NRC FORM 651
(10-2004)
10 CFR 72

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	1~~7~~8	TBD	USA/72-1014

Issued To: (Name/Address)

Holtec International
Holtec Technology Campus
One Holtec Blvd.
Camden, NJ 08104

Safety Analysis Report Title

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

CONDITIONS

This certificate is conditional 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 except Version E, HI-TRAC MS, MPC-32M, and Version 1 of MPC-32 and MPC-68; the attached Appendix C (Technical Specifications) and Appendix D (Approved Contents and Design Features) for the HI-STORM 100S Version E, HI-TRAC MS, MPC-32M, and Version 1 of MPC-32 and MPC-68M; 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 (CoC). 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 portions of MPC components that may come into contact with spent fuel pool water or the ambient environment are made 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 twelve types of MPCs: the MPC-24, MPC-24E, MPC-24EF, MPC-32, MPC-32F, MPC-32 Version 1, MPC-32M, MPC-68, MPC-68 Version 1, 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 twelve 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. All transfer cask sizes have identical cavity diameters. The higher weight HI-TRAC transfer casks have thicker shielding and larger outer dimensions than the lighter HI-TRAC transfer casks.

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. 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 air vents at the bottom and at the top to allow air to circulate naturally through the cavity to cool the MPC inside. 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. The version E can be arrayed in a free standing or anchored configuration.

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.

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 or Section 5.2 of Appendix C and Sections 3.4.6 and 3.5 (if applicable) of Appendix B or D, 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 or D, as applicable, 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 or D, as applicable, 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, C, and A-100U (Technical Specifications) and Appendices B, D, 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

a. For the storage configuration, each user of a HI-STORM 100 Cask and HI-STORM 100U Cask with a heat load equal to or greater than 20 kW shall perform a thermal validation test in which the user measures the total air mass flow rate through the cask system using direct measurements of air velocity in the inlet vents. The user shall then perform an analysis of the cask system with the taken measurements to demonstrate that the measurements validate the analytic methods described in Chapter 4 of the FSAR. The thermal validation test and analysis results shall be submitted in a letter report to the NRC pursuant to 10 CFR 72.4 within 180 days of the user's loading of the first cask with a heat load equal to or greater than 20 kW. To satisfy condition 9(a) for casks of the same system type (i.e., HI-STORM 100 casks, HI-STORM 100U casks), in lieu of additional submittals pursuant to 10 CFR 72.4, users may document in their 72.212 report a previously performed test and analysis submitted by letter report to the NRC that demonstrates validation of the analytic methods described in Chapter 4 of the FSAR.

b. For the transfer configuration, each user of the HI-STORM 100 Cask and HI-STORM 100U Cask shall procure, if necessary, a Supplemental Cooling System (SCS) capable of providing the thermal-hydraulic characteristics (coolant temperature at the annulus inlet, coolant temperature located at the annulus outlet, and coolant flow rate) that will ensure that thermal limits (described in Appendix 2.C of the FSAR) are not exceeded during transfer operations. The thermal-hydraulic characteristics of the SCS shall be determined using the analytical methods described in Chapter 4 for the transfer configuration. For the transfer configuration, each first time user shall measure the SCS thermal-hydraulic characteristics to validate the performance of the SCS. The SCS analysis and validation shall be documented in an update to the 72.212 report within 180 days of the user's first transfer operation with the SCS. Condition 9(b) does not apply to the MPC-68M or the MPC-32M.

NRC FORM 651 | U.S. NUCLEAR REGULATORY COMMISSION

(3-1999)
10 CFR 72

CERTIFICATE OF COMPLIANCE FOR SPENT FUEL STORAGE CASKS

Supplemental Sheet

Certificate No. 1014
Amendment No. 1~~7~~8

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, C, and A-100U.

