| | |
|---|---|
| Conditions | |
| Local_Temperature Limit Under 30-Day 100% Vent Blockage Accident Conditions | See Table 2.2.3 in this FSAR and similar tables in other HI-STORM FSARs |
| Local Temperature Temperature Limit Under Short Term, Off Normal, and Accident Conditions (Note 9) | See Table 2.2.3 in this FSAR and similar tables in other HI-STORM FSARs |
| Aggregate Maximum Value of Coefficient of Thermal Expansion (tangent in the range of 70°F to 100°F) | 6E-06 inch/inch/°F (See Note 1) (NUREG-1536, 3.V.2.b.i.(2)(c)2.b) |

Notes:

1. The following aggregate types are a priori acceptable: limestone, marble, basalt, granite, gabbro, rhyolite, hematite, magnetite, or barite. Careful consideration shall be given to the potential of long-term degradation of concrete due to chemical reactions between the aggregate and cement selected for HI-STORM overpack concrete.
1. Density values used in the safety analysis of the different overpacks may be greater than the minimums provided in this table and are pre-empted by those set down in Chapter 5 of the applicable FSAR.

2. The coarse aggregate shall meet the requirements of ASTM C33 for class designation 1S from Table 3. However, if the requirements of ASTM C33 cannot be met, concrete aggregates that have been shown by special tests or actual service to produce concrete of adequate strength, unit weight, and durability meeting the requirements of Tables 1.D.1 and 1.D.2 are acceptable in accordance with ACI 349 Section 3.3.2. The high-density coarse aggregate percentage of Material Finer than No. 200 Sieve may be increased to 10-% if the material is essentially free of clay or shale.

3. The 300°F long term temperature limit is specified in accordance with Paragraph A.4.3 of Appendix A to ACI 349 for normal conditions considering the very low maximum stresses calculated and discussed in Section 3.4 of this FSAR for normal conditions. In accordance with this paragraph of the governing code, the specified concrete compressive strength is supported by test data and the concrete is shown not to deteriorate, as evidenced by a lack of reduction in concrete density or durability.

3. The listed value of thermal conductivity is a lower bound and is considered to be acceptable *a' priori* as in most cases it would likely be exceeded [1.D.7]. A higher conductivity of plain concrete may be used in a site-specific safety qualification if supported by appropriate conduction tests. The conductivity value used in Chapter 4 controls and must be demonstrated for a site-specific application by testing.

4. Tests of materials and concrete, as required, shall be made in accordance with standards of the American Society for Testing and Materials (ASTM) as specified here, to ensure that the *critical characteristics* for the HI-STORM concrete are achieved. ASTM Standards to be used include: C 31, C 33, C 39, C 88, C 131, C 138, C 143, C 150, C 172, C 192, C 494, C 637. Equivalent standards may be approved for use after a 10CFR72.48 safety evaluation by Holtec.

5. The compressive strength of HI-STORM concrete is used in determining the extent of penetration into the cask by a medium or small Design Basis Missile treated in this FSAR. For sites subject to more severe missiles, the minimum concrete strength may be increased, as necessary, to meet site specific requirements. Lower than the reference strength is seldom required to improve safety margins at a site; however, if required, a lower concrete

Table 4.2.1

SUMMARY OF HI-STORM SYSTEM MATERIALS
THERMAL PROPERTY REFERENCES

| Material | Emissivity | Conductivity | Density | Heat Capacity |
|---|---|---|---|---|
| Helium | N/A | Handbook [4.2.2] | Ideal Gas Law | Handbook [4.2.2] |
| Air | N/A | Handbook [4.2.2] | Ideal Gas Law | Handbook [4.2.2] |
| Argon | N/A | Lemmon et al. [4.2.21] | Ideal Gas Law | Not used |
| Zircaloy | [4.2.3], [4.2.17], [4.2.18], [4.2.7] | NUREG [4.2.6] | Rust [4.2.4] | Rust [4.2.4] |
| $UO_2$ | Note 1 | NUREG [4.2.6] | Rust [4.2.4] | Rust [4.2.4] |
| Stainless Steel (machined forgings)[6] | Kern [4.2.5] | ASME [4.2.8] | Marks' [4.2.1] | Marks' [4.2.1] |
| Stainless Steel Plates[7] | ORNL [4.2.11], [4.2.12] | ASME [4.2.8] | Marks' [4.2.1] | Marks' [4.2.1] |
| Carbon Steel | Kern [4.2.5] | ASME [4.2.8] | Marks' [4.2.1] | Marks' [4.2.1] |
| Boral | Note 1 | Test Data (Note 2) | Test Data (Note 2) | Test Data (Note 2) |
| Holtite-A | Note 1 | [4.2.13] | Not Used | Not Used |
| Concrete | Note 1 | Marks' [4.2.1] | Appendix 1.D | Handbook [4.2.2] |
| Lead | Note 1 | Handbook [4.2.2] | Handbook [4.2.2] | Handbook [4.2.2] |
| Water | Note 1 | ASME [4.2.10] | ASME [4.2.10] | ASME [4.2.10] |
| METAMIC | Note 1 | Test Data [4.2.14], [4.2.15] | Test Data [4.2.14], [4.2.15] | Test Data [4.2.14], [4.2.15] |
| Aluminum Alloy 2219 | Table 1.III.3 | ASM [4.2.20] | ASM [4.2.20] | ASM [4.2.20] |

Note 1: Emissivity not reported as radiation heat dissipation from these surfaces is conservatively neglected.
Note 2: AAR Structures Boral thermophysical test data.

