 2.C during onsite transfer of an MPC containing HBF emplaced in a HI-TRAC transfer cask. As stated earlier, the exact design and operation of the SCS is necessarily site-specific. The design is required to satisfy the specifications and operational requirements of Appendix 2.C to ensure compliance with ISG-11 [4.1.4] temperature limits.~~

~~As discussed in Subsection 4.5.4, MPC fuel unloading operations are performed with the MPC inside the HI-TRAC cask. For this operation, a helium cooldown system may be engaged to the MPC via lid access ports and a forced helium cooling of the fuel and MPC initiated. With the HI-TRAC cask external surfaces dissipating heat to a UHS in a manner in which the ambient air access is not restricted by bounding surfaces or large objects in the immediate vicinity of the cask, the temperatures reported in Table 4.5.4 will remain bounding during fuel unloading operations.~~

The requirements of utilizing SCS system in the onsite transfer operation are listed in the Table 4.5.4. Condition 3 of Table 4.5.4 mandates the use of SCS for the MPC containing one or more HBF above the threshold heat load. This will assure that cladding temperature limits are met at these higher heat loads for HBF. See Appendix 2.C for the SCS requirements.

A 3-D FLUENT thermal model of an MPC inside a HI-TRAC transfer cask was constructed as described in Subsection 4.5.1 to evaluate temperature distributions under onsite transport. In the onsite transport mode, the annular region between the canister and the cask has air and the cask is subject to heat input from insolation. The ambient temperature is assumed to be 90°F when HI-TRAC is placed in the outdoor environment, correspond to the maximum outdoor ambient temperature specified in Table 2.2.2 under short term operations. Even though the duration of onsite transport is typically short enough to preclude the MPC and HI-TRAC from reaching steady-state, a steady-state thermal analysis is conservatively performed. The results summarized herein are when steady state conditions have been reached.

The safety analysis of the onsite transport scenario requires the computation of the margins of safety with respect to the peak fuel cladding temperature of moderate and high burnup fuel[3], MPC internal pressure, fuel basket metal temperature, hydraulic pressure in the water jacket and the temperature of the HI-TRAC body parts.

The water in the water jacket surrounding the HI-TRAC transfer cask body provides necessary neutron shielding. During normal handling and onsite transport operations this shielding water is contained within the water jacket at an elevated pressure. The water jacket is equipped with two pressure relief devices to prevent overpressure.

The steady state analyses are first performed for the design basis heat load under the two extreme allowable regionalized storage scenarios (Q = 36.9 kW, X = 0.5 and Q = 30.17 kW, X = 3 in MPC-32), which are the maximum permissible heat load allowed to be stored in HI-STORM system defined in the Subsection 2.1.9.1. The computed fuel temperatures in this scenario remain below the cladding temperature limit of moderate burnup fuel, but exceed the temperature limit of high burnup fuel (Table 4.3.1). For both regionalized storage scenarios, the MPC internal pressure, fuel basket and the HI-TRAC parts temperatures are presented in Table 4.5.6. and their corresponding allowable limits show positive margins of safety. As these are bounding steady state temperatures, the results support onsite transport of fuel in the HI-TRAC without the aid of any supplemental cooling for MPC containing only moderate fuel burnup and cooling times up to the maximum design basis heat load of the HI-STORM System.

The steady state analyses are then performed for the threshold heat load which requires SCS for MPC containing HBF, which is defined in Table 4.5.4. In this scenario, the heat generation rate in the MPC is reduced to 90% of maximum design basis rate. Under the two extreme allowable regionalized storage scenarios (Q = 33.21 kW, X = 0.5 and Q = 27.15 kW, X = 3 in MPC-32), the computed fuel temperatures remain below the cladding temperature limits of high and moderate burnup fuel (Table 4.3.1). The MPC components, fuel basket and the HI-TRAC parts temperatures are presented in Table 4.5.7, and their corresponding allowable limits show positive margins of safety. Therefore, the results support onsite transport of fuel in the HI-TRAC without the aid of any supplemental cooling for any fuel burnup and cooling times up to the 90% of maximum design basis heat load of the HI-STORM System.

4.5.5.2 Evaluation of HI-TRAC inside Fuel Loading Building

When HI-TRAC is located inside the fuel loading building, the ambient air temperature inside building may be higher than the outdoor environment evaluated in Subsection 4.5.5.1. It is assumed that the ambient air temperature is 110°F and since it is inside the building, ~~without~~ insolation is not applied in this scenario, which is correspond to the maximum indoor air temperature specified in Table 2.2.2 under short term operations. A steady state analysis is performed for the 90% of design basis heat load under the regionalized storage scenario (Q = 27.15 kW, X = 3 in MPC-32), which results in the lowest PCT safety margin for high burnup fuel. The peak cladding, fuel basket and the

3 The cladding temperature limit for the high burn up fuel is more restrictive (See Table 4.3.1).

HI-TRAC parts temperatures are presented in Table 4.5.8 and below their corresponding results for outdoor environment presented in Table 4.5.7. Therefore, the environment condition of 110°F and without insolation is not the limiting condition.

4.5.5.2 Moisture Removal Limits and Requirements

Vacuum Drying (VD) is permitted for MBF under certain thermal conditions as described in Subsection 4.5.3.1. If these thermal conditions are not met, or if the MPC contains any HBF, then a FHD system must be used for moisture removal. The requirements and limits for moisture removal are provided in LCO 3.1.1 and are specific to the amendment to which the HI-STORM 100 System is being loaded.

As stated in Subsection 4.5.3.1, above, an axisymmetric FLUENT thermal model of the MPC is developed for the vacuum condition. For the MPC-24E and MPC-32 designs, and for the higher heat load ranges in the MPC-24 and MPC-68 designs, the model also includes an isotropic fuel basket thermal conductivity. Each MPC is analyzed at the maximum heat load for which vacuum drying is permitted. The steady-state peak cladding results, with partial recognition for higher axial heat dissipation where included, are summarized in Table 4.5.5[4]. The peak fuel clad temperatures for moderate burnup fuel during short-term vacuum drying operations with design-basis maximum heat loads are calculated to be less than 1058°F for all MPC baskets by a significant margin.

4.5.5.3 Evaluation of SCS Failure

Table 4.5.4 mandates the use of the SCS for MPC containing one or more HBF above the threshold heat load to ensure fuel remains below the short-term operation temperature limits mandated by ISG-11, Rev. 3. If the SCS fails during operation, an accident condition defined in Section 11.2, the thermal state of the fuel would asymptotically approach steady state maximum conditions corresponding to the coincident thermal payload in the HI-TRAC transfer cask. The results of steady state analysis are provided in Table 4.5.6 for the design basis heat load. It is shown that the fuel remains well below the 1058°F ISG-11, Rev. 3 accident limit.

4.5.5.4 Evaluation of SCS for Lower Backfill Pressure Limit

[4] Although partial recognition for higher axial heat dissipation is considered for steady-state analysis (during vacuum drying under the flushing condition) and is reflected in the temperatures reported in Table 4.5.5, it is not credited in the safety analysis to meet ISG-11 Rev. 3 limits since vacuum drying of an MPC with a heat load greater than 23 kW is limited to 40 hours.

As stated in Table 1.2.2. MPC is allowed to be backfilled with a lower pressure limit than that specified in Table 4.4.12, if the MPC heat load meets the threshold heat load requirement in Table 1.2.2. The analyses that support the threshold heat load scenario and lower helium backfill pressure limits are reported in the Revision 6 of HI-STORM 100 FSAR. To evaluate the requirement of SCS system (Table 4.5.4) for the threshold heat load with lower backfill pressure limit, a steady state analysis is performed for the bounding heat load scenario, i.e. MPC-32 with heat load of uniform 28.74 kW, under the ambient environment outside of fuel building. The computed fuel temperatures in this scenario remain below the cladding temperature limit of moderate burnup fuel, but exceed the temperature limit of high burnup fuel (Table 4.3.1). The fuel basket and the HI-TRAC parts temperatures are presented in Table 4.5.9, and their corresponding allowable limits show positive margins of safety. As these are bounding steady state temperatures, the results support onsite transport of fuel in the HI-TRAC without the aid of any supplemental cooling for MPC containing only moderate fuel burnup and cooling times up to the threshold heat load in Table 1.2.2.

The steady state analyses are then performed for 90% of threshold heat load, i.e. Q = 25.86 kW uniform in MPC-32, the computed fuel temperatures remain below the cladding temperature limits of high and moderate burnup fuel (Table 4.3.1). The MPC components, fuel basket and the HI-TRAC parts temperatures are presented in Table 4.5.9, and their corresponding allowable limits show positive margins of safety. Therefore, the results support onsite transport of high burnup fuel in the HI-TRAC without the aid of any supplemental cooling for any fuel burnup and cooling times up to the 90% of threshold heat load in Table 1.2.2.

4.5.5.5 Environmental Temperature Requirements

Short term operations involving the HI-TRAC transfer cask can be carried out on the basis of the safety evaluation herein if the reference ambient temperature (three day average around the cask) is below the "Threshold Temperature" defined in Table 2.2.2 as 110 deg. F for operations inside the part 50 structural boundary and 90 deg. F outside of it. The determination of the Threshold Temperature compliance shall be made based on the best available thermal data for the site.

If the reference ambient temperature exceeds the corresponding Threshold Temperature then a site specific analysis using the methodology set down in Section 4.5 shall be performed using the actual heat load and reference ambient temperature equal to the three day average to ensure that the steady state peak fuel cladding temperature will remain below the FSAR Table 2.2.3 limit. If the peak fuel cladding temperature exceeds Table 2.2.3 limit then the use of a Supplemental Cooling System (SCS) is mandatory.

A Supplemental Cooling System (SCS) is operated to ensure fuel remains below the short-term operation temperature limits mandated by ISG-11, Rev. 3. If the SCS fails during operation, an accident condition defined in Section 11.2, the thermal state of the fuel would asymptotically approach steady state maximum conditions corresponding to the coincident thermal payload in the HI-TRAC transfer cask. To bound the thermal payload under all previously approved and currently licensed heat loads two heat load scenarios are defined below and steady state maximum fuel temperatures computed.

~~Scenario A: The MPCs are loaded to a maximum thermal payload of 28.74 kW and helium backfilled to ensure a normal storage pressure of 5 atm absolute.~~

~~Scenario B: The MPCs are loaded to a maximum thermal payload of 36.9 kW and helium backfilled to ensure a normal storage pressure of 7 atm absolute.~~

~~As an additional measure of conservatism, insolation heating of the HI-TRAC with a theoretical absorbtivity equal to 1.0 and a hot ambient temperature of 100°F is assumed. The results of the analysis provided below show that the fuel remains well below the 1058°F ISG-11, Rev. 3 accident limit.~~

~~Maximum Cladding Temperatures~~
~~Scenario A: 872°F~~
~~Scenario B[5]: 883°F~~

4.5.6 Maximum Internal Pressure

After fuel loading and vacuum drying, but prior to installing the MPC closure ring, the MPC is initially filled with helium. During handling and on-site transport operations in the HI-TRAC transfer cask, the gas temperature within the MPC rises to its maximum operating temperature as determined by on the thermal analysis methodology described previously. In Table 4.5.6, the MPC internal pressure co-incident with the MPC temperature is reported and compared with the short term (off-normal) pressure limit specified in Table 2.2.1 to show compliance with design limit~~During handling and on-site transfer operations in the HI-TRAC transfer cask, the gas temperature will correspond to the thermal conditions within the MPC. Based on the calculations described in Subsection 4.5.5.1 that yield conservative temperatures, the MPC internal pressure is determined for normal onsite transport conditions, as well as off-normal conditions of a postulated accidental release of fission product gases caused by fuel rod rupture. Based on NUREG-1536 [4.4.1] recommended fission gases release fraction data, net free volume and initial fill gas pressure, the bounding maximum gas pressures with 1% and 10% rod rupture are given in Table 4.5.6. The MPC gas pressures listed in Table 4.5.6, based on a lower than prescribed helium backfill level, are all below the MPC design internal pressure listed in Table 2.2.1~~.

~~As stated in Section 4.5.5.1, the gas temperature in the MPC at any given heat load will be less than that computed using the conservative model described in this section which credits approximately 30% less helium than that prescribed. In accordance with the ideal gas law, the gas pressure rises in direct proportion to the increase in the average temperature of the MPC cavity from ambient temperature up to operating conditions. A lesser rise in temperature (due to increased thermosiphon action under actual helium backfill requirements) will result in a corresponding smaller rise in gas~~

~~5 Although the thermal payload under Scenario B is significantly greater the temperatures are unaffected because of the increased heat dissipation under the higher helium fill pressure.~~

~~pressure. An approximately 40% increase in the initial gas pressure based on actual backfill requirements compared to analyzed backfill quantities. therefore, is mitigated by a smaller rise in the gas pressure. Noting that the gas pressure in the analyzed condition (see Table 4.5.6 and discussion in preceding paragraph) had over 100% margin against the analyzed maximum permissible pressure (200 psig per Table 2.2.1) the maximum pressure in the MPC is guaranteed to remain below 200 psig and thus the physical integrity of the confinement boundary is assured.~~

Table 4.5.1
THRESHOLD HEAT LOADS FOR MOISTURE REMOVAL OPERATIONS

Drying Method	Fuel Burnup	Threshold Heat Load[Note 1]	Time Limits
Vacuum Drying	MBF	Q1	None
Vacuum Drying	MBF	MPC Heat Load > Q1 and ≤ Q2	Yes (40 hrs)
FHD	MBF and/or HBF	36.9 kW	None
Note 1: Threshold heat loads are defined below: Q1 = 26 kW (Uniform) Q2 = 30 kW (Uniform)			

~~EFFECTIVE RADIAL THERMAL CONDUCTIVITY OF THE WATER JACKET~~

~~Temperature (°F)~~	~~Thermal Conductivity (Btu/ft-hr-°F)~~
~~200~~	~~1.376~~
~~450~~	~~1.408~~
~~700~~	~~1.411~~

Table 4.5.4

THRESHOLD HEAT LOADS FOR SUPPLEMENT COOLING SYSTEM REQUIREMENT

Condition*	Fuel in MPC	Heat Load Reduction Factor *	SCS Required
1	All MBF	100%	NO
2	One or ~~M~~More HBF	≤ 90%	NO
3	One or M~~M~~ore HBF	>~~≥~~ 90%	YES

* The threshold heat load is obtained by multiplying the design basis heat load per storage cell defined in Subsection 2.1.9.1 by the reduction factor listed in this table.

Table 4.5.5

MAXIMUM FUEL TEMPERATURES UNDER VACUUM DRYING OPERATIONS

Threshold Heat Load[Note 1]	Time Limit	Temperature (°F)	Temperature Limit[Note 2]	Margin (°F)
Q1	None	1046	1058	12
Q2	40 hrs	1035	1058	23

Notes:

1) Threshold heat loads defined in Table 4.5.1.
2) Temperature limit of moderate burnup fuel shown. Vacuum drying of high burn-up fuel is not permitted (See Subsection 4.5.3).

Table 4.5.6

HI-TRAC ONSITE TRANSFER- TEMPERATURE AND PRESSURE FOR DESIGN BASIS HEAT LOAD

Component	Maximum Temperatures (°F)	
	X=0.5	X=3
Fuel Cladding	748	784
MPC Basket	745	779
Basket Peripheral Panels	612	567
MPC Shell	473	459
HI-TRAC Inner Shell	282	268
Radial Lead	279	266
HI-TRAC Water Jacket Shell	250	232
Axial Neutron Shield[Note 1]	280	279
Water Jacket Bulk Water	244	225
Pressure (psig) [Note 2]		
Normal Condition	103.0	96.6
Note 1: Maximum section average temperature. Note 2: The MPC pressure is computed under the maximum backfill pressure specified in Table 4.4.12.		