NRC FORM 651
(3-1999)
10 CFR 72

U.S. NUCLEAR REGULATORY COMMISSION

CERTIFICATE OF COMPLIANCE
FOR SPENT FUEL STORAGE CASKS
Supplemental Sheet

Certificate No. 1014
Amendment No. 18~~7~~
Page 5 of 5

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, B-100U, C, and D 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
Storage and Transportation Licensing Branch
Division of Fuel Management
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
5. Appendix C
6. Appendix D

PROPOSED CERTIFICATE OF COMPLIANCE NO. 1014

APPENDIX A

TECHNICAL SPECIFICATIONS

FOR THE HI-STORM 100 CASK SYSTEM

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.2	Verify all OVERPACK inlets and outlets are free of blockage from solid debris or floodwater.	Table 3-5
	<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 $\leq$ 155°F for OVERPACKS containing PWR MPCs, $\leq$ 137°F for OVERPACKS containing BWR MPCs (except MPC-68M) and ≤ 164°F for OVERPACKS containing MPC-68M. For sites that have loaded in accordance with the Topical Report HI-2200343-A, Revision 2, verify that the difference between the average OVERPACK air outlet temperature and ISFSI ambient temperature is less than or equal to the value computed using the topical report methodology.	Table 3-5

Table 3-1a
MPC Cavity Drying Limits for all MPC Types for VENTILATED OVERPACK Note 9

Fuel Burnup (MWD/MTU)	MPC Heat Load (kW)	Method of Moisture Removal (Notes 1 and 2)
All Assemblies ≤ 45,000	≤ 26 (MPC-24/24E/24EF, MPC-32/32F, MPC-68/68F/68FF)	VDS Note 5 or FHD Note 6
	≤ 36.9 (MPC-68M) Note 6	VDS or FHD
	≤ 42.8 (MPC-68M) Note 7	VDS or FHD
All Assemblies ≤ 45,000	≤ 36.9 (MPC-24/24E/24EF, MPC-32/32F, MPC-68/68F/68FF) Note 6	VDS Note 8 or FHD
One or more assemblies > 45,000	≤ 29 (MPC-68M)	VDS Note 4
One or more assemblies > 45,000	≤ 36.9 (MPC-24/24E/24EF/MPC-32/32F/MPC-68/68F/68FF) Note6	VDS Note8 or FHD
	≤ 36.9 (MPC-68M) Note6	VDS Note8 or FHD
	≤ 42.8 (MPC-68M) Note 7	VDS Note8 or FHD

Notes:

9. ~~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.

9. ~~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.

9. ~~3.~~ Vacuum drying of the system must be performed with the annular gap between the MPC and the TRANSFER CASK filled with water.

9. ~~4.~~ The maximum allowable decay heat per fuel storage location is 0.426 kW.

5. Maximum allowable storage cell heat load is 1.083 kW (MPC-24/24E/24EF), 0.812 kW (MPC-32/32F) and 0.382 kW (MPC-68/68F/68FF).

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

7. Maximum per assembly allowable heat loads defined in Appendix B Figures 2.4-1 through 2.4-4.

8. Vacuum drying of the MPC must be performed using cycles of the drying system, according to the guidance contained in ISG-11 Revision 3. The time limit for these cycles shall be determined based on site specific conditions. Applies when any one assembly heat load is greater than 0.426 kW.

9. Alternative heat load limits may be developed following the methodology in Topical Report HI-2200343-A, Revision 2. These patterns must have a total MPC heat load less than or equal to 50 kW. Dryness criteria are still as specified in Notes 1 or 2 as applicable to the selected drying process, and Note 3 still applies to vacuum drying.

Table 3-2a
MPC Helium Backfill Limits for VENTILATED OVERPACK[Note 1,2~~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 OR ≥ 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	
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 OR ≥ 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 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

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

MPC-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 OR ≥ 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
iii. Cask Heat Load ≤ 42.8 kW QSHL Loading Pattern shown in Appendix B, Figure 2.4-1 QSHL patterns shown in Appendix B, Figures 2.4-2 through2.4-4	~~≥ 43.5 psig and ≤ 46.5 psig~~ ~~≥ 45.5 psig and ≤ 48.5 psig~~

Notes

1. Helium used for backfill of MPC shall have a purity of ≥ 99.995%. Pressure range is at a reference temperature of 70°F
2. For heat load patterns developed in accordance with Table 3-1, Note 9, helium backfill limits shall be calculated in accordance with Topical Report HI-2200343-A Revision 2

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/68M	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. For heat load patterns developed in accordance with Table 3-1, Note 9, these limits do not apply.