6 Used in the top lid of the MPC.
7 Used in the basket panels, neutron absorber sheathing, MPC shell, and MPC baseplate.

Table 4.2.2

SUMMARY OF HI-STORM SYSTEM MATERIALS
THERMAL CONDUCTIVITY DATA

| Material | At 200°F (Btu/ft-hr-°F) | At 450°F (Btu/ft-hr-°F) | At 700°F (Btu/ft-hr-°F) | At 1000°F (Btu/ft-hr-°F) |
|---|---|---|---|---|
| Helium | 0.0976 | 0.1289 | 0.1575 | 0.1890 |
| Air* | 0.0173 | 0.0225 | 0.0272 | 0.0336 |
| Alloy X*** | 8.4 | 9.8 | 11.0 | 12.4 |
| Carbon Steel | 24.4 | 23.9 | 22.4 | 20.0 |
| Concrete** | 1.05 | 1.05 | 1.05 | 1.05 |
| Lead | 19.4 | 17.9 | 16.9 | N/A |
| Water | 0.392 | 0.368 | N/A | N/A |
| Aluminum Alloy 2219** | 69.3 | 69.3 | 69.3 | 69.3 |
| Argon | 0.0102 @ 80°F<br>0.0129 @ 260°F<br>0.0153 @ 440°F<br>0.0175 @ 620°F | | | |

* At lower temperatures, Air conductivity is between 0.0139 Btu/ft-hr-°F at 32°F and 0.0176 Btu/ft-hr-°F at 212°F.

** Conservatively assumed to be constant for the entire range of temperatures.

*** Individual thermal conductivities of the alloys that comprise the Alloy X materials are reported in Appendix 1.A. Lowerbound Alloy X thermal conductivity is tabulated herein.

Table 4.2.5

DENSITY AND HEAT CAPACITY PROPERTIES SUMMARY*

| Material | Density (lbm/ft$^3$) | Heat Capacity (Btu/lbm-°F) |
|---|---|---|
| Helium | (Ideal Gas Law) | 1.24 |
| Argon | (Ideal Gas Law) | Not used |
| Zircaloy | 409 | 0.0728 |
| Fuel ($UO_2$) | 684 | 0.056 |
| Carbon steel | 489 | 0.1 |
| Stainless steel | 501 | 0.12 |
| Boral | 154.7 | 0.13 |
| Concrete | 140** | 0.156 |
| Lead | 710 | 0.031 |
| Water | 62.4 | 0.999 |
| METAMIC | 163.4** | 0.22** |
| Aluminum Alloy 2219 | 177.3 | 0.207 |

* See Table 4.2.1 for cited references.

** Lowerbound values reported for conservatism.

Table 4.2.6

GASES VISCOSITY* VARIATION WITH TEMPERATURE

| **Temperature (°F)** | **Helium Viscosity (Micropoise)** | **Temperature (°F)** | **Air Viscosity (Micropoise)** | **Argon Viscosity (Micropoise)** |
|---|---|---|---|---|
| 167.4 | 220.5 | 32.0 | 172.0 | 227.0 @ 80ºF<br>286.0 @ 260 ºF<br>339.0 @ 440 ºF<br>388.0 @ 620 ºF |
| 200.3 | 228.2 | 70.5 | 182.4 | |
| 297.4 | 250.6 | 260.3 | 229.4 | |
| 346.9 | 261.8 | 338.4 | 246.3 | |
| 463.0 | 288.7 | 567.1 | 293.0 | |
| 537.8 | 299.8 | 701.6 | 316.7 | |
| 737.6 | 338.8 | 1078.2 | 377.6 | |
| 921.2 | 373.0 | - | - | |
| 1126.4 | 409.3 | - | - | |

* Viscosity for helium and air ~~O~~obtained from Rohsenow and Hartnett [4.2.2]. Viscosity for argon obtained from Lemmon et al. [4.2.21]

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 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.

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 transfer 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. The MPC gas pressure listed in Table 4.5.6 is below the MPC design internal pressure listed in Table 2.2.1.

4.5.7 Onsite Transfer under Low Environmental Temperatures

Per Chapter 9 of this FSAR, ethylene glycol is added to the water jacket if the normal onsite transfer operations are performed under ambient temperatures below 32°F. However, as stated therein, this requirement does not apply if the MPC heat load is above a minimum value at which freezing of the water in the water jacket is of no concern. A calculation is performed to determine the minimum decay heat such that the addition of ethylene glycol is not required (i.e. water jacket stays above the freezing temperature of water). Since the conditions can vary with site, a site-specific evaluation can be performed with the model and methodology consistent with that presented in Section 4.5.1.

An example calculation is performed and documented in the companion thermal report [4.5.1] to demonstrate this approach. Steady state evaluation is performed using the licensing basis thermal model for an ambient temperature of 0°F (min. ambient temeperature from Table 2.2.2) and an MPC decay heat of 10kW. It is demonstrated that the water temperature is well above its freezing point and therefore addition of ethylene glycol is not required.

[4.2.8] ASME Boiler and Pressure Vessel Code, Section II, Part D, (1995).

[4.2.9] Jakob, M. and Hawkins, G.A., "Elements of Heat Transfer," John Wiley & Sons, New York, (1957).

[4.2.10] ASME Steam Tables, 3rd Edition (1977).

[4.2.11] "Nuclear Systems Materials Handbook, Vol. 1, Design Data", ORNL TID 26666.

[4.2.12] "Scoping Design Analyses for Optimized Shipping Casks Containing 1-, 2-, 3-, 5-, 7-, or 10-Year-Old PWR Spent Fuel", ORNL/CSD/TM-149 TTC-0316, (1983).

[4.2.13] "Holtite A: Development History and Thermal Performance Data", Holtec Report HI-2002396, Rev. 3., Holtec International, Marlton, NJ, 08053.

[4.2.14] "Qualification of METAMIC for Spent-Fuel Storage Application", EPRI Report 1003137, (October 2001), EPRI, Palo Alto, CA.

