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Table 1.0.3 (continued)

HI-STORM 100 SYSTEM TSAR CLARIFICATIONS AND EXCEPTIONS TO NUREG-1536

NUREG-1536 Requirement	Alternate Method to Meet NUREG-1536 Intent	Justification
4.V.5.c, Page 4-10, Para. 3 "free volume calculations should account for thermal expansion of the cask internal components and the fuel when subjected to accident temperatures.	Exception: All free volume calculations use nominal confinement boundary dimensions, but the volume occupied by the MPC internals (i.e., fuel assemblies, fuel basket, etc.) are calculated using maximum weights and minimum densities.	Calculating the volume occupied by the MPC internals (i.e., fuel assemblies, fuel basket, etc.) using maximum weights and minimum densities conservatively overpredicts the volume occupied by the internal components and correspondingly underpredicts the remaining free volume.
7.V.4.c, Page 7-7, Para. 2 and 3 "Because the leak is assumed to be instantaneous, the plume meandering factor of Regulatory Guide 1.145 is not typically applied." and "Note that for an instantaneous release (and instantaneous exposure), the time that an individual remains at the controlled area boundary is not a factor in the dose calculation."	Exception: As described in Section 7.3, in lieu of an instantaneous release, the assumed leakage rate is set equal to the leakage rate acceptance criteria ($5x10^{-6}$ atm-cm^3/s) plus 50% for conservatism, which yields $7.5x10^{-6}$ atm-cm^3/s. Because the release is assumed to be a leakage rate, the individual is assumed to be at the controlled area boundary for 720 hours. Additionally, the atmospheric dispersion factors of Regulatory Guide 1.145 are applied.	The MPC uses redundant closures to assure that there is no release of radioactive materials under all credible conditions. Analyses presented in Chapters 3 and 11 demonstrate that the confinement boundary does not degrade under all normal, off-normal, and accident conditions. Multiple inspection methods are used to verify the integrity of the confinement boundary (e.g., helium leakage, hydrostatic, and volumetric weld inspection). The NRC letter to Holtec International dated 9/15/97, Subject: Supplemental Request for Additional Information - HI-STAR 100 Dual Purpose Cask System (TAC No. L22019), RAI 7.3 states "use the verified confinement boundary leakage rate in lieu of the assumption that the confinement boundary fails."

Table 1.0.3 (continued)

HI-STORM 100 SYSTEM TSAR CLARIFICATIONS AND EXCEPTIONS TO NUREG-1536

NUREG-1536 Requirement	Alternate Method to Meet NUREG-1536 Intent	Justification
9.V.1.a, Page 9-4, Para. 4 "Acceptance criteria should be defined in accordance with NB/NC-5330, "Ultrasonic Acceptance Standards"."	Clarification: Section 9.1.1.1 and the Design Drawings specify that the ASME Code, Section III, Subsection NB, Article NB-5332 will be used for the acceptance criteria for the volumetric examination of the MPC lid-to-shell weld.	In accordance with the first line on page 9-4, the NRC endorses the use of "...appropriate acceptance criteria as defined by either the ASME code, or an alternative approach..." The ASME Code, Section III, Subsection NB, Paragraph NB-5332 is appropriate acceptance criteria for pre-service examination.
9.V.1.d, Para. 1 "Tests of the effectiveness of both the gamma and neutron shielding may be required if, for example, the cask contains a poured lead shield or a special neutron absorbing material."	Exception: Subsection 9.1.5 describes the control of special processes, such as neutron shield material installation, to be performed in lieu of scanning or probing with neutron sources.	The dimensional compliance of all shielding cavities is verified by inspection to Design Drawing requirements prior to shield installation. The Holtite-A shield material is installed in accordance with written, approved, and qualified special process procedures. The composition of the Holtite-A is confirmed by inspection and tests prior to first use. Following the first loading for the HI-TRAC transfer cask and each HI-STORM overpack, a shield effectiveness test is performed in accordance with written approved procedures, as specified in Section 9.1.

1.2.1.1 Multi-Purpose Canisters

The MPCs are welded cylindrical structures as shown in cross sectional views of Figures 1.2.2 and 1.2.4. The outer diameter and cylindrical height of each MPC are fixed. Each spent fuel MPC is an assembly consisting of a honeycombed fuel basket, a baseplate, canister shell, a lid, and a closure ring, as depicted in the MPC cross section elevation view, Figure 1.2.5. The number of spent nuclear fuel storage locations in each of the MPCs depends on the fuel assembly characteristics. There are three MPC models, distinguished by the type and number of fuel assemblies authorized for loading. The MPC-24 is designed to store up to 24 intact PWR fuel assemblies. The MPC-68 is designed to store up to 68 intact or damaged BWR fuel assemblies. The MPC-68F is designed to store up to 68 intact or damaged BWR fuel assemblies and up to four BWR fuel assemblies classified as fuel debris. Design Drawings for all of the MPCs are provided in Section 1.5.

The MPC provides the confinement boundary for the stored fuel. Figure 1.2.6 provides an elevation view of the MPC confinement boundary. The confinement boundary is defined by the MPC baseplate, shell, lid, port covers, and closure ring. The confinement boundary is a seal-welded enclosure of all stainless steel construction.

The construction features of the PWR MPC-24 and the BWR MPC-68 are similar. However, the PWR MPC-24 canister in Figure 1.2.4, which is designed for high-enriched PWR fuel, differs in construction from the MPC-68 in one important aspect: the fuel storage cells are physically separated from one another by a "flux trap", for criticality control. All MPC baskets are formed from an array of plates welded to each other, such that a honeycomb structure is created which resembles a multiflanged, closed-section beam in its structural characteristics.

The MPC fuel basket is positioned and supported within the MPC shell by a set of basket supports welded to the inside of the MPC shell. Between the periphery of the basket, the MPC shell, and the basket supports, heat conduction elements are installed. These heat conduction elements are fabricated from thin aluminum alloy 1100 in shapes which enable a snug fit in the confined spaces and ease of installation. The heat conduction elements are installed along the full length of the MPC basket to create a nonstructural thermal connection which facilitates heat transfer from the basket to shell. In their installed condition, the heat conduction elements contact the MPC shell and basket walls.

Lifting lugs attached to the inside surface of the MPC canister shell serve to permit placement of the empty MPC into the HI-TRAC transfer cask. The lifting lugs also serve to axially locate the MPC lid prior to welding. These internal lifting lugs are not used to handle a loaded MPC. Since the MPC lid is installed prior to any handling of a loaded MPC, there is no access to the lifting lugs once the MPC is loaded.

The top end of the MPC incorporates a redundant closure system. Figure 1.2.6 shows the MPC closure details. The MPC lid is a circular plate edge-welded to the MPC outer shell. This plate is equipped with vent and drain ports which are utilized to remove moisture and air from the MPC, and backfill the MPC with a specified mass of inert gas (helium). The vent and drain ports are covered and seal welded before the closure ring is installed. The closure ring is a circular ring edge-welded to the MPC shell and lid. The MPC lid provides sufficient rigidity to allow the entire MPC loaded with SNF to be lifted by threaded holes in the MPC lid.

To maintain a constant exterior axial length between the MPC-24 and MPC-68, the thickness of the MPC-24 lid is ½ inch thinner than the MPC-68 lid to accommodate the longest PWR fuel assembly which is approximately a ½ inch longer than the longest BWR fuel assembly. For fuel assemblies that are shorter than the design basis length, upper and lower fuel spacers (as appropriate) maintain the axial position of the fuel assembly within the MPC basket. The upper fuel spacers are threaded into the underside of the MPC lid as shown in Figure 1.2.5. The lower fuel spacers are placed in the bottom of each fuel basket cell. The upper and lower fuel spacers are designed to withstand normal, off-normal, and accident conditions of storage. An axial clearance of approximately 2 inches is provided to account for the irradiation and thermal growth of the fuel assemblies. The upper and lower fuel spacer lengths are listed in Tables 2.1.9 and 2.1.10 for each fuel assembly type.

The MPC is constructed entirely from stainless steel alloy materials (except for the neutron absorber and aluminum heat conduction elements). No carbon steel parts are permitted in the MPC. Concerns regarding interaction of coated carbon steel materials and various MPC operating environments [1.2.1] are not applicable to the MPC. All structural components in a MPC shall be made of Alloy X, a designation which warrants further explanation.

Alloy X is a material which is expected to be acceptable as a Mined Geological Disposal System (MGDS) waste package and which meets the thermophysical properties set forth in this document.

At this time, there is considerable uncertainty with respect to the material of construction for an MPC which would be acceptable as a waste package for the MGDS. Candidate materials being considered for acceptability by the DOE include:

- Type 316
- Type 316LN
- Type 304
- Type 304LN

The DOE material selection process is primarily driven by corrosion resistance in the potential environment of the MGDS. As the decision regarding a suitable material to meet disposal requirements is not imminent, this application requests approval for use of any one of the four Alloy X materials.

For the MPC design and analysis, Alloy X (as defined in this application) may be one of the following materials (only a single alloy from the list of acceptable Alloy X materials may be used in the fabrication of a single MPC).

- Type 316
- Type 316LN
- Type 304
- Type 304LN

The Alloy X approach is accomplished by qualifying the MPC for all mechanical, structural, neutronic, radiological, and thermal conditions using material thermophysical properties which are the least favorable for the entire group for the analysis in question. For example, when calculating the rate of heat rejection to the outside environment, the value of thermal conductivity used is the lowest for the candidate material group. Similarly, the stress analysis calculations use the lowest value of the ASME Code allowable stress intensity for the entire group. Stated differently, we have defined a material, which is referred to as Alloy X, whose thermophysical properties, from the MPC design perspective, are the least favorable of the candidate materials.

The evaluation of the Alloy X constituents to determine the least favorable properties is provided in Appendix 1.A.

Other alloy materials which are identified to be more suitable by the DOE for the MGDS in the future and which are also bounded by the Alloy X properties set forth in Appendix 1.A can be used in the MPC after an amendment to this TSAR is approved.

The Alloy X approach is conservative because no matter which material is ultimately utilized in the MPC construction, the Alloy X approach guarantees that the performance of the MPC will exceed the analytical predictions contained in this document.

1.2.1.2 Overpacks

1.2.1.2.1 HI-STORM 100 Overpack (Storage)

The HI-STORM 100 overpack is a rugged, heavy-walled cylindrical vessel. Figures 1.2.7 and 1.2.8 provide cross sectional views of the HI-STORM 100 System. The main structural function of the storage overpack is provided by carbon steel, and the main shielding function is provided by plain concrete. The overpack plain concrete is enclosed by cylindrical steel shells, a thick steel baseplate, and a top plate. The overpack lid has appropriate concrete shielding attached to its underside and top to provide neutron and gamma attenuation in the vertical direction.

The storage overpack provides an internal cylindrical cavity of sufficient height and diameter for housing an MPC. The inner shell of the overpack has channels attached to its inner diameter. The channels provide guidance for MPC insertion and removal and a flexible medium to absorb impact loads during the non-mechanistic tip-over, while still allowing the cooling air flow to circulate through the overpack. Stainless steel shims are attached to channels to allow the proper inner diameter dimension to be obtained and to provide a guiding surface for MPC insertion and removal.

The storage overpack has air ducts to allow for passive natural convection cooling of the contained MPC. Four air inlets and four air outlets are located at the lower and upper extremities of the overpack, respectively. The air inlets and outlets are covered by a fine mesh screen to reduce the potential for blockage. Routine inspection of the screens (or, alternatively, temperature monitoring) ensures that blockage of the screens themselves will be detected and removed in a timely manner. Analysis, provided in this TSAR, evaluates the effects of partial and complete blockage of the air ducts.

The four air inlets and four air outlets are penetrations through the thick concrete shielding provided by the HI-STORM overpack. Within the air inlets and outlets, an array of gamma shield cross plates are installed. These gamma shield cross plates are designed to scatter any particles traveling through the ducts. The result of scattering the particles in the ducts is a significant decrease in the local dose rates around the four air inlets and four air outlets. The configuration of the gamma shield cross plates is such that the increase in the resistance to flow in the air inlets and outlets is minimized.

Four threaded anchor blocks at the top of the overpack are provided for lifting. The anchor blocks are integrally welded to the radial plates which in turn are full-length welded to the overpack inner shell, outer shell, and baseplate (see Figure 1.2.7). The four anchor blocks are located on 90° centers. The overpack may also be lifted from the bottom using specially-designed lifting transport devices, including hydraulic jacks, air pads, and Hilman rollers. Slings or other suitable devices mate with lifting lugs which are inserted into threaded holes in the top surface of the overpack lid to allow lifting of the overpack lid. After the lid is bolted to the storage overpack main body, these lifting bolts shall be removed and replaced with flush plugs.

The plain concrete between the overpack inner and outer steel shells is specified to provide the necessary shielding properties and compressive strength. The concrete shall be in accordance with the requirements specified in Appendix 1.D.

The principal function of the concrete is to provide shielding against gamma and neutron radiation. However, in an implicit manner it helps enhance the performance of the HI-STORM overpack in other respects as well. For example, the massive bulk of concrete imparts a large thermal inertia to the HI-STORM overpack, allowing it to moderate the rise in temperature of the system under hypothetical conditions when all ventilation passages are assumed to be blocked. The case of a postulated fire accident at the ISFSI is another example where the high thermal inertia characteristics of the HI-STORM concrete control the temperature of the MPC. Although the annular concrete mass in the overpack shell is not a structural member, it does act as an elastic/plastic filler of the inter-shell space, such that, while its cracking and crushing under a tip-over accident is not of significant consequence, its deformation characteristics are germane to the analysis of the structural members.

Density and compressive strength are the key parameters which delineate the performance of concrete in the HI-STORM System. The density of concrete used in the inter-shell annulus, pedestal, and HI-STORM lid has been set as defined in Appendix 1.D. For evaluating the physical properties of concrete for completing the analytical models, conservative formulations of Reference [1.2.6] are used.

To ensure the stability of the concrete at temperature, the concrete composition has been specified in accordance with NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems" [1.2.10]. Thermal analyses, presented in Chapter 4, show that the temperatures during normal storage conditions do not threaten the physical integrity of the HI-STORM overpack concrete.

1.2.1.2.2 HI-TRAC (Transfer Cask)

Like the storage overpack, the HI-TRAC transfer cask is a rugged, heavy-walled cylindrical vessel. The main structural function of the transfer cask is provided by carbon steel, and the main neutron and gamma shielding functions are provided by water and lead, respectively. The transfer cask is a steel, lead, steel layered cylinder with a water jacket attached to the exterior. Figure 1.2.9 provides a typical cross section of a HI-TRAC with the pool lid installed.

The transfer cask provides an internal cylindrical cavity of sufficient size for housing an MPC. The top lid has additional neutron shielding to provide neutron attenuation in the vertical direction (from SNF in the MPC below). The MPC access hole through the HI-TRAC top lid is provided to allow the lowering/raising of the MPC between the HI-TRAC transfer cask, and the HI-STORM or HI-STAR overpacks. The HI-TRAC is provided with two bottom lids, each used separately. The pool lid is bolted to the bottom flange of the HI-TRAC and is utilized during MPC fuel loading and sealing operations. In addition to providing shielding in the axial direction, the pool lid incorporates a seal which is designed to hold clean demineralized water in the HI-TRAC inner cavity, thereby preventing contamination of the exterior of the MPC by the contaminated fuel pool water. After the MPC has been drained, dried, and sealed, the pool lid is removed and the HI-TRAC transfer lid is attached. The transfer lid incorporates two sliding doors which allow the opening of the HI-TRAC bottom for the MPC to be raised/lowered. Figure 1.2.10 provides a cross section of the HI-TRAC with the transfer lid installed.