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/68M	0.414
MPC-32	0.898

Note: For heat load patterns developed in accordance with Table 3-1, Note 9, these limits do not apply.

Table 3-5: Completion Time for Actions to Restore SFSC Heat Removal System Operable[Note 2]

MPC Material	MPC Type	Decay Heat Limits per Storage Location	Condition B Completion Time	Condition C Completion Time	Surveillance Frequency
Alloy X Except Duplex[1]	MPC-24/24E/24EF	Appendix B, Section 2.4	8 hrs	24 hrs	24 hrs
	MPC-32/32F				
	MPC-68/68F/68FF/68M				
	MPC-68M	Appendix B, Figures 2.4-1 through 2.4-4			
Alloy X	MPC-24/24E/24EF	Appendix B, Section 2.4	8 hrs	16 hrs	16 hrs
	MPC-32/32F				
	MPC-68/68F/68FF/68M				
Alloy X	MPC-68M	Appendix B, Figures 2.4-1 through 2.4-4	4 hrs	12 hrs	12 hrs
Alloy X Except Duplex[1]	MPC-24	Appendix A, Table 3-3 (Regionalized) OR Appendix A, Table 3-4 (Uniform)	8 hrs	64 hrs	24 hrs
	MPC-24E/EF				
	MPC-32/32F				
	MPC-68/68F/68FF/68M				
Alloy X	MPC-24	Appendix A, Table 3-3 (Regionalized) OR Appendix A, Table 3-4 (Uniform)	8 hrs	24 hrs	24 hrs
	MPC-24E/EF				
	MPC-32/32F				
	MPC-68/68F/68FF/68M				
Alloy X	MPC-24/24E/24EF	0.75 kW	24 hrs	64 hrs	30 days
	MPC-32/32F	0.5 kW			
	MPC-68/68F/68FF/68M	0.264 kW			

Note

2) ~~1)~~ If any component of the MPC is made of duplex, these completion times are not applicable.

2) For patterns developed in accordance with Table 3-1, Note 9, alternative completion times shall be calculated in accordance with Topical Report HI-2200343-A Revision 2

PROPOSED CERTIFICATE OF COMPLIANCE NO. 1014

APPENDIX B

APPROVED CONTENTS AND DESIGN FEATURES

FOR THE HI-STORM 100 CASK SYSTEM

2.4.2 Regionalized Fuel Loading Decay Heat Limits for ZR-Clad Fuel for VENTILATED OVERPACK

The maximum allowable decay heat per fuel storage location for intact or undamaged fuel assemblies in regionalized loading is determined using the following equations:

$Q(X) = 2 \times Q_0 / (1 + X^y)$

$y = 0.23 / X^{0.1}$

$q_2 = Q(X) / (n_1 \times X + n_2)$

$q_1 = q_2 \times X$

Where:

Q_0 = Maximum uniform storage MPC decay heat (34 kW)

X = Inner region to outer region assembly decay heat ratio
($0.5 \leq X \leq 3$)

n_1 = Number of storage locations in inner region from Table 2.4-2.

n_2 = Number of storage locations in outer region from Table 2.4-2.

Allowable heat loads for Damaged Fuel and Fuel Debris in regionalized loading are shown in Table 2.4-5.

Optional loading patterns for MPC-68M are shown in Figures 2.4-1 through 2.4-4.

Alternatively to the heat load patterns in Sections 2.4.1 and 2.4.2, per cell allowable heat loads may be determined per Topical Report HI-2200343-A Revision 2.

2.4.3 Burnup Limits as a Function of Cooling Time for ZR-Clad Fuel for VENTILATED OVERPACK

The maximum allowable ZR-clad fuel assembly average burnup varies with the minimum required fuel assembly cooling time. Tables 2.4-3 and 2.4-4 provide for each MPC the allowable maximum burnup based on the assembly's particular cooling time. These same limits apply for heat load patterns developed in accordance with the topical report, HI-2200343-A, Revision 2.