[4.2.15] "Sourcebook for METAMIC Performance Assessment", Holtec Report HI-2043215, Holtec International, Marlton, NJ, 08053.

[4.2.16] USNRC Docket no 72-1027, TN-68 FSAR & Docket no 72-1021 TN-32 FSAR.

[4.2.17] Hagrman, Reymann and Mason, "MATPRO-Version 11 (Revision 2) A Handbook of Materials Properties for Use in the Analysis of Light Water Reactor Fuel Rod Behavior," NUREG/CR-0497, Tree 1280, Rev. 2, EG&G Idaho, August 1981.

[4.2.18] "Effective Thermal Conductivity and Edge Conductance Model for a Spent-Fuel Assembly," R. D. Manteufel & N. E. Todreas, Nuclear Technology, 105, 421- 440, (March 1994).

[4.2.19] Aluminum and Aluminum Alloys, ASM Speciality Handbook, 2007.

[4.2.20] Aluminum Alloy 2219 Material Data Sheet, ASM Aerospace Specification Metals, Inc., Pompano Beach, FL.

[4.2.21] "Viscosity and Thermal Conductivity Equations for Nitrogen, Oxygen, Argon, and Air," E.W.Lemmon and R.T.Jacobsen, International Journal of Thermophysics, 25, 21-69 (2004).

[4.3.1] Lanning and Beyer, "Estimated Maximum Cladding Stresses for Bounding PWR Fuel Rode During Short Term Operations for Dry Cask Storage," PNNL White Paper, (January 2004).

e. Install the HI-STORM lid, and if the HI-STORM anchor blocks are not utilized for cask movement, install the lid studs and nuts or lid closure bolts. ~~Install the HI-STORM lid and the lid studs and nuts or lid closure bolts.~~ See Table 8.1.5 for bolting requirements. Install the HI-STORM 100 lid stud shims if necessary. See Figure 8.1.27 for rigging.

f. Install the HI-STORM exit vent gamma shield cross plates, temperature elements (if used) and vent screens. See Table 8.1.5 for torque requirements. See Figure 8.1.34a.

g. Remove the HI-STORM lid lifting device and install the hole plugs in the empty holes, if present. Store the lifting device in an approved plant storage location. See Table 8.1.5 for torque requirements.

| **Warning:** |
|---|
| HI-STORM dose rates are measured to ensure they are within expected values. Dose rates exceeding the expected values could indicate that fuel assemblies not meeting the CoC may have been loaded. |

h. Perform the HI-STORM surface dose rate measurements in accordance with the technical specifications. These dose rate measurements fulfill the requirement for the operational shielding effectiveness testing described in Section 9.1.5.2. Measured dose rates must be compared with calculated dose rates that are consistent with the calculated doses that demonstrate compliance with the dose limits of 10 CFR 72.104(a).

i. Secure HI-STORM to the transporter device as necessary ensuring that the HI-STORM lid is secured in place by the lifting device if not secured in place by the lid studs and nuts or lid closure bolts.

| Note: |
|---|
| The site-specific transport route conditions must satisfy the requirements of the technical specification. |

19. Perform a transport route walkdown to ensure that the cask transport conditions are met.

20. Transfer the HI-STORM to its designated storage location at the appropriate pitch. See Figure 8.1.35. If the lid studs and nuts or lid closure bolts are not installed, install them at this time to secure the lid to the cask body.

| **Note:** |
|---|
| Any jacking system shall have the provisions to ensure uniform loading of all four jacks during the lifting operation. |

a. If air pads were used, insert the HI-STORM lifting jacks and raise HI-STORM. See Figure 8.1.36. Remove the air pad.

b. Lower and remove the HI-STORM lifting jacks, if used.

.During the review of the FSAR for license renewal, two time limited aging analyses (TLAAs) were identified that were updated to support the renewed license life. Full details of the analyses are contained in Reference [9.A.1].

- Neutron Absorber Depletion – as described in Section 3.4.12, the calculation has been evaluated for the full 60 year license and demonstrates there is more than enough boron to account for any depletion so no aging management program is needed to manage the absorber aging.
- MPC Fatigue Evaluation – A review of MPC fatigue indicated that repeated lifting cycles could change the fatigue life. The renewal application [9.A.1] indicates that the number of lifting cycles allowable is in excess of anything that would be expected for handling of the MPC throughout the extended storage period.

9.A.1.7 100 UVH AMP

The Version UVH overpack shares in many inspection criterions applicable to the standard HI-STORM 100 overpack~~, with certain key differences. Namely, inspections of the internal cavity of the overpack are rendered unnecessary by isolating the internal cavity from the external, ambient environment through the use of a seal.~~ While the lack of vents and the heavy lid limit the exposure of the Version UVH overpack internal cavity to the external environment, the internal cavity may have some exposure to outdoor air in cases such as when the lid raises to release internal cavity pressure as described in subsection 1.IV.2.1.2.1. Therefore, the Table 9.A.1-2 Overpack AMP applies to the Version UVH overpack. ~~full program is described in Table 9.A.1-6~~