Table 4.5.7

HI-TRAC ONSITE TRANSFER- TEMPERATURE
FOR 90% OF DESIGN BASIS HEAT LOAD

Component	Maximum Temperatures (°F)	
	X=0.5	X=3
Fuel Cladding	702	734
MPC Basket	698	729
Basket Peripheral Panels	577	534
MPC Shell	446	437
HI-TRAC Inner Shell	268	257
Radial Lead	266	253
HI-TRAC Water Jacket Shell	239	223
Axial Neutron Shield[Note 1]	279	266
Water Jacket Bulk Water	234	217
Note 1: Maximum section average temperature.		

Table 4.5.8

HI-TRAC ONSITE TRANSFER- TEMPERATURE
FOR 110°F AMBIENT TEMPERATURE AND WITHOUT INSOLATION [Note 1]

Component	Maximum Temperatures (°F)
Fuel Cladding	730
MPC Basket	723
Basket Peripheral Panels	532
MPC Shell	430
HI-TRAC Inner Shell	246
Radial Lead	244
HI-TRAC Water Jacket Shell	216
Axial Neutron Shield[Note2]	262
Water Jacket Bulk Water	210
Note 1: The results presented in this table are for 90% of design basis heat load with X=3. Note 2: Maximum section average temperature.	

Table 4.5.9

HI-TRAC ONSITE TRANSFER- TEMPERATURE
FOR THRESHOLD HEAT LOAD AND LOWER BACKFILL PRESSURE IN TABLE 1.2.2

Component	Maximum Temperatures (°F)	
	Threshold Heat Load	90% Threshold Heat Load
Fuel Cladding	774	721
MPC Basket	768	716
Basket Peripheral Panels	558	527
MPC Shell	426	401
HI-TRAC Inner Shell	257	246
Radial Lead	253	244
HI-TRAC Water Jacket Shell	228	219
Axial Neutron Shield[Note1]	255	250
Water Jacket Bulk Water	223	214
Note 1: Maximum section average temperature.		

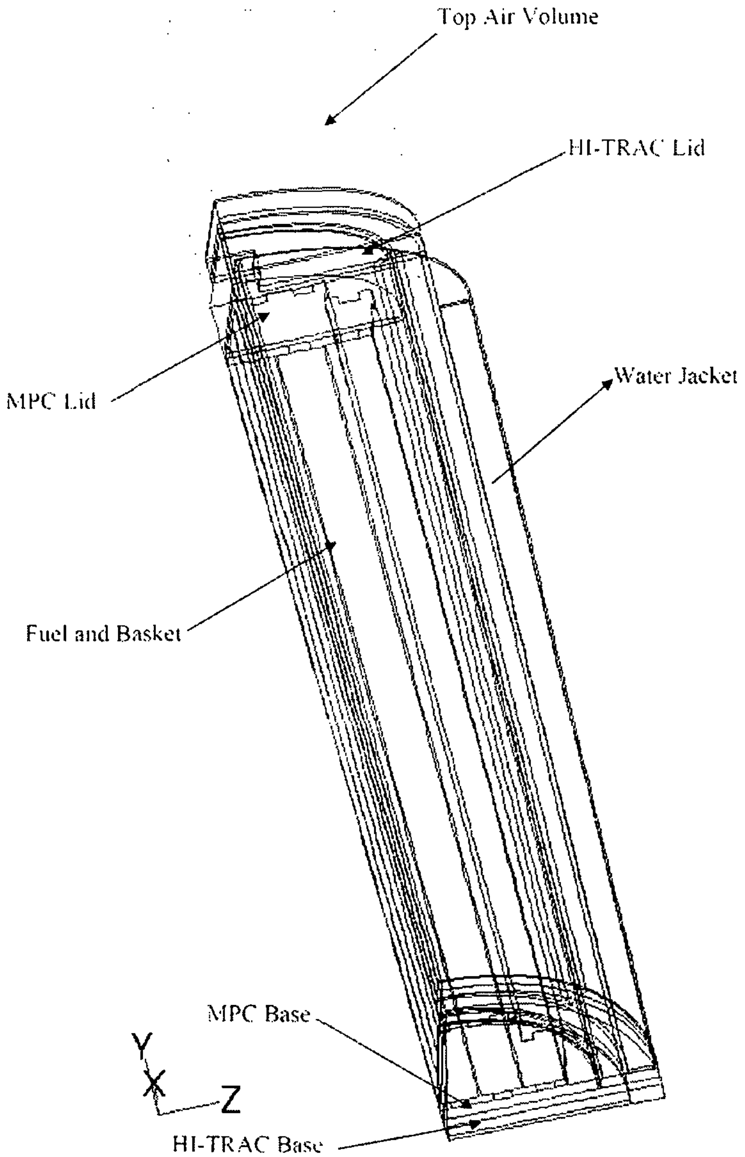


Figure 4.5.1: 3D QUARTER SYMMETRIC THERMAL MODEL OF THE HI-TRAC TRANSFER CASK

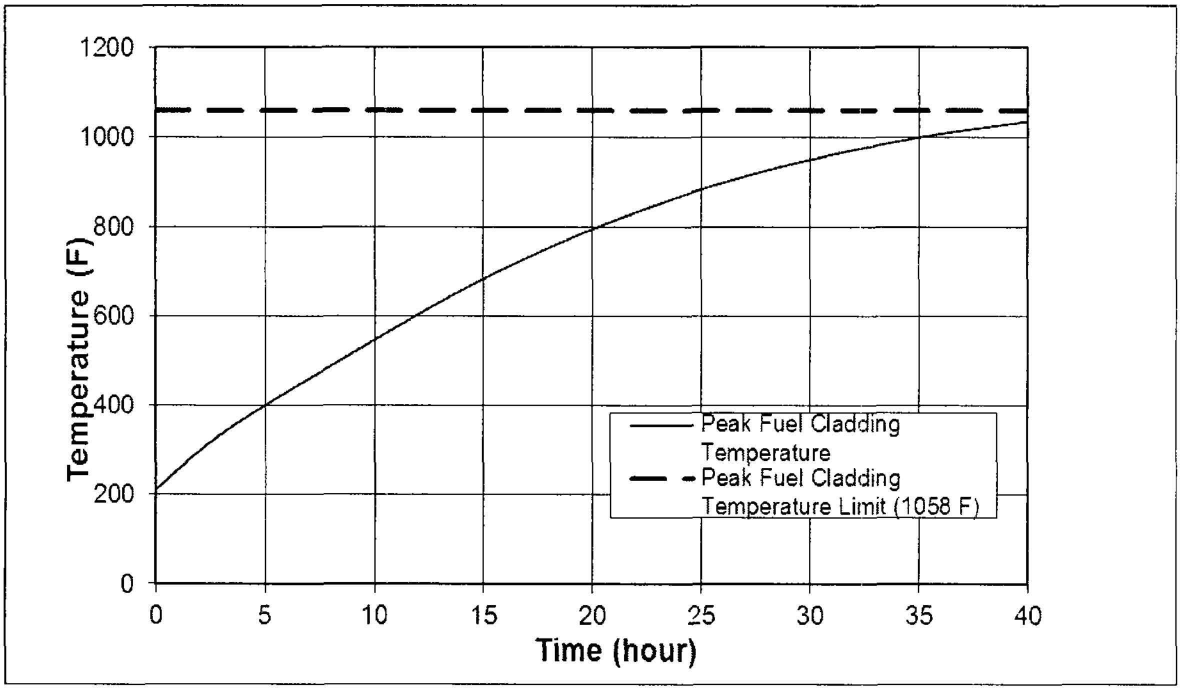


Figure 4.5.2: PEAK CLADDING TEMPERATURE CURVE UNDER VACUUM DRYING OPERATIONS AT THRESHOLD HEAT LOAD Q2

Table 4.5.4

HI-TRAC TRANSFER CASK STEADY-STATE MAXIMUM TEMPERATURES

Component	Temperature [°F]
Fuel Cladding	872[6]
MPC Basket	852
Basket Periphery	600
MPC Outer Shell Surface	455
HI-TRAC Inner Shell Inner Surface	322
Water Jacket Inner Surface	314
Enclosure Shell Outer Surface	224

6 This calculated value exceeds the allowable limit for high burnup fuel. A Supplemental Cooling System that satisfies the criteria in Appendix 2.C shall be used to comply with applicable temperature limits when an MPC contains one or more high burnup fuel assemblies or exceeds a threshold heat load (see Section 1.5.5.1).

Water Jacket Bulk Water	258
Axial Neutron Shield[7]	258

Table 4.5.5

PEAK CLADDING TEMPERATURE IN VACUUM[8]
(MODERATE BURNUP FUEL ONLY)

MPC	Lower Decay Heat Load Range Temperatures (°F)	Higher Decay Heat Load Range Temperature (°F)
MPC-24	827	960
MPC-68	822	1014
MPC-32	n/a	1040
MPC-24E	n/a	942

7 Local neutron shield section temperature.

8 Steady state temperatures at the MPC design maximum heat load are reported. For the higher decay heat load range these results consider the effects of axial heat dissipation. Since vacuum drying time limits are mandated for heat loads greater than 23 kW (see Section 4.5.3.1.3) credit for axial heat dissipation is not required for the safety analysis to meet ISG-11 Rev. 3 limits for short-term operations.

Table 4.5.6

SUMMARY OF MPC CONFINEMENT BOUNDARY PRESSURES[‡] FOR NORMAL HANDLING AND ONSITE TRANSPORT

Condition	Pressure (psig)
MPC-24:	
Assumed initial backfill (at 70°F)	31.3
Normal condition	76.0
With 1% rod rupture	76.8
With 10% rod rupture	83.7
MPC-68:	
Assumed initial backfill (at 70°F)	31.3
Normal condition	76.0
With 1% rods rupture	76.5
With 10% rod rupture	80.6
MPC-32:	
Assumed initial backfill (at 70°F)	31.3
Normal condition	76.0
With 1% rods rupture	77.1
With 10% rod rupture	86.7
MPC-24E:	
Assumed initial backfill (at 70°F)	31.3
Normal condition	76.0
With 1% rods rupture	76.8
With 10% rod rupture	83.7

[‡] Includes gas from BPRA rods for PWR MPCs

Table 4.5.7 Assumed Heat Loads in Thermal Analysis for Operational Considerations Equally Distributed Pattern		
MPC Model	Assumed Cell Heat Load (kW)	Total MPC Heat Load (kW)
MPC-32/32F	0.898	28.74
MPC-68/68FF	0.414	28.19
MPC-24	1.157	27.77
MPC-24E/24EF	1.173	28.17

Table 4.5.8 Assumed Heat Loads in Thermal Analysis for Operational Considerations Specific Regionalized Pattern [Note 1]				
MPC Model	Number of Fuel Storage Locations in the Inner and Outer Regions	Assumed Inner Region Cell Heat Load (kW)	Assumed Outer Region Cell Heat Load (kW)	Total MPC Heat Load (kW)
MPC-32/32F	12 and 20	1.131	0.600	25.572
MPC-68/68FF	32 and 36	0.500	0.275	25.90
MPC-24	4 [Note 2] and 20	1.470	0.900	23.88
MPC-24E/24EF	4 [Note 2] and 20	1.540	0.900	24.16
Note 1: This pattern was analyzed and approved in Amendment 1. Note 2: The inner region for MPC-24/24E/24EF as it applies here are cell numbers 9, 10, 15, and 16.				

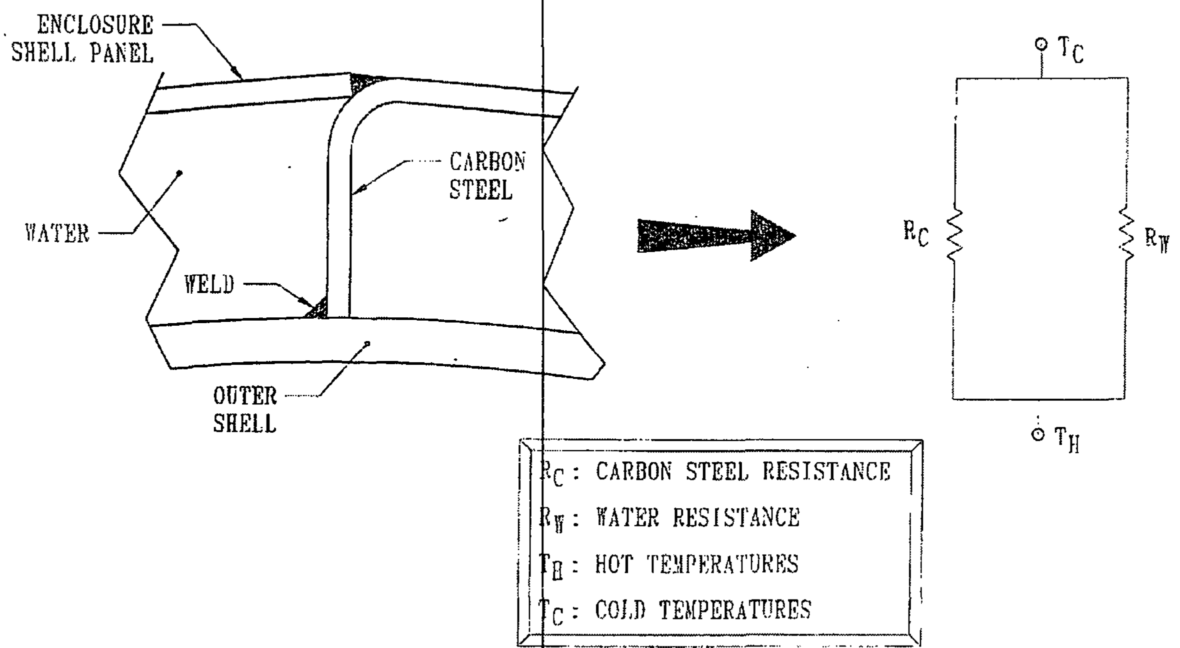


FIGURE 4.5.1; WATER JACKET RESISTANCE NETWORK ANALOGY FOR EFFECTIVE CONDUCTIVITY CALCULATION

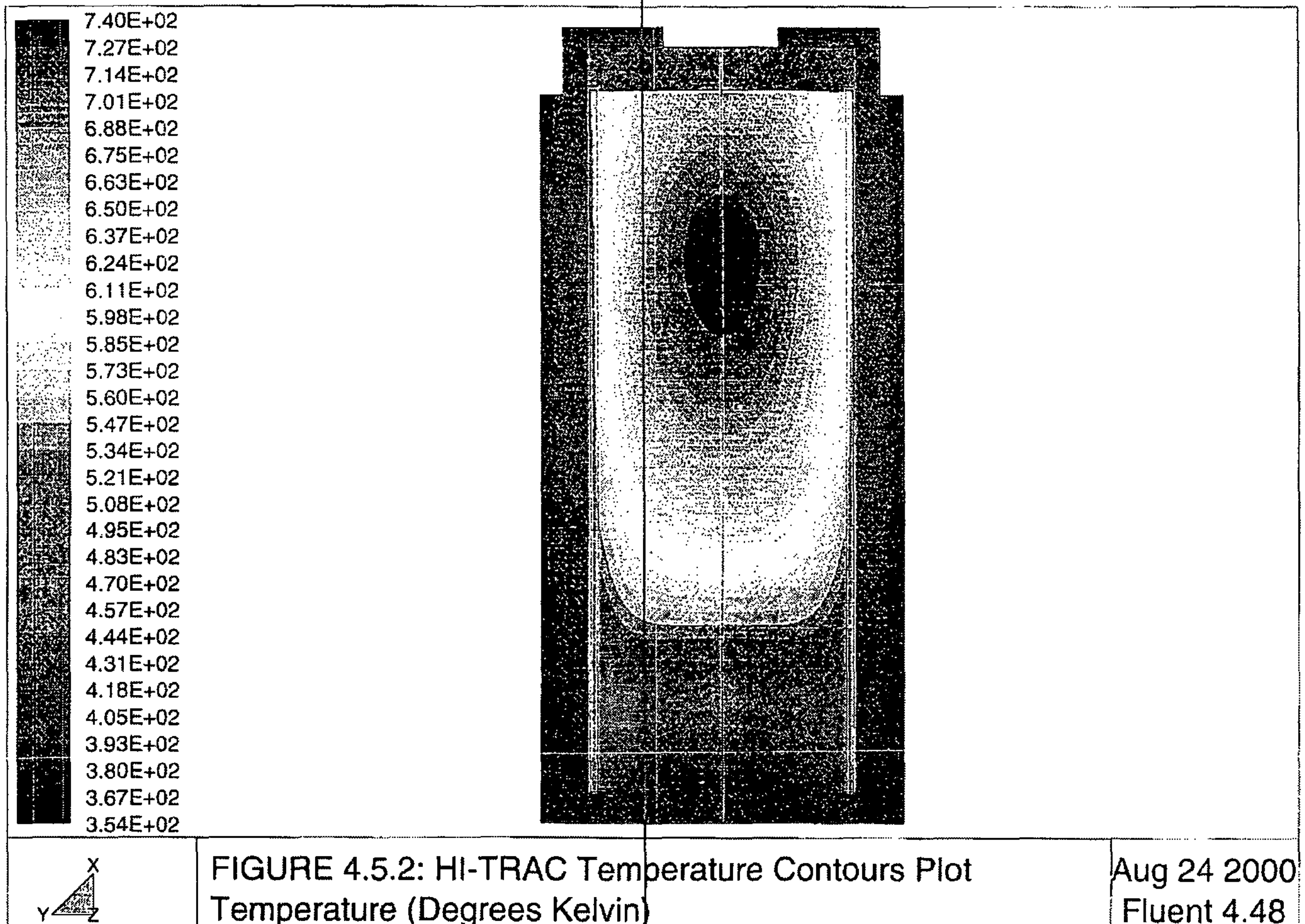


FIGURE 4.5.2: HI-TRAC Temperature Contours Plot
Temperature (Degrees Kelvin)
Max = 7.398E+02 Min = 3.540E+02

Aug 24 2000
Fluent 4.48
Fluent Inc.