2.4.3.2 ~~2.4.3.1~~ Linear interpolation of burnups between cooling times is permitted. For example, the allowable burnup for a cooling time of 4.5 years may be interpolated between those burnups calculated for 4 year and 5 years.

~~2.4.3.2~~2.4.3.3 Calculated burnup limits shall be rounded down to the nearest integer.

2.4.3.4 ~~2.4.3.3~~ Calculated burnup limits greater than 68,200 MWD/MTU for PWR fuel and 65,000 MWD/MTU for BWR must be reduced to be equal to these values.

2.4.4 When complying with the maximum fuel storage location decay heat limits, users must account for the decay heat from both the fuel assembly and any NON-FUEL HARDWARE, as applicable for the particular fuel storage location, to ensure the decay heat emitted by all contents in a storage location does not exceed the limit.

2.4.5 Fuel Loading Decay Heat Limits for UNVENTILATED OVERPACK

Tables 2.4-6a and 2.4-6b provide the maximum allowable decay heat per fuel storage location for MPC-68M in an UNVENTILATED OVERPACK.

A minor deviation from the prescribed loading pattern in an MPC's permissible contents to allow one slightly thermally-discrepant fuel assembly per quadrant to be loaded as long as the peak cladding temperature for the MPC remains below the ISG-11 Rev 3 requirements is permitted for essential dry storage campaigns to support decommissioning.

2.4.6 Burnup and Cooling Time Qualifications for the MPC-68M for UNVENTILATED OVERPACK

The burnup and cooling time for every fuel loaded into the MPC-68M must satisfy the following equation:

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

where,
Ct = Minimum cooling time (years),
Bu = Assembly-average burnup (MWd/mtU),
A, B, C, D= Polynomial coefficients listed in Table 2.4-9

These same limits apply for heat load patterns developed in accordance with the topical report HI-2200343-A, Revision 2.

TABLE 2.4-9
Burnup and Cooling Time Fuel Qualification Requirements for MPC-68M for UNVENTILATED OVERPACK

Cell Decay Heat Load Limit (kW)	**Polynomial Coefficients, see Subsection 2.4.5**			
	A	**B**	**C**	**D**
≤ 0.382	9.44656e-14	-8.01992e-09	2.79524e-04	-4.10441e-01
>0.382 ~~< decay heat ≤ 1.625~~	8.59250e-15	-1.40950e-09	9.57523e-05	-1.02585e+00

PROPOSED CERTIFICATE OF COMPLIANCE

NO. 1014 APPENDIX C

TECHNICAL SPECIFICATIONS

FOR THE HI-STORM 100S VERSION E CASK

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.2	Verify all OVERPACK inlets and outlet area are free of blockage from solid debris or floodwater.	Table 3-3
	OR	
	For OVERPACKS with installed temperature monitoring equipment, verify that the difference between the average OVERPACK air outlet temperature and ISFSI ambient temperature is ≤ 142°F (MPC-32M), or ≤ 163°F (MPC-32 Version 1/MPC-68 Version 1), or ≤ 155°F (MPC-24/24E/24EF/32/32F), or ≤ 137°F (MPC-68/68F/68FF) or ≤ 164°F (MPC-68M). For sites that have loaded in accordance with the Topical Report HI-2200343-A, Revision 2, verify that the difference between the average OVERPACK air outlet temperature and ISFSI ambient temperature is less than or equal to the value computed using the topical report methodology.	Table 3-3

Table 3-1a
MPC Cavity Drying Limits for
VENTILATED OVERPACK[Note 7, 13]