| | |
|---|---|
| | (such as staining or rust) to determine if normally inaccessible components located in the overpack internal (i.e., container shell bottom plate, cask bottom) need additional inspection.<br><br>Overpack Internal<br><br>A visual inspection of the overpack annular space and the interior areas of ~~the~~ any vents shall be performed using a boroscope (or equivalent). This visual inspection shall meet the requirements of a VT-3 Examination, as given in the ASME Boiler & Pressure Vessel Code (B&PVC) Section XI, Article IWA-2200, to the extent practical.<br><br>The internal inspection shall be performed on one overpack at each site at a frequency of 5 years (+/- 1.25 years). The first inspection should occur within 365 days of the 20th anniversary of initial overpack loading at the site or within 365 days after the issuance of the renewed license, whichever is later. For ALARA reasons, it is recommended that the site use the overpack that contains the MPC used for the MPC AMP.<br><br>The inspection shall be documented, including a detailed description of the surface condition and location of areas showing surface degradation. |
| 5. Monitoring and Trending | The inspections and surveillances described for both the internal and external subcomponents of the overpack are performed periodically in order to identify areas of degradation. The results will be evaluated by a qualified individual, and areas of degradation not meeting established criteria will be entered into the corrective action program for resolution or more detailed evaluation. The results will be compared against previous inspections in order to monitor and trend the progression of the aging effects over time. |
| 6. Acceptance Criteria | Overpack External<br><br>The external metallic surfaces of the overpack are coated, and significant corrosion is not anticipated. Vents shall be free from obstructions. Overpack lid shall be free of dents, scratches, gouges or other damage. Gouges and depressions that are less than 25% of the thickness, less than 20% of the largest lineal dimension of the part long, less than ¼ inch width, with a minimum separation between gouges of 5% of the largest lineal dimension of the part are considered acceptable without further evaluation. Gouges of this size were considered acceptable without further evaluation during fabrication, and continue to be acceptable during storage.<br><br>The area of ISFSI pad concrete adjacent to the overpack shall not show any evidence of corrosion such as rust. |

**Table 9.A.1-6 Version UVH AMP**

| Element | Description |
|---|---|
| 1. Scope of Program | This program covers the subcomponents of the HI-STORM 100 UVH Overpack identified in Table 3.3-1, from [9.A.2], which require the Overpack AMP to ensure their continued operation into the extended storage period. |
| 2. Preventative Actions | This AMP uses condition monitoring to manage aging effects. The design of the system is intended to minimize aging effects, but this AMP focuses on condition monitoring and detecting any evidence of degradation. No new preventative actions are included in this AMP. |
| 3. Parameters Monitored / Inspected | The inspections shall be site-specific and performed at sites which utilize HI-STORM 100 Version UVH systems. Visual inspections cover all of the normally accessible external surfaces of the overpack.<br><br>Normally accessible portions of the overpack surfaces are visually examined for indication of any surface deterioration. Degradation could affect the ability of the overpack to provide support or confinement to the MPCs, to provide radiation shielding, or to provide missile shielding. The items inspected should cover (but are not limited to) those listed below:<br>Lid studs and nuts or lid closure bolts, as accessible<br>The accessible overpack body and lid painted surfaces<br>Overpack lid seal, as accessible |
| 4. Detection of Aging Effects | The overpack AMP is a visual inspection in order to detect any aging effects. The visual survey performed on all overpacks annually will identify the source of any staining or corrosion-related activity and the degree of damage. The visual survey is performed in accordance with site implementing procedures and may be satisfied by continuing the overpack external surface (accessible) visual examination in the HI-STORM FSAR Table 9.2.1 |
| 5. Monitoring and Trending | The inspections and surveillances described for the external subcomponents of the overpack are performed periodically in order to identify areas of degradation. The results will be evaluated by a qualified individual, and areas of degradation not meeting established criteria will be entered into the corrective action program for resolution or more detailed evaluation. The results will be compared against previous inspections in order to monitor and trend the progression of the aging effects over time. |
| 6. Acceptance Criteria | The external metallic surfaces of the overpack are coated, and significant corrosion is not anticipated. The overpack lid shall be free of dents, scratches, gouges or other damage. Gouges and depressions that are less than 25% of the thickness, less than 20% of the largest lineal dimension of the part long, less than ¼ inch width, with a minimum separation between gouges of 5% of the largest lineal dimension of the part are considered acceptable without further evaluation. Gouges of this |

| | |
|---|---|
| | size were considered acceptable without further evaluation during fabrication and continue to be acceptable during storage.<br><br>Any indication of general or localized corrosion (pitting and crevice) on the steel surfaces, or degradation of coatings shall be identified for trending purposes. If indications requiring additional evaluation are found, the issue would be entered into the site's corrective action program and an engineering evaluation would be performed to determine the extent and impact of the degradation on the component's ability to perform its intended function. These evaluations may include additional visual, surface, or volumetric non-destructive examination methods to determine the loss of material. If the degradation does not compromise the overpack's ability to maintain its function, then no further evaluation is required, but the degradation should be tracked for future inspections.<br><br>The overpack seal shall be free of signs of corrosion, scratches, gouges, or any other signs of degradation. Presence of signs of degradation on the seal will require further evaluation. If the degradation does not compromise the seal's ability to maintain its function, then no further evaluation is required, but the degradation should be tracked for future inspections. |
| 7. Corrective Actions | The corrective actions performed based on any detected aging effects are in accordance with the site's Quality Assurance (QA) program. The QA Program ensures that corrective actions are completed. The QA program and corrective action program will determine any necessary actions, identify any changes to the existing AMP, and determine if the condition is reportable, as applicable.<br><br>The corrective actions will also identify any actions needed to be taken for increased scope or frequency of inspections as necessary, based on any detected aging effects.<br><br>The corrective action program will also identify any dispositions needed from Holtec. |
| 8. Confirmation Process | The confirmation process will be commensurate with the site QA program. The QA program ensures that inspections, evaluations, and corrective actions are completed. |
| 9. Administrative Controls | The site QA program and implementing procedures for this AMP will address instrument calibration and maintenance, inspector requirements, record retention requirements, and document control.<br><br>This AMP will be updated, as necessary, based on the toll gate assessments described in Section 4 of [9.A.2]. Inspection results will be documented and made available for NRC inspection as necessary. |

| | |
|---|---|
| 10. Operating Experience | Previous Operating Experience<br>Section 3.1.2 of [9.A.2] summarizes HI-STORM 100 operating experience, which indicates very minimal corrosion detected to date, mostly limited to small rust spots and coating degradation. That operating experience has been incorporated into the guidance on inspections and acceptance criteria contained in this AMP.<br><br>Future Operating Experience<br>As the overpack inspections are performed, sites will upload information into the INPO AMID database to be shared with other users. |

## 1.IV.1 Introduction to the Storage System

This supplement adds HI-STORM 100 Version UVH overpack model to the HI-STORM 100 system. The other components, namely the MPCs and the HI-TRAC transfer casks remain unchanged from the versions previously qualified and certified in this FSAR.