Trunnions are provided for lifting and rotating the transfer cask body between vertical and horizontal positions. The lifting trunnions are located just below the top flange and the pocket trunnions are located above the bottom flange. The two lifting trunnions are provided to lift and vertically handle the HI-TRAC, and the pocket trunnions provide a pivot point for the rotation of the HI-TRAC for downending or upending.

Two HI-TRAC transfer casks of different weights are provided to house the MPCs. The 125 ton HI-TRAC weight does not exceed 125 tons during any loading or transfer operation. The 100 ton HI-TRAC weight does not exceed 100 tons during any loading or transfer operation. The internal cylindrical cavities of the two HI-TRACs are identical. However, the external dimensions are different. The 100 ton HI-TRAC has a reduced thickness of lead and water shielding and consequently, the external dimensions are different. The structural steel thickness is identical in the two HI-TRACs. This allows most structural analyses of the 125 ton HI-TRAC to bound the 100 ton HI-TRAC design. Additionally, as the two HI-TRACs are identical except for a reduced thickness of lead and water, the 125 ton HI-TRAC has a larger thermal resistance than the smaller and lighter 100 ton HI-TRAC. Therefore, for normal conditions the 125 ton HI-TRAC thermal analysis bounds that of the 100 ton HI-TRAC. Separate shielding analyses are performed for each HI-TRAC since the shielding thicknesses are different between the two.

1.2.1.3 Shielding Materials

The HI-STORM 100 System is provided with shielding to ensure the radiation and exposure requirements in 10CFR72.104 and 10CFR72.106 are met. This shielding is an important factor in minimizing the personnel doses from the gamma and neutron sources in the SNF in the MPC for ALARA considerations during loading, handling, transfer, and storage. The fuel basket structure of edge-welded composite boxes and Boral™ neutron poison panels attached to the fuel storage cell vertical surfaces provide the initial attenuation of gamma and neutron radiation emitted by the radioactive spent fuel. The MPC shell, baseplate, lid and closure ring provide additional thicknesses of steel to further reduce the gamma flux at the outer canister surfaces.

In the HI-STORM 100 storage overpack, the primary shielding in the radial direction is provided by concrete and steel. In addition, the storage overpack has a thick circular concrete slab attached to the underside of the lid, and a thick circular concrete pedestal upon which the MPC rests. These slabs provide gamma and neutron attenuation in the axial direction. The thick overpack lid and concrete shield ring atop the lid provide additional gamma attenuation in the upward direction, reducing both direct radiation and skyshine. Several steel plate and shell elements provide additional gamma shielding as needed in specific areas, as well as incremental improvements in the overall shielding effectiveness.

In the HI-TRAC transfer cask radial direction, gamma and neutron shielding consists of steel-lead-steel and water, respectively. In the axial direction, shielding is provided by the top lid, and the pool or transfer lid. In the HI-TRAC pool lid, layers of steel-lead-steel provide an additional measure of gamma shielding to supplement the gamma shielding at the bottom of the MPC. In the transfer lid, layers of steel-lead-steel provide gamma attenuation. For the 125 ton HI-TRAC transfer lid, the neutron shield material, Holtite-A, is also provided. The 125 ton HI-TRAC top lid is composed of steel-neutron shield-steel, with the neutron shield material being Holtite-A. The 100 ton HI-TRAC top lid is composed of steel only providing gamma attenuation.

1.2.1.3.1 Boral Neutron Absorber

Boral is a thermal neutron poison material composed of boron carbide and aluminum (aluminum powder and plate). Boron carbide is a compound having a high boron content in a physically stable and chemically inert form. The boron carbide contained in Boral is a fine granulated powder that conforms to ASTM C-750-80 nuclear grade Type III. The Boral cladding is made of alloy aluminum, a lightweight metal with high tensile strength which is protected from corrosion by a highly resistant oxide film. The two materials, boron carbide and aluminum, are chemically compatible and ideally suited for long-term use in the radiation, thermal, and chemical environment of a nuclear reactor, spent fuel pool, or dry cask.

The documented historical applications of Boral, in environments comparable to those in spent fuel pools and fuel storage casks, dates to the early 1950s (the U.S. Atomic Energy Commission's AE-6 Water-Boiler Reactor [1.2.2]). Technical data on the material was first printed in 1949, when the report "Boral: A New Thermal Neutron Shield" was published [1.2.3]. In 1956, the first edition of the Reactor Shielding Design Manual [1.2.4] was published and it contained a section on Boral and its properties.

In the research and test reactors built during the 1950s and 1960s, Boral was frequently the material of choice for control blades, thermal-column shutters, and other items requiring very good thermal-neutron absorption properties. It is in these reactors that Boral has seen its longest service in environments comparable to today's applications.

Boral found other uses in the 1960s, one of which was a neutron poison material in baskets used in the shipment of irradiated, enriched fuel rods from Canada's Chalk River laboratories to Savannah River. Use of Boral in shipping containers continues, with Boral serving as the poison in current British Nuclear Fuels Limited casks and the recently licensed Storable Transport Cask by Nuclear Assurance Corporation [1.2.5].

As indicated in Tables 1.2.3-1.2.5, Boral has been licensed by the NRC for use in numerous BWR and PWR spent fuel storage racks and has been extensively used in international nuclear installations.

Boral has been exclusively used in fuel storage applications in recent years. Its use in spent fuel pools as the neutron absorbing material can be attributed to its proven performance and several unique characteristics, such as:

- The content and placement of boron carbide provides a very high removal cross section for thermal neutrons.
- Boron carbide, in the form of fine particles, is homogeneously dispersed throughout the central layer of the Boral panels.
- The boron carbide and aluminum materials in Boral do not degrade as a result of long-term exposure to radiation.
- The neutron absorbing central layer of Boral is clad with permanently bonded surfaces of aluminum.
- Boral is stable, strong, durable, and corrosion resistant.

Boral absorbs thermal neutrons without physical change or degradation of any sort from the anticipated exposure to gamma radiation and heat. The material does not suffer loss of neutron attenuation capability when exposed to high levels of radiation dose.

Holtec International's QA Program ensures that Boral is manufactured under the control and surveillance of a Quality Assurance/Quality Control Program that conforms to the requirements of 10CFR72, Subpart G. Holtec International has procured over 200,000 panels of Boral from

AAR Advanced Structures in over 30 projects. Boral has always been purchased with a minimum ^{10}B loading requirement. Coupons extracted from production runs were tested using the wet chemistry procedure. The actual ^{10}B loading, out of thousands of coupons tested, has never been found to fall below the design specification. The size of this coupon database is sufficient to provide reasonable assurance that all future Boral procurements will continue to yield Boral with full compliance with the stipulated minimum loading. Furthermore, the surveillance, coupon testing, and material tracking processes which have so effectively controlled the quality of Boral are expected to continue to yield Boral of similar quality in the future. Nevertheless, to add another layer of insurance, only 75% ^{10}B credit of the fixed neutron absorber is assumed in the criticality analysis in compliance with Chapter 6.0, IV, 4.c of NUREG-1536, Standard Review Plan for Dry Cask Storage Systems.

1.2.1.3.2 Neutron Shielding

The specification of the HI-STORM overpack and HI-TRAC transfer cask neutron shield material is predicated on functional performance criteria. These criteria are:

- Attenuation of neutron radiation to appropriate levels;
- Durability of the shielding material under normal conditions, in terms of thermal, chemical, mechanical, and radiation environments;
- Stability of the homogeneous nature of the shielding material matrix;
- Stability of the shielding material in mechanical or thermal accident conditions to the desired performance levels; and
- Predictability of the manufacturing process under adequate procedural control to yield an in-place neutron shield of desired function and uniformity.

Other aspects of a shielding material, such as ease of handling and prior nuclear industry use, are also considered, within the limitations of the main criteria. Final specification of a shield material is a result of optimizing the material properties with respect to the main criteria, along with the design of the shield system, to achieve the desired shielding results.

Neutron attenuation in the HI-STORM overpack is provided by the thick walls of concrete contained in the steel vessel, lid, and pedestal. Concrete is a shielding material with a long proven history in the nuclear industry. The concrete composition has been specified to ensure its continued integrity at the long term temperatures required for SNF storage.

The HI-TRAC transfer cask is equipped with a water jacket providing radial neutron shielding. Demineralized water will be utilized in the water jacket. To ensure operability for low temperature conditions, ethylene glycol (25% in solution) will be added to reduce the freezing point for low temperature operations (e.g., below 32°F) [1.2.7].

Neutron shielding in the 125 ton HI-TRAC transfer cask in the axial direction is provided by Holtite-A within the top lid and transfer lid. Holtite-A is a poured-in-place solid borated synthetic neutron-absorbing polymer commercially available under the trade name NS-4-FR (or equivalent) and will be specified with a minimum B_4C loading of 1 weight percent for the HI-STORM 100 System. Appendix 1.B provides the Holtite-A material properties. Holtec has performed confirmatory qualification tests on Holtite-A under the company's QA program.

In the following, a brief summary of the performance characteristics and properties of Holtite-A is provided.

Density

The specific gravity of Holtite-A is 1.68 g/cm^3 as specified in Appendix 1.B. To conservatively bound any potential weight loss at the design temperature and any inability to reach the theoretical density, the density is reduced by 4% to 1.61 g/cm^3. The density used for the shielding analysis is conservatively assumed to be 1.61 g/cm^3 to underestimate the shielding capabilities of the neutron shield.

Hydrogen

The weight concentration of hydrogen is 6.0%. However, all shielding analyses conservatively assume 5.9% hydrogen by weight in the calculations.

Boron Carbide

Boron carbide dispersed within Holtite-A in finely dispersed powder form is present in 1% (minimum) weight concentration. Holtite-A may be specified with a B_4C content of up to 6.5 weight percent. For the HI-STORM 100 System, Holtite-A is specified with a minimum B_4C weight percent of 1%.

Design Temperature

The design temperature of Holtite-A is set at 300°F. The maximum spatial temperature of Holtite-A under all normal operating conditions must be demonstrated to be below this design temperature.

Thermal Conductivity

Table 1.B.1 lists the thermal conductivity of Holtite-A specified by the manufacturer.

The Holtite-A neutron shielding material is stable below the design temperature for the long term and provides excellent shielding properties for neutrons. Technical papers provided in Appendix 1.B validate the neutron shield material's long-term stability within the design temperature and the material's ability to resist the effects of a fire accident. Holtite-A has been utilized in similar applications and has been licensed for use in a transportation cask under Docket No. 71-9235 and for storage in the HI-STAR 100 overpack under Docket No. 72-1008.

1.2.1.3.3 Gamma Shielding Material

For gamma shielding, the HI-STORM 100 storage overpack primarily relies on massive concrete sections contained in a robust steel vessel. A carbon steel plate, the shield shell, is located adjacent to the overpack inner shell to provide additional gamma shielding (Figure 1.2.7). Carbon steel supplements the concrete gamma shielding in most portions of the storage overpack, most notably the baseplate and the lid. To reduce the radiation streaming through the overpack air inlets and outlets, gamma shield cross plates are installed in the ducts (Figure 1.2.8) to scatter the radiation. This scattering acts to significantly reduce the local dose rates adjacent to the overpack air inlets and outlets.

In the HI-TRAC transfer cask, the primary gamma shielding is provided by lead. As in the storage overpack, carbon steel supplements the lead gamma shielding of the HI-TRAC transfer cask.

1.2.1.4 Lifting Devices

Lifting of the HI-STORM 100 System may be accomplished either by attachment at the top of the storage overpack ("top lift"), as would typically be done with a crane, or by attachment at the bottom ("bottom lift"), as would be effected by a number of lifting/handling devices.

For a top lift, the storage overpack is equipped with four threaded anchor blocks arranged circumferentially around the overpack. These anchor blocks are used for overpack lifting as well as securing the overpack lid to the overpack body. The anchor blocks are integrally welded to the overpack radial plates which in turn are full-length welded to the overpack inner shell, outer shell, and baseplate. Studs are threaded into the anchor blocks to secure the lid and provide for lifting. These four studs provide for direct attachment of lifting devices which, along with a specially-designed lift rig to ensure a vertical lift, allow lifting by a crane or similar equipment. The lift rig shall be designed to lift a fully-loaded storage overpack with margins of safety specified in ANSI N14.6 [1.2.9].

A bottom lift of the HI-STORM 100 storage overpack is effected by the insertion of four hydraulic jacks underneath the inlet vent horizontal plates (Figure 1.2.1). A slot in the overpack baseplate allows the hydraulic jacks to be placed underneath the inlet vent horizontal plate. The hydraulic jacks lift the loaded overpack to a sufficient height to allow air pads to be placed or removed from under the overpack baseplate.

The HI-TRAC transfer cask is equipped with two lifting trunnions and two pocket trunnions. The lifting trunnions are positioned just below the top forging. The two pocket trunnions are located above the bottom forging and attached to the outer shell. The pocket trunnions are designed to allow rotation of the HI-TRAC. All trunnions are built from a high strength alloy with proven corrosion and non-galling characteristics. The lifting trunnions are designed in accordance with NUREG-0612 and ANSI N14.6. The lifting trunnions are installed by threading into tapped holes just below the top forging. The lifting trunnions feature a locking plate, which is placed onto the trunnion shaft and bolted to the HI-TRAC external surface to prevent the lifting trunnion from backing out.

The top of the MPC lid is equipped with four threaded holes that allow lifting of the loaded MPC. These holes allow the loaded MPC to be raised/lowered through the HI-TRAC transfer cask using lifting cleats. The threaded holes in the MPC lid are designed in accordance with NUREG-0612 and ANSI N14.6.

1.2.1.5 Design Life

The design life of the HI-STORM 100 System is 40 years. This is accomplished by using material of construction with a long proven history in the nuclear industry and specifying materials known to withstand their operating environments with little to no degradation. A maintenance program, as specified in Chapter 9, is also implemented to ensure the HI-STORM 100 System will exceed its design life of 40 years. The design considerations that assure the HI-STORM 100 System performs as designed throughout the service life include the following:

HI-STORM Overpack and HI-TRAC Transfer Cask

- Exposure to Environmental Effects
- Material Degradation
- Maintenance and Inspection Provisions

MPC

- Corrosion
- Structural Fatigue Effects
- Maintenance of Helium Atmosphere

- Allowable Fuel Cladding Temperatures
- Neutron Absorber Boron Depletion

The adequacy of the HI-STORM 100 System for its design life is discussed in Sections 3.4.11 and 3.4.12.

1.2.2 Operational Characteristics

1.2.2.1 Design Features

The HI-STORM 100 System incorporates some unique design improvements. These design innovations have been developed to facilitate the safe long term storage of SNF. Some of the design originality is discussed in Subsection 1.2.1 and below.

The free volume of the MPCs is inerted with 99.995% pure helium gas during the spent nuclear fuel loading operations. Table 1.2.2 specifies the helium fill mass to be placed in the MPC internal cavity as a function of the free space. As the fill pressure is highly dependent on the MPC internal temperature, which increases because of the decay heat and the vacuum drying process, it is more accurate to measure the mass placed in the MPC internal cavity rather than pressure.

The HI-STORM overpack has been designed to synergistically combine the benefits of steel and concrete. The steel-concrete-steel construction of the HI-STORM overpack provides ease of fabrication, increased strength, and an optimal radiation shielding arrangement. The concrete is primarily provided for radiation shielding and the steel is primarily provided for structural functions.