Fuel Burnup (MWD/MTU)	**MPC Heat Load (kW)[Note 12]**	**Method of Moisture Removal (Notes 1, 2, and 3)**
All Assemblies ≤ 45,000	≤ 26 (MPC-32 Version 1, MPC-68 Version 1)	VDS[Note 5] or FHD[Note 6]
	≤ 36.9 (MPC-32 Version 1, MPC-68 Version 1)[Note 6]	VDS[Note 8] or FHD
	≤ 41.2 (MPC-32M)[Note 9]	VDS or FHD
	≤ 40 (MPC-32M)[Note 10]	
One or more assemblies > 45,000	≤ 27 (MPC-32M)	VDS[Note 4]
	≤ 36.9 (MPC-32 Version 1, MPC-68 Version 1)[Note 6]	VDS[Note 8] or FHD
	≤ 41.2 (MPC-32M)[Note 9]	VDS[Note 8,11] or FHD
	≤ 40 (MPC-32M)[Note 10]	

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. Vacuum drying of the system must be performed with the annular gap between the MPC and the TRANSFER CASK filled with water.

4. The maximum allowable decay heat per fuel storage location is 0.843 kW for MPC-32M.

5. Maximum allowable storage cell heat load is 0.812 kW (MPC-32 Version 1) and 0.382 kW (MPC-68 Version 1).

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

7. For limits applicable to MPC-24/24E/24EF/32/32F/68/68F/68FF/68M see Appendix A Table 3-1.

8. Vacuum drying of the MPC must be performed using cycles of the drying system, according to the guidance contained in ISG-11 Revision 3. The time limit for these cycles shall be determined based on site-specific conditions.

9. Maximum per assembly allowable heat loads defined in Appendix D, Section 2.4.1.

10. Maximum per assembly allowable heat loads defined in Appendix D Figures 2.4-1 and 2.4-2.

11. Applies when any one storage cell heat load is greater than 0.843kW.

12. For MPC-32M, these heat load limits may need to be modified based on fuel height, in accordance with Appendix D Section 2.4.4.

~~12.~~13. Alternative heat load limits may be developed following the methodology in Topical Report HI-2200343-A Revision 2. These heat load patterns must have a total MPC heat load less than 50 kW. Dryness criteria are still as specified in Notes 1 or 2 as applicable to the selected drying process , and Note 3 still applies to vacuum drying.

Table 3-2a
MPC Helium Backfill Limits for
VENTILATED OVERPACK[Notes 1,3, 4]

MPC MODEL	LIMIT
MPC-32M[Note 4]	
i. Cask Heat Load ≤ 41.2 kW Regionalized Loading per Appendix D, Section 2.4.1	≥ 43.0 psig and ≤ 46.0 psig
ii. Cask Heat Load ≤ 40.0 kW Discrete Loading Patterns per Appendix D, Section 2.4.2	≥ Note 2 and ≤ 46.8 psig
MPC-32 Version 1/ MPC-68 Version 1	
i. All allowable heat loads per Appendix D Section 2.4	≥ 49.5 psig and ≤ 52.5 psig

Notes:

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

2. Minimum permitted helium backfill is equal to:
   $43.8\sqrt{(Q/Q')}$

   Where:
   Q = aggregate heat load for MPC at time of fuel loading (kW)
   Q' = allowable maximum heat load for the canister in Appendix D, Table 2.4-3

   For any scenario where Q/Q' ≤ 0.9, 0.9 shall be used.

3. For limits applicable to MPC-24/24E/24EF/32/32F/68/68F/68FF/68M see Appendix A Table 3-2.

4. These heat load limits may need to be modified based on fuel height, in accordance with Appendix D Section 2.4.4

~~4.~~5. For heat load patterns developed in accordance with Table 3-1a, Note 13, helium backfill limits shall be calculated in accordance with Topical Report HI-2200343-A Revision 2.

Table 3-3
Completion Time for Actions to Restore HI-STORM 100S Version E SFSC Heat Removal System to Operable [Note1]