Because the Storage system does not rely on ventilation action, its heat rejection capacity is rather modest, governed by the natural convection and radiation from the external surfaces of the overpack. To quantify the heat removal rate, a quiescent condition (no wind) is assumed in the thermal analysis summarized in Chapter 4.IV.

Version UVH is engineered to limit exposure of the overpack internal cavity to the external environmentprovide a controlled environment within the overpack internal cavity, thus reducing the probability of stress corrosion cracking (SCC) in the stainless steel canisterprotecting the Canister from stress corrosion while also serving as a low-dose MPC storage system.

In all physical respects, the Version UVH storage system is essentially identical to its ventilated counterpart. Thus, like other ventilated HI-STORM 100 overpack models, the Version UVH overpack can be staged in a free standing configuration on a sheltered or unsheltered pad. Other key characteristics of the Storage system that it shares with other HI-STORM 100 systems are:

- Because the storage cask is not used to load fuel in the pool, the storage system does not run the risk of being infected with the pool's contamination.
- The MPC, designed and qualified to be *leak-tight*, is a compact "*waste package*" which can be readily retrieved and transported off-site in a suitably certified transport cask.
- The MPC confinement boundary, deemed to be leak-tight pursuant to ISG-18, provides an incomparably greater protection against leakage than a gasketed metal cask with a bare basket.
- The principle system components listed in Table 1.IV.1.1 are designated Important-to-safety (ITS). The ISFSI pad is NITS.

## 1.IV.2 General Description

### 1.IV.2.1 System Characteristics

The components of the UVH Storage system are listed in Table 1.IV.1.1. The description of the UVH Overpack is provided in this section. The HI-TRACs and MPCs are described in Chapter 1 and other adopted supplements to this FSAR, and these descriptions remain applicable to this supplement. The overpack, illustrated in the licensing drawing in Section 1.IV.5, is sized to store the designated reference MPCs described below.

1.IV.2.1.1 MPCs:

No new MPC designs are proposed in this supplement and there are no modifications to existing designs for this supplement. The MPC models qualified for the HI STORM 100 Version UVH System were previously certified or are subject to certification in Supplements 1.II and 1.III of this FSAR.

1.IV.2.1.2.1 Version UVH Overpack:

This supplement adds the HI-STORM 100 Version UVH ("Version UVH") overpack to the HI-STORM 100 Canister storage system. Like all other overpack models previously evaluated in this FSAR, Version UVH is a dual buttressed steel shell structure with the inter-shell space filled with plain concrete. Because of its steel external body, Version UVH can be arrayed in a freestanding configuration. Likewise, the storage system can be deployed in a sheltered (inside a ventilated building) or unsheltered state.

The key distinguishing feature of Version UVH is that it has no inlet or outlet vents. Thus, there is no ventilation flow of air around the MPC. Rather the cask is designed to reject the fuel's decay heat from the external surface of the Canister without the benefit of ventilation flow. Rejection of heat from the external surface of the Canister to the external surface of the overpack is facilitated by a combination of conduction and radiation modes of heat transmission. The diametrical clearance between the overpack and the MPC is minimal which, under the design basis heat load, is further reduced allowing for conduction based heat transfer to assist in heat dissipation. Radiation from the hot MPC surfaces to the cask's inner surfaces also plays an active heat dissipation role. Additionally, radial ribs in the overpack body and lid assist in heat dissipation to cask external surfaces. Finally, the shielding concrete used in Version UVH is of high density rich in hematite class of aggregate which ensures a high thermal conductance across its mass. Heat rejection from the overpack to the ambient environment like all other HI-STORM overpack models, occurs through natural convection from the cask's exposed surfaces.

The Closure Lid for Version UVH is also a steel structural weldment with high density, high conductivity concrete installed inside its structure to provide protection against sky shine. The Closure Lid is installed on the cask body by a set of equidistant anchor bolts with a small clearance and an interposed flat concentric gasket limiting exposure of the overpack internal cavity to the external environment ~~providing a barrier against the intrusion of air in the overpack's annulus space~~ and, thus, reducing the probability of stress corrosion cracking (SCC) in the stainless steel

MPCprotecting the MPC from the deleterious effect of airborne species that may induce stress corrosion cracking (SCC) in stainless steel. Precluding Reducing the incidence of SCC in the MPC shell during extended period of storage by creating a still air environment around it is a principal benefit of Version UVH. The weight of the Closure Lid helps the sealing action of the gasket. In the event the air in the overpack annulus were to pressurize, the weight of the lid is counteracted allowing the air to escape. Thus the overpack has a built-in protection against overpressure.

In addition to providing a barrier against ingress of aggressive species in the space around the MPC, Version UVH also accrues several salutary benefits, such as:

- Absence of vent openings eliminates a source of radiation to the environment emitted from the Canister.
- The overpack is rendered much more rugged against mechanical projectiles in absence of vent openings. The intermediate and penetrant Design Basis Missiles (see Table 2.IV.2.1) cease to be a safety concern.
- The Version UVH overpack, made of steel and devoid of any vents, emulates a metal cask in respect of critical functions under accident conditions such as the Design Basis Fire. However, thanks to its larger footprint and greater mass, it is a far superior in respect of shielding capacity and seismic stability in comparison to any peer metal cask.
- The aging related deterioration of the paint on the cask's internal surface is substantially retarded because of the hot and dry air environment in contact with it.
- Periodic inspection of the vent openings and associated LCOs in the CoC become unnecessary, eliminating this source of radiation dose to the site staff.