The strength of concrete in tension and shear is conservatively neglected. Only the compressive strength of the concrete is accounted for in the analyses.

The criticality control features of the HI-STORM 100 are designed to maintain the neutron multiplication factor k-effective (including uncertainties and calculational bias) at less than 0.95 under all normal, off-normal, and accident conditions of storage as analyzed in Chapter 6. This level of conservatism and safety margins is maintained, while providing the highest storage capacity.

1.2.2.2 Sequence of Operations

Table 1.2.6 provides the basic sequence of operations necessary to defuel a spent fuel pool using the HI-STORM 100 System. The detailed sequence of steps for storage-related loading and handling operations is provided in Chapter 8 and is supported by the Design Drawings in Section 1.5. A summary of the loading and unloading operations is provided below. Figures 1.2.16 and 1.2.17 provide a pictorial view of typical loading and unloading operations, respectively.

Loading Operations

At the start of loading operations, the HI-TRAC transfer cask is configured with the pool lid installed. The HI-TRAC water jacket is filled with demineralized water or a 25% ethylene glycol solution depending on the ambient temperature conditions. The lift yoke is used to position HI-TRAC in the designated preparation area or setdown area for HI-TRAC inspection and MPC insertion. The annulus is filled with plant demineralized water, and an inflatable annulus seal is installed. The inflatable seal prevents contact between spent fuel pool water and the MPC shell reducing the possibility of contaminating the outer surfaces of the MPC. The MPC is then filled with spent fuel pool water or plant demineralized water. HI-TRAC and the MPC are lowered into the spent fuel pool for fuel loading using the lift yoke. Pre-selected assemblies are loaded into the MPC and a visual verification of the assembly identification is performed.

While still underwater, a thick shielding lid (the MPC lid) is installed. The lift yoke is remotely engaged to the HI-TRAC lifting trunnions and is used to lift the HI-TRAC close to the spent fuel pool surface. As an ALARA measure, dose rates are measured on the top of the HI-TRAC and MPC prior to removal from the pool to check for activated debris on the top surface. The MPC lift bolts (securing the MPC lid to the lift yoke) are removed. As HI-TRAC is removed from the spent fuel pool, the lift yoke and HI-TRAC are sprayed with demineralized water to help remove contamination.

HI-TRAC is removed from the pool and placed in the designated preparation area. The top surfaces of the MPC lid and the upper flange of HI-TRAC are decontaminated. The inflatable annulus seal is removed, and an annulus shield is installed. 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 and around the mid-height circumference of HI-TRAC to ensure that the dose rates are within expected values. The Automated Welding System baseplate shield is installed to reduce dose rates around the top of the cask. The MPC water level is lowered slightly and the MPC lid is seal-welded using the Automated Welding System (AWS). Liquid penetrant examinations are performed on the root and final passes. A volumetric examination is also performed on the MPC lid-to-shell weld. The water level is raised to the top of the MPC and the weld is hydrostatically tested. Then a small volume of the water is displaced with helium gas. The helium gas is used for leakage testing. A helium leakage rate test is performed on the MPC lid confinement weld (lid-to-shell) to verify weld integrity and to ensure that required leakage rates are within acceptance criteria. The water level is raised to the top of the MPC again and then the MPC water is displaced from the MPC by blowing pressurized helium or nitrogen gas into the vent port of the MPC, thus displacing the water through the drain line. The volume of water displaced from the MPC is measured to determine the free volume inside the MPC. This information is used to determine the helium backfill requirements for the MPC.

The Vacuum Drying System (VDS) is connected to the MPC and is used to remove all liquid water from the MPC in a stepped evacuation process. The stepped evacuation process is used to preclude the formation of ice in the MPC and Vacuum Drying System lines. The internal pressure is reduced and held for a duration to ensure that all liquid water has evaporated.

Following this dryness test, the VDS is disconnected and the Helium Backfill System (HBS) is attached and the MPC is backfilled with a predetermined amount of helium gas. The helium backfill ensures adequate heat transfer during storage, provides an inert atmosphere for long-term fuel integrity, and provides the means of future leakage rate testing of the MPC confinement boundary welds. 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. The cover plates are helium leakage tested to confirm that they meet the established leakage rate criteria.

The MPC closure ring is then placed on the MPC, aligned, tacked in place, and seal welded, providing redundant closure of the MPC lid and cover plates confinement closure welds. Tack welds are visually examined, and the root and final welds are inspected using the liquid penetrant examination technique to ensure weld integrity. The annulus shield is removed and the remaining water in the annulus is drained. The AWS Baseplate shield is removed. The MPC lid and accessible areas of the top of the MPC shell are smeared for removable contamination and HI-TRAC dose rates are measured. The HI-TRAC top lid is installed and the bolts are torqued. The MPC lift cleats are installed on the MPC lid. The MPC lift cleats are the primary lifting point of the MPC. Two cleats provide redundant support of the MPC when it is lifted or supported.

Two or four stays (depending on the site crane hook configuration) are installed between the MPC lift cleats and the lift yoke main pins. The stays secure the MPC within HI-TRAC while the pool lid is replaced with the transfer lid. The HI-TRAC is manipulated to replace the pool lid with the transfer lid. The MPC lift cleats and stays support the MPC during the transfer operations.

MPC transfer from the HI-TRAC transfer cask into the overpack may be performed inside or outside the fuel building. Similarly, HI-TRAC and HI-STORM may be transferred to the ISFSI in several different ways. The loaded HI-TRAC may be handled in the vertical or horizontal orientation. The loaded HI-STORM can only be handled vertically.

For MPC transfers inside the fuel building, the empty HI-STORM overpack is inspected and positioned in the truck bay with the lid removed and the vent duct shield inserts installed. The loaded HI-TRAC is placed using the fuel building crane on top of HI-STORM. Alignment pins help guide HI-TRAC during this operation.

After the HI-TRAC is positioned atop the HI-STORM, the MPC is raised slightly. The transfer lid door locking pins are removed and the doors are opened. The MPC is lowered into HI-STORM. Following verification that the MPC is fully lowered, slings are disconnected and lowered onto the MPC lid. The doors are closed and the locking pins are installed. HI-TRAC is removed from on top of HI-STORM along with the vent shield inserts. The MPC lift cleats and slings are removed from atop the MPC. The HI-STORM lid is installed, and the upper vent screens and gamma shield cross plates are installed. The HI-STORM lid studs are installed and torqued.

For MPC transfers outside of the fuel building, the empty HI-STORM overpack is inspected and positioned in the cask transfer facility with the lid removed and the vent duct shield inserts installed. The loaded HI-TRAC is transported to the cask transfer facility in the vertical or horizontal orientation. A number of methods may be utilized as long as the handling limitations prescribed in the technical specifications are not exceeded.

To place the loaded HI-TRAC in a horizontal orientation a transport frame or "cradle" is utilized. The cradle is equipped with rotation trunnions which engage the HI-TRAC 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.

If the loaded HI-TRAC is transferred to the cask transfer facility in the horizontal orientation, the HI-TRAC and 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.

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. Alignment pins help guide HI-TRAC during this operation.

After the HI-TRAC is positioned atop the HI-STORM, the MPC is raised slightly. The transfer lid door locking pins are removed and the doors are opened. The MPC is lowered into HI-STORM. Following verification that the MPC is fully lowered, slings are disconnected and lowered onto the MPC lid. The doors are closed and the locking pins are installed. HI-TRAC is removed from on top of HI-STORM along with the vent duct shield inserts. The MPC lift cleats and slings are removed from atop the MPC. The HI-STORM lid is installed, and the upper vent screens and gamma shield cross plates are installed. The HI-STORM lid studs are installed and torqued.

After the HI-STORM has been loaded either within the fuel building or at a dedicated cask transfer facility, the HI-STORM is then moved to its designated position on the ISFSI pad. The HI-STORM overpack may be moved using a number of methods as long as the handling limitations listed in the technical specifications are not exceeded. The loaded HI-STORM must be handled in the vertical orientation. However, the loaded overpack may be lifted from the top through the lid studs or from the bottom by the inlet vents. After the loaded HI-STORM is lifted, it may be placed on a transport mechanism or continue to be lifted by the lid studs and transported to the storage location. The transport mechanism may be an air pad, crawler, railcar, heavy-haul trailer, dolly, etc. During the transport of the loaded HI-STORM, standard plant heavy load handling practices shall be applied including administrative controls for the travel path and tie-down mechanisms. Once in position at the storage pad, vent operability testing is performed to ensure that the system is functioning within its design parameters.

Unloading Operations

The HI-STORM 100 System unloading procedures describe the general actions necessary to prepare the MPC for unloading, cool the stored fuel assemblies in the MPC, flood the MPC cavity, remove the lid welds, unload the spent fuel assemblies, and recover HI-TRAC and empty the MPC. Special precautions are outlined to ensure personnel safety during the unloading operations, and to prevent the risk of MPC overpressurization and thermal shock to the stored spent fuel assemblies.

The MPC is recovered from HI-STORM either at the cask transfer facility or the fuel building using any of the methodologies described in Section 8.1. The HI-STORM lid is removed, the vent duct shield inserts are installed, and the MPC lift cleats are attached to the MPC. The MPC lift slings are attached to the MPC lift cleats. HI-TRAC is raised and positioned on top of HI-STORM. The MPC is raised into HI-TRAC. Once the MPC is raised into HI-TRAC, the HI-TRAC transfer lid doors are closed and the locking pins are installed. HI-TRAC is removed from on top of HI-STORM.

The HI-TRAC is brought into the fuel building and manipulated for bottom lid replacement. The transfer lid is replaced with the pool lid. The MPC lift cleats and stays support the MPC during the transfer operations.

HI-TRAC and its enclosed MPC are returned to the designated preparation area and the MPC stays, MPC lift cleats, and HI-TRAC top lid are removed. The annulus is filled with plant demineralized water. The annulus shield is installed to protect the annulus from debris produced from the lid removal process. Similarly, HI-TRAC top surfaces are covered with a protective fire-retarding blanket.

The MPC closure ring and vent and drain port cover plates are core drilled. Local ventilation is established around the MPC ports. The RVOAs are attached to the vent and drain port. The RVOAs allow access to the inner cavity of the MPC, while providing a hermetic seal. The MPC is cooled using a closed-loop heat exchanger to reduce the MPC internal temperature to allow water flooding. Following the fuel cool-down, the MPC is flooded with water. The MPC lid-to-MPC shell weld is removed. Then, all weld removal equipment is removed with the MPC lid left in place.

The inflatable annulus seal is installed and pressurized. The MPC lid is rigged to the lift yoke and the lift yoke is engaged to HI-TRAC lifting trunnions. If weight limitations require, the neutron shield jacket is drained. HI-TRAC is placed in the spent fuel pool and the MPC lid is removed. All fuel assemblies are returned to the spent fuel storage racks and the MPC fuel cells are vacuumed to remove any assembly debris. HI-TRAC and MPC are returned to the designated preparation area where the MPC water is pumped back into the spent fuel pool. The annulus water is drained and the MPC and HI-TRAC are decontaminated in preparation for re-utilization.

1.2.2.3 Identification of Subjects for Safety and Reliability Analysis

1.2.2.3.1 Criticality Prevention

Criticality is controlled by geometry and neutron absorbing materials in the fuel basket. The MPC-24 and MPC-68 do not rely on soluble boron credit during loading or the assurance that water cannot enter the MPC during storage to meet the stipulated criticality limits.

The MPC-68 basket is equipped with Boral with a minimum ^{10}B areal density of 0.0372 g/cm^2. The MPC-24 basket is equipped with Boral with a minimum ^{10}B areal density of 0.0267 g/cm^2. Due to the lower reactivity of the fuel to be stored in the MPC-68F as specified by the Technical Specifications in Chapter 12, the MPC-68F is equipped with Boral with a minimum ^{10}B areal density of 0.01 g/cm^2.

1.2.2.3.2 Chemical Safety

There are no chemical safety hazards associated with operations of the HI-STORM 100 dry storage system. A detailed evaluation is provided in Section 3.4.

1.2.2.3.3 Operation Shutdown Modes

The HI-STORM 100 System is totally passive and consequently, operation shutdown modes are unnecessary. Guidance is provided in Chapter 8, which outlines the HI-STORM 100 unloading procedures, and Chapter 11, which outlines the corrective course of action in the wake of postulated accidents.

1.2.2.3.4 Instrumentation

As stated earlier, the HI-STORM 100 confinement boundary is the MPC, which is seal welded and leak tested. The HI-STORM 100 is a completely passive system with appropriate margins of safety; therefore, it is not necessary to deploy any instrumentation to monitor the cask in the storage mode. At the option of the user, a thermocouple may be utilized to monitor the air temperature of the HI-STORM overpack exit vent in lieu of routinely inspecting the ducts for blockage. See Subsection 2.3.3.2 and the Technical Specifications in Chapter 12 for additional details.

1.2.2.3.5 Maintenance Technique

Because of their passive nature, the HI-STORM 100 System requires minimal maintenance over its lifetime. No special maintenance program is required. Chapter 9 describes the acceptance criteria and maintenance program set forth for the HI-STORM 100.

1.2.3 Cask Contents

The HI-STORM 100 System is designed to house different types of MPCs. The MPCs are designed to store both BWR and PWR spent nuclear fuel assemblies. Tables 1.2.1 and 1.2.2 provide key design parameters for the MPCs. A description of acceptable fuel assemblies for storage in the MPCs is provided in Section 2.1 and the Technical Specifications.

At this time, failed fuel assemblies discharged from Dresden Unit 1 and Humboldt Bay reactors have been evaluated and this application requests approval of these two types of damaged fuel assemblies and fuel debris as contents for storage in the MPC-68. Damaged fuel assemblies and fuel debris shall be placed in damaged fuel containers prior to loading into the MPC to facilitate handling and contain loose components. Any combination of damaged fuel assemblies in damaged fuel containers and intact fuel assemblies, up to a total of 68, may be stored in the standard MPC-68. The MPC-68 design to store fuel debris is almost identical to the MPC-68 design to store intact or damaged fuel, the sole difference being the former requires a lower minimum B^{10} areal density in the Boral. Therefore, an MPC-68 which is to store damaged fuel containers with fuel assemblies classified as fuel debris must be designated during fabrication to ensure the proper minimum B^{10} areal density criteria is applied. To distinguish an MPC-68 which is fabricated to store damaged fuel containers with fuel assemblies classified as fuel debris, the MPC shall be designated as an "MPC-68F".

Up to 4 damaged fuel containers with fuel assemblies classified as fuel debris and meeting the requirements in the Technical Specifications may be stored within an MPC-68F. The quantity of damaged fuel containers with fuel debris is limited to meet the off-site transportation requirements of 10CFR71, specifically, 10CFR71.63(b).

Table 1.2.1

KEY SYSTEM DATA FOR HI-STORM 100 SYSTEM

ITEM	QUANTITY	NOTES
Types of MPCs included in this revision of the submittal	3	1 for PWR 2 for BWR
MPC storage capacity:	MPC-24	Up to 24 intact zircaloy or stainless steel clad PWR fuel assemblies. Control components and non-fuel hardware are not authorized for loading.
	MPC-68 MPC-68F	Any combination of damaged fuel assemblies in damaged fuel containers and intact fuel assemblies, up to a total of 68 in the MPC-68 OR Up to 4 damaged fuel containers with zircaloy clad BWR fuel debris and the complement damaged zircaloy clad BWR fuel assemblies in damaged fuel containers or intact fuel assemblies within an MPC-68F.