System to cool the spent nuclear fuel within design temperature limits during and after fire is not compromised.

<u>(b) HI-TRAC Fire</u>

~~The acceptability of fire-accident HI-TRAC condition following a 50-gallon fuel spill fire at a co-incident decay heat load of 28.74 kW has been ascertained under the HI-STORM CoC 1014, Amendment 2, as supported by HI-STORM FSAR Rev. 4. This fire accident evaluation is bounding up to the HI-TRAC un-assisted cooling threshold heat load, 28.74 kW, defined in Section 4.5.5 . At greater heat loads forced cooling of the MPC using the Supplemental Cooling System (SCS) defined in Section 2.C is mandatory (See Subsection 4.5.5.1, Conditions 2 and 3). The SCS, sized for 36.9 kW heat removal capacity, will insure that the cladding temperatures will be well below the temperatures under the threshold heat load scenario, when the SCS is not used. As such the SCS cooled HI-TRAC pre-fire thermal condition is bounded by the threshold heat load scenario. The principal HI-TRAC thermal loading during this accident (50-gallon fire heat input) is bounded by the CoC 1014-2 evaluation referenced above. Therefore the fire accident consequences are likewise bounded~~During the handling of the HI-TRAC transfer cask, the transporter fuel tank capacity must be limited to a 50 gallons. The duration of the 50-gallon fire under the conservatively postulated spill defined in the HI-STORM fire evaluation computes as 4.775 minutes. To demonstrate the fuel cladding and MPC pressure boundary integrity under exposure to this fire duration event during a fire accident analysis of the loaded 100-ton HI-TRAC is performed. In this analysis, the contents of the HI-TRAC are conservatively postulated to undergo a transient heat-up as a lumped mass from the decay heat input and heat input from the short duration fire. This analysis, because of the lower mass of the 100-ton HI-TRAC, bounds the effects for the 125-ton HI-TRAC. Using understated thermal inertia of the HI-TRAC and design maximum heat load (36.9 kW) the temperature rise rate computes as 5.553°F/min. Therefore, the temperature rise computed as the product of this rate and the fire duration reported above is 26.5°F. In this manner the maximum cladding temperature obtained by adding the temperature rise to the initial condition (See Table 4.5.6 for design basis heat load with X=3) computes as 811°F. The maximum fire temperature computed in the conservative manner above remains below the 1058°F accident temperature limit (Table 4.3.1) by substantial margins.

The elevated temperatures as a result of the fire accident will cause the pressure in the water jacket to increase and the overpressure relief valves to vent steam to the atmosphere. Based on the fire heat input to the water jacket, 11% of the water in the water jacket is boiled off. However, it is conservatively assumed, for dose calculations, that all the water in the water jacket is lost. In the 125-ton HI-TRAC, which uses Holtite in the lids for neutron shielding, the elevated fire temperatures would cause the Holtite to exceed its design accident temperature limits. This condition is conservatively addressed by ignoring neutron shield in the accident dose calculations.

Due to the increased temperatures of the MPC during fire accident the internal MPC pressure increases. The fire accident pressure is computed assuming the MPC cavity temperature rises by the fire accident temperature rise computed in this section. The result is tabulated in Table 4.6.2. The fire accident MPC pressure is substantially below the accident pressure limit (Table 2.2.1).

4.6.2.2 Jacket Water Loss

~~In this subsection, the fuel cladding and MPC boundary integrity is evaluated for a postulated loss of water from the HI-TRAC water jacket. The HI-TRAC is equipped with an array of water compartments filled with water. For a bounding analysis, all water compartments are assumed to lose their water and be replaced with air. As an additional measure of conservatism, the air in the water jacket is assumed to be motionless (i.e. natural convection neglected) and radiation heat transfer in the water jacket spaces ignored. The HI-TRAC is assumed to have the maximum thermal payload (design heat load) and assumed to have reached steady state (maximum) temperatures. Under these assumed set of adverse conditions, the maximum temperatures are computed and reported in Table 4.6.3. The results of jacket water loss evaluation confirm that the cladding, MPC and HI-TRAC component temperatures are below the limits prescribed in Chapter 2 (Table 2.2.3). The co-incident MPC pressure is also computed and compared with the MPC accident design pressure (Table 2.2.1). The result (Table 4.6.2) is confirmed to be below the limit.~~

In this subsection, the fuel cladding and MPC boundary integrity is evaluated for a postulated loss of water from the HI-TRAC water jacket. The HI-TRAC is equipped with an array of water compartments filled with water. For a bounding analysis, all water compartments are assumed to lose their water and be replaced with air. Heat dissipation by natural convection and radiation in the air space is included in the thermal model. The HI-TRAC is assumed to have the maximum thermal payload (design heat load) and assumed to have reached steady state (maximum) temperatures. Under these assumed set of adverse conditions, the maximum temperatures are computed using the 3D HI-TRAC thermal model constructed in Section 4.5 with the water in water jacket spaces replaced with air. The computed results are tabulated in Table 4.6.3 for the design basis heat load. The results of jacket water loss evaluation confirm that the cladding, MPC and HI-TRAC component temperatures are below the limits prescribed in Chapter 2 (Table 2.2.3). The co-incident MPC pressure is also computed and compared with the MPC accident design pressure (Table 2.2.1). The result (Table 4.6.2) is confirmed to be below the limit.

4.6.2.3 Extreme Environmental Temperatures

To evaluate the effect of extreme weather conditions, an extreme ambient temperature (Table 2.2.2) is postulated to persist for a 3-day period. For a conservatively bounding evaluation the extreme temperature is assumed to last for a sufficient duration to allow the HI-STORM 100 System to reach steady state conditions. Because of the large mass of the HI-STORM 100 System, with its corresponding large thermal inertia and the limited duration for the extreme temperature, this assumption is conservative. Starting from a baseline condition evaluated in Section 4.4 (normal ambient temperature and limiting fuel storage configuration) the temperatures of the HI-STORM 100 System are conservatively assumed to rise by the difference between the extreme and normal

Table 4.6.2
OFF-NORMAL AND ACCIDENT CONDITION MAXIMUM MPC PRESSURES FOR DESIGN BASIS HEAT LOAD

Condition	Pressure (psig)
Off-Normal Conditions	
Off-Normal Ambient	101.4
Partial Blockage of Inlet Ducts	100.4
Accident Conditions	
Extreme Ambient Temperature	104.4
100% Blockage of Air Inlets	118.1
Burial Under Debris	134.8
HI-TRAC Fire Accident	106.2
HI-TRAC Jacket Water Loss	108.6~~112.2~~

Table 4.6.3

HI-TRAC JACKET WATER LOSS ACCIDENT MAXIMUM TEMPERATURES FOR DESIGN BASIS HEAT LOAD

Component	Temperature (°F)	
	X = 0.5	X =3
Fuel Cladding	811	837
MPC Basket	808	829
MPC Shell	514	496
HI-TRAC Inner Shell	365	342
HI-TRAC Radial Lead Gamma Shield	363	342
HI-TRAC Water Jacket Shell	289	271
HI-TRAC Lid Neutron Shield Section Average	304	309

Table 4.6.4

EXTREME ENVIRONMENTAL CONDITION MAXIMUM HI-STORM TEMPERATURES

Component	Temperature[6] (°F)
Fuel Cladding	756
MPC Basket	753
MPC Shell	514
Overpack Inner Shell	367
Lid Concrete Bottom Plate	347
Lid Concrete Section Temperature	291

6 Obtained by adding the extreme ambient to normal temperature difference (45°F) to normal condition temperatures reported in Section 4.4.

[4.5.1] "~~Deleted~~HI-STORM THERMAL-HYDRAULIC ANALYSES SUPPORTING UPTO 36.9 KW HIGH HEAT LOAD AMENDMENT", Holtec Report HI-2043317, Revsion 18 ~~.~~

[4.5.2] HI-STORM FW FSAR, Holtec Report HI-2084239, Rev. 1, Section 3.4.4.1.11, Docket No. 72-1032.~~J.P. Holman, "Heat Transfer," McGraw-Hill Book Company, Sixth Edition, 1986.~~

[4.6.1] United States Code of Federal Regulations, Title 10, Part 71.

[4.6.2] Gregory, J.J. et. al., "Thermal Measurements in a Series of Large Pool Fires", SAND85-1096, Sandia National Laboratories, (August 1987).

8.1 PROCEDURE FOR LOADING THE HI-STORM 100 SYSTEM IN THE SPENT FUEL POOL

8.1.1 Overview of Loading Operations:

The HI-STORM 100 System is used to load, transfer and store spent fuel. Specific steps are performed to prepare the HI-STORM 100 System for fuel loading, to load the fuel, to prepare the system for storage and to place it in storage at an ISFSI. The MPC transfer may be performed in the cask receiving area, at the ISFSI, or any other location deemed appropriate by the user. HI-TRAC and/or HI-STORM may be transferred between the ISFSI and the fuel loading facility using a specially designed transporter, heavy haul transfer trailer, or any other load handling equipment designed for such applications as long as the lift height restrictions are met (lift height restrictions apply only to suspended forms of transport). Users shall develop detailed written procedures to control on-site transport operations. Section 8.1.2 provides the general procedures for rigging and handling of the HI-STORM overpack and HI-TRAC transfer cask. Figure 8.1.1 shows a general flow diagram of the HI-STORM loading operations.

Refer to the boxes of Figure 8.1.2 for the following description. At the start of loading operations, an empty MPC is upended (Box 1). The empty MPC is raised and inserted into HI-TRAC (Box 2). The annulus is filled with plant demineralized water[†] and the MPC is filled with either spent fuel pool water or plant demineralized water (borated as required) (Box 3). An inflatable seal is installed in the upper end of the annulus between the MPC and HI-TRAC to prevent spent fuel pool water from contaminating the exterior surface of the MPC. HI-TRAC and the MPC are then raised and lowered into the spent fuel pool for fuel loading using the lift yoke (Box 4). Pre-selected assemblies are loaded into the MPC and a visual verification of the assembly identification is performed (Box 5).

While still underwater, a thick shielded lid (the MPC lid) is installed using either slings attached to the lift yoke or the optional Lid Retention System (Box 6). The lift yoke remotely engages to the HI-TRAC lifting trunnions to lift the HI-TRAC and loaded MPC close to the spent fuel pool surface (Box 7). When radiation dose rate measurements confirm that it is safe to remove the HI-TRAC from the spent fuel pool, the cask is removed from the spent fuel pool. If the Lid Retention System is being used, the HI-TRAC top lid bolts are installed to secure the MPC lid for the transfer to the cask preparation area. The lift yoke and HI-TRAC are sprayed with demineralized water to help remove contamination as they are removed from the spent fuel pool.

HI-TRAC is placed in the designated preparation area and the Lift Yoke and Lid Retention System (if utilized) are removed. The next phase of decontamination is then performed. The top surfaces of the MPC lid and the upper flange of HI-TRAC are decontaminated. The Temporary Shield Ring (if utilized) is installed and filled with water and the neutron shield jacket is filled with water[1] (if drained). The inflatable annulus seal is removed, and the annulus shield (if utilized) is installed. The Temporary Shield Ring provides additional personnel shielding around

[†] Users may substitute domestic water in each step where demineralized water is specified.

[1] Filled water jacket is relied in Section 4.5 thermal analysis of HI-TRAC in the dry and helium filled MPC condition.

the top of the HI-TRAC during MPC closure operations. The annulus shield provides additional personnel shielding at the top of the annulus and also prevents small items from being dropped into the annulus. Dose rates are measured at the MPC lid to ensure that the dose rates are within expected values.

The MPC water level is lowered slightly, the MPC is vented, and the MPC lid is seal welded using the automated welding system (Box 8). Visual examinations are performed on the tack welds. Liquid penetrant (PT) examinations are performed on the root and final passes. An ultrasonic or multi-layer PT examination is performed on the MPC Lid-to-Shell weld to ensure that the weld is satisfactory. As an alternative to volumetric examination of the MPC lid-to-shell weld, a multi-layer PT is performed including one intermediate examination after approximately every three-eighth inch of weld depth. The MPC Lid-to-Shell weld is then pressure tested followed by an additional liquid penetrant examination performed on the MPC Lid-to-Shell weld to verify structural integrity. To calculate the helium backfill requirements for the MPC (if the backfill is based upon helium mass or volume measurements), the free volume inside the MPC must first be determined. This free volume may be determined by measuring the volume of water displaced or any other suitable means.

Depending upon the burn-up or decay heat load of the fuel to be loaded in the MPC, moisture is removed from the MPC using either a vacuum drying system or forced helium dehydration system. For MPCs without high burn-up fuel and with sufficiently low decay heat, the vacuum drying system may be connected to the MPC and used to remove all liquid water from the MPC in a stepped evacuation process (Box 9). A stepped evacuation process is used to preclude the formation of ice in the MPC and vacuum drying system lines. The internal pressure is reduced to below 3 torr and held for 30 minutes to ensure that all liquid water is removed.

For high-burn-up fuel or MPCs with high decay heat, or as an alternative for MPCs without high burn-up fuel and with lower decay heat, a forced helium dehydration system is utilized to remove residual moisture from the MPC. Gas is circulated through the MPC to evaporate and remove moisture. The residual moisture is condensed until no additional moisture remains in the MPC. The temperature of the gas exiting the system demoisturizer is maintained below 21 °F for a minimum of 30 minutes to ensure that all liquid water is removed

Following MPC moisture removal, the MPC is backfilled with a predetermined amount of helium gas. If the MPC contains high burn-up fuel ~~or~~and MPC heat load greater than the threshold heat load setting in Table 4.5.4. ~~has a sufficiently high decay heat load.~~ then a Supplemental Cooling System (SCS) is connected to the HI-TRAC annulus prior to helium backfill and is used to circulate coolant to maintain fuel cladding temperatures below ISG-11 Rev. 3 limits (See Figure 2.C.1). The helium backfill ensures adequate heat transfer during storage, and provides an inert atmosphere for long-term fuel integrity. Cover plates are installed and seal welded over the MPC vent and drain ports with liquid penetrant examinations performed on the root and final passes (for multi-pass welds) (Box 10). The cover plate welds are then leak tested.

The MPC closure ring is then placed on the MPC and dose rates are measured at the MPC lid to ensure that the dose rates are within expected values. The closure ring is aligned, tacked in place and seal welded providing redundant closure of the MPC confinement boundary closure welds.

l. Disconnect the gas supply line from the MPC.

m. Disconnect the drain line from the MPC.