The HI-STORM 100 Version UVH overpack is qualified to store all MPCs model types listed in Table 2.IV.1.1 with permissible heat loads as described in Section 2.IV.1. Table 1.IV.2.2 provides essential design data required for the safety analysis of the Version UVH overpack cask in the subsequent chapters.

1.IV.2.1.2.2 Transfer Cask

HI-TRAC transfer casks qualified for other HI STORM 100 models may be used with Version UVH. No new transfer cask design is proposed in this supplement and there are no modifications to existing designs.

1.IV.2.1.3 Shielding Materials:

There is no change in the shielding materials used in the HI-STORM 100 UVH system from the shielding materials described for other models of the HI-STORM 100 System. Table 1.IV.2.1 contains additional information.

# CHAPTER 2.IV: PRINCIPAL DESIGN CRITERIA

## 2.IV.0 Introduction

The principal design criteria for the HI-STORM 100 Version UVH canister storage system is unchanged in all respects except for those relating to its function related to limiting exposure of the overpack internal cavity to the external environmentenvironment control.

The Version UVH overpack does not have any open penetrations such as air vents in the classical design to permit ventilation of the ambient air and the Closure Lid is installed with a concentric gasket which inhibits the exchange of gas inside the cask with the ambient air. The Closure Lid is emplaced on the cask body with a set of large body bolts which are installed with a small axial clearance to allow any significant increase in internal gas pressure above the ambient pressure, to be relieved once it overcomes the counteracting lid's weight. A simple force equilibrium shows that a pressure rise of 5 psi in the cask cavity is not possible to sustain even under the scenario of maximum density concrete installed in the cask's lid. However, the structural evaluations are performed using a higher internal pressure.

The loadings associated with Version UVH must include internal pressure and external pressure which are not present in the ventilated cask. For all other Design Basis Loadings, Version UVH cask body is the same as the standard HI-STORM 100 cask body described in this FSAR. In this chapter, the Design pressures appropriate to Version UVH are defined and the overpack loadings are re-visited to ensure that the safety analyses presented in other chapters are comprehensive.

The ITS category of the Structures, Systems and Components (HI-STORM 100 UVH Overpack, MPCs, HI-TRACs) important-to-safety for the HI-STORM 100 UVH System are provided in the licensing drawings for the respective components as follow:

- HI-STORM 100 UVH Overpack: Licensing Drawing in Section 1.IV.5 of the Supplement
- MPC-32M: Licensing Drawing in Section 1.II.5 of Supplement II of this FSAR
- MPC-68M: Licensing Drawing in Section 1.5 of Chapter 1 of this FSAR

### 2.IV.0.1 Principal Design Criteria for the ISFSI Pad

The principal design criteria for the ISFSI pad applicable for the Version UVH cask remains unchanged from the main body of the FSAR with the exception of the requirements identified in Table 2.IV.0.1.

# SUPPLEMENT 4.IV: THERMAL EVALUATION OF HI-STORM 100 UVH SYSTEM

## 4.IV.0 OVERVIEW

The thermal compliance of the HI-STORM 100 Version UVH system to the ISG-11 Rev 3[4.1.4] and other limits specified in Supplement 2.IV is established in this supplement. As described in Supplement 1.IV, Version UVH is an unventilated variant of the HI-STORM 100 overpack. The thermal acceptance criteria provide specific limits on the maximum cladding temperature of the stored commercial spent fuel (CSF) and the integrity of the MPC confinement space under all operating scenarios. Specifically, the requirements are:

i. The fuel cladding temperature must meet the temperature limit under normal, off-normal, and accident conditions appropriate to its burnup level and condition of storage or handling set forth in Table 4.3.1[1].

ii. The maximum internal pressure of the MPC and the ~~air~~ annulus should remain within their design pressures for normal, short-term, off-normal, and accident conditions set forth in Table 2.IV.2.3.

iii. The temperatures of the cask materials shall remain below their allowable limits set forth in Table 2.IV.2.4 under all scenarios.

The analyses consider passive rejection of decay heat from the stored SNF assemblies to the environment under normal, off-normal, and accident conditions of storage. Effects of incident solar radiation (insolation) and partial radiation blockage due to the presence of neighboring casks at an ISFSI site are included in the analyses.

The safety evaluations of the storage system loaded with MPC-32M and MPC-68M canisters (already evaluated for storage in ventilated systems in Supplements 4.II and 4.III respectively) are carried out using the QA validated Code, ANSYS Fluent [4.IV.1.2] (which has been widely used in thermal safety analyses in Holtec dockets, including all analyses documented in Chapter 4, Supplement 4.II and Supplement 4.III of this FSAR). The analyses employ a set of conservative assumptions that seek to overstate the computed temperatures and pressures.

[1] All table references without a Roman numeral in the second place indicate that they are in the main SAR (i.e., not in a supplement)

]
Following the above principles and ruleset in Section 4.IV.1.1, several limiting patterns are identified for MPC-32M and MPC-68M baskets. Therefore, following this strategy, several regionalized patterns for MPC-32M and MPC-68M are identified and evaluated using 3-D Computational Fluid Dynamics (CFD) models (Section 4.IV.4.2).

### 4.IV.1.4 Backfill Pressure Limits

The minimum and maximum initial helium backfill pressures for MPCs stored in Version UVH system are listed in Table 4.IV.1.3. The annular gap between the MPC and the Version UVH overpack is ~~air~~ backfilled with air, nitrogen, or argon to atmospheric conditions such that the operating pressure under normal long-term storage conditions is within the limits set forth in Supplement 2.IV. The initial backfill pressure for HI-STORM annulus ~~air~~ gas is listed in Table 4.IV.1.3.