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 conditions Accident Conditions	 100 100 125	 100 100 125
Total heat load, max. (kW)	20.88 (MPC-24)	21.4 (MPC-68)
Maximum permissible peak fuel cladding temperature: Normal (°F) Short Term & Accident (°F)	 See Table 2.2.3 1058°	 See Table 2.2.3 1058°
MPC internal environment Helium fill (g-moles/l of free space)	 0.1212 (MPC-24)	 0.1218 (MPC-68 & MPC-68F)
Maximum permissible multiplication factor (k_{eff}) including all uncertainties and biases	<0.95	<0.95
Boral ^{10}B Areal Density (g/cm^2)	0.0267 (MPC-24)	0.0372 (MPC-68) 0.01 (MPC-68F)
End closure(s)	Welded	Welded
Fuel handling	Opening compatible with standard grapples	Opening compatible with standard grapples
Heat dissipation	Passive	Passive

† 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.

Table 1.2.3

BORAL EXPERIENCE LIST
DOMESTIC PRESSURIZED WATER REACTORS

Plant	Utility
Donald C. Cook	American Electric Power
Indian Point 3	New York Power Authority
Maine Yankee	Maine Yankee Atomic Power
Salem 1,2	Public Service Electric and Gas
Sequoyah 1,2	Tennessee Valley Authority
Yankee Rowe	Yankee Atomic Power
Zion 1,2	Commonwealth Edison Company
Byron 1,2	Commonwealth Edison Company
Braidwood 1,2	Commonwealth Edison Company
Three Mile Island I	GPU Nuclear
Sequoyah (rerack)	Tennessee Valley Authority
D.C. Cook (rerack)	American Electric Power
Maine Yankee	Maine Yankee Atomic Power Company
Connecticut Yankee	Northeast Utilities Service Company
Salem Units 1 & 2 (rerack)	Public Service Electric & Gas Company

Table 1.2.4

BORAL EXPERIENCE LIST
DOMESTIC BOILING WATER REACTORS

Plant	Utility
Browns Ferry 1,2,3	Tennessee Valley Authority
Brunswick 1,2	Carolina Power & Light
Clinton	Illinois Power
Dresden 2,3	Commonwealth Edison Company
Duane Arnold Energy Center	Iowa Electric Light and Power
J.A. FitzPatrick	New York Power Authority
E.I. Hatch 1,2	Georgia Power Company
Hope Creek	Public Service Electric and Gas
Humboldt Bay	Pacific Gas and Electric Company
LaCrosse	Dairyland Power
Limerick 1,2	Philadelphia Electric Company
Monticello	Northern States Power
Peachbottom 2,3	Philadelphia Electric Company
Perry 1,2	Cleveland Electric Illuminating
Pilgrim	Boston Edison Company
Susquehanna 1,2	Pennsylvania Power & Light
Vermont Yankee	Vermont Yankee Atomic Power
Hope Creek	Public Service Electric and Gas Company
Shearon Harris Pool B	Carolina Power & Light Company
Duane Arnold	Iowa Electric Light and Power
Pilgrim	Boston Edison Company
LaSalle Unit 1	Commonwealth Edison Company
Millstone Point Unit One	Northeast Utilities Service Company

Table 1.2.5

BORAL EXPERIENCE LIST
FOREIGN PLANTS

INTERNATIONAL INSTALLATIONS USING BORAL	
COUNTRY	PLANT(S)
France	12 PWR Plants
South Africa	Koeberg 1,2
Switzerland	Beznau 1,2 Gosgen
Taiwan	Chin-Shan 1,2 Kuosheng 1,2
Mexico	Laguna Verde Units 1,2
Korea	Ulchin Units 1, 2
Brazil	Angra 1
United Kingdom	Sizewell B

Table 1.2.6

HI-STORM 100 OPERATIONS SEQUENCE

Site-specific handling and operations procedures will be prepared, reviewed, and approved by each owner/user.	
1	HI-TRAC and MPC lowered into the fuel pool without lids
2	Fuel assemblies transferred into the MPC fuel basket
3	MPC lid lowered onto the MPC
4	HI-TRAC/MPC assembly moved to the decon pit and MPC lid welded in place, volumetrically or multi-layer PTexamined, hydrostatically tested, and leak tested
5	MPC dewatered, vacuum dried, backfilled with helium, and the closure ring welded
6	HI-TRAC annulus drained and external surfaces decontaminated
7	MPC lifting cleats installed and MPC weight supported by rigging
8	HI-TRAC pool lid removed and transfer lid attached
9	MPC lowered and seated on HI-TRAC transfer lid
10	HI-TRAC/MPC assembly transferred to atop HI-STORM overpack
11	MPC weight supported by rigging and transfer lid doors opened
12	MPC lowered into HI-STORM overpack, HI-TRAC transfer lid doors closed, and HI-TRAC removed from atop HI-STORM overpack
13	HI-STORM overpack lid installed and bolted in place
14	HI-STORM overpack placed in storage at the ISFSI pad

1.5 GENERAL ARRANGEMENT DRAWINGS

The following HI-STORM 100 System design drawings and bills of materials are provided on subsequent pages in this subsection:

Drawing Number/Sheet	Description	Rev.
5014-1395 Sht 1/4	HI-STAR 100 MPC-24 Construction	10
5014-1395 Sht 2/4	HI-STAR 100 MPC-24 Construction	9
5014-1395 Sht 3/4	HI-STAR 100 MPC-24 Construction	9
5014-1395 Sht 4/4	HI-STAR 100 MPC-24 Construction	8
5014-1396 Sht 1/6	HI-STAR 100 MPC-24 Construction	12
5014-1396 Sht 2/6	HI-STAR 100 MPC-24 Construction	9
5014-1396 Sht 3/6	HI-STAR 100 MPC-24 Construction	9
5014-1396 Sht 4/6	HI-STAR 100 MPC-24 Construction	8
5014-1396 Sht 5/6	HI-STAR 100 MPC-24 Construction	8
5014-1396 Sht 6/6	HI-STAR 100 MPC-24 Construction	7
5014-1401 Sht 1/4	HI-STAR 100 MPC-68 Construction	11
5014-1401 Sht 2/4	HI-STAR 100 MPC-68 Construction	8
5014-1401 Sht 3/4	HI-STAR 100 MPC-68 Construction	9
5014-1401 Sht 4/4	HI-STAR 100 MPC-68 Construction	8
5014-1402 Sht 1/6	HI-STAR 100 MPC-68 Construction	13
5014-1402 Sht 2/6	HI-STAR 100 MPC-68 Construction	11
5014-1402 Sht 3/6	HI-STAR 100 MPC-68 Construction	11
5014-1402 Sht 4/6	HI-STAR 100 MPC-68 Construction	9
5014-1402 Sht 5/6	HI-STAR 100 MPC-68 Construction	9
5014-1402 Sht 6/6	HI-STAR 100 MPC-68 Construction	7
5014-1495 Sht 1/6	HI-STORM 100 Assembly	8
5014-1495 Sht 2/6	Cross Section "Z" - "Z" View of HI-STORM	9
5014-1495 Sht 3/6	Section "Y" - "Y" of HI-STORM	7

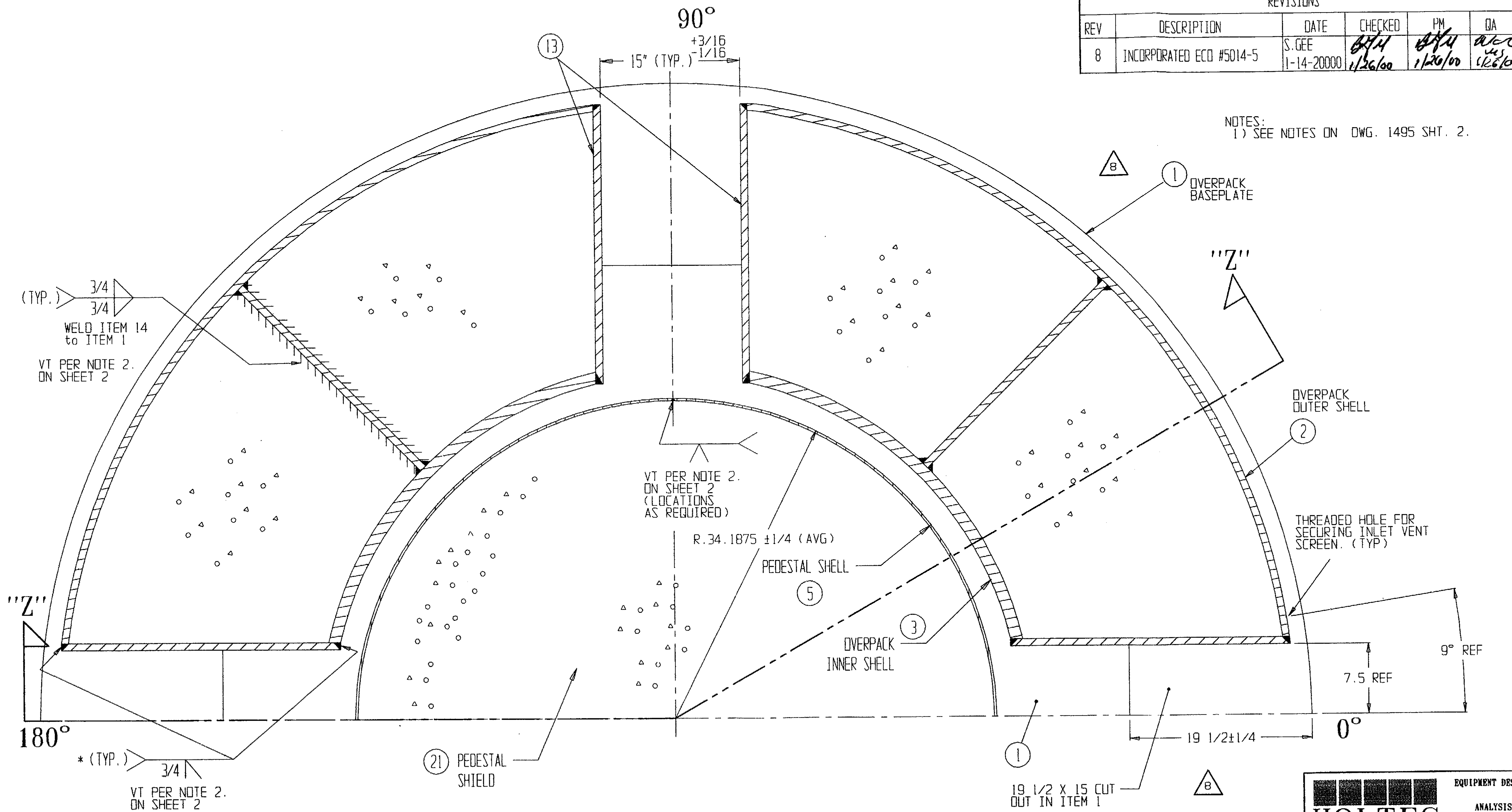
Drawing Number/Sheet	Description	Rev.
5014-1495 Sht 4/6	Section "X" -"X" of HI-STORM	8
5014-1495 Sht 5/6	Section "W" -"W" of HI-STORM	9
5014-1495 Sht 6/6	HI-STORM Outlet Vent Thermocouple Mounting Hardware	3
5014-1561 Sht 1/5	View "A" -"A" of HI-STORM	7
5014-1561 Sht 2/5	Detail "B" of HI-STORM	7
5014-1561 Sht 3/5	Detail of Air Inlet of HI-STORM	7
5014-1561 Sht 4/5	Detail of Air Outlet of HI-STORM	7
5014-1561 Sht 5/5	Miscellaneous Detail of HI-STORM	7
5014-1783 Sht 1/1	General Arrangement Damaged Fuel Container	2
5014-1784 Sht 1/1	Damaged Fuel Container Details	1
5014-1880 Sht 1/10	125 Ton HI-TRAC Outline with Pool Lid	7
5014-1880 Sht 2/10	125 Ton HI-TRAC Body Sectioned Elevation	8
5014-1880 Sht 3/10	125 Ton HI-TRAC Body Sectioned Elevation "B" - "B"	7
5014-1880 Sht 4/10	125 Ton Transfer Cask Detail of Bottom Flange	8
5014-1880 Sht 5/10	125 Ton Transfer Cask Detail of Pool Lid	8
5014-1880 Sht 6/10	125 Ton Transfer Cask Detail of Top Flange	8
5014-1880 Sht 7/10	125 Ton Transfer Cask Detail of Top Lid	7
5014-1880 Sht 8/10	125 Ton Transfer Cask View "Y" - "Y"	7
5014-1880 Sht 9/10	125 Ton Transfer Cask Lifting Trunnion and Locking Pad	5
5014-1880 Sht 10/10	125 Ton Transfer Cask View "Z" - "Z"	7
5014-1928 Sht 1/2	125 Ton HI-TRAC Transfer Lid Housing Detail	8
5014-1928 Sht 2/2	125 Ton HI-TRAC Transfer Lid Door Detail	8
5014-2145 Sht 1/10	100 Ton HI-TRAC Outline with Pool Lid	6
5014-2145 Sht 2/10	100 Ton HI-TRAC Body Sectioned Elevation	6
5014-2145 Sht 3/10	100 Ton HI-TRAC Body Sectioned Elevation 'B-B'	6

Drawing Number/Sheet	Description	Rev.
5014-2145 Sht 4/10	100 Ton HI-TRAC Detail of Bottom Flange	5
5014-2145 Sht 5/10	100 Ton HI-TRAC Detail of Pool Lid	4
5014-2145 Sht 6/10	100 Ton HI-TRAC Detail of Top Flange	6
5014-2145 Sht 7/10	100 Ton HI-TRAC Detail of Top Lid	6
5014-2145 Sht 8/10	100 Ton HI-TRAC View Y-Y	6
5014-2145 Sht 9/10	100 Ton HI-TRAC Lifting Trunnions and Locking Pad	3
5014-2145 Sht 10/10	100 Ton HI-TRAC View Z-Z	5
5014-2152 Sht 1/2	100 Ton HI-TRAC Transfer Lid Housing Detail	6
5014-2152 Sht 2/2	100 Ton HI-TRAC Transfer Lid Door Detail	6
BM-1478, Sht 1/2	Bills-of-Materials for 24-Assembly HI-STAR 100 PWR MPC	9
BM-1478, Sht 2/2	Bills of Material for 24-Assembly HI-STAR 100 PWR MPC	11
BM-1479, Sht 1/2	Bills-of-Material for 68-Assembly HI-STAR 100 BWR MPC	10
BM-1479, Sht 2/2	Bills-of-Material for 68-Assembly HI-STAR 100 BWR MPC	13
BM-1575, Sht 1/2	HI-STORM 100 Storage Overpack Bill of Materials	8
BM-1575, Sht 2/2	HI-STORM 100 Storage Overpack Bill of Materials	8
BM-1819, Sht 1/1	Bills-of-Materials for HI-STAR 100 System Failed Fuel Canister	1
BM-1880, Sht 1/2	Bill of Material for 125 Ton HI-TRAC	7
BM-1880, Sht 2/2	Bill of Material for 125 Ton HI-TRAC	5
BM-1928, Sht 1/1	Bill of Material for 125 Ton HI-TRAC Transfer Lid	7
BM-2145 Sht 1/2	Bills-of-Materials for 100 Ton HI-TRAC	4
BM-2145 Sht 2/2	Bills-of-Materials for 100 Ton HI-TRAC	3
BM-2152 Sht 1/1	Bills-of-Materials for 100 Ton HI-TRAC Transfer Lid	5

Notes: 1. The HI-STAR 100 MPCs are identical to the MPCs used in the HI-STORM 100 System.