MPC Material	MPC Type	Decay Heat Limits per Storage Location	Condition A Completion Time	Condition B Completion Time	Surveillance Frequency
Alloy X Except Duplex [Note3]	MPC-32 Version 1/ MPC-68 Version 1	Appendix D, Section 2.4	8 hrs	24 hrs	24 hrs
Alloy X	MPC-32 Version 1/ MPC-68 Version 1	Appendix D, Section 2.4	8 hrs	16 hrs	16 hrs
Alloy X	MPC-32 Version 1	0.5 kW	24 hrs	64 hrs	30 days
	MPC-68 Version 1	0.264 kW			
	MPC-32M	0.75 kW [Note 2]			
Alloy X Except Duplex [Note 3]	MPC-32M	Appendix D Section [Note 2] 2.4.1 OR Appendix D Section [Note 2] 2.4.2	8 hrs	24 hrs	24 hrs
Alloy X	MPC-32M	Appendix D Section [Note 2] 2.4.1 OR Appendix D Section [Note 2] 2.4.2	8 hrs	24 hrs	24 hrs

Notes:

1. For limits applicable to MPC-24/24E/24EF/32/32F/68/68F/68FF/68M see Appendix A Table 3-5.
2. For MPC-32M, heat load limits may need to be modified based on fuel height, in accordance with Appendix D Section 2.4.4.
3. If any component of the MPC is made of duplex, these completion times are not applicable.

~~3.~~4. For heat load patterns developed in accordance with Table 3-1a, Note 13, alternative completion times may be calculated in accordance with Topical Report HI-2200343-A Revision 2

PROPOSED CERTIFICATE OF COMPLIANCE NO. 1014

APPENDIX D

APPROVED CONTENTS AND DESIGN FEATURES

FOR THE HI-STORM 100S VERSION E CASK AND HI-TRAC MS

2.4 Decay Heat Limits

For MPC-24/24E/24EF/32/32F/68/68F/68FF/68M decay heat, burnup, and cooling time limits from Appendix B Section 2.4 apply for ZR clad fuel. Decay heat limits from Appendix B Table 2.1-1 apply for SS clad fuel.

For MPC-32 Version 1 decay heat, burnup and cooling time limits for MPC-32 from Appendix B Section 2.4 apply for ZR clad fuel. Decay heat limits for MPC-32 from Appendix B Table 2.1-1 apply for SS clad fuel.

For MPC-68 Version 1 decay heat, burnup and cooling time limits for MPC-68 from Appendix B Section 2.4 apply for ZR clad fuel. Decay heat limits for MPC-68 from Appendix B Table 2.1-1 apply for SS clad fuel.

Decay heat limits for ZR clad for storage in MPC-32M in HI-STORM 100S Version E are provided in the following subsections. Burnup and cooling time limits for the MPC-32M are provided in Table 2.1-4. These burnup/cooling time limits also apply for heat load patterns developed in accordance with the topical report HI-2200343-A Revision 2.

2.4.1 Regionalized Fuel Loading Decay Heat Limits for ZR-Clad Fuel for MPC-32M for a VENTILATED OVERPACK

The maximum allowable decay heat per fuel storage location for intact fuel assemblies in regionalized loading is determined using the following equations:

$Q(X) = 2 \times Q_0 / (1 + X^y)$

$y = 0.23 / X^{0.1}$

$q_2 = Q(X) / (n_1 \times X + n_2)$

$q_1 = q_2 \times X$

Where:

Q_0 = Maximum uniform storage MPC decay heat (38 kW)

X = Inner region to outer region assembly decay heat ratio ($0.5 \le X \le 3$)

n_1 = Number of storage locations in inner region from Table 2.4-3.

n_2 = Number of storage locations in outer region from Table 2.4-3.

Allowable heat loads for Damaged Fuel and Fuel Debris are shown in Table 2.4-1. Allowable storage locations for Damaged Fuel in DFIs and Damaged Fuel or Fuel Debris in DFCs are shown in Table 2.4-1. Cell heat load limits and total heat load limits may need to be adjusted in accordance with Section 2.4.4.

2.4.2 Discrete Loading Pattern Decay Heat Limits for ZR-Clad Fuel in MPC-32M for a VENTILATED OVERPACK

Discrete decay heat loading patterns (Patterns A and B) for MPC-32M are shown in Figures 2.4-1 and 2.4-2. Figures 2.4-1 and 2.4-2 provide the maximum allowable decay heat loads per fuel storage location. Table 2.4-2 provides the maximum total allowable decay heat load and maximum

allowable quadrant decay heat load for Figures 2.4-1 and 2.4-2. Cell heat load limits, quadrant heat load limits and total heat load limit may need to be adjusted in accordance with Section 2.4.4.