Note:
Vacuum drying or moisture removal using FHD (for high burn-up fuel or high decay heat) is performed to remove moisture and oxidizing gasses from the MPC. This ensures a suitable environment for long-term storage of spent fuel assemblies and ensures that the MPC pressure remains within design limits. The vacuum drying process described herein reduces the MPC internal pressure in stages. Dropping the internal pressure too quickly may cause the formation of ice in the fittings. Ice formation could result in incomplete removal of moisture from the MPC. The moisture removal process limits bulk MPC temperatures by continuously circulating gas through the MPC. Section 8.1.5 Steps 6a through q are used for the vacuum drying method of drying and backfill. Section 8.1.5 Steps 7a through i are used for the FHD method of drying and backfill.

6. Dry and Backfill the MPC as follows (Vacuum Drying Method):

Note:
During vacuum drying, the annulus between the MPC and the HI-TRAC must be maintained full of water. Water lost due to evaporation or boiling must be replaced to maintain the water level. ~~For MPCs above a threshold heat load (see Technical Specifications), water must be continuously flowed through the annulus at sufficient rate to ensure a water temperature at the outlet of the annulus below 125°F. Confirmation of water outlet temperature must be confirmed via measurement.~~

a. Fill the annulus between the MPC and HI-TRAC with clean water. The water level must be within 6" of the top of the MPC.~~If required by MPC heat load connect a source of water with sufficient flow to maintain an exit water temperature below 125°F during all vacuum drying operations.~~

b. Attach the drying system (VDS) to the vent and drain port RVOAs. See Figure 8.1.22a. Other equipment configurations that achieve the same results may also be used.

Note:
The vacuum drying system may be configured with an optional fore-line condenser. Other equipment configurations that achieve the same results may be used.
Note:
To prevent freezing of water, the MPC internal pressure should be lowered in incremental steps. The vacuum drying system pressure will remain at about 30 torr until most of the liquid water has been removed from the MPC.

c. Open the VDS suction valve and reduce the MPC pressure to below 3 torr.

d. Shut the VDS valves and verify a stable MPC pressure on the vacuum gage.

Note:
For an MPC containing high burn-up fuel assemblies fuel and MPC heat load greater than the threshold heat load setting in Table 4.5.4~~or has a sufficiently high decay heat load.~~, the Supplemental Cooling System is required to be operated within LCO 3.1.4 time limits following completion of backfill (see Section 4.5).- In the event of a Supplemental Cooling System failure, a HI-TRAC in a horizontal orientation must be placed into a vertical orientation within 24 hours.

1. Remove the annulus shield (if used) and store it in an approved plant storage location
2. If use of the SCS is not required, attach a drain line to the HI-TRAC and drain the remaining water from the annulus to the spent fuel pool or the plant liquid radwaste system.
3. Install HI-TRAC top lid as follows:

Warning:
When traversing the MPC with the HI-TRAC top lid using non-single-failure proof (or equivalent safety factors), the lid shall be kept less than 2 feet above the top surface of the MPC. This is performed to protect the MPC lid from a potential lid drop.

   a. Install HI-TRAC top lid. Inspect the bolts for general condition. Replace worn or damaged bolts with new bolts.
   b. Install and torque the top lid bolts. See Table 8.1.5 for torque requirements.
   c. Inspect the lift cleat bolts for general condition. Replace worn or damaged bolts with new bolts.
   d. Install the MPC lift cleats and MPC slings. See Figure 8.1.24 and 8.1.25. See Table 8.1.5 for torque requirements.
   e. Drain and remove the Temporary Shield Ring, if used.

4. Replace the pool lid with the transfer lid as follows (Not required for HI-TRAC 100D and 125D):

ALARA Note:
The transfer slide is used to perform the bottom lid replacement and eliminate the possibility of directly exposing the bottom of the MPC. The transfer slide consists of the guide rails, rollers, transfer step and carriage. The transfer slide carriage and jacks are powered and operated by remote control. The carriage consists of short-stroke hydraulic jacks that raise the carriage to support the weight of the bottom lid. The transfer step produces a tight level seam between the transfer lid and the pool lid to minimize radiation streaming. The transfer slide jacks do not have sufficient lift capability to support the entire weight of the HI-TRAC. This was selected specifically to limit floor loads. Users should designate a specific area that has sufficient room and support for performing this operation.

Note:
The following steps are performed to pretension the MPC slings.

6. Perform a HI-STORM receipt inspection and cleanliness inspection in accordance with a site-approved inspection checklist, if required. See Figure 8.1.27 for HI-STORM lid rigging.

> **Note:**
> MPC transfer may be performed in the truck bay area, at the ISFSI, or any other location deemed appropriate by the licensee. The following steps describe the general transfer operations (See Figure 8.1.28). The HI-STORM may be positioned on an air pad, roller skid in the cask receiving area or at the ISFSI. The HI-STORM or HI-TRAC may be transferred to the ISFSI using a heavy haul transfer trailer, special transporter or other equipment specifically designed for such a function (See Figure 8.1.29) as long as the HI-TRAC and HI-STORM lifting requirements are not exceeded (See technical specifications). The licensee is responsible for assessing and controlling floor loading conditions during the MPC transfer operations. Installation of the lid, vent screen, and other components may vary according to the cask movement methods and location of MPC transfer.

8.1.7 Placement of HI-STORM into Storage

1. Position an empty HI-STORM module at the designated MPC transfer location. The HI-STORM may be positioned on the ground, on a de-energized air pad, on a roller skid, on a flatbed trailer or other special device designed for such purposes. If necessary, remove the exit vent screens and gamma shield cross plates, temperature elements and the HI-STORM lid. See Figure 8.1.28 for some of the various MPC transfer options.
    a. Rinse off any road dirt with water. Inspect all cavity locations for foreign objects. Remove any foreign objects.
    b. Transfer the HI-TRAC to the MPC transfer location.
2. De-energize the air pad or chock the vehicle wheels to prevent movement of the HI-STORM during MPC transfer and to maintain level, as required.

> **ALARA Note:**
> The HI-STORM vent duct shield inserts eliminate the streaming path created when the MPC is transferred past the exit vent ducts. Vent duct shield inserts are not used with the HI-STORM 100S.

3. Install the alignment device (or mating device for HI-TRAC 100D and 125D) and if necessary, install the HI-STORM vent duct shield inserts. See Figure 8.1.30.

> **Caution:**
> ~~For~~MPCs loaded with high burn-up fuel and MPC heat load greater than the threshold heat load defined~~setting~~ in Table 4.5.4 requirei~~ng~~ operation of the ~~s~~Supplemental ~~c~~Cooling System~~,~~ ~~the time to complete the transfer may be limited~~ to prevent fuel cladding temperatures in excess of ISG-11 Rev. 3 limits. (See Section 4.5) All preparatory work related to the transfer should be completed prior to terminating the supplemental cooling operations.

4. If used, discontinue the supplemental cooling operations and disconnect the SCS. Drain water from the HI-TRAC annulus to an appropriate plant discharge point.

Table 8.1.6
HI-STORM 100 SYSTEM ANCILLARY EQUIPMENT OPERATIONAL DESCRIPTION (Continued)

Equipment	Important To Safety Classification	Reference Figure[†]	Description
Deleted			
Deleted			
Mating Device	Important-To-Safety – Category B	8.1.31	Used to mate HI-TRAC 100D and 125D to HI-STORM during transfer operations. Includes sliding drawer for use in removing HI-TRAC pool lid.
MPC Support Slings	Important To Safety – Category A – Rigging shall be provided in accordance with NUREG 0612.	8.1.25	Used to secure the MPC to the lift yoke during HI-TRAC bottom lid replacement operations. Attaches between the MPC lift cleats and the lift yoke. Can be configured for different crane hook configuration.
MPC Upending Frame	Not Important to Safety	8.1.6	A steel frame used to evenly support the MPC during upending operations. and control the upending process.
Supplemental Cooling System	Important to Safety – Category B	2.C.1	A system used to circulate water or other coolant through the HI-TRAC annulus in order to maintain fuel cladding temperatures below ISG-11 Rev. 3 limits during operations with the MPC in the HI-TRAC. Required only for MPC containing high burn-up fuel with a sufficiently high decay heat load as determined in accordance with Section 4.5. Calibration of the temperature instruments used to demonstrate heat removal from the HI-TRAC shall be performed in accordance with the requirements for Important to Safety Category B. the remaining components in the system are NITS.
MSLD (Helium Leakage Detector)	Not Important to Safety	Not shown	Used for helium leakage testing of the vent/drain port cover plate welds.
Deleted			
Temporary Shield Ring	Not Important To Safety	8.1.18	A water-filled tank that fits on the cask neutron shield around the upper forging and provides supplemental shielding to personnel performing cask loading and closure operations.
Vacuum Drying (Moisture Removal) System	Not Important To Safety	8.1.22a	Used for removal of residual moisture from the MPC following water draining.
Forced Helium Dehydration System	Important to Safety – Category B	8.1.22b	Used for removal of residual moisture from the MPC following water draining. Calibration of the instrumentation used to confirm Tech Spec compliance shall be performed in accordance with the requirements for Important to Safety Category B. the remaining components of the system are NITS.
Vent and Drain RVOAs	Not Important To Safety	8.1.16	Used to access the vent and drain ports. The vent and drain RVOAs allow the vent and drain ports to be operated like valves and prevent the need to hot tap into the penetrations during unloading operation.
Deleted			
Weld Removal System	Not Important To Safety	8.3.2b	Semi-automated weld removal system used for removal of the MPC field weld to support unloading operations.

[†] Figures are representative and may not depict all configurations for all users.

5. Engage the lift yoke to the HI-TRAC lifting trunnions.

6. Align HI-TRAC over HI-STORM and mate the overpacks. See Figure 8.1.31.

7. If necessary, install the MPC downloader.

8. Remove the transfer lid (or mating device) locking pins and open the doors (mating device drawer).

ALARA Warning:
If trim plates are not used, personnel should remain clear of the immediate door area during MPC downloading since there may be some radiation streaming during MPC raising and lowering operations.

9. At the user's discretion, install trim plates to cover the gap above and below the door (drawer for 100D and 125D). The trim plates may be secured using hand clamps or any other method deemed suitable by the user. See Figure 8.1.33.

10. Attach the ends of the MPC sling to the lifting device or MPC downloader. See Figure 8.1.32.

Caution: Limitations for ~~the~~ handling an MPC containing high burn-up fuel ~~or~~and total MPC heat load greater than ~~28.74 kW~~the threshold heat load setting in Table 4.5.4 at the time of unloading in a HI-TRAC are evaluated and established on a canister basis to ensure that acceptable cladding temperatures are not exceeded. Refer to FSAR Section 4.5 for guidance. The Supplemental Cooling System (SCS) is used to prevent fuel cladding temperatures from exceeding ISG-11 Rev. 3 limits. Operation of the SCS is initiated in accordance with the TS and continues until MPC re-flooding operations have commenced. Staging and check-out of the SCS shall be completed prior to transferring the MPC to the HI-TRAC.

11. Raise the MPC into HI-TRAC.

12. Verify the MPC is in the full-up position.

13. Close the HI-TRAC doors (or mating device drawer) and install the door locking pins.

14. For the HI-TRAC 100D and 125D, bolt the pool lid to the HI-TRAC. See Table 8.1.5 for torque requirements.

15. Lower the MPC onto the transfer lid doors (or pool lid for 100D and 125D).

16. Disconnect the slings from the MPC lift cleats.

17. If necessary, remove the MPC downloader from the top of HI-TRAC.

18. Remove HI-TRAC from the top of HI-STORM.

HI-TRAC Off-Normal Ambient Temperature

For each event, the postulated cause of the event, detection of the event, analysis of the event effects and consequences, corrective actions, and radiological impact from the event are presented.

The results of the evaluations performed herein demonstrate that the HI-STORM 100 System can withstand the effects of off-normal events without affecting function, and are in compliance with the applicable acceptance criteria. The following subsections present the evaluation of the HI-STORM 100 System for the design basis off-normal conditions that demonstrate that the requirements of 10CFR72.122 are satisfied, and that the corresponding radiation doses satisfy the requirements of 10CFR72.104(a) and 10CFR20.

11.1.1 Off-Normal Pressures

The sole pressure boundary in the HI-STORM 100 System is the MPC enclosure vessel. The off-normal pressure condition is specified in Subsection 2.2.2. The off-normal pressure for the MPC internal cavity is a function of the initial helium fill pressure and the temperature reached within the MPC cavity under normal storage. The MPC internal pressure is evaluated with 10% of the fuel rods ruptured and 100% of the rods fill gas and 30% of the fission gases released to the cavity.

11.1.1.1 Postulated Cause of Off-Normal Pressure

After fuel assembly loading, the MPC is drained, dried, and backfilled with an inert gas (helium) to assure long-term fuel cladding integrity during dry storage. Therefore, the probability of failure of intact fuel rods in dry storage is low. Nonetheless, the event is postulated and evaluated.

11.1.1.2 Detection of Off-Normal Pressure

The HI-STORM 100 System is designed to withstand the MPC off-normal internal pressure without any effects on its ability to meet its safety requirements. There is no requirement for detection of off-normal pressure and, therefore, no monitoring is required.

11.1.1.3 Analysis of Effects and Consequences of Off-Normal Pressure

The MPC off normal internal pressure is reported in Subsection 4.6.1 for the following conditions: limiting fuel storage scenario, tech. spec. maximum helium backfill and 10% rod rupture with 100% of rod fill gas and 30% of gaseous fission products released into the MPC cavity. The analysis shows that the MPC pressure remains below the design MPC internal pressure (Table 2.2.1).

It should be noted that this bounding temperature rise does not take any credit for the increase in thermosiphon action that would accompany the pressure increase that results from both the temperature rise and the addition of the gaseous fission products to the MPC cavity. As any such increase in thermosiphon action would decrease the temperature rise, the calculated pressure is higher than would actually occur.

Thermal

There is no effect on thermal performance.

Shielding

There is no effect on the shielding performance.

Criticality

There is no effect on the criticality control.

Confinement

There is no effect on the confinement function.

Radiation Protection

As there is no effect on the shielding or confinement functions, there is no effect on occupational or public exposures.

Based on this evaluation, it is concluded that the SCS failure does not affect the safe operation of the HI-STORM 100 System.

11.1.7.4 Corrective Action for SCS Power Failure

The HI-STORM 100 System is designed to withstand a power failure without an adverse effect on its normal operation. Consequently no corrective action is required.

11.1.7.5 Radiological Impact of SCS Power Failure

The event has no radiological impact because the confinement barrier and shielding integrity are not affected.

11.1.8 HI-TRAC Off-Normal Ambient Temperature

As evaluated in Section 4.5 the HI-TRAC is designed to conduct short term operations inside fuel handling building and in the outside environment under design basis ambient temperatures defined in Table 2.2.2. In an event where these temperatures are approached or exceeded an evaluation is required to support operations under greater than design ambient temperatures.

11.1.8.1 Postulated Cause of Off-Normal Ambient Temperatures

The off-normal environmental temperature is postulated as an exceedance of design ambient temperatures caused by extreme weather conditions. To evaluate the effects of off-normal temperatures, it is conservatively assumed that these temperatures persist for a sufficient duration to allow the HI-TRAC temperatures to reach asymptotic steady state conditions. Because of the large mass and thermal inertia of the HI-TRAC and the limited durations for the off-normal temperatures, this assumption is conservative.

11.1.8.2 Detection of Off-Normal Ambient Temperatures

The HI-TRAC is designed with robust margins to withstand off-normal environmental temperatures without challenging short term safety limits. There is no requirement for detection of off-normal environmental temperatures for the HI-TRAC. To address potential exceedance of ambient temperatures at hot sites Appendix B of the HI-STORM Technical Specifications, Section 3.1 requires cask users to evaluate site ambient temperatures.

11.1.8.3 Effects and Consequences of Off-Normal Ambient Temperatures

Structural

There is no effect on the structural performance of the system as a result of this off-normal event.

Thermal

There is no effect on the thermal performance of the system as a result of this off-normal event.