### 4.IV.1.5 Use of Nitrogen or Argon as HI-STORM 100 UVH Annulus Backfill Medium

In addition to air, the use of either nitrogen or argon (two non-oxidizing gases) is also permitted as the backfill medium between the MPC and the overpack as described in Supplement 8.IV. Since both gases have lower thermal conductivity and density than air, additional calculations are performed with the most bounding scenario to demonstrate that all components meet their respective temperature and pressure limits under all conditions of storage. Argon has significantly lower thermal conductivity than air, while the thermal conductivity and other thermophysical properties of nitrogen are very close to those of air. Therefore, these evaluations are performed with argon as the annulus backfill medium. The conclusions from these evaluations can be extended to a nitrogen backfill without any loss of generality.

Steady state thermal evaluations are performed for the bounding heat load pattern, i.e., uniform heat load pattern for MPC-32M in a cask array. The results of this evaluation are presented in Table 4.IV.4.3. The results for the pressure calculations are presented in Table 4.IV.4.4. The results show that the temperatures are similar to those with air in the annulus (also presented in the same tables), and all components meet their temperature and pressure limits.

Table 4.IV.1.3

INITIAL BACKFILL PRESSURE FOR MPC HELIUM AND ANNULUS ~~AIR~~GAS

| Condition | MPC Helium Backfill Pressure Limits (psig) | Annulus ~~Air~~ Gas Fill Pressure Limits (psig) |
|---|---|---|
| MPC-32M | Minimum: 40<br>Maximum: 43 | 0 Note-2 |
| MPC-68M | Minimum: 42<br>Maximum: 45 | |

Note-1: Initial backfill pressures of helium is specified at a reference temperature of 70ºF (21ºC).
Note-2: Annulus is backfilled to atmospheric conditions.

## 4.IV.4 THERMAL EVALUATION OF NORMAL CONDITIONS OF STORAGE

Thermal analyses to demonstrate the safety of long-term storage of MPC-32M and MPC-68M in the HI-STORM Version UVH overpack is presented in this section.

### 4.IV.4.1 Thermal Model

The Storage system consists of the MPC standing upright on the cask's baseplate and the surrounding cask made of steel and plain concrete. The MPC and SNF thermal model is identical to that described in Supplements 4.II and 4.III of this FSAR. [

PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10CFR2.390

]

#### 4.IV.4.1.1 Effect of Neighboring Casks

HI-STORM casks are typically stored on an ISFSI pad in regularly spaced arrays. Relative to an isolated HI-STORM, cask the heat dissipation from a HI-STORM UVH cask placed in an array is somewhat disadvantaged. [

PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10CFR2.390

Table 4.IV.4.3
BOUNDING HEAT LOAD PATTERN MAXIMUM TEMPERATURES IN HI-STORM 100 VERSION UVH UNDER LONG TERM STORAGE (CASK ARRAY CONFIGURATION)

[

PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10CFR2.390

]

Table 4.IV.4.4

SUMMARY OF BOUNDING MPC CAVITY AND HI-STORM UVH ANNULUS PRESSURES UNDER LONG-TERM (CASK ARRAY CONFIGURATION)

[

PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10CFR2.390

]

## 8.IV.1 PROCEDURE FOR LOADING THE HI-STORM 100 UVH SYSTEM IN THE SPENT FUEL POOL

The procedures presented within Subsections 8.1.1 through 8.1.65 of Chapter 8 are identical for the HI-STORM 100 UVH system. The changes to operations when placing the HI-STORM 100 UVH into storage are described below.

### 8.IV.1.7 Placement of HI-STORM 100 UVH into Storage

The following instructions shall be incorporated to the cask operations as additional steps to the generic guidance in Section 8.1.76 on loading operations for unventilated cask models in Chapter 8:

1. After Step 18a, prior to Step 18e:
    a. Inspect cask cavity and confirm to be visibly dry (free of standing water).
2. After Step 18.c, prior to Step 18.e:
    a. Before installing the Closure Lid on the cask body, the lid gasket is placed on the top of the cask's top ring.
    b. Remove drain assembly plugs to prevent pressurization of cavity during HI-STORM transfer operations.
3. Perform Step 18.e, taking care not to crush or otherwise damage the gasket. No pre-load should be applied at this time.
4. Omit Step 18.f.
5. After Step 20:
    a. Tighten lid hex nuts to the point of contact with the washer. Then loosen nut to provide a nominal axial gap of 0.5".

| **Note:** |
|---|
| The HI-STORM 100 UVH cavity initial pressure is adjusted as necessary in accordance with Section 4.IV.1.4. |

    b. Reinstall the drain assembly plugs.
6. Omit Step 21, 22, & 23.

1. ~~Before installing the Closure Lid on the cask body, the lid gasket is placed on the top of the cask's top ring.~~

2. ~~Inspect cask cavity and confirm to be visibly dry (free of standing water).~~

3. ~~Place cask lid on top of the gasket.~~

4. ~~Continue with the steps of Subsection 8.1.7 of Chapter 8 for conducting the required surface dose rate measurements in accordance with the Technical Specification and movement of the overpack to its storage location on the ISFSI pad.~~

5. ~~After the cask is placed in its storage location on the ISFSI pad, install lid studs, washers, and hex nuts onto the cask.~~

6. ~~Tighten lid hex nuts to the point of contact with the washer. Then loosen nut to provide a nominal axial gap of 0.5".~~

7. ~~Evacuate air in the MPC/HI-STORM 100 UVH annulus and replace with dry nitrogen (or another non-oxidizing gas) using couplings provided in the small penetrations in the cask body. The target fill pressure of the non-oxidizing fill gas shall be as indicated on Table 4.IV.1.3.~~

| Table 8.IV.1.8<br><br>HI-STORM 100 UVH SYSTEM OVERPACK INSPECTION CHECKLIST |
|---|
| **Note:**<br><br>This checklist provides a supplement to the main table 8.2.31.8 as a basis for establishing additional steps to a site-specific inspection checklist for the HI-STORM 100 UVH overpack. Specific findings shall be brought to the attention of the appropriate site organizations for assessment, evaluation, and potential corrective action prior to use. |

HI-STORM 100 UVH Overpack Lid:

1. Lid sealing surfaces shall be cleaned and inspected for corrosion, scratches, and gouges.
2. Lid seal shall be inspected for cuts, abrasions, or other damage which may affect is function.