REVISIONS					
REV	DESCRIPTION	DATE	CHECKED	PM	QA
8	INCORPORATED ECO #5014-5	S.GEE 1-14-20000	1/26/00	1/26/00	1/26/00

NOTES:
1) SEE NOTES ON DWG. 1495 SHT. 2.



HOLTEC INTERNATIONAL — EQUIPMENT DESIGN, ANALYSIS, CONSULTING

DESCRIPTION: *SECTION "X" - "X" OF HI-STORM*

CLIENT: N/A

COMPANION DRAWINGS: 1561, B/M 1575

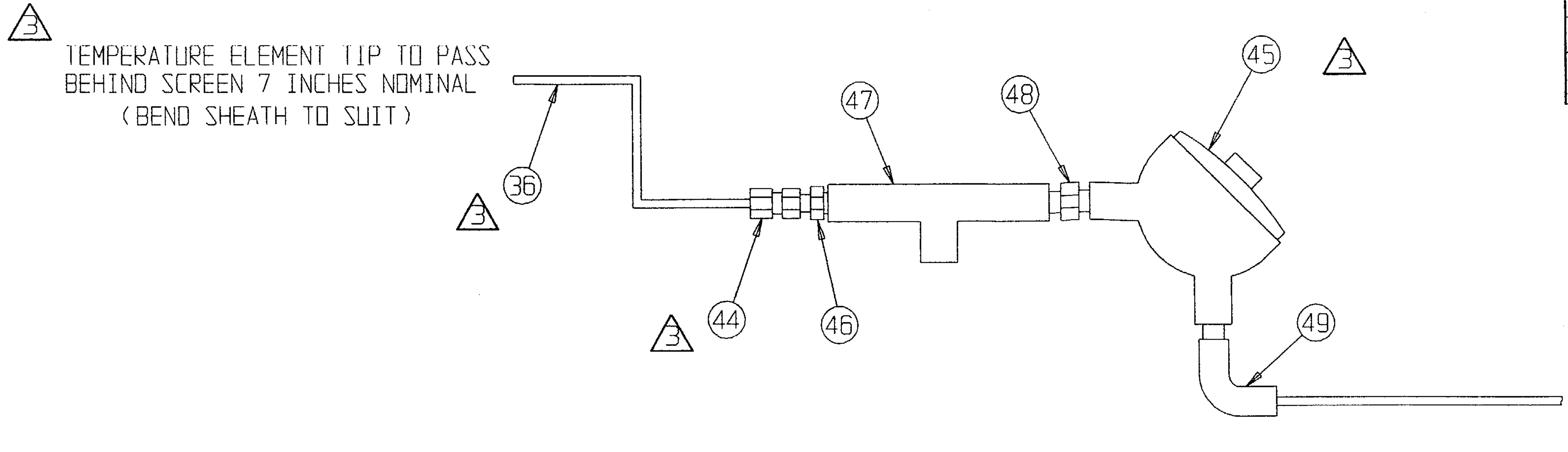
PROJECT No.:	SCALE:	DRAWING No.:	REV.:
5014	.09375 = 1	1495 (E.I.D.2834)	8
P.O. No.: N/A			SHEET: 4 of 6

e\DRAWINGS\5014\5014\HI-STORM\1495-4R8

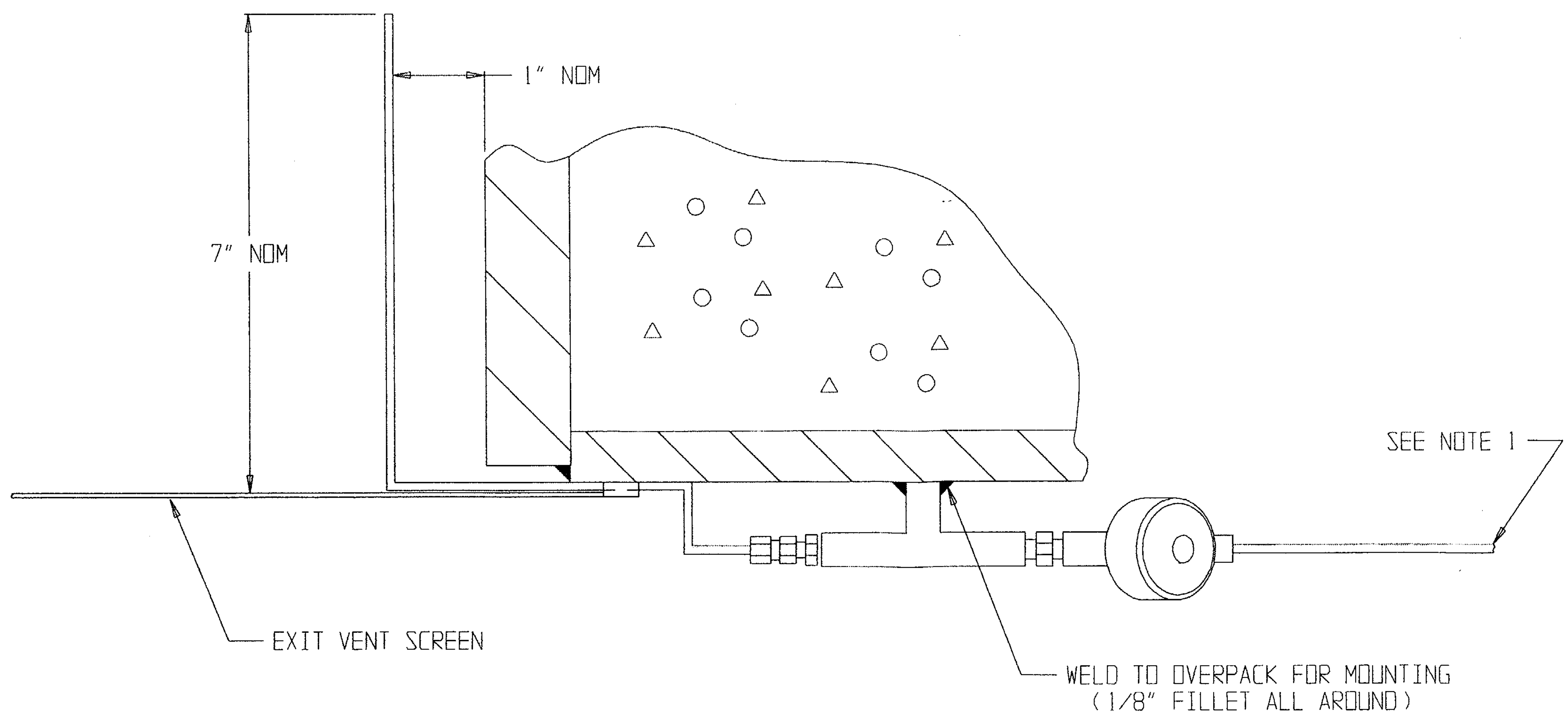
REVISIONS

REV	DESCRIPTION	DATE	CHECKED	PM	QA
3	INCORPORATED ECO# 5014-5	S.GEE 1-14-2000	1/26/00	1/26/00	1/26/00

NOTES:
1. SUITABLY SIZED CONDUIT MAY BE ATTACHED TO THE HI-STORM OVERPACK BY BRACKETS OR OR OTHER SUITABLE DEVICES WHICH ARE TACK WELDED TO THE OVERPACK OUTER SHELL.



3 HI-STORM OUTLET VENT TEMPERATURE ELEMENT MOUNTING HARDWARE



HOLTEC INTERNATIONAL — EQUIPMENT DESIGN, ANALYSIS, CONSULTING

DESCRIPTION:	HI-STORM OUTLET VENT TEMPERATURE ELEMENT MOUNTING HARDWARE
CLIENT:	N/A
COMPANION DRAWINGS:	1561, B/M 1575
PROJECT No.: 5014	SCALE: N/A
P.O. No.: N/A	DRAWING No.: 1495 (E.I.D. 2835)
REV.: 3	SHEET: 6 of 6

BM-1575 (E.I.D. 2839) BILL OF MATERIAL FOR HI-STORM (DWG. 1495, 1561) SHT 1 OF 2

REV. NO.	PREP. BY	CHECKED BY	PROJ. MANAGER	QA. MANAGER
8	S.GEE 2-1-2000 INCORPORATED ECO 5014-12	[signature] 2/1/00	[signature] 2/1/00	[signature] 2/1/00

	ITEM	QTY.	SPECIFICATION	NOMENCLATURE	DESCRIPTION
	1	1	SA 516 GR. 70	BASEPLATE	2 THK. X 133 7/8Ø BASEPLATE
	2	1	SA 516 GR. 70	OUTER SHELL	3/4 THK. X 224 1/2 LG. X 132 1/2 O.D. CYLINDER (MAY BE MADE IN SECTIONS, SEE DWG 1495 SHT 5)
	3	1	SA 516 GR. 70	INNER SHELL	1 1/4 THK. X 224 1/2 LG. X 76 O.D. CYLINDER
	4	1	CONCRETE	RADIAL SHIELD	26 3/4 THK. RADIAL SHIELD
8	5	1	SA 516 GR. 70	PEDESTAL SHELL	1/4 THK. X 68 3/8 O.D. X 21 5/8 LG. CYLINDER
	6	1	SA 516 GR. 70	LID BOTTOM PLATE	1 1/4 THK. X 69" Ø PLATE.
	7	1	SA 516 GR. 70	LID SHELL	1 THK. X 10 1/2 WIDE X 69 O.D.
	8	4	SA 516 GR. 70	EXIT VENT HORIZONTAL PLATE	1 1/4 THK. X 26 WIDE X 30 LG. PLATE (SEE DET. DWG. 1561 SHT. 4)
	9	1	SA 516 GR. 70	TOP PLATE	3/4 THK. X 131 1/2 O.D. X 81 1/2 I.D RING (CUT IN 4 PIECES)
	10	1	SA-516-70	LID TOP PLATE	4 THK. X 126 Ø PLATE (MADE FROM TWO 2" THICK PLATES)
	11	4	SA-516-70	INLET VENT HORIZONTAL PLATE	2 THK. X 16 1/2 WIDE X 30 1/4 LG. PLATE (SEE DET. DWG. 1561 SHT. 3)
	12	8	SA 516 GR. 70	EXIT VENT VERTICAL PLATE	1/2 THK. X 5 1/4 WIDE X 30 APPROX. LG. PLATE
	13	8	SA 516 GR. 70	INLET VENT VERTICAL PLATE	3/4 THK. X 10 WIDE X 29 3/16 APPROX. LG. PLATE
	14	4	SA 516 GR. 70	RADIAL PLATE	3/4 THK. X 27 1/2 WIDE X 224 1/2 LG. PLATE
8	15	4	SA 193 2H	TOP LID NUT	3 1/4 - 4 UNC HEAVY HEX NUT
8	16	4	SA 564-630 AGE HARDENED AT 1075°F	LID STUD	3 - 4 UNC X 16 LG. (SEE DWG. 1561, SHT 2)
	17	4	SA 350 LF3 OR SA 203 E	BOLT ANCHOR BLOCK	5 X 5 X 6 ANCHOR BLOCK W/ 3 - 4 UNC X 5 LG HOLE IN CENTER
	18	--	--	DELETED	---
	19	16	SA 516 GR. 70	CHANNEL	3/16 THK. X 6 WIDE X 170 7/8 LG. CHANNEL (SEE DETAIL 1495 SH. 5)
	20	1	SA 516 GR. 70	SHIELD BLOCK RING	1/4 THK. X 64 1/2 I.D. X 85 1/2 O.D. (MAY BE MADE FROM MORE THAN 1 PIECE.)
	21	1	CONCRETE	PEDESTAL SHIELD	17" THK. PLATFORM
	22	1	CONCRETE	LID SHIELD	10 1/2 THK. TOP SHIELD
	23	--	--	DELETED	---
	24	1	SA 516 GR. 70	PEDESTAL PLATFORM	5 THK. X 67 7/8 Ø PLATE (MAY USE MULTIPLE PLATES OF LESSER THICKNESS)
	25	1	CONCRETE	SHIELD BLOCK	8" THK.
	26	1	SA 516 GR. 70	SHIELD BLOCK SHELL	1/2 THK X 86 O.D. CYLINDER X 8" HIGH (MAY MAKE OUT OF MORE THAN 1 PIECE)
	27	1	SA 516 GR. 70	SHIELD BLOCK SHELL	1/2 THK X 64 O.D. CYLINDER X 8" HIGH (MAY MAKE OUT OF MORE THAN 1 PIECE)
*	28	4	SA 516 GR. 70	SHIELD SHELL	3/4 THK. X 58.5 APPROX. WIDE X 205" LG. PLATE
*	29	1	SA 240 304	STORAGE MARKING NAME PLATE	14 GAGE (0.0751 THK.) X 4 WIDE X 10 LG. SHEET
*	30	4	C/S OR S/S	LID PLUGS	1 1/2"-6UNC X 2 1/2" DP BOLT

NOTE:

1) THE CONCRETE MATERIAL IS TO MEET THE REQUIREMENTS SPECIFIED IN APPENDIX 1.D OF THE HI-STORM 100 TSAR DOCKET NUMBER 72-1014 (LATEST REVISION).

2) ALL DIMENSIONS IDENTIFIED ON BM-1575 ARE APPROXIMATE DIMENSIONS EXCEPT THICKNESSES OF STEEL PLATES WHICH IN THE RAW MATERIAL FORM MUST HAVE TOLERANCES MEETING THE APPLICABLE SPECIFICATION.