Shielding

There is no effect on the shielding performance of the system as a result of this off-normal event.

Criticality

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

Confinement

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

Radiation Protection

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

Based on this evaluation, it is concluded that off-normal environmental temperatures do not affect the safe operation of the HI-TRAC.

11.1.8.4 Corrective Action for Off-Normal Environmental Temperatures

The HI-TRAC is designed with robust margins to withstand off-normal ambient temperatures. No corrective actions are necessary.

11.1.8.5 Radiological Impact of Off-Normal Environmental Temperatures

Off-normal ambient temperatures have no radiological impact, as the confinement barrier and shielding integrity are not affected.

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

12.2.11 Verifying Compliance with Total MPC Heat Load

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

Example 1:

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

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

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

~~1. Vacuum drying without annulus flushing: The MPC *cannot* be dried using vacuum drying without annulus flushing because the maximum heat load in any cell is greater than 0.316 kW (See Tables in FSAR Section 4.5.3.1.2).~~

~~2.~~1.Vacuum drying~~-with annulus flushing~~: The MPC *cannot* be dried using vacuum drying~~-with annulus flushing~~ because the Q_{CoC} heat load~~maximum heat load in any cell~~ is greater than 30 k~~0.414 k~~W (See ~~-Tables in~~FSAR Table 4.5.1~~Section 4.5.3.1.3~~).

~~3.~~2.Forced Helium Dehydration: ~~Even though the aggregate heat load is less than 26kW the~~The MPC should be dried using forced helium dehydration since the Q_{CoC} heat load exceeds the vacuum drying threshold heat loads (See FSAR Table 4.5.1).~~s in one or more cells do not meet the values in Tables 4.5.7 or 4.5.8.~~

~~4.~~3.Helium Backfill Pressure Range: The MPC should be backfilled to the higher pressure range given in the TS because the Q_{CoC} heat load exceeds the threshold heat loads in FSAR Table 1.2.2.~~s in one or more cells do not meet the values in Tables~~

~~4.5.7 or 4.5.8~~.

~~5.~~4.Supplemental Cooling System: A supplemental cooling system would be required for on-site transport of High Burnup Fuel in the HI-TRAC after the MPC is dried, backfilled and sealed because the Q_{CoC} heat load exceeds the 90% design basis threshold heat load in FSAR Table 4.5.4.~~s in one or more cells do not meet the values in Table 4.5.7 or 4.5.8~~.

~~6.~~5.Heat Removal Surveillance (LCO 3.1.2): The user has 24 hours to clear blockage on the system containing this MPC since the Q_{CoC} heat load exceeds the 28.74 kW threshold heat load in LCO 3.1.2.~~s in the cells do not meet the values in Table 4.5.7 or 4.5.8.~~

~~7.~~6.Time to boil determination: The user can calculate the time to boil limit based on the aggregate MPC heat load of 18.917 kW since this is a bulk adiabatic heat up calculation strictly based on the aggregate heat in the MPC.

~~8.~~7.Air mass flow rate test requirements per Condition 9 of the CoC: The user can determine if this test needs to be performed based on the aggregate MPC heat load of 18.917 kW since the air flow on the outside of the MPC is strictly based on the aggregate heat in the MPC.

Example 2

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

General observations on this loading plan:

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

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

~~1. Vacuum drying without annulus flushing: The MPC *cannot* be dried using vacuum drying without annulus flushing since annulus flushing during vacuum drying of MPC-32 is always required (See Tables in FSAR Section 4.5.3.1.2).~~

~~2.~~1.Vacuum drying~~ with annulus flushing~~: The MPC can be dried using vacuum drying~~ if annulus flushing is used~~ since the Q_{CoC} ~~maximum~~ heat load is bounded by the threshold heat load Q2 in FSAR Table 4.5.1. The vacuum drying is time limited as

Q_{CoC} exceeds threshold heat load Q2 in FSAR Table 4.5.1.in any cell does not exceed 0.898 kW (See Tables in FSAR Section 4.5.3.1.3) and the aggregate MPC heat load is less than 26 kW. No time limit is applied to drying this canister since the aggregate heat load (17.471 kW) is less than or equal to 23 kW.

3.2.Forced Helium Dehydration: The MPC can be dried using forced helium dehydration but it is not required.

4.3.Helium Backfill Pressure Range: The MPC may be backfilled to either pressure range given in the TS because the Q_{CoC} heat load is bounded by the threshold heat load in FSAR Table 1.2.2.maximum heat load in any cell is below the values in Table 4.5.7.

5.4.Supplemental Cooling System: A supplemental cooling system would NOT be required for on-site transport in the HI-TRAC after the MPC is dried, backfilled and sealed because the Q_{CoC} heat load is bounded by the 90% design basis threshold heat load in FSAR Table 4.5.4.maximum heat load in any cell is below the values in Table 4.5.7.

6.5.Heat Removal Surveillance (LCO 3.1.2): The user has 64 hours to clear blockage on the system containing this MPC since the Q_{CoC} heat load is bounded by the 28.74 kW threshold heat load in LCO 3.1.2.maximum heat load in any cell is below the values in Table 4.5.7.

7.6.Time to boil determination: The user can calculate the time to boil limit based on the aggregate MPC heat load of 17.471 kW since this is a bulk adiabatic heat up calculation strictly based on the aggregate heat in the MPC.

8.7.Air mass flow rate test requirements per Condition 9 of the CoC: The user can determine if this test needs to be performed based on the aggregate MPC heat load of 17.471 kW since the air flow on the outside of the MPC is strictly based on the aggregate heat in the MPC.

Example 3

Table 1.2.9 contains a proposed heat load pattern for loading a MPC-32. The table provides the decay heat of each storage location. It is assumed that each of these assemblies meets the burnup, cooling time and enrichment criteria for loading as described in the previous examples in Section 12.2.10.

General observations on this loading plan:

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

4. The maximum heat load in any cell is 1.273 kW.
5. Since this MPC is loaded in a regionalized pattern, Q_{CoC}, as defined in Section 2.1.9.1.2 equation e is 32.484 kW. (12*1.282+20*0.855)

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

~~1. Vacuum drying without annulus flushing: The MPC *cannot* be dried using vacuum drying without annulus flushing since annulus flushing during vacuum drying of MPC-32 is always required (See Tables in FSAR Section 4.5.3.1.2).~~

~~2.~~1. Vacuum drying~~with annulus flushing~~: The MPC cannot be dried using vacuum drying~~if annulus flushing is used~~ since the Q_{CoC} heat load under uniform loading (1.273 kWx32 equals 40.736 kW) exceeds the threshold heat loads in FSAR Table 4.5.1.~~maximum heat load in any cell exceeds 0.898 kW (See Tables in FSAR Section 4.5.3.1.3).~~

~~3.~~2.Forced Helium Dehydration: The MPC must be dried using forced helium dehydration only because ~~the~~ vacuum drying is not permitted (see above) and regionalized loading Q_{CoC} is bounded by the design basis heat load in FSAR Table 4.5.1.~~maximum heat load in at least one cell is greater than the value in Table 4.5.7 and the maximum heat load in at least one cell in the inner region is greater than the value in Table 4.5.8.~~

~~4.~~3.Helium Backfill Pressure Range: The MPC must be backfilled to the higher pressure range given in the TS because the uniform loading Q_{CoC} heat load exceeds the threshold heat load in FSAR Table 1.2.2.~~maximum heat load in at least one cell is greater than the value in Table 4.5.7 and the maximum heat load in at least one cell in the inner region is greater than the value in Table 4.5.8.~~

~~5.~~4.Supplemental Cooling System: A supplemental cooling system is required for on-site transport of High Burnup Fuel in the HI-TRAC after the MPC is dried, backfilled and sealed because~~the~~ both uniform loading Q_{CoC} and storage cell heat loads under regionalized storage exceed the 90% design basis threshold heat load in FSAR Table 4.5.4.~~maximum heat load in at least one cell is greater than the value in Table 4.5.7 and the maximum heat load in at least one cell in the inner region is greater than the value in Table 4.5.8.~~

~~6.~~5.Heat Removal Surveillance (LCO 3.1.2): The user has 24 hours to clear blockage on the system containing this MPC since the uniform loading Q_{CoC} heat load exceeds the 28.74 kW threshold heat load in LCO 3.1.2. ~~maximum heat load in at least one cell is greater than the value in Table 4.5.7 and the maximum heat load in at least one cell in the inner region is greater than the value in Table 4.5.8.~~

~~7.~~6.Time to boil determination: The user can calculate the time to boil limit based on the aggregate MPC heat load of 20.697 kW since this is a bulk adiabatic heat up calculation strictly based on the aggregate heat in the MPC.

~~8.~~7.Air mass flow rate test requirements per Condition 9 of the CoC: The user can determine if this test needs to be performed based on the aggregate MPC heat load of 20.697 kW since the air flow on the outside of the MPC is strictly based on the

BASES

ACTIONS (continued)

A.2

Once the quantity of moisture potentially left in the MPC cavity is determined, a corrective action plan shall be developed and actions initiated to the extent necessary to return the MPC to an analyzed condition. Since the quantity of moisture estimated under Required Action A.1 can range over a broad scale, different recovery strategies may be necessary. Since moisture remaining in the cavity during these modes of operation may represent a long-term degradation concern, immediate action is not necessary. The Completion Time is sufficient to develop and initiate the corrective actions commensurate with the safety significance of the CONDITION.

B.1

~~Although Holtec steady state analysis for vacuum drying the MPC at the maximum heat load allowed indicates that PCT limits will not be exceeded, a time limit for vacuum drying based on the MPC heat load was mandated by the NRC in the approval of CoC 1014 Amendment 5 [4]. NRC considered that limiting the heat load to 23 kW provided added margin to the PCT limit.~~

If the MPC cavity vacuum drying acceptance criterion is not met during the allowable time, the Required Action ensures a sufficient quantity of helium within the MPC cavity to provide additional margin to the PCT limits. The Completion Time is sufficient to complete the corrective action commensurate with the safety significance of the CONDITION.

(continued)

BASES

SURVEILLANCE REQUIREMENTS	SR 3.1.1.1, SR 3.1.1.2 , and SR 3.1.1.3 (continued)
	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~~NRC SER for CoC 72-1014 Amendment #5, ML082030170, Section 4.10.2~~

BASES

LCO	The Supplemental Cooling System must be operable if the MPC/TRANSFER cask assemblage meets one of the following conditions in the Applicability portion of the LCO in order to preserve the assumptions made in the thermal analysis.
APPLICABILITY	The LCO is applicable within 4 hours after completion of MPC drying operations in accordance with LCO 3.1.1 or within 4 hours of transferring the MPC into the TRANSFER CASK if the MPC is to be unloaded, and the following conditions are met: MPC~~s~~ having one or more fuel assemblies with an average burnup greater than 45,000 MWD/MTU and either (i) MPC backfilled to higher helium backfill limits in Table 3-2 of Technical~~,~~ Specification~~,~~ Appendix B and having decay heat greater than 90% of the design basis heat load defined in Subsection 2.1.9.1 or (ii) MPC backfilled to lower helium backfill limits in Table 3-2 and having decay heat greater than 90% of heat load limits in Tables 3-3 or 3-4 of Tech. Spec. Appendix A.~~s having a decay heat load exceeding 28.74 kW[1]~~.
ACTIONS	A.1 If the SCS has been determined to be inoperable, the thermal analysis shows that the fuel cladding temperature would not exceed the short term temperature limit applicable to an off-normal condition, even with no water in the TRANSFER CASK-to-MPC annulus. Actions should be taken to restore the SCS to operable status in a timely manner. Because the thermal analysis is a steady-state analysis, there is an indefinite period of time available to make repairs to the SCS. However, it is prudent to require the actions to be completed in a reasonably short period of time. A Completion Time of 7 days is considered appropriate and a reasonable amount of time to plan the work, obtain needed parts, and execute the work in a controlled manner. (continued)

BASES

ACTIONS (continued)

B.1

If, after 7 days, the SCS cannot be restored to operable status, actions should be taken to remove the fuel assemblies from the MPC and place them back into the spent fuel pool storage racks. Thirty days is considered a reasonable time frame given that the MPC will be adequately cooled while this action is being planned and implemented, and certain equipment for this infrequent evolution (e.g., weld cutting machine) may take some time to acquire.

SURVEILLANCE REQUIREMENTS

SR 3.1.4.1

The long-term integrity of the stored fuel is dependent on the ability of the SFSC to reject heat from the MPC to the environment, including during short-term evolutions such as on-site transportation in the TRANSFER CASK. The SCS is required to ensure adequate fuel cooling in certain cases. The SCS should be verified to be operable every two hours. This would involve verification that the coolant~~ flow rate and~~ temperatures are within the design limits defined in Appendix 2.C.~~expected ranges~~. This is a reasonable Frequency given the typical oversight occurring during the on-site transportation evolution, the duration of the evolution, and the simple equipment involved.

AMBIENT TEMPERATURE REQUIREMENTS

Cask users are required in accordance with Design Features section in Tech. Specs. Appendix B to evaluate three day average ambient temperatures for compliance with FSAR Table 2.2.2 temperature limits under HI-TRAC transfer operations inside the part 50 structural boundary and outside of it. The three day average temperatures maybe computed from best available site data or based on local weather forecasts during scheduled periods of HI-TRAC movement or a suitably conservative method for bounding the three day average.

SUPPLEMENT 11.I

ACCIDENT EVALUATION FOR THE HI-STORM 100U SYSTEM

11.I.0 INTRODUCTION

This supplement is focused on the off-normal and accident condition evaluations of the HI-STORM 100U vertical ventilated module (VVM). Only those events that are actually affected by the design of the overpack are discussed in detail herein. The reader is referred to the main body of Chapter 11 for discussions of any off-normal or accident conditions that are not dependent on the design of the storage overpack (i.e., MPC-only or HI-TRAC events).

The evaluations described herein parallel those of the HI-STORM 100 overpack contained in the main body of Chapter 11 of this FSAR. To ensure readability, the sections in this supplement are numbered to be directly analogous to the sections in the main body of the chapter. For example, the fire accident evaluation presented in Supplement Subsection 11.I.2.4 for the HI-STORM 100U is analogous to the evaluation presented in Subsection 11.2.4 of the main body of Chapter 11 for the HI-STORM 100. Tables and figures (if any) in this supplement, however, are labeled sequentially by section. If there is an analogous table or figure in the main body of Chapter 11, an appropriate notation is made in the supplement table or figure.

11.I.1 OFF-NORMAL EVENTS

A general discussion of off-normal events is presented in Section 11.1 of the main body of Chapter 11. The following off-normal events are discussed in this supplement:

- Off-Normal Pressure
- Off-Normal Environmental Temperature
- Leakage of One MPC Seal Weld
- Partial Blockage of Air Inlets
- Off-Normal Handling of HI-TRAC Transfer Cask
- Malfunction of FHD System
- SCS Power Failure
- Off-Normal Wind
- HI-TRAC Off-Normal Ambient Temperatures

The results of the evaluations presented herein demonstrate that the HI-STORM 100U System can withstand the effects of off-normal events without affecting its ability to perform its intended function, and is in compliance with the applicable acceptance criteria.

11.I.1.1 Off-Normal Pressure

A discussion of this off-normal condition is presented in Subsection 11.1.1 of the main body of Chapter 11. A description of the cause of, detection of, corrective actions for and radiological impact of this event is presented therein.

Criticality

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

Confinement

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

Radiation Protection

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

Based on this evaluation, it is concluded that the specified off-normal wind event does not affect the safe operation of the HI-STORM 100U System. The HI-STORM 100U System is designed to withstand the off-normal wind without any effect on its ability to maintain safe storage conditions. There are no corrective actions required for the off-normal wind. The off-normal wind has no radiological impact, and the confinement barrier and shielding integrity are not affected.

11.1.1.9 HI-TRAC Off-Normal Ambient Temperature

A discussion of this off-normal condition is presented in Subsection 11.1.8 of the main body of Chapter 11. The discussion presented therein remains completely applicable as the design and method of operation of the HI-TRAC under the HI-STORM 100U is same as under the aboveground system.

11.1.2 ACCIDENT EVENTS

A general discussion of accident events is presented in Section 11.1 of the main body of Chapter 11. The following accident events are discussed in this supplement section:

- HI-TRAC Transfer Cask Handling Accident
- HI-STORM 100U Overpack Handling Accident
- Tip-Over
- Fire Accident
- Partial Blockage of MPC Basket Vent Holes
- Tornado
- Flood
- Earthquake
- 100% Fuel Rod Rupture
- Confinement Boundary Leakage
- Explosion
- Lightning

Structural

The structural evaluation of the MPC enclosure vessel for accident condition internal pressure bounds the pressure resulting from this event. Therefore, the resulting stresses from this event are bounded by the design-basis internal pressure and are well within the allowable values, as discussed in Section 3.4.

Thermal

Supplement 4.I calculates bounding temperatures for the HI-STORM 100U under the extreme environmental temperature condition. The calculated bounding temperatures and pressures are reported in Table 4.I.8 and are below the MPC and VVM accident temperature and pressure limits (Tables 2.2.3, 2.I.8 and 2.2.1).

Shielding

There is no effect on the shielding performance of the system as a result of this accident event, since the concrete temperature does not exceed the short-term temperature limit specified in Table 2.2.3.

Criticality

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

Confinement

There is no effect on the confinement function of the MPC as a result of this accident event. As discussed in the structural evaluation above, all stresses remain within allowable values, assuring confinement boundary integrity.

Radiation Protection

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

Based on this evaluation, it is concluded that the extreme environment temperature accident does not affect the safe operation of the HI-STORM 100U System.

11.I.2.16 Supplemental Cooling System (SCS) Failure

A discussion of this accident~~off-normal~~ condition is presented in Subsection 11.2.16 of the main body of Chapter 11. The discussion presented therein remains completely applicable, as the design and method of operation of the SCS and the HI-TRAC is unchanged for use with the HI-STORM 100U System.

11.1.2.17 Additional Hazards during Construction Proximate to the ISFSI

To protect an installed ISFSI from any site construction activity in its proximity, a certain minimum ground buffer distance beyond the edge of the perimeter of the VVM arrays ~~is prescribed in the licensing drawings~~shall be established. This distance, referred to as the Excavation Exclusion Zone (EEZ), is the minimum distance from the ISFSI where excavation can occur if a retaining wall was not installed at the ISFSI per the licensing drawing and Table 2.1.2. This distance is established based on soil conditions and the strength of the DBE as discussed in Section 3.I. If the user installs a retaining wall at or beyond the Radiation Protection Space (RPS) then the EEZ boundary is the retaining wall (see Section 2.I.2, item vi). If a retaining wall is not installed, the EEZ boundary for a site is established using the methodology described in Section 3.I.4.~~This radiation protection space (RPS) defines the no-construction zone around the installed and loaded VVMs (see Section 1.1.4).~~

As is required for deploying casks certified under 10CFR72, Subpart L, every site modification that may potentially impact the continued operability of the ISFSI must be evaluated for acceptability under 10CFR72.212. A generic evaluation of the shielding consequences of digging a cavity adjacent to the ~~radiation protection zone~~RPS has been considered in Supplement 5.I of this FSAR. The analyses show that the dose at the edge of the cavity is below 0.2 mrem/hr, which is well below the customary limit that requires radiation posting at nuclear power plants.

Subsection 2.I.4-6 considers loadings from extreme environmental phenomena assuming that a deep cavity at the edge of the RPS perimeter with a retaining wall has been created as a part of site construction work and an accidental mechanical loading event across such cavity is credible. Analyses summarized in Subsection 3.I.4 show that the design basis projectiles (large, medium, or small), specified in Chapter 2 of this FSAR, applied in the most vulnerable location of the construction cavity, will fail to reach the CEC.

In addition to the generic analyses documented in this FSAR to validate the sufficiency of the RPS boundary, analyses of the consequences of any credible site specific loads or events during site construction work shall be performed with due consideration of the duration and nature of the site construction activity. The user's §72.212 evaluation program, used in considering ISFSI-proximate activities at aboveground ISFSIs, shall apply to the HI-STORM 100U installation as well without limitation.

To summarize, as discussed in Supplement 2.I and documented in the licensing drawing package in Section 1.5, and the technical specifications; a ~~radiation protection space (~~RPS~~)~~ has been established per supplement 5.I with sufficient margin (ground buffer) against design basis projectiles analyzed in supplement 3.I. An EEZ shall be established within which excavation activities cannot be performed. If the retaining wall is present at or beyond the RPS the EEZ boundary is the located at the retaining wall. ~~As documented in t~~The ~~technical specifications, the~~ RPS boundary and EEZ shall not be encroached upon during any site construction activity (this includes excavation). In addition to the generic analyses documented in this FSAR, site specific evaluation pursuant to §72.212 shall be performed for all other credible hazards that can be

postulated during site construction. Administrative controls to guard against accidental human error in excavations (such as encroachment of the RPS) shall be addressed through written procedures consistent with the required controls needed for a safety significant activity within a Part 50 controlled area.

Subsection 2.I.2~~6~~(iv~~xii~~) also requires the ISFSI owner to perform a seismic analysis of the ISFSI for the instance when the maximum amount of excavation of the area adjacent to the ~~RPS~~ EEZ will exist to show that the RPS will not be encroached upon if a retaining wall is not used or be limited to excavation at a distance ten times the planned excavation depth from the ISFSI. The site's Design Basis Earthquake (DBE) will be used. PRA considerations shall not be used to diminish the strength of the seismic input. The Design Basis Seismic Model, described in 3.I.4, shall be used with appropriate representation of the construction cavity.

Because the actual projectiles for a specific ISFSI site are often different from the tornado borne missiles analyzed in Supplement 3.I herein, a site specific analysis of the effect of all credible missiles shall be performed assuming that the largest construction cavity adjacent to the ISFSI exists. PRA considerations shall not be used to rule out any missile that has been determined to be credible in the plant's FSAR.

Furthermore, the ISFSI owner shall implement ameliorative measures to prevent unacceptable damage to the ISFSI from any other credible adverse scenarios unique to a site that has not been considered in this FSAR. An example of such a measure is the installation of a berm to protect against environmental events such as soil erosion and mud slides. Such site specific design initiatives at any "100U" ISFSI, like its aboveground counterpart, are within the purview of the plant's §72.212 process.

U.S. NUCLEAR REGULATORY COMMISSION

CERTIFICATE OF COMPLIANCE FOR SPENT FUEL STORAGE CASKS

The U.S. Nuclear Regulatory Commission is issuing this Certificate of Compliance pursuant to Title 10 of the Code of Federal Regulations, Part 72, "Licensing Requirements for Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste" (10 CFR Part 72). This certificate is issued in accordance with 10 CFR 72.238, certifying that the storage design and contents described below meet the applicable safety standards set forth in 10 CFR Part 72, Subpart L, and on the basis of the Final Safety Analysis Report (FSAR) of the cask design. This certificate is conditional upon fulfilling the requirements of 10 CFR Part 72, as applicable, and the conditions specified below.

Certificate No.	Effective Date	Expiration Date	Docket No.	Amendment No.	Amendment Effective Date	Package Identification No.
1014	05/31/00	05/31/20	72-1014	~~8~~9	05/02/12	USA/72-1014

Issued To: (Name/Address)

Holtec International
Holtec Center
555 Lincoln Drive West
Marlton, NJ 08053

Safety Analysis Report Title

Holtec International Inc.,
Final Safety Analysis Report for the
HI-STORM 100 Cask System

CONDITIONS

This certificate is conditioned upon fulfilling the requirements of 10 CFR Part 72, as applicable, the attached Appendix A (Technical Specifications) and Appendix B (Approved Contents and Design Features) for aboveground systems or the attached Appendix A-100U (Technical Specifications) and Appendix B-100U (Approved Contents and Design Features) for underground systems, and the conditions specified below:

1. CASK

   a. Model No.: HI-STORM 100 Cask System

   The HI-STORM 100 Cask System (the cask) consists of the following components: (1) interchangeable multi-purpose canisters (MPCs), which contain the fuel; (2) a storage overpack (HI-STORM), which contains the MPC during storage; and (3) a transfer cask (HI-TRAC), which contains the MPC during loading, unloading and transfer operations. The cask stores up to 32 pressurized water reactor fuel assemblies or 68 boiling water reactor fuel assemblies.

   b. Description

   The HI-STORM 100 Cask System is certified as described in the Final Safety Analysis Report (FSAR) and in the U. S. Nuclear Regulatory Commission's (NRC) Safety Evaluation Report (SER) accompanying the Certificate of Compliance. The cask comprises three discrete components: the MPC, the HI-TRAC transfer cask, and the HI-STORM storage overpack.

   The MPC is the confinement system for the stored fuel. It is a welded, cylindrical canister with a honeycombed fuel basket, a baseplate, a lid, a closure ring, and the canister shell. All MPC components that may come into contact with spent fuel pool water or the ambient environment are made entirely of stainless steel or passivated aluminum/aluminum alloys such as the neutron absorbers. The canister shell, baseplate, lid, vent and drain port cover plates, and closure ring are the main confinement boundary components. All confinement boundary components are made entirely of stainless steel. The honeycombed basket, which contains neutron absorbing material, provides criticality control.

1. b. Description (continued)

There are nine models of MPCs: the MPC-24, MPC-24E, MPC-24EF, MPC-32, MPC-32F, MPC-68, MPC-68F, MPC-68FF, and MPC-68M. The number suffix indicates the maximum number of fuel assemblies permitted to be loaded in the MPC. All nine MPC models have the same external diameter.

The HI-TRAC transfer cask provides shielding and structural protection of the MPC during loading, unloading, and movement of the MPC from the spent fuel pool to the storage overpack. The transfer cask is a multi-walled (carbon steel/lead/carbon steel) cylindrical vessel with a neutron shield jacket attached to the exterior. Two sizes of HI-TRAC transfer casks are available: the 125 ton HI-TRAC and the 100 ton HI-TRAC. The weight designation indicates ~~is~~ the approximate weight of a loaded transfer cask during any loading, unloading, or transfer operation. Both transfer cask sizes have identical cavity diameters. The 125 ton HI-TRAC transfer cask has thicker shielding and larger outer dimensions than the 100 ton HI-TRAC transfer cask.

Above Ground Systems

The HI-STORM 100 or 100S storage overpack provides shielding and structural protection of the MPC during storage. The HI-STORM 100S is a variation of the HI-STORM 100 overpack design that includes a modified lid which incorporates the air outlet ducts into the lid, allowing the overpack body to be shortened. The overpack is a heavy-walled steel and concrete, cylindrical vessel. Its side wall consists of plain (un-reinforced) concrete that is enclosed between inner and outer carbon steel shells. The overpack has four air inlets at the bottom and four air outlets at the top to allow air to circulate naturally through the cavity to cool the MPC inside. The inner shell has supports attached to its interior surface to guide the MPC during insertion and removal, provide a medium to absorb impact loads, and allow cooling air to circulate through the overpack. A loaded MPC is stored within the HI-STORM 100 or 100S storage overpack in a vertical orientation. The HI-STORM 100A and 100SA are variants of the HI-STORM 100 family and are outfitted with an extended baseplate and gussets to enable the overpack to be anchored to the concrete storage pad in high seismic applications.

Underground Systems

The HI-STORM 100U System is an underground storage system identified with the HI-STORM 100 Cask System. The HI-STORM 100U storage Vertical Ventilated Module (VVM) utilizes a storage design identified as an air-cooled vault or caisson. The HI-STORM 100U storage VVM relies on vertical ventilation instead of conduction through the soil, as it is essentially a below-grade storage cavity. Air inlets and outlets allow air to circulate naturally through the cavity to cool the MPC inside. The subterranean steel structure is seal welded to prevent ingress of any groundwater from the surrounding subgrade, and it is mounted on a stiff foundation. The surrounding subgrade and a top surface pad provide significant radiation shielding. A loaded MPC is stored within the HI-STORM 100U storage VVM in the vertical orientation.

2. OPERATING PROCEDURES

Written operating procedures shall be prepared for cask handling, loading, movement, surveillance, and maintenance. The user's site-specific written operating procedures shall be consistent with the technical basis described in Chapter 8 of the FSAR.

3. ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

Written cask acceptance tests and maintenance program shall be prepared consistent with the technical basis described in Chapter 9 of the FSAR. At completion of welding the MPC shell to baseplate, an MPC confinement weld helium leak test shall be performed using a helium mass spectrometer. This test shall include the base metals of the MPC shell and baseplate. A helium leak test shall also be performed on the base metal of the fabricated MPC lid. In the field, a helium leak test shall be performed on the vent and drain port confinement welds and cover plate base metal. The confinement boundary leakage rate tests shall be performed in accordance with ANSI N14.5 to "leak-tight" criteria. If a leakage rate exceeding the acceptance criteria is detected, then the area of leakage shall be determined and the area repaired per ASME Code Section III, Subsection NB requirements. Re-testing shall be performed until the leakage rate acceptance criterion is met.

4. QUALITY ASSURANCE

Activities in the areas of design, purchase, fabrication, assembly, inspection, testing, operation, maintenance, repair, modification of structures, systems and components, and decommissioning that are important to safety shall be conducted in accordance with a Commission-approved quality assurance program which satisfies the applicable requirements of 10 CFR Part 72, Subpart G, and which is established, maintained, and executed with regard to the cask system

5. HEAVY LOADS REQUIREMENTS

Each lift of an MPC, a HI-TRAC transfer cask, or any HI-STORM overpack must be made in accordance to the existing heavy loads requirements and procedures of the licensed facility at which the lift is made. A plant-specific review (under 10 CFR 50.59 or 10 CFR 72.48, if applicable) is required to show operational compliance with existing plant specific heavy loads requirements. Lifting operations outside of structures governed by 10 CFR Part 50 must be in accordance with Section 5.5 of Appendix A and Sections 3.4.6 and 3.5 of Appendix B, for above ground systems, section 5.5 of Appendix A-100U for the underground systems.

6. APPROVED CONTENTS

Contents of the HI-STORM 100 Cask System must meet the fuel specifications given in Appendices B for aboveground systems or B-100U for underground systems to this certificate.

7. DESIGN FEATURES

Features or characteristics for the site, cask or ancillary equipment must be in accordance with Appendices B for aboveground systems or B-100U for underground systems to this certificate.

8. CHANGES TO THE CERTIFICATE OF COMPLIANCE

The holder of this certificate who desires to make changes to the certificate, which includes Appendices A and A-100U (Technical Specifications) and Appendices B and B-100U (Approved Contents and Design Features), shall submit an application for amendment of the certificate.

9. SPECIAL REQUIREMENTS FOR FIRST SYSTEMS IN PLACE

The air mass flow rate through the cask system will be determined by direct measurements of air velocity in the overpack cooling passages for the first HI-STORM Cask Systems placed into service by any user with an aggregate heat load equal to or greater than 20 kW. In the aboveground HI-STORM Models (HI-STORM 100, 100S, etc.), the velocity will be measured in the annulus formed between the MPC shell and the overpack inner shell. In the underground HI-STORM Model (HI-STORM 100U), the velocity will be measured in the vertical downcomer air passage. An analysis shall be performed that demonstrates the measurements validate the analytic methods and thermal performance predicted by the licensing-basis thermal models in Chapter 4 of the FSAR.

Each first time user of a cask supplemental cooling system (SCS) which has not been previously tested and documented with the NRC shall measure and record coolant temperatures for the inlet and outlet of cooling provided to the annulus between the HI-TRAC and MPC and the coolant flow rate. (Not applicable to the MPC-68M). The user shall also record the MPC operating pressure and decay heat. An analysis shall be performed, using this information that validates the thermal methods described in the FSAR which were used to determine the type and amount of supplemental cooling necessary.

Letter reports summarizing the results of each thermal validation tests and SCS validation test and analysis shall be submitted to the NRC in accordance with 10 CFR 72.4. Cask users may satisfy these requirements by referencing validation test reports submitted to the NRC by other cask users.

10. PRE-OPERATIONAL TESTING AND TRAINING EXERCISE

A dry run training exercise of the loading, closure, handling, unloading, and transfer of the HI-STORM 100 Cask System shall be conducted by the licensee prior to the first use of the system to load spent fuel assemblies. The training exercise shall not be conducted with spent fuel in the MPC. The dry run may be performed in an alternate step sequence from the actual procedures, but all steps must be performed. The dry run shall include, but is not limited to the following:

a. Moving the MPC and the transfer cask into the spent fuel pool or cask loading pool.

b. Preparation of the HI-STORM 100 Cask System for fuel loading.

c. Selection and verification of specific fuel assemblies to ensure type conformance.

d. Loading specific assemblies and placing assemblies into the MPC (using a dummy fuel assembly), including appropriate independent verification.

e. Remote installation of the MPC lid and removal of the MPC and transfer cask from the spent fuel pool or cask loading pool.

f. MPC welding, NDE inspections, pressure testing, draining, moisture removal (by vacuum drying or forced helium dehydration, as applicable), and helium backfilling. (A mockup may be used for this dry-run exercise.)

g. Operation of the HI-STORM 100 SCS or equivalent system, if applicable.

h. Transfer cask upending/downending on the horizontal transfer trailer or other transfer device, as applicable to the site's cask handling arrangement.

i. Transfer of the MPC from the transfer cask to the overpack/VVM.

j. Placement of the HI-STORM 100 Cask System at the ISFSI, for aboveground systems only.

k. HI-STORM 100 Cask System unloading, including flooding MPC cavity, removing MPC lid welds. (A mockup may be used for this dry-run exercise.)

11. The NRC has approved an exemption request by the CoC applicant from the requirements of 10 CFR 72.236(f), to allow a Supplemental Cooling System to provide for decay heat removal in accordance with Section 3.1.4 of Appendices A and A-100U.

12. AUTHORIZATION

The HI-STORM 100 Cask System, which is authorized by this certificate, is hereby approved for general use by holders of 10 CFR Part 50 licenses for nuclear reactors at reactor sites under the general license issued pursuant to 10 CFR 72.210, subject to the conditions specified by 10 CFR 72.212, this certificate, and the attached Appendices A, B, A-100U, and B-100U, as applicable. The HI-STORM 100 Cask System may be fabricated and used in accordance with any approved amendment to CoC No. 1014 listed in 10 CFR 72.214. Each of the licensed HI-STORM 100 System components (i.e., the MPC, overpack, and transfer cask), if fabricated in accordance with any of the approved CoC Amendments, may be used with one another provided an assessment is performed by the CoC holder that demonstrates design compatibility.

FOR THE U. S. NUCLEAR REGULATORY COMMISSION

TBD, Chief
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards
Washington, DC 20555

Dated TBD

Attachments:
1. Appendix A
2. Appendix B
3. Appendix A-100U
4. Appendix B-100U

TABLE OF CONTENTS

| 3.0.1 SURVEILLANCE REQUIREMENT (SR) APPLICABILITY

SR 3.0.3 (continued)	When the Surveillance is performed within the delay period and the Surveillance is not met, the LCO must immediately be declared not met, and the applicable Condition(s) must be entered.
SR 3.0.4	Entry into a specified condition in the Applicability of an LCO shall not be made unless the LCO's Surveillances have been met within their specified Frequency. This provision shall not prevent entry into specified conditions in the Applicability that are required to comply with Actions or that are related to the unloading of an SFSC.

3.1 SFSC INTEGRITY

3.1.1 Multi-Purpose Canister (MPC)

LCO 3.1.1 The MPC shall be dry and helium filled.

Table 3-1 provides decay heat and burnup limits for forced helium dehydration (FHD) and vacuum drying. FHD is not subject to time limits. Vacuum drying of the MPC-68M is not subject to time limits. Vacuum drying, for all other MPCs, is subject to the following time limits, from the end of bulk water removal until the start of helium backfill:

MPC Total Decay Heat (Q) (Note 1)	Vacuum Drying Time Limit
Q ≤ ~~23~~ 26 kW	None
~~23~~ 26 kW < Q ≤ ~~28.74~~30 kW	40 hours
Q > ~~28.74~~30 kW	Not Permitted (see Table 3-1)

Note 1: Maximum storage cell heat load must not exceed MPC heat load limits in the table divided by number of storage cells.

APPLICABILITY: During TRANSPORT OPERATIONS and STORAGE OPERATIONS.

ACTIONS

--NOTES--

Separate Condition entry is allowed for each MPC.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. MPC cavity vacuum drying pressure or demoisturizer exit gas temperature limit not met.	A.1 Perform an engineering evaluation to determine the quantity of moisture left in the MPC.	7 days
	<u>AND</u>	
	A.2 Develop and initiate corrective actions necessary to return the MPC to compliance with Table 3-1.	30 days

3.1 SFSC INTEGRITY

3.1.2 SFSC Heat Removal System

LCO 3.1.2 The SFSC Heat Removal System shall be operable

---NOTE---
The SFSC Heat Removal System is operable when 50% or more of the inlet and outlet vent areas are unblocked and available for flow or when air temperature requirements are met.

APPLICABILITY: During STORAGE OPERATIONS.

ACTIONS

---NOTE---
Separate Condition entry is allowed for each SFSC.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. SFSC Heat Removal System operable, but partially (<50%) blocked.	A.1 Remove blockage.	N/A
B. SFSC Heat Removal System inoperable.	B.1 Restore SFSC Heat Removal System to operable status.	8 hours
C. Required Action B.1 and associated Completion Time not met.	C.1 Measure SFSC dose rates in accordance with the Radiation Protection Program.	Immediately and once per 12 hours thereafter
	<u>AND</u>	
	C.2.1 Restore SFSC Heat Removal System to operable status.	64 hours (Storage cell~~MPC~~ heat loads ≤ Tables 3-3 or 3-4 limits~~28.74 kW~~) 24 hours (Storage cell~~MPC~~ heat loads > Tables 3-3 or 3-4 limits~~28.74 kW~~)
	<u>OR</u>	

CONDITION	REQUIRED ACTION	COMPLETION TIME
	C.2.2 Transfer the MPC into a TRANSFER CASK.	64 hours (Storage cell~~MPC~~ heat loads ≤ Tables 3-3 or 3-4 limits~~28.74 kW~~) 24 hours (Storage cell~~MPC~~ heat loads > Tables 3-3 or 3-4 limits~~28.74 kW~~)

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.2	Verify all OVERPACK inlets and outlets are free of blockage from solid debris or floodwater.	24 hours
	<u>OR</u> For OVERPACKS with installed temperature monitoring equipment, verify that the difference between the average OVERPACK air outlet temperature and ISFSI ambient temperature is ≤ 155°F for OVERPACKS containing PWR MPCs, ≤ 137°F for OVERPACKS containing BWR MPCs.	24 hours

3.1 SFSC INTEGRITY

3.1.4 Supplemental Cooling System

LCO 3.1.4 A supplemental cooling system (SCS) shall be operable

---NOTE---
Upon reaching steady state operation, the SCS may be temporarily disabled for a short duration (≤ 7 hours) to facilitate necessary operational evolutions, such as movement of the TRANSFER CASK through a door way, or other similar operation.

APPLICABILITY: This LCO is not applicable to the MPC-68M. For all other MPCs this LCO is applicable when the loaded MPC is in the TRANSFER CASK and:

a. Within 4 hours of the completion of MPC drying operations in accordance with LCO 3.1.1 or within 4 hours of transferring the MPC into the TRANSFER CASK if the MPC is to be unloaded

AND

b~~1~~. The MPC contains one or more fuel assemblies with an average burnup > 45,000 MWD/MTU

AND ~~OR~~

c1~~b2~~. ~~The MPC~~ MPC backfilled to higher helium backfill limits in Table 3-2 AND any storage cell decay heat load exceeds ~~28.74 kW~~90% of maximum allowable~~design basis~~ storage cell heat load defined in Appendix B, Section 2.4.1 or 2.4.2 and FSAR Section 2.1.9.1 procedures.

OR

c2. MPC backfilled to lower helium backfill limits in Table 3-2 AND any storage cell heat load exceeds 90% of storage cell heat load limits defined in Tables 3-3 or 3-4.

Table 3-1
MPC Cavity Drying Limits (Note 3)

Fuel Burnup (MWD/MTU)	MPC Heat Load (kW)	Method of Moisture Removal (Notes 1 and 2)
All Assemblies ≤ 45,000	≤ ~~28.74~~30[Note 5] (MPC-24/24E/24EF, MPC-32/32F, MPC-68/68F/68FF) ≤ 36.9[Note 6] (MPC-68M)	VDS or FHD
All Assemblies ≤ 45,000	> ~~28.74~~30[Note 5] (MPC-24/24E/24EF, MPC-32/32F, MPC-68/68F/68FF)	FHD
One or more assemblies > 45,000	≤ 29 (MPC-68M)	VDS (Note 4) or FHD
One or more assemblies > 45,000	≤ 36.9[Note 6] (MPC-24/24E/24EF~~/)~~ ~~≤ 36.9 (~~MPC-32/32F~~/)~~ ~~≤ 36.9 (~~MPC-68/68F/68FF~~/)~~ ~~≤36.9 (~~MPC-68M)	FHD

Notes:

1. VDS means a vacuum drying system. The acceptance criterion when using a VDS is MPC cavity pressure shall be ≤ 3 torr for ≥ 30 minutes.

2. FHD means a forced helium dehydration system. The acceptance criterion when using an FHD system is the gas temperature exiting the demoisturizer shall be ≤ 21°F for ≥ 30 minutes or the gas dew point exiting the MPC shall be ≤ 22.9°F for ≥ 30 minutes.

3. ~~For total decay heat loads up to and including 20.88 kW for the MPC-24 and 21.52 kW for the MPC-68, v~~Vacuum drying of the MPC must be performed with the annular gap between the MPC and the HI-TRAC filled with water. ~~For higher total decay heat loads in the MPC-24 and MPC-68 or for any decay heat load in an MPC-24E or MPC-32, the annular gap must be continuously flushed with water with sufficient flow to keep the exit water temperature below 125°F. For total decay heat loads up to and including 36.9 kW for the MPC-68M, vacuum drying of the MPC, when permitted as described above, must be performed with the annular gap between the MPC and HI-TRAC filled with water.~~
4. The maximum allowable decay heat per fuel storage location is 0.426 kW.

5. Maximum allowable storage cell heat load is 1.25 kW (MPC-24/24E/24EF), 0.937 kW (MC-32/32F) and 0.441 kW (MPC-68/68F/68FF).

6. Maximum allowable heat loads under uniform or regionalized storage defined in Appendix B, Section 2.4.1 or 2.4.2.

Table 3-2
MPC Helium Backfill Limits[1]

MPC MODEL	LIMIT
MPC-24/24E/24EF	
i. Cask Heat Load ≤ 27.77 kW (MPC-24) or ≤ 28.17 kW (MPC-24E/EF) - uniformly distributed per Table 3-4 or regionalized loading per Table 3-3	0.1212 +/-10% g-moles/l <u>OR</u> ≥ 29.3 psig and ≤ 48.5 psig
ii. Cask Heat Load >27.77 kW (MPC-24) or > 28.17 kW (MPC-24E/EF) - uniformly distributed -or greater than regionalized heat load limits per Table 3-3	≥ 45.5 psig and ≤ 48.5 psig
MPC-68/68F/68FF/68M	
i. Cask Heat Load ≤ 28.19 kW - uniformly distributed per Table 3-4 or regionalized loading per Table 3-3	0.1218 +/-10% g-moles/l <u>OR</u> ≥ 29.3 psig and ≤ 48.5 psig
ii. Cask Heat Load > 28.19 kW - uniformly distributed or greater than regionalized heat load limits per Table 3-3	≥ 45.5 psig and ≤ 48.5 psig
MPC-32/32F	
i. Cask Heat Load ≤ 28.74 kW - uniformly distributed per Table 3-4 or regionalized leading per Table 3-3	≥ 29.3 psig and ≤ 48.5 psig
ii. Cask Heat Load >28.74 kW - uniformly distributed or greater than regionalized heat load limits per Table 3-3	≥ 45.5 psig and≤ 48.5 psig

[1] Helium used for backfill of MPC shall have a purity of ≥ 99.995%. Pressure range is at a reference temperature of 70°F

Table 3-3: Regionalized Storage[Note 2] Cell Heat Load Limits

MPC Type	Number of Cells in Inner Region[Note 1]	Storage Cell Heat Load (Inner Region) (kW)	Number of Cells in Outer Region[Note 1]	Storage Cell Heat Load (Outer Region) (kW)
MPC-24	4	1.470	20	0.900
MPC-24E/EF	4	1.540	20	0.900
MPC-32/32F	12	1.131	20	0.600
MPC-68/68F/68FF	32	0.500	36	0.275

Note 1: The location of MPC-32 and MPC-68 inner and outer region cells are defined in Appendix B Figures 2.1-3 and 2.1-4 respectively.
The MPC-24 and MPC-24E/EF cell locations are defined below:
Inner Region Cell numbers 9,10,15, 16 in Appendix B Figures 2.1-1 and 2.1-2 respectively.
Outer Region Cell numbers 1-8,11-14,17-24
in Appendix B Figures 2.1-1 and 2.1-2 respectively.

Note 2: The storage cell regionalization is defined in Note 1 in accordance with safety analyses under the heat load limits of this Table.

Table 3-4: Uniform Storage Cell Heat Load Limits

MPC Type	Heat Load (kW)
MPC-24	1.157
MPC-24E/EF	1.173
MPC-68/68F/68FF	0.414
MPC-32	0.898

TABLE OF CONTENTS

3.1 SFSC INTEGRITY

3.1.1 Multi-Purpose Canister (MPC)

LCO 3.1.1 The MPC shall be dry and helium filled.

Table 3-1 provides decay heat and burnup limits for forced helium dehydration (FHD) and vacuum drying. FHD is not subject to time limits. Vacuum drying is subject to the following time limits, from the end of bulk water removal until the start of helium backfill:

MPC Total Decay Heat (Q) (Note 1)	Vacuum Drying Time Limit
Q ≤ ~~23~~ 26 kW	None
~~23~~ 26 kW < Q ≤ ~~28.74~~ 30 kW	40 hours
Q > ~~28.74~~ 30 kW	Not Permitted (see Table 3-1)

Note 1: Maximum storage cell heat load must not exceed MPC heat load limits in the table divided by number of storage cells.

APPLICABILITY: During TRANSPORT OPERATIONS and STORAGE OPERATIONS.

ACTIONS

---NOTES---

Separate Condition entry is allowed for each MPC.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. MPC cavity vacuum drying pressure or demoisturizer exit gas temperature limit not met.	A.1 Perform an engineering evaluation to determine the quantity of moisture left in the MPC.	7 days
	<u>AND</u>	
	A.2 Develop and initiate corrective actions necessary to return the MPC to compliance with Table 3-1.	30 days

3.1 SFSC INTEGRITY

3.1.4 Supplemental Cooling System

LCO 3.1.4 A supplemental cooling system (SCS) shall be operable

---NOTE---
Upon reaching steady state operation, the SCS may be temporarily disabled for a short duration (≤ 7 hours) to facilitate necessary operational evolutions, such as movement of the TRANSFER CASK through a door way, or other similar operation.

APPLICABILITY: This LCO is applicable when the loaded MPC is in the TRANSFER CASK and:

a. Within 4 hours of the completion of MPC drying operations in accordance with LCO 3.1.1 or within 4 hours of transferring the MPC into the TRANSFER CASK if the MPC is to be unloaded

AND

b~~1~~. The MPC contains one or more fuel assemblies with an average burnup > 45,000 MWD/MTU

AND ~~OR~~

c1~~b2~~. ~~The MPC~~MPC backfilled to higher helium backfill limits in Table 3-2 AND any storage cell decay heat load exceeds ~~28.74 kW~~90% of maximum allowable~~design basis~~ storage cell heat load defined in Appendix B, Section 2.4.1 or 2.4.2 and FSAR Section 2.1.9.1 procedures.