HI-STORM 100 Main Body:

1. Vents inspections are not required because the HI-STORM 100 UVH body does not include vents.

## 8.IV.4. MPC TRANSFER TO A HI-STAR 100 OVERPACK FOR TRANSPORT OR STORAGE

When the MPC is recovered from storage and transferred to a HI-STAR 100 Overpack, the procedures from section 8.43 are used. There are no HI-STAR operations that will change.

## 8.IV.5. MPC TRANSFER INTO THE HI-STORM 100 UVH OVERPACK DIRECTLY FROM TRANSPORT

When the MPC is recovered received from storage transport and transferred to a HI-STAR STORM 100 UVH Overpack the procedures from Section 8.35 are used. There are no HI-STAR transfer operations that require change.

# CHAPTER 9.IV:
# ACCEPTANCE CRITERIA AND MAINTENANCE PROGRAM

## 9.IV.0 INTRODUCTION

The addition of the Unventilated overpack through Supplement IV does not involve the introduction of any new structural or shielding materials, MPCs, or transfer casks to the Storage system. Therefore, no change to the areas which cover most of Chapter 9 is necessary. Any additional tests, inspections, and maintenance activities are identified in the following sections. The following sections describe the Acceptance and Maintenance activities that are unique to the HI-STORM 100 UVH system and thus supplement the information presented in Chapter 9. Where practical, the section numbers used below directly reference the corresponding sections in Chapter 9. For example, Subsection 9.IV.1.3 supplements the operations described in Subsection 9.1.3. The guidance provided in this supplement shall be used along with the Acceptance and Maintenance Activities provided in Chapter 9 to develop the site-specific maintenance procedures for the HI-STORM 100 UVH.

## 9.IV.1 ACCEPTANCE CRITERIA

### 9.IV.1.1 Fabrication and Nondestructive Examination (NDE)

The HI-STORM 100 UVH does not introduce any new fabrication or NDE requirements.

### 9.IV.1.2 Structural and Pressure Tests

The HI-STORM 100 UVH does not introduce any new structural or pressure test beyond what is presented in Subsection 9.1.2. Pressure testing of the HI-STORM 100 UVH Body is not required due to low operating pressure.

### 9.IV.1.2.3 Materials Testing

There are no new structural and shielding materials used for the HI-STORM 100 UVH. No additional materials testing is required for the HI-STORM 100 UVH. The HI-STORM Lid seal will be a metallic material that is demonstrated to not degrade over the service life of the cask.

### 9.IV.1.3 Leakage Testing

There is no leakage test required for the HI-STORM 100 UVH boundary. The function of the HI-STORM 100 UVH seal is to limit the exposure of the overpack internal cavity to the deleterious effects of the environment, not as a pressure boundary. The only requirement is that the gasket is inspected to ensure that it is intact and new before the lid is installed

### 9.IV.1.4 Component Tests

#### 9.IV.1.4.1 Valves, Pressure Relief Devices, and Fluid Transport Devices

There are no additional valves or pressure relief devices introduced for the HI-STORM 100 UVH System. Excess pressure is released from the boundary by the HI-STORM lid momentarily lifting from the body and then re-seating.

#### 9.IV.1.4.2 Seals and Gaskets

The Lid to Cask body in the unventilated overpack features a gasket to limit exposure of the overpack internal cavity to the external, ambient environment~~isolate the environment in the cask's cavity space from ambient air~~. The gasket does not perform a safety significant function and thus no additional testing is required.

### 9.IV.1.5 Shielding Integrity

There are no new tests or inspections required for shielding integrity.

### 9.IV.1.6 Thermal Acceptance Tests

The Air Temperature Rise test will not be required for the HI-STORM 100 UVH unventilated overpack. There are no inlet and outlet vents that require monitoring or inspection.

### 9.IV.1.7 Cask Identification

There are no new marking requirements.

# 9.IV.2 MAINTENANCE PROGRAM

As the addition of the unventilated overpack through Supplement ~~#~~ IV does not involve the introduction of any new structural or shielding materials, MPCs or transfer cask to the Storage system, only minimal changes to the Maintenance activities outlined in Section 9.2 of Chapter 9 are required. Any additional tests, inspections, and maintenance activities are identified in the following Subsections.

## 9.IV.2.1 Structural and Pressure Parts

No additional maintenance for structural and pressure parts is required for the HI-STORM 100 UVH.

## 9.IV.2.2 Leakage Tests

Leakage tests are not a requirement for the storage maintenance program.

The unventilated Storage system lid gasket requires the additional maintenance step of replacement anytime the joint is completely disassembled. A new gasket shall be used upon re-assembly.

## 9.IV.2.3 Subsystem Maintenance

The HI-STORM 100 UVH does not have vents and will not have the option of a monitoring system which must be maintained.

## 9.IV.2.4 Pressure Relief Devices

There is no additional pressure relief device introduced for the HI-STORM 100 UVH System which must be maintained.

## 9.IV.2.5 Shielding

There are no additional shielding maintenance requirements for the HI-STORM 100 UVH.

## 9.IV.2.6 Thermal

The HI-STORM 100 UVH does not include air vents. As a result, surveillance or monitoring is not required during storage operations.