3) ITEMS WITH A * CONSIDERED NOT TO BE NF CLASS 3 (NON STRUCTURAL)

BM-1575 (E.I.D. 2836) BILL OF MATERIAL FOR HI-STORM (DWG. 1495, 1561) SHT 2 OF 2

REV. NO.	PREP. BY	CHECKED BY	PROJ. MANAGER	QA. MANAGER
8	S. GEE 1-13-2000 INCORPORATED ECO-5014-5	[signature] 1/26/00	[signature] 1/26/00	[signature] 1/26/00

	ITEM	QTY.	SPECIFICATION	NOMENCLATURE	DESCRIPTION
	31	--	---	DELETED	---
*	32	4	SA 240 304	EXIT VENT SCREEN SHEET	16 GAGE (0.0595 THK.) X 6 1/4 WIDE X 28 LG. SHEET
*	33	4	SA 240 304	EXIT VENT SCREEN FRAME	16 GAGE (0.0595 THK.)
*	34	1	COMMERCIAL	SCREEN	16 WIDE X 212 LG. 6 X 6 MESH 0.020 WIRE Ø 0.147 WIDTH OPEN FROM McMASTER-CARR 101 PAGE# 2521 ITEM# 9220T67 CUT AS NECESSARY OR EQUIVALENT
*	35	4	SA 240 304	INLET VENT SCREEN FRAME	16 GAGE (0.0595 THK.)
8 *	36	2	COMMERCIAL	THERMOCOUPLE OR RTD	1/8 Ø SHEATH WITH TEMPERATURE ELEMENT (BY USER).
*	37	16	SA240-304	GAMMA SHIELD CROSS PLATE	1/4 THK X 2.75 X 24
*	38	4	SA240-304	GAMMA SHIELD CROSS PLATE	1/4 THK X 24 X 24 5/8
*	39	40	SA240-304	CROSS PLATE TABS	.075 THK X 1/4 X 2 1/2
*	40	8	SA240-304	GAMMA SHIELD CROSS PLATE	1/4 THK X 14 5/8 X 24
*	41	16	SA240-304	GAMMA SHIELD CROSS PLATE	1/4 THK X 3.09 X 24
*	42	2	C/S OR S/S	DRAIN PIPE	1Ø X 1/4THK WALL X 11 1/2 LG
8 *	43	8	SA240-304	GAMMA SHIELD CROSS PLATE	1/4 THK X 5.09 X 17 1/4
*	44	2	316 SS	COMPRESSION FITTING	1/8" X 1/4 NPT MALE PASS THRU COMPRESSION FITTING (OPTIONAL)
*	45	2	CAST IRON	PROTECTION HEAD	1/2 NPT X 1/2 NPT (OPTIONAL)
*	46	2	304 SS	BUSHING	1/4 X 1/2 NPT (OPTIONAL)
*	47	2	304 SS	COUPLING	1/2 NPT COUPLING W/ MOUNTING STUD 1/2 DIA X 3" LG. (OPTIONAL)
*	48	2	304 SS	HEX NIPPLE	1/2 X 1/2 NPT HEX NIPPLE (OPTIONAL)
*	49	2	304 SS	CONNECTION	1/2 NPT CONDUIT CONNECTION (OPTIONAL)
*	50	3	C/S	SQUARE TUBING	1/2" X 1/2" 16 GAUGE
	51	1	CONCRETE	DUCT SHIELD INSERT	5 3/4 THK X 24 11/16 X 26 LG CONCRETE, ACI 318 (146 LB/CU FT MIN) 21 X 25 GRID OF WWF 4 X 4 -W3.5 X W3.5
	52	1	C/S	EMBEDDED PLATE	1.0 THK X 6 SQ PLATE
	53	2	C/S	NELSON STUD	Ø 1/4 X 2 1/2 LONG

After curing, non-shrink grout shall be applied as necessary to account for any shrinkage of the concrete elevation. Then, the top plate (Item 9) is welded to the overpack inner and outer shells (Items 3 and 2, respectively) and the pedestal shell (Item 5) is welded to the pedestal platform (Item 24).

To fabricate the overpack lid an identical process is followed. The lid shell (Item 7) is welded to the lid bottom plate (Item 6) and the inner and outer shield block shells (Items 27 and 26, respectively) are welded to the lid top plate (Item 10). The overpack lid is transported to the reactor site or a nearby concrete facility. The lid will be inspected to ensure the structure meets the requirements of Sections 5.1 and 6.1 of ACI 349. The concrete shall be mixed, conveyed, and deposited in accordance with Sections 5.2 through 5.4 of ACI 349. Sufficient rigidity in the overpack lid is provided such that all the concrete may be placed in a single pour. If bracing and support is required, it shall be provided in accordance with Section 6.1 of ACI 349 to maintain the proper position and shape. If more than one pour is performed, the requirements of Section 6.4 of ACI 349 must be met for construction joints.

Mixing and placing of the concrete for the lid shall follow the guidance of Sections 5.6 and 5.7 for cold and hot weather conditions, respectively. Curing of the concrete shall be in accordance with Section 5.5 of ACI 349, except that accelerated curing in accordance with Section 5.5.3 is not permitted. The water curing method shall be utilized in accordance with ACI 308-92, Standard Practice for Curing Concrete. After curing, the lid shell (Item 7) is welded to the lid top plate (Item 10) and the shield block ring (Item 20) is welded to the inner and outer shield block shells (Items 27 and 26, respectively).

Table 1.D.1 provides the construction limitations and requirements applicable to the overpack plain concrete. These requirements are drawn from ACI 349 (85).

1.D.5 Testing Requirements

Table 1.D.2 provides the testing requirements applicable to the overpack plain concrete. These requirements are drawn from ACI 349 (85).

Table 1.D.1: Requirements on Plain Concrete

ITEM	APPLICABLE LIMIT OR REFERENCE
Density (Minimum)	146 (lb/cubic feet)
Specified Compressive Strength	4,000 psi (min.)
Compressive and Bearing Stress Limit	Per ACI 318-95
Cement Type and Mill Test Report	Type II; Section 3.2 (ASTM C 150 or ASTM C595)
Aggregate Type	Section 3.3 (including ASTM C33(Note 2))
Nominal Maximum Aggregate Size	3/4 (inch)
Water Quality	Per Section 3.4
Material Testing	Per Section 3.1
Admixtures	Per Section 3.6
Air Content	6%[1] (Table 4.5.1)
Maximum Water to Cement Ratio	0.5 (Table 4.5.2)
Maximum Water Soluble Chloride Ion Cl in Concrete	1.00 percent by weight of cement (Table 4.5.4)
Concrete Quality	Per Chapter 4 of ACI 349
Mixing and Placing	Per Chapter 5 of ACI 349
Consolidation	Per ACI 309-87
Quality Assurance	Per Holtec Quality Assurance Manual, 10 CFR Part 72, Appendix G commitments
Maximum Local Temperature Limit Under Normal and Off-normal Conditions	200EF (See Note 3)
Maximum Local Temperature Limit Under Accident Conditions	350EF (Appendix A, Subsection A.4.2)
Aggregate Maximum Value[2] of Coefficient of Thermal Expansion (tangent in the range of 70EF to 100EF)	6E-06 inch/inch/EF (NUREG-1536, 3.V.2.b.i.(2)(c)2.b)

Notes:

1. All section and table references are to ACI 349 (85).
2. The coarse aggregate shall meet the requirements of ASTM C33 for class designation 1S from Table

---

1 This limit is specified to accommodate severe exposure to freezing and thawing (Table 4.5.1).

2 The following aggregate types are a priori acceptable: limestone, dolomite, marble, basalt, granite, gabbro, or rhyolite. The thermal expansion coefficient limit does not apply when these aggregates are used. 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 100 overpack concrete.

2.2 HI-STORM 100 DESIGN CRITERIA

The HI-STORM 100 System is engineered for unprotected outside storage for the duration of its design life. Accordingly, the cask system is designed to withstand normal, off-normal, and environmental phenomena and accident conditions of storage. Normal conditions include the conditions that are expected to occur regularly or frequently in the course of normal operation. Off-normal conditions include those infrequent events that could reasonably be expected to occur during the lifetime of the cask system. Environmental phenomena and accident conditions include events that are postulated because their consideration establishes a conservative design basis.

Normal condition loads act in combination with all other loads (off-normal or environmental phenomena/accident). Off-normal condition loads and environmental phenomena and accident condition loads are not applied in combination. However, loads which occur as a result of the same phenomena are applied simultaneously. For example, the tornado winds loads are applied in combination with the tornado missile loads.

In the following subsections, the design criteria are established for normal, off-normal, and accident conditions for storage. Loads that require consideration under each condition are identified and the design criteria discussed. Based on consideration of the applicable requirements of the system, the following loads are identified:

Normal Condition: Dead Weight, Handling, Pressure, Temperature, Snow

Off-Normal Condition: Pressure, Temperature, Leakage of One Seal, Partial Blockage of Air Inlets, Off-Normal Handling of HI-TRAC

Accident Condition: Handling Accident, Tip-Over, Fire, Partial Blockage of MPC Basket Vent Holes, Tornado, Flood, Earthquake, Fuel Rod Rupture, Confinement Boundary Leakage, Explosion, Lightning, Burial Under Debris, 100% Blockage of Air Inlets, Extreme Environmental Temperature

Each of these conditions and the applicable loads are identified with applicable design criteria established. Design criteria are deemed to be satisfied if the specified allowable limits are not exceeded.

2.2.1 Normal Condition Design Criteria

2.2.1.1 Dead Weight

The HI-STORM 100 System must withstand the static loads due to the weights of each of its components, including the weight of the HI-TRAC with the loaded MPC atop the storage overpack.

2.2.1.2 Handling

The HI-STORM 100 System must withstand loads experienced during routine handling. Normal handling includes:

i. vertical lifting and transfer to the ISFSI of the HI-STORM 100 Overpack with loaded MPC
ii. lifting, upending/downending, and transfer to the ISFSI of the HI-TRAC with loaded MPC in the vertical or horizontal position
iii. lifting of the loaded MPC into and out of the HI-TRAC, HI-STORM, or HI-STAR Overpack

The loads shall be increased by 15% to include any dynamic effects from the lifting operations as directed by CMAA #70 [2.2.16].

Handling operations of the loaded HI-TRAC transfer cask or HI-STORM 100 Overpack is limited to ambient temperatures above 0EF. This limitation is specified to ensure that a sufficient safety margin exists before brittle fracture might occur during handling operations. Subsection 3.1.2.3 provides the demonstration of the adequacy of the HI-TRAC transfer cask and the HI-STORM 100 Overpack for use during handling operations at a minimum service temperature of 0° F.

Lifting attachments and devices shall meet the requirements of ANSI N14.6† [2.2.3].

† Yield and ultimate strength values used in the stress compliance demonstration per ANSI N14.6 shall utilize confirmed material test data through either independent coupon testing or material suppliers' CMTR or COC, as appropriate. To ensure consistency between the design and fabrication of a lifting component, compliance with ANSI N14.6 in this TSAR implies that the guidelines of ASME Section III, Subsection NF for Class 3 structures are followed for material procurement and testing, fabrication, and for NDE during manufacturing.

2.2.1.3 Pressure

The MPC internal pressure is dependent on the initial volume of cover gas (helium), the volume of fill gas in the fuel rods, the fraction of fission gas released from the fuel matrix, the number of fuel rods assumed to have ruptured, and temperature.

The normal condition MPC internal design pressure bounds the cumulative effects of the maximum fill gas volume, normal environmental ambient temperatures, the maximum MPC heat load, and an assumed 1% of the fuel rods ruptured with 100% of the fill gas and 30% of the significant radioactive gases (e.g., H^3, Kr, and Xe) released in accordance with NUREG-1536.

Table 2.2.1 provides the design pressures for the HI-STORM 100 System.

For the storage of damaged Dresden Unit 1 or Humboldt Bay BWR fuel assemblies or fuel debris (Assembly Classes 6x6A, 6x6B, 6x6C, 7x7A, and 8x8A) in a damaged fuel container, it is conservatively assumed that 100% of the fuel rods are ruptured with 100% of the rod fill gas and 30% of the significant radioactive gases (e.g., H^3, Kr, and Xe) released for both normal and off-normal conditions. This condition is bounded by the pressure calculation for design basis intact fuel with 100% of the fuel rods ruptured in all 68 of the BWR fuel assemblies. It is shown in Chapter 4 that the normal condition design pressure is not exceeded with 100% of the fuel rods ruptured in all 68 of the design basis BWR fuel assemblies. Therefore, rupture of 100% of the fuel rods in the damaged fuel assemblies or fuel debris will not cause the MPC internal pressure to exceed the normal design pressure.

The MPC internal design pressure under accident conditions is discussed in Subsection 2.2.3.

The HI-STORM 100 Overpack and MPC external pressure is a function of environmental conditions which may produce a pressure loading. The normal and off-normal condition external design pressure is set at ambient standard pressure (1 atmosphere).

The HI-STORM 100 Overpack is not capable of retaining internal pressure due to its open design, and, therefore, no analysis is required or provided for the overpack internal pressure.

The HI-TRAC is not capable of retaining internal pressure due to its open design and, therefore, ambient and hydrostatic pressures are the only pressures experienced. Due to the thick steel walls of the HI-TRAC transfer cask, it is evident that the small hydrostatic pressure can be easily withstood; no analysis is required or provided for the HI-TRAC internal pressure. However, the HI-TRAC water jacket does experience internal pressure due to the heat-up of the water contained in the water jacket. Analysis is presented in Chapter 3 which demonstrates that the design pressure in Table 2.2.1 can be withstood by the water jacket and Chapter 4 demonstrates by analysis that the water jacket design pressure will not be exceeded. To provide an additional layer of safety, a pressure relief device set at the design pressure is provided, which ensures the pressure will not be exceeded.

2.2.1.4 Environmental Temperatures

To evaluate the long-term effects of ambient temperatures on the HI-STORM 100 System, an upper bound value on the annual average ambient temperatures for the continental United States is used. The normal temperature specified in Table 2.2.2 is bounding for all reactor sites in the contiguous United States. The "normal" temperature set forth in Table 2.2.2 is intended to ensure that it is greater than the annual average of ambient temperatures at any location in the continental United States. In the northern region of the U.S., the design basis "normal" temperature used in this TSAR will be exceeded only for brief periods, whereas in the southern U.S, it may be straddled daily in summer months. Inasmuch as the sole effect of the "normal" temperature is on the computed fuel cladding temperature to establish long-term fuel integrity, it should not lie below the time averaged yearly mean for the ISFSI site. Previously licensed cask systems have employed lower "normal" temperatures (viz. 75°F in Docket 72-1007) by utilizing national meteorological data.

Likewise, within the thermal analysis, a conservatively assumed soil temperature of the value specified in Table 2.2.2 is utilized to bound the annual average soil temperatures for the continental United States. The 1987 ASHRAE Handbook (HVAC Systems and Applications) reports average earth temperatures, from 0 to 10 feet below grade, throughout the continental United States. The highest reported annual average value for the continental United States is 77°F for Key West, Florida. Therefore, this value is specified in Table 2.2.2 as the bounding soil temperature.

Confirmation of the site-specific annual average ambient temperature and soil temperature is to be performed by the licensee, in accordance with 10CFR72.212. The annual average temperature is combined with insolation in accordance with 10CFR71.71 averaged over 24 hours to establish the normal condition temperatures in the HI-STORM 100 System.

2.2.1.5 Design Temperatures

The ASME Boiler and Pressure Vessel Code (ASME Code) requires that the value of the vessel design temperature be established with appropriate consideration for the effect of heat generation internal or external to the vessel. The decay heat load from the spent nuclear fuel is the internal heat generation source for the HI-STORM 100 System. The ASME Code (Section III, Paragraph NCA-2142) requires the Design Temperature to be set at or above the maximum through thickness mean metal temperature of the pressure part under normal service (Level A) condition. Consistent with the terminology of NUREG-1536, we refer to this temperature as the "Design Temperature for Normal Conditions". Conservative calculations of the steady-state temperature field in the HI-STORM 100 System, under assumed environmental normal temperatures with the maximum decay heat load, result in HI-STORM component temperatures at or below the normal condition design temperatures for the HI-STORM 100 System defined in Table 2.2.3.

Maintaining fuel rod cladding integrity is also a design consideration. The maximum fuel rod cladding temperature limits for normal conditions are calculated by the DCCG (Diffusion Controlled Cavity Growth) methodology outlined in the LLNL report [2.2.14] in accordance with NUREG-1536. However, for conservatism, the PNL methodology outlined in PNL report [2.0.3] produces a lower fuel cladding temperature, which is used to establish the *permissible* fuel cladding temperature limits, which are used to determine the allowable fuel decay heat load. Maximum fuel rod stainless steel cladding temperature limits recommended in EPRI report [2.2.13] are greater than the long-term allowable zircaloy fuel cladding temperature limits. However, in this TSAR the long-term zircaloy fuel cladding temperature limits are conservatively applied to the stainless steel clad fuel. The short term temperature limits for zircaloy and stainless steel cladding are taken from references [2.2.15] and [2.2.13], respectively. A detailed description of the maximum fuel rod cladding temperature limits determination is provided in Section 4.3.

2.2.1.6 Snow and Ice

The HI-STORM 100 System must be capable of withstanding pressure loads due to snow and ice. ASCE 7-88 (formerly ANSI A58.1) [2.2.2] provides empirical formulas and tables to compute the effective design pressure on the overpack due to the accumulation of snow for the contiguous U.S. and Alaska. Typical calculated values for heated structures such as the HI-STORM 100 System range from 50 to 70 pounds per square foot. For conservatism, the snow pressure loading is set at a level in Table 2.2.8 which bounds the ASCE 7-88 recommendation.

2.2.2 Off-Normal Conditions Design Criteria

As the HI-STORM 100 System is passive, loss of power and instrumentation failures are not defined as off-normal conditions. The off-normal condition design criteria are defined in the following subsections.

A discussion of the effects of each off-normal condition is provided in Section 11.1. Section 11.1 also provides the corrective action for each off-normal condition. The location of the detailed analysis for each event is referenced in Section 11.1.

2.2.2.1 Pressure

The HI-STORM 100 System must withstand loads due to off-normal pressure. The off-normal condition MPC internal design pressure bounds the cumulative effects of the maximum fill gas volume, off-normal environmental ambient temperatures, the maximum MPC heat load, and an assumed 10% of the fuel rods ruptured with 100% of the fill gas and 30% of the significant radioactive gases (e.g., H^3, Kr, and Xe) released in accordance with NUREG-1536. For conservatism, the MPC normal internal design pressure bounds both normal and off-normal conditions. Therefore, the normal and off-normal condition MPC internal pressures are set equal for analysis purposes.

2.2.2.2 Environmental Temperatures

The HI-STORM 100 System must withstand off-normal environmental temperatures. The off-normal environmental temperatures are specified in Table 2.2.2. The lower bound temperature occurs with no solar loads and the upper bound temperature occurs with steady- state insolation. Each bounding temperature is assumed to persist for a duration sufficient to allow the system to reach steady-state temperatures.

Limits on the peaks in the time-varying ambient temperature at an ISFSI site is recognized in the TSAR in the specification of the off-normal temperatures. The lower bound off-normal temperature is defined as the minimum of the 72-hour average of the ambient temperature at an ISFSI site. Likewise, the upper bound off-normal temperature is defined by the maximum of 72-hour average of the ambient temperature. The lower and upper bound off-normal temperatures listed in Table 2.2.2 are intended to cover all ISFSI sites in the continent U.S. The 72-hour average of temperature used in the definition of the off-normal temperature recognizes the considerable thermal inertia of the HI-STORM 100 storage system which reduces the effect of undulations in instantaneous temperature on the internals of the multi-purpose canister.

2.2.2.3 Design Temperatures

In addition to the normal design temperature, we also define an "off-normal/accident condition temperature" pursuant to the provisions of NUREG-1536 and Regulatory Guide 3.61. This is, in effect, the short-term temperature which may exist during a transition state or a transient event (examples of such instances are short-term temperature excursion during canister vacuum drying and backfilling operations (transition state) and fire (transient event)). The off-normal/accident design temperatures of Table 2.2.3 are set down to bound the maximax (maximum in time and space) value of the thru-thickness average temperature of the structural or non-structural part, as applicable, during a short-term event. These enveloping values, therefore, will bound the maximum temperature reached anywhere in the part, excluding skin effects during or immediately after, a short-term event.

2.2.2.4 Leakage of One Seal

The HI-STORM 100 System must withstand leakage of one seal in the radioactive material confinement boundary.

The confinement boundary is defined by the MPC shell, baseplate, MPC lid, port cover plates, and closure ring. Most confinement boundary welds are inspected by radiography or ultrasonic examination. Field welds are examined by the liquid penetrant method on the root and final pass. In addition to liquid penetrant examination, the MPC lid-to-shell weld is leakage tested, hydrostatic tested, and volumetrically examined or multi-pass liquid penetrant examined. The vent and drain port cover plates are leakage tested in addition to the liquid penetrant examination. These inspection and testing techniques are performed to verify the integrity of the confinement boundary.

Although, leakage of one seal is not a credible accident, it is analyzed in Chapter 11.

2.2.2.5 Partial Blockage of Air Inlets

The HI-STORM 100 System must withstand the partial blockage of the overpack air inlets. This event is conservatively defined as a complete blockage of one-half (2) of the four air inlets. Because the overpack air inlets and outlets are covered by fine mesh steel screens, located 90° apart, and inspected routinely (or alternatively, exit vent air temperature monitored), it is unlikely that all vents could become blocked by blowing debris, animals, etc. during normal and off-normal operations. One-half of the air inlets are conservatively assumed to be completely blocked to demonstrate the inherent thermal stability of the HI-STORM 100 System.

2.2.2.6 Off-Normal HI-TRAC Handling

During upending and/or downending of the HI-TRAC transfer cask, the total lifted weight is distributed among both the upper lifting trunnions and the lower pocket trunnions. Each of the four trunnions on the HI-TRAC therefore supports approximately one-quarter of the total weight. This even distribution of the load would continue during the entire rotation operation.

If the lifting device is allowed to "go slack", the total weight would be applied to the lower pocket trunnions only. Under this off-normal condition, the pocket trunnions would each be required to support one-half of the total weight, doubling the load per trunnion. This condition is analyzed to demonstrate that the pocket trunnions possess sufficient strength to support the increased load under this off-normal condition.

2.2.3 Environmental Phenomena and Accident Condition Design Criteria

Environmental phenomena and accident condition design criteria are defined in the following subsections.

The minimum acceptance criteria for the evaluation of the accident conditions are that the MPC confinement boundary maintains radioactive material confinement, the MPC fuel basket structure maintains the fuel contents subcritical, the stored SNF can be retrieved by normal means, and the system provides adequate shielding.

A discussion of the effects of each environmental phenomenon and accident condition is provided in Section 11.2. The consequences of each accident or environmental phenomenon are evaluated against the requirements of 10CFR72.106 and 10CFR20. Section 11.2 also provides the corrective action for each event. The location of the detailed analysis for each event is referenced in Section 11.2.

2.2.3.1 Handling Accident

The HI-STORM 100 System must withstand loads due to a handling accident. Even though the HI-STORM 100 System will be lifted in accordance with approved, written procedures and will use lifting equipment which complies with ANSI N14.6-1993 [2.2.3], certain drop events are considered herein to demonstrate the defense-in-depth features of the design.

The loaded HI-STORM 100 Overpack will be lifted so that the bottom of the cask is at a height less than the vertical lift limit (see Table 2.2.8) above the ground. For conservatism, the postulated drop event assumes that the loaded HI-STORM 100 Overpack falls freely from the vertical lift limit height before impacting a thick reinforced concrete pad. The deceleration of the MPC must be maintained below 60g's under axial loading to ensure the analysis performed in the HI-STAR Safety Analysis Reports [2.2.4 and 2.2.5] bounds the HI-STORM 100 Overpack vertical handling accident. Additionally, the overpack must continue to suitably shield the radiation emitted from the loaded MPC. The use of lifting equipment with redundant drop protection and lifting devices designed in accordance with the requirements specified in Section 2.3.3.1 to lift the loaded overpack will eliminate the lift height limit. The lift height limit is dependent on the characteristics of the impacting surface which are specified in Table 2.2.9. For site-specific conditions, which are not encompassed by Table 2.2.9, the licensee shall evaluate the site-specific conditions to ensure that the drop accident loads do not exceed 45 g's. The methodology used in this alternative analysis shall be commensurate with the analyses in Appendix 3.A and shall be reviewed by the Certificate Holder.

The loaded HI-TRAC will be lifted so that the side of the cask is at a height less than the calculated horizontal lift height limit (see Table 2.2.8) above the ground, when lifted horizontally outside of the reactor facility. For conservatism, the postulated drop event assumes that the loaded HI-TRAC falls freely from the horizontal lift height limit before impact. Analysis is provided which demonstrates that the HI-TRAC continues to suitably shield the radiation emitted from the loaded MPC, and that the HI-TRAC end plates (top lid and transfer lid) remain attached. Furthermore, the HI-TRAC inner shell is demonstrated by analysis to not deform sufficiently to affect retrieval of the MPC. The horizontal lift height limit is dependent on the characteristics of the impacting surface which are specified in Table 2.2.9. For site-specific conditions, which are not encompassed by Table 2.2.9, the licensee shall evaluate the site-specific conditions to ensure that the drop accident loads do not exceed 45 g's. The methodology used in this alternative analysis shall be commensurate with the analyses in Appendix 3.AN and shall be reviewed by the Certificate Holder. The use, during horizontal lifting of the loaded HI-TRAC outside of the reactor facilities, of lifting equipment with redundant drop protection and lifting devices designed in accordance with the requirements specified in Section 2.3.3.1, will eliminate the need for a horizontal lift height limit.

The loaded HI-TRAC, when lifted in the vertical position outside of the reactor facility shall be lifted by lifting equipment with redundant drop protection features and lifting devices designed in accordance with ANSI N14.6. Therefore, a vertical drop or tip-over is not a credible accident for the HI-TRAC transfer cask and no vertical lift height limit is provided. Likewise, while the loaded HI-TRAC is positioned atop the HI-STORM 100 Overpack for transfer of the MPC into the overpack, the lifting equipment will remain engaged with the lifting trunnions of the HI-TRAC transfer cask or suitable restraints will be provided to secure the HI-TRAC. This ensures that a tip-over or drop from atop the HI-STORM 100 Overpack is not a credible accident for the HI-TRAC transfer cask. This condition of use for the MPC transfer operations from the HI-TRAC transfer cask to the HI-STORM 100 Overpack is specified in the Technical Specifications in Chapter 12 and Subsection 2.3.3.1, and is included in the operating procedures of Chapter 8.

The loaded MPC is lowered into the HI-STORM or HI-STAR Overpacks or raised from the overpacks using the HI-TRAC transfer cask and a MPC lifting system designed to be single failure proof and lifting devices designed in accordance with ANSI N14.6. Therefore, the possibility of a loaded MPC falling freely from its highest elevation during the MPC transfer operations into the HI-STORM or HI-STAR Overpacks is not credible.

The magnitude of loadings imparted to the HI-STORM 100 System due to drop events is heavily influenced by the compliance characteristics of the impacted surface. The concrete pad design for storing the HI-STORM 100 System shall comply with Table 2.2.9 and shall be reviewed by the Certificate Holder to ensure that impactive and impulsive loads under accident events such as cask drop and non-mechanistic tip-over are less than those calculated by the dynamic models used in the structural qualifications.

2.2.3.2 Tip-Over

The HI-STORM 100 System is demonstrated by analysis to remain kinematically stable under the design basis environmental phenomena (tornado, earthquake, etc.). However, the HI-STORM 100 Overpack and MPC shall also withstand impacts due to a hypothetical tip-over event. The structural integrity of a loaded HI-STORM 100 System after a tip-over onto a reinforced concrete pad is demonstrated by analysis. The cask tip-over is not postulated as an outcome of any environmental phenomenon or accident condition. The cask tip-over is a non-mechanistic event.

The ISFSI pad requirements are specified in Table 2.2.9.

2.2.3.3 Fire

The possibility of a fire accident near an ISFSI site is considered to be extremely remote due to the absence of significant combustible materials. The only credible concern is related to a transport vehicle fuel tank fire engulfing the loaded HI-STORM 100 Overpack or HI-TRAC transfer cask while it is being moved to the ISFSI.

The HI-STORM 100 System must withstand temperatures due to a fire event. The HI-STORM 100 Overpack and HI-TRAC transfer cask fire accidents for storage are conservatively postulated to be the result of the spillage and ignition of 50 gallons of combustible transporter fuel. The HI-STORM 100 Overpack and HI-TRAC transfer cask surfaces are considered to receive an incident radiation and forced convection heat flux from the fire. Table 2.2.8 provides the fire durations for the HI-STORM 100 Overpack and HI-TRAC transfer cask based on the amount of flammable materials assumed. The temperature of fire is assumed to be 1475°F in accordance with 10CFR71.73.

The accident condition design temperatures for the HI-STORM 100 System, and the fuel rod cladding limits are specified in Table 2.2.3. The specified fuel cladding temperature limits are based on the short-term temperature limit specified in reports [2.2.13 and 2.2.15].

2.2.3.4 Partial Blockage of MPC Basket Vent Holes

The HI-STORM 100 System is designed to withstand reduction of flow area due to partial blockage of the MPC basket vent holes. As the MPC basket vent holes are internal to the confinement barrier, the only events that could partially block the vents are fuel cladding failure and debris associated with this failure, or the collection of crud at the base of the stored SNF assembly. The HI-STORM 100 System maintains the SNF in an inert environment with fuel rod cladding temperatures below accepted values (Table 2.2.3). Therefore, there is no credible mechanism for gross fuel cladding degradation during storage in the HI-STORM 100. For the storage of damaged BWR fuel assemblies or fuel debris, the assemblies and fuel debris will be placed in damaged fuel containers prior to placement in the MPC. The damaged fuel container is equipped with fine mesh screens which ensure that the damaged fuel and fuel debris will not escape to block the MPC basket vent holes. In addition, each MPC will be loaded once for long-term storage and, therefore, buildup of crud in the MPC due to numerous loadings is precluded. Using crud quantities reported in an Empire State Electric Energy Research Corporation Report [2.2.6], a layer of crud of conservative depth is assumed to partially block the MPC basket vent holes. The crud depths for the different MPCs are listed in Table 2.2.8.

2.2.3.5 Tornado

The HI-STORM 100 System must withstand pressures, wind loads, and missiles generated by a tornado. The prescribed design basis tornado and wind loads for the HI-STORM 100 System are consistent with NRC Regulatory Guide 1.76 [2.2.7], ANSI 57.9 [2.2.8], and ASCE 7-88 [2.2.2]. Table 2.2.4 provides the wind speeds and pressure drops which the HI-STORM 100 Overpack must withstand while maintaining kinematic stability. The pressure drop is bounded by the accident condition MPC external design pressure.

The kinematic stability of the HI-STORM 100 Overpack, and continued integrity of the MPC confinement boundary, while within the storage overpack or HI-TRAC transfer cask, must be demonstrated under impact from tornado-generated missiles in conjunction with the wind loadings. Standard Review Plan (SRP) 3.5.1.4 of NUREG-0800 [2.2.9] stipulates that the postulated missiles include at least three objects: a massive high kinetic energy missile which deforms on impact (large missile); a rigid missile to test penetration resistance (penetrant missile); and a small rigid missile of a size sufficient to pass through any openings in the protective barriers (micro-missile). SRP 3.5.1.4 suggests an automobile for a large missile, a rigid solid steel cylinder for the penetrant missile, and a solid sphere for the small rigid missile, all impacting at 35% of the maximum horizontal wind speed of the design basis tornado. Table 2.2.5 provides the missile data used in the analysis, which is based on the above SRP guidelines. The effects of a large tornado missile are considered to bound the effects of a light general aviation airplane crashing on an ISFSI facility.

During horizontal handling of the loaded HI-TRAC transfer cask, tornado missile shields shall be placed at either end of the HI-TRAC to prevent tornado missiles from impacting either end of the HI-TRAC. The tornado missile shield shall be designed such that the large tornado missile cannot impact the bottom or top of the loaded HI-TRAC, while in the horizontal position. Also, the missile shield positioned to protect the top of the HI-TRAC shall be designed to preclude the penetrant missile and micro-missile from passing through the penetration in the HI-TRAC top lid, while in the horizontal position. With the tornado missile shields in place the impacting of a large tornado missile on either end of the loaded HI-TRAC or the penetrant missile or micro-missile entering the penetration of the top lid is not credible. Therefore, no analyses of these impacts are provided.

2.2.3.6 Flood

The HI-STORM 100 System must withstand pressure and water forces associated with a flood. Resultant loads on the HI-STORM 100 System consist of buoyancy effects, static pressure loads, and velocity pressure due to water velocity. The flood is assumed to deeply submerge the HI-STORM 100 System (see Table 2.2.8). The flood water depth is based on the hydrostatic pressure which is bounded by the MPC external pressure stated in Table 2.2.1.

It must be shown that the MPC does not collapse, buckle, or allow water in-leakage under the hydrostatic pressure from the flood.

The flood water is assumed to be nonstagnant. The maximum allowable flood water velocity is determined by calculating the equivalent pressure loading required to slide or tip over the HI-STORM 100 System. The design basis flood water velocity is stated in Table 2.2.8 and the resultant differential pressure on the overpack is stated in Table 2.2.1. Site-specific safety reviews by the licensee must confirm that flood parameters do not exceed the flood depth, slide, or tip-over forces.

If the flood water depth exceeds the elevation of the top of the HI-STORM 100 Overpack inlet vents, then the cooling air flow would be blocked. The flood water may also carry debris which may act to block the air inlets of the HI-STORM 100 Overpack. Blockage of the air inlets is addressed in Subsection 2.2.3.12.

Most reactor sites are hydrologically characterized as required by Paragraph 100.10(C) of 10CFR100 and further articulated in Reg. Guide 1.59, "Design Basis Floods for Nuclear Power Plants" and Reg. Guide 1.102, "Flood Protection for Nuclear Power Plants." It is assumed that a complete characterization of the ISFSI's hydrosphere including the effects of hurricanes, floods, seiches and tsunamis is available to enable a site-specific evaluation of the HI-STORM 100 System for kinematic stability. An evaluation for tsunamis[†] for certain coastal sites should also be performed to demonstrate that sliding or tip-over will not occur and that the maximum flood depth will not be exceeded.

† A tsunami is an ocean wave from seismic or volcanic activity or from submarine landslides. A tsunami may be the result of nearby or distant events. A tsunami loading may exist in combination with wave splash and spray, storm surge and tides.

Analysis for each site for such transient hydrological loadings must be made for that site. It is expected that the plant licensee will perform this evaluation under the provisions of 10CFR72.212.

2.2.3.7 Seismic Design Loadings

The HI-STORM 100 must withstand loads arising due to a seismic event and must be shown not to tip over during a seismic event. Subsection 3.4.7 contains calculations based on conservative static "incipient tipping" calculations which demonstrate static stability. The calculations in Section 3.4.7 result in the values reported in Table 2.2.8, which provide the maximum horizontal zero period acceleration (ZPA) versus vertical acceleration multiplier above which static incipient tipping would occur. This conservatively assumes the peak acceleration values of each of the two horizontal earthquake components occur simultaneously. The maximum horizontal ZPA provided in Table 2.2.8 is the vector sum of two horizontal earthquakes.

2.2.3.8 100% Fuel Rod Rupture

The HI-STORM 100 System must withstand loads due to 100% fuel rod rupture. For conservatism, 100 percent of the fuel rods are assumed to rupture with 100 percent of the fill gas and 30% of the significant radioactive gases (e.g., H^3, Kr, and Xe) released in accordance with NUREG-1536.

2.2.3.9 Confinement Boundary Leakage

No credible scenario has been identified that would cause failure of the confinement system. To demonstrate the overall safety of the HI-STORM 100 System, the largest test leakage rate for the confinement boundary plus 50% for conservatism is assumed as the maximum credible confinement boundary leakage rate and 100 percent of the fuel rods are assumed to have failed. Under this accident condition, doses to an individual located at the boundary of the controlled area are calculated.

2.2.3.10 Explosion

The HI-STORM 100 System must withstand loads due to an explosion. The accident condition MPC external pressure and overpack pressure differential specified in Table 2.2.1 bounds all credible external explosion events. There are no credible internal explosive events since all materials are compatible with the various operating environments, as discussed in Section 3.4.1. The MPC is composed of stainless steel, Boral, and aluminum alloy 1100, all of which have a long proven history of use in fuel pools at nuclear power plants. For these materials there is no credible cause for an internal explosive event.

2.2.3.11 Lightning

The HI-STORM 100 System must withstand loads due to lightning. The effect of lightning on the HI-STORM 100 System is evaluated in Chapter 11.

2.2.3.12 Burial Under Debris

The HI-STORM 100 System must withstand burial under debris. Such debris may result from floods, wind storms, or mud slides. Mud slides, blowing debris from a tornado, or debris in flood water may result in duct blockage, which is addressed in Subsection 2.2.3.13. The thermal effects of burial under debris on the HI-STORM 100 System is evaluated in Chapter 11. Siting of the ISFSI pad shall ensure that the storage location is not located near shifting soil. Burial under debris is a highly unlikely accident, but is analyzed in this TSAR.

2.2.3.13 100% Blockage of Air Inlets

For conservatism, this accident is defined as a complete blockage of all four bottom air inlets. Such a blockage may be postulated to occur during accident events such as a flood or tornado with blowing debris. The HI-STORM 100 System must withstand the temperature rise as a result of 100% blockage of the air inlets and outlets. The fuel cladding temperature must be shown to remain below the short term temperature limit specified in Table 2.2.3.

2.2.3.14 Extreme Environmental Temperature

The HI-STORM 100 System must withstand extreme environmental temperatures. The extreme accident level temperature is specified in Table 2.2.2. The extreme accident level temperature occurs with steady-state insolation. This temperature is assumed to persist for a duration sufficient to allow the system to reach steady-state temperatures. The HI-STORM 100 Overpack and MPC have a large thermal inertia. Therefore, this temperature is assumed to persist over three days (3-day average).

2.2.4 Applicability of Governing Documents

The ASME Boiler and Pressure Vessel Code (ASME Code), 1995 Edition, with Addenda through 1997 [2.2.1], is the governing code for the structural design of the MPC, the metal structure of the HI-STORM 100 Overpack, and the HI-TRAC transfer cask. The MPC enclosure vessel and fuel basket are designed in accordance with Section III, Subsections NB Class 1 and NG Class 1, respectively. The metal structure of the overpack and the HI-TRAC transfer cask are designed in accordance with Section III, Subsection NF Class 3. The ASME Code is applied to each component consistent with the function of the component.

ACI 349 is the governing code for the plain concrete in the HI-STORM 100 Overpack. ACI 318-95 is the applicable code utilized to determine the allowable compressive strength of the plain concrete credited during structural analysis. Appendix 1.D provides the sections of ACI 349 and ACI 318-95 applicable to the plain concrete.

Table 2.2.6 provides a summary of each structure, system and component (SSC) of the HI-STORM 100 System which is identified as important to safety, along with its function and governing Code. Some components perform multiple functions and in those cases, the most restrictive Code is applied. In accordance with NUREG/CR-6407, "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components", and according to importance to safety, components of the HI-STORM 100 System are classified as A, B, C, or NITS (not important to safety) in Table 2.2.6. Section 13.1 provides the criteria used to classify each item. The classification of necessary auxiliary equipment is provided in Table 8.1.6.

Table 2.2.7 lists the applicable governing Code for material procurement, design, fabrication and inspection of the components of the HI-STORM 100 System. The ASME Code section listed in the design column is the section used to define allowable stresses for structural analyses.

Table 2.2.15 lists the exceptions to the ASME Code for the HI-STORM 100 System and the justification for those exceptions.

The MPC utilized in the HI-STORM 100 System is identical to the MPC described in the applications for the HI-STAR 100 System for storage (Docket 72-1008) and transport (Docket 71-9261) certification. To avoid unnecessary repetition of the large numbers of stress analyses, attention is directed in this document to establish that the MPC loadings for storage in the HI-STORM 100 System do not exceed those computed in the referenced applications. Many of the loadings in the HI-STAR applications envelope the HI-STORM loadings on the MPC, and, therefore, a complete re-analysis of the MPC is not provided in the TSAR.

Table 2.2.16 provides a summary comparison between the loading elements. Table 2.2.16 shows that most of the loadings remain unchanged and several are less than the HI-STAR loading conditions. In addition to the magnitude of the loadings experienced by the MPC, the application of the loading must also be considered. Therefore, it is evident from Table 2.2.16 that the MPC stress limits can be ascertained to be qualified a priori if the HI-STAR analyses and the thermal loadings under HI-STORM storage are not more severe compared to previously analyzed HI-STAR conditions. In the analysis of each of the normal, off-normal, and accident conditions, the effect on the MPC is evaluated and compared to the corresponding condition analyzed in the HI-STAR 100 System SARs [2.2.4 and 2.2.5]. If the HI-STORM loading is greater than the HI-STAR loading or the loading is applied differently, the analysis of its effect on the MPC is evaluated in Chapter 3.

2.2.5 Service Limits

In the ASME Code, plant and system operating conditions are commonly referred to as normal, upset, emergency, and faulted. Consistent with the terminology in NRC documents, this TSAR utilizes the terms normal, off-normal, and accident conditions.

The ASME Code defines four service conditions in addition to the Design Limits for nuclear components. They are referred to as Level A, Level B, Level C, and Level D service limits, respectively. Their definitions are provided in Paragraph NCA-2142.4 of the ASME Code. The four levels are used in this TSAR as follows:

a. Level A Service Limits: Level A Service Limits are used to establish allowables for normal condition load combinations.

b. Level B Service Limits: Level B Service Limits are used to establish allowables for off-normal condition load combinations.

c. Level C Service Limits: Level C Service Limits are not used.

d. Level D Service Limits: Level D Service Limits are used to establish allowables for accident condition load combinations.

The ASME Code service limits are used in the structural analyses for definition of allowable stresses and allowable stress intensities. Allowable stresses and stress intensities for structural analyses are tabulated in Chapter 3. These service limits are matched with normal, off-normal, and accident condition loads combinations in the following subsections.

The MPC confinement boundary is required to meet Section III, Class 1, Subsection NB stress intensity limits. Table 2.2.10 lists the stress intensity limits for the Levels A, B, C, and D service limits for Class 1 structures extracted from the ASME Code (1995 Edition). The limits for the MPC fuel basket, required to meet the stress intensity limits of Subsection NG of the ASME Code, are listed in Table 2.2.11. Table 2.2.12 lists allowable stress limits for the steel structure of the HI-STORM 100 Overpack and HI-TRAC which are analyzed to meet the stress limits of Subsection NF, Class 3. Only service levels A, B, and D requirements, normal, off-normal, and accident conditions, are applicable.

2.2.6 Loads

Subsections 2.2.1, 2.2.2, and 2.2.3 describe the design criteria for normal, off-normal, and accident conditions, respectively. Table 2.2.13 identifies the notation for the individual loads that require consideration. The individual loads listed in Table 2.2.13 are defined from the design criteria. Each load is assigned a symbol for subsequent use in the load combinations.

The loadings listed in Table 2.2.13 fall into two broad categories; namely, (i) those which primarily affect kinematic stability, and (ii) those which produce significant stresses. The loadings in the former category are principally applicable to the overpack. Wind (W), earthquake (E), tornado (W′), and tornado-borne missile (M) are essentially loadings which can destabilize a cask. Analyses reported in Chapter 3 show that the HI-STORM 100 Overpack structure will remain kinematically stable under these loadings. Additionally, for the missile impact case (M), analyses which demonstrate that the overpack structure remains unbreached by the postulated missiles are provided in Chapter 3.

Loadings in the second category produce global stresses which must be shown to comply with the stress intensity or stress limits, as applicable. The relevant loading combinations for the fuel basket, the MPC, the HI-TRAC and the HI-STORM 100 Overpack are different because of differences in their function. For example, the fuel basket does not experience a pressure loading because it is not a pressure vessel. The specific load combination for each component is specified in Subsection 2.2.7.

2.2.7 Load Combinations

To demonstrate compliance with the design requirements for normal, off-normal, and accident conditions of storage, the individual loads, identified in Table 2.2.13, are combined into load combinations. In the formation of the load combinations, it is recognized that the number of combinations requiring detailed analyses is reduced by defining bounding loads. Analyses performed using bounding loads serve to satisfy the requirements for analysis of a multitude of separately identified loads in combination.

For example, the values established for internal and external pressures (P_i and P_o) are defined such that they bound other surface-intensive loads, namely snow (S), tornado wind (W′), flood (F), and explosion (E^*). Thus, evaluation of pressure in a load combination established for a given storage condition enables many individual load effects to be included in a single load combination.

Table 2.2.14 identifies the combinations of the loads that are required to be considered in order to ensure compliance with the design criteria set forth in this chapter. Table 2.2.14 presents the load combinations in terms of the loads that must be considered together. A number of load combinations are established for each ASME Service Level. Within each loading case, there may be more than one analysis that is required to demonstrate compliance. Since the breakdown into specific analyses is most applicable to the structural evaluation, the identification of individual analyses with the applicable loads for each load combination is found in Chapter 3. Table 3.1.3 through 3.1.5 define the particular evaluations of loadings that demonstrate compliance with the load combinations of Table 2.2.14.

For structural analysis purposes, Table 2.2.14 serves as an intermediate classification table between the definition of the loads (Table 2.2.13 and Section 2.2) and the detailed analysis combinations (Tables 3.1.3 through 3.1.5).

Finally, it should be noted that the load combinations identified in NUREG-1536 are considered as applicable to the HI-STORM 100 System. The majority of load combinations in NUREG-1536 are directed towards reinforced concrete structures. Those load combinations applicable to steel structures are directed towards frame structures. As stated in NUREG-1536, Page 3-35 of Table 3-1, "Table 3-1 does not apply to the analysis of confinement casks and other components designed in accordance with Section III of the ASME B&PV code." Since the HI-STORM 100 System is a metal shell structure, with concrete primarily employed as shielding, the load combinations of NUREG-1536 are interpreted within the confines and intent of the ASME Code.

2.2.8 Allowable Stresses

The stress intensity limits for the MPC confinement boundary for the design condition and the service conditions are provided in Table 2.2.10. The MPC confinement boundary stress intensity limits are obtained from ASME Code, Section III, Subsection NB. The stress intensity limits for the MPC fuel basket are presented in Table 2.2.11 (governed by Subsection NG of Section III). The steel structure of the overpack and the HI-TRAC meet the stress limits of Subsection NF of ASME Code, Section III for plate and shell components. Limits for the Level D condition are obtained from Appendix F of ASME Code, Section III for the steel structure of the overpack. The ASME Code is not applicable to the HI-TRAC transfer cask for accident conditions, service level D conditions. The HI-TRAC transfer cask has been shown by analysis to not deform sufficiently to apply a load to the MPC, have any shell rupture, or have the top lid, pool lid, or transfer lid detach. The following definitions of terms apply to the tables on stress intensity limits; these definitions are the same as those used throughout the ASME Code:

S_m: Value of Design Stress Intensity listed in ASME Code Section II, Part D, Tables 2A, 2B and 4

S_y: Minimum yield strength at temperature

S_u: Minimum ultimate strength at temperature

Table 2.2.8

ADDITIONAL DESIGN INPUT DATA FOR NORMAL, OFF-NORMAL, AND ACCIDENT CONDITIONS

Item	Condition	Value
Snow Pressure Loading (lb./ft^2)	Normal	100
Constriction of MPC Basket Vent Opening By Crud Settling (Depth of Crud, in.)	Accident	0.85 (MPC-68) 0.