OR

c2. MPC backfilled to lower helium backfill limits in Table 3-2 AND any storage cell heat load exceeds 90% of storage cell heat load limits defined in Tables 3-3 or 3-4.

Table 3-1
MPC Cavity Drying Limits

Fuel Burnup (MWD/MTU)	MPC Heat Load (kW)	Method of Moisture Removal (Notes 1 and 2)
All Assemblies ≤ 45,000	≤ ~~29~~ 30[Note 4] (MPC-24/24E/EF/32/32F/68/68F/68FF) ~~≤ 26 30 (MPC-32)~~ ~~≤ 26 30 (MPC-68)~~	VDS or FHD
All Assemblies ≤ 45,000	> ~~29~~ 30[Note 4] (MPC-24/24E/24EF/~~)~~ ~~≥ 26~~ MPC-32/32F/~~)~~ > ~~26~~ MPC-68/68F/68FF)	FHD
One or more assemblies > 45,000	≤ 36.9 (MPC-24/24E/24EF/32/32F/68/68F/68FF)[Note 5]	FHD

Notes:

1. VDS means a vacuum drying system. The acceptance criterion when using a VDS is the MPC cavity pressure shall be ≤ 3 torr for ≥ 30 minutes.
2. FHD means a forced helium dehydration system. The acceptance criterion when using an FHD System is the gas temperature exiting the demoisturizer shall be ≤ 21°F for ≥ 30 minutes or the gas dew point exiting the MPC shall be ≤ 22.9°F for ≥ 30 minutes.
3. ~~For total decay heat loads up to and including 20.88 kW for the MPC-24 and 21.52 kW for the MPC-68, v~~Vacuum drying of the MPC must be performed with the annular gap between the MPC and the HI-TRAC filled with water~~. For higher total decay heat loads in the MPC-24 and MPC-68 or for any decay heat load in an MPC-24E or MPC-32, the annular gap must be continuously flushed with water with sufficient flow to keep the exit water temperature below 125°F~~.
4. Maximum allowable storage cell heat load is 1.25 kW (MPC-24/24E/24EF), 0.937 kW (MC-32/32F) and 0.441 kW (MPC-68/68F/68FF).
5. Maximum allowable heat loads under uniform or regionalized storage defined in Appendix B, Section 2.4.1 or 2.4.2.

Table 3-2
MPC Helium Backfill Limits[1]

MPC MODEL	LIMIT
MPC-24/24E	
i. Cask Heat Load ≤ 27.77 kW (MPC-24) or ≤ 28.17 kW (MPC-24E) - uniformly distributed per Table 3-4 or regionalized loading per Table 3-3	0.1212 +/-10% g-moles/l <u>OR</u> ≥ 29.3 psig and ≤ 48.5 psig
ii. Cask Heat Load >27.77 kW (MPC-24) or > 28.17 kW (MPC-24E) - uniformly distributed or greater than regionalized heat load limits per Table 3-3	≥ 45.5 psig and ≤ 48.5 psig
MPC-32	
i. Cask Heat Load ≤ 28.74 kW – uniformly distributed per Table 3-4 or regionalized loading per Table 3-3	≥ 29.3 psig and ≤ 48.5 psig
ii. Cask Heat Load >28.74 kW – uniformly distributed or greater than regionalized heat load limits per Table 3-3	≥ 45.5 psig and ≤ 48.5 psig
MPC-68	
i. Cask Heat Load ≤ 28.19 kW - uniformly distributed per Table 3-4 or regionalized loading per Table 3-3	0.1218 +/-10% g-moles/l <u>OR</u> ≥ 29.3 psig and ≤ 48.5 psig
ii. Cask Heat Load > 28.19 kW – uniformly distributed or greater than regionalized heat load limits per Table 3-3	> 45.5 psig and < 48.5 psig

1 Helium used for backfill of MPC shall have a purity of ≥ 99.995%. Pressure range is at a reference temperature of 70°F

Table 3-3: Regionalized Storage[Note 2] Cell Heat Load Limits

MPC Type	Number of Cells in inner Region[Note 1]	Storage Cell Heat Load (Inner Region) (kW)	Number of Cells in Outer Region[Note 1]	Storage Cell Heat Load (Outer Region) (kW)
MPC-24	4	1.470	20	0.900
MPC-24E/EF	4	1.540	20	0.900
MPC-32/32F	12	1.131	20	0.600
MPC-68/68F/68FF	32	0.500	36	0.275

Note 1: The location of MPC-32/32F and MPC-68/68F/68FF inner and outer region cells are defined in Appendix B Figures 2.1-3 and 2.1-4 respectively.
The MPC-24 and MPC-24E/24EF cell locations are defined below:
<u>Inner Region</u> Cell numbers 9,10,15,16 in Appendix B Figures 2.1-1 and 2.1-2 respectively.
<u>Outer Region</u> Cell numbers 1-8,11-14,17-24
in Appendix B Figures 2.1-1 and 2.1-2 respectively.

Note 2: The storage cell regionalization is defined in Note 1 in accordance with safety analyses under the heat load limits of this Table.

Table 3-4: Uniform Storage Cell Heat Load Limits

MPC Type	Heat Load (kW)
MPC-24	1.157
MPC-24E/EF	1.173
MPC-68/68F/68FF	0.414
MPC-32/32F	0.898

TABLE OF CONTENTS

3.4 Site-Specific Parameters and Analyses (continued)

7. In cases where engineered features (i.e., berms and shield walls) are used to ensure that the requirements of 10CFR72.104(a) are met, such features are to be considered important to safety and must be evaluated to determine the applicable quality assurance category.

8. LOADING OPERATIONS, TRANSPORT OPERATIONS, and UNLOADING OPERATIONS shall only be conducted with working area ambient temperatures ≥ 0° F.

9. For those users whose site-specific design basis includes an event or events (e.g., flood) that result in the blockage of any OVERPACK inlet or outlet air ducts for an extended period of time (i.e, longer than the total Completion Time of LCO 3.1.2), an analysis or evaluation may be performed to demonstrate adequate heat removal is available for the duration of the event. Adequate heat removal is defined as fuel cladding temperatures remaining below the short term temperature limit. If the analysis or evaluation is not performed, or if fuel cladding temperature limits are unable to be demonstrated by analysis or evaluation to remain below the short term temperature limit for the duration of the event, provisions shall be established to provide alternate means of cooling to accomplish this objective.

10. Users shall establish procedural and/or mechanical barriers to ensure that during LOADING OPERATIONS and UNLOADING OPERATIONS, either the fuel cladding is covered by water, or the MPC is filled with an inert gas.

11. Site ambient temperature under HI-TRAC TRANSPORT OPERATIONS shall be evaluated in accordance with Section 3.9 requirements.

(continued)

3.7 Supplemental Cooling System

3.7.1 System Description

A supplemental cooling system (SCS) is an external system for cooling the MPC inside the HI-TRAC transfer cask during on-site transport. Use of an SCS for MPC-68M is not required. Use of an SCS is required for post-backfill HI-TRAC operations of an MPC containing one or more high burnup (> 45,000 MWD/MTU) fuel assemblies ~~or~~ and ~~MPC~~ storage cell withs heat loads in excess of ~~28.74kW~~90% of maximum permissible~~design basis~~ storage cell heat loads defined in ~~Appendix B,~~ Section 2.4.~~2~~ under higher helium backfill limits in Table 3-2 of Appendix A or 90% of heat load limits in Tables 3-3 or 3-4 of Appendix A under lower helium backfill limits in Table 3-2 of Appendix A.- The SCS shall be designed for normal operation (i.e., excluding startup and shutdown ramps) in accordance with the criteria in Section 3.7.2.

3.7.2 Design Criteria

3.7.2.1 Not Used.

3.7.2.2 If water is used as the coolant, the system shall be sized to limit the coolant temperature to below 180°F under steady-state conditions for the design basis heat load at an ambient air temperature of 11~~0~~0°F. Any electric motors shall have a backup power supply for uninterrupted operation.

3.7.2.3 The system shall utilize a contamination-free fluid medium in contact with the external surfaces of the MPC and inside surfaces of the HI -TRAC transfer cask to minimize corrosion.

3.7.2.4 All passive components such as tubular heat exchangers, manually operated valves and fittings shall be designed to applicable standards (TEMA, ANSI).

3.7.2.5 The heat dissipation capacity of the SCS shall be equal to or greater than the minimum necessary to ensure that the peak cladding temperature is below 400°C (752°F). All heat transfer surfaces in heat exchangers shall be assumed to be fouled to the maximum limits specified in a widely used heat exchange equipment standard such as the Standards of Tubular Exchanger Manufacturers Association.

3.7.2.6 The coolant utilized to extract heat from the MPC shall be high purity water or air. Antifreeze may be used to prevent water from freezing if warranted by operating conditions. (continued)

DESIGN FEATURES (continued)

3.8 Combustible Gas Monitoring During MPC Lid Welding and Cutting

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

3.9 Environmental Temperature Requirements

Short term operations involving the HI-TRAC transfer cask can be carried out on the basis of the safety evaluation in the FSAR if the reference ambient temperature (three day average around the cask) is below the "Threshold Temperature" defined in the FSAR. The "threshold temperature" is defined in FSAR Table 2.2.2 as 110 deg. F ambient temperature applicable during HI-TRAC transfer operations inside the part 50 structural boundary and 90 deg. F outside of it. The determination of the Threshold Temperature compliance shall be made based on the best available thermal data for the site.

If the reference ambient temperature exceeds the corresponding Threshold Temperature then a site specific analysis using the methodology set down in Section 4.5 of the FSAR shall be performed using the actual heat load and reference ambient temperature equal to the three day average to ensure that the steady state peak fuel cladding temperature will remain below the FSAR Table 2.2.3 limit. If the peak fuel cladding temperature exceeds Table 2.2.3 limit then the operation of a Supplemental Cooling System (SCS) in accordance with LCO 3.1.4 is mandatory.

SCS operation is mandatory if site data is not available or if a user elects to deploy Supplemental Cooling in lieu of site ambient temperature evaluation.

TABLE OF CONTENTS

DESIGN FEATURES (continued)

3.7 Supplemental Cooling System

3.7.1 System Description

A supplemental cooling system (SCS) is a water circulation system for cooling the MPC inside the HI-TRAC transfer cask during on-site transport. Use of an SCS is required for post-backfill HI-TRAC operations of an MPC containing one or more high burnup (> 45,000 MWD/MTU) fuel assemblies andor MPC storage cell withs heat loads in excess of 90% of maximum permissible storage cell -heat loads defined in FSAR Section 2.1.9.Appendix B, Section 2.4.2 under higher helium backfill limits in Table 3-2 of Appendix A or 90% of heat load limits in Tables 3-3 or 3-4 of Appendix A under lower helium backfill limits in Table 3-2 of Appendix A128.74 kW.- The SCS shall be designed for normal operation (i.e., excluding startup and shutdown ramps) in accordance with the criteria in Section 3.7.2.

3.7.2 Design Criteria

3.7.2.1 Not Used.

3.7.2.2 If water is used as the coolant, the system shall be sized to limit the coolant temperature to below 180°F under steady-state conditions for the design basis heat load at an ambient air temperature of 1100°F. Any electric motors shall have a backup power supply for uninterrupted operation.

3.7.2.3 The system shall utilize a contamination-free fluid medium in contact with the external surfaces of the MPC and inside surfaces of the HI -TRAC transfer cask to minimize corrosion.

3.7.2.4 All passive components such as tubular heat exchangers, manually operated valves and fittings shall be designed to applicable standards (TEMA, ANSI).

3.7.2.5 The heat dissipation capacity of the SCS shall be equal to or greater than the minimum necessary to ensure that the peak cladding temperature is below 400°C (752°F). All heat transfer surfaces in heat exchangers shall be assumed to be fouled to the maximum limits specified in a widely used heat exchange equipment standard such as the Standards of Tubular Exchanger Manufacturers Association.

3.7.2.6 The coolant utilized to extract heat from the MPC shall be high purity water or air. Antifreeze may be used to prevent water from freezing if warranted by operating conditions.

3.11 Environmental Temperature Requirements

Short term operations involving the HI-TRAC transfer cask can be carried out on the basis of the safety evaluation in the FSAR if the reference ambient temperature (three day average around the cask) is below the "Threshold Temperature" defined in the FSAR. The "threshold temperature" is defined in FSAR Table 2.2.2 as 110 deg. F ambient temperature applicable during HI-TRAC transfer operations inside the part 50 structural boundary and 90 deg. F outside of it. The determination of the Threshold Temperature compliance shall be made based on the best available thermal data for the site.

If the reference ambient temperature exceeds the corresponding Threshold Temperature then a site specific analysis using the methodology set down in Section 4.5 of the FSAR shall be performed using the actual heat load and reference ambient temperature equal to the three day average to ensure that the steady state peak fuel cladding temperature will remain below the FSAR Table 2.2.3 limit. If the peak fuel cladding temperature exceeds Table 2.2.3 limit then the operation of a Supplemental Cooling System (SCS) in accordance with LCO 3.1.4 is mandatory.

SCS operation is mandatory if site data is not available or if a user elects to deploy Supplemental Cooling in lieu of site ambient temperature evaluation.

AFFIDAVIT PURSUANT TO 10 CFR 2.390

I, P. Stefan Anton, being duly sworn, depose and state as follows:

(1) I have reviewed the information described in paragraph (2) which is sought to be withheld, and am authorized to apply for its withholding.

(2) The information sought to be withheld are Attachments 9 and 10 to Holtec Letter 5014750, which contain Holtec Proprietary information.

(3) In making this application for withholding of proprietary information of which it is the owner, Holtec International relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4) and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10CFR Part 9.17(a)(4), 2.390(a)(4), and 2.390(b)(1) for "trade secrets and commercial or financial information obtained from a person and privileged or confidential" (Exemption 4). The material for which exemption from disclosure is here sought is all "confidential commercial information", and some portions also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by Holtec's competitors without license from Holtec International constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.

c. Information which reveals cost or price information, production, capacities, budget levels, or commercial strategies of Holtec International, its customers, or its suppliers;

d. Information which reveals aspects of past, present, or future Holtec International customer-funded development plans and programs of potential commercial value to Holtec International;

e. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs 4.a, 4.b and 4.e above.

(5) The information sought to be withheld is being submitted to the NRC in confidence. The information (including that compiled from many sources) is of a sort customarily held in confidence by Holtec International, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by Holtec International. No public disclosure has been made, and it is not available in public sources. All

disclosures to third parties, including any required transmittals to the NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge. Access to such documents within Holtec International is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, by the manager of the cognizant marketing function (or his designee), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside Holtec International are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information classified as proprietary was developed and compiled by Holtec International at a significant cost to Holtec International. This information is classified as proprietary because it contains detailed descriptions of analytical approaches and methodologies not available elsewhere. This information would provide other parties, including competitors, with information from Holtec International's technical database and the results of evaluations performed by Holtec International. A substantial effort has been expended by Holtec International to develop this information. Release of this information would improve a competitor's position because it would enable Holtec's competitor to copy our technology and offer it for sale in competition with our company, causing us financial injury.

AFFIDAVIT PURSUANT TO 10 CFR 2.390

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to Holtec International's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of Holtec International's comprehensive spent fuel storage technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology, and includes development of the expertise to determine and apply the appropriate evaluation process.

The research, development, engineering, and analytical costs comprise a substantial investment of time and money by Holtec International.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

Holtec International's competitive advantage will be lost if its competitors are able to use the results of the Holtec International experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to Holtec International would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive Holtec International of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing these very valuable analytical tools.

AFFIDAVIT PURSUANT TO 10 CFR 2.390

STATE OF NEW JERSEY)
) ss:
COUNTY OF BURLINGTON)

P. Stefan Anton, being duly sworn, deposes and says:

That he has read the foregoing affidavit and the matters stated therein are true and correct to the best of his knowledge, information, and belief.

Executed at Marlton, New Jersey, this 17th day of April, 2013.

P. Stefan Anton
Acting Licensing Manager
Holtec International

Subscribed and sworn before me this 17th day of April, 2013.

MARIA C. MASSI
NOTARY PUBLIC OF NEW JERSEY
My Commission Expires April 25, 2015