Alternatively to the patterns in Sections 2.4.1 and 2.4.2, decay heat limits may be determined per Topical Report HI-2200343-A Revision 2.

2.4.3 When complying with the maximum fuel storage location decay heat limits, users must account for the decay heat from both the fuel assembly and any NON-FUEL HARDWARE, as applicable for the particular fuel storage location, to ensure the decay heat emitted by all contents in a storage location does not exceed the limit.

2.4.4 Variable Fuel Height for MPC-32M

2.4.4.1 For fuel with a longer active fuel length than the reference fuel (144 in), the total heat load, quadrant heat load limits and specific heat load limits in each cell, may be increased by the ratio SQRT(L/144), where L is the active length of the fuel in inches.

2.4.4.2 For fuel with a shorter active fuel length than the reference fuel (144 in), the total heat load, quadrant heat load limits and specific heat load limits in each cell, shall be reduced linearly by the ratio L/144, where L is the active fuel length of the fuel in inches.

2.4.5 Decay Heat Limits for MPC-32M for the UNVENTILATED OVERPACK

Tables 2.4-5a and 2.4-5b provide the maximum allowable decay heat per fuel storage location for MPC-32M for UNVENTILATED OVERPACK.

A minor deviation from the prescribed loading pattern in an MPC's permissible contents to allow one slightly thermally-discrepant fuel assembly per quadrant to be loaded as long as the peak cladding temperature for the MPC remains below the ISG-11 Rev 3 requirements is permitted for essential dry storage campaigns to support decommissioning.

Table 2.4-1

Allowable Heat Loads and Soluble Boron Requirements for MPC-32M

Row No.	DFC/DFI (Note 1)	Number of DFC/DFI Locations	Locations/Storage Cell Numbers (Note 2)	Penalty on per storage cell heat load limit (Note 3)	Min. Soluble Boron Content
1	DFC	4	2, 11, 22, 31 (NOTE 4)	0%	Appendix C Table 3-6
2		8	1, 4, 5, 10, 23, 28, 29, 32	5%	Appendix C Table 3-5
3		12	1, 2, 4, 5, 10, 16, 17, 23, 28, 29, 31, 32	5%	Appendix C Table 3-5
4		16	1, 2, 3, 4, 5, 10, 11, 16, 17, 22, 23, 28, 29, 30, 31, 32 (NOTE 4)	0%	Appendix C Table 3-6
5		16	1, 2, 3, 4, 5, 10, 11, 16, 17, 22, 23, 28, 29, 30, 31, 32	5%	Appendix C Table 3-6
6	DFI	4	2, 11, 22, 31	10%	Appendix C Table 3-4
7		12	1, 2, 4, 5, 10, 16, 17, 23, 28, 29, 31, 32	40%	Appendix C Table 3-4
8		16	1, 2, 3, 4, 5, 10, 11, 16, 17, 22, 23, 28, 29, 30, 31, 32	40%	Appendix C Table 3-4
9	DFI or DFC	16	1, 2, 3, 4, 5, 10, 11, 16, 17, 22, 23, 28, 29, 30, 31, 32	DFCs – 5% DFIs – 40%	Appendix C Table 3-6

Note 1: Damaged fuel assemblies or fuel debris can be loaded in DFCs while only damaged fuel assemblies that can be handles by normal means can be loaded in DFIs.

Note 2: DFCs/DFIs are allowed for storage in certain basket peripheral locations as defined herein. Basket storage cell numbers are identified in Figure 2.1-1.

Note 3: Heat load penalties are applicable to ONLY those cells where DFCs/DFIs are located and are applied to the allowable undamaged fuel assembly decay heat limit in that storage cell location. The penalties remain the same for all regionalized patterns and discrete loading patterns. Alternatively decay heat limits may be determined per Topical Report HI-2200343-A Revision 2.

Note 4: Storage cell locations 6, 9, 24, 27 all must remain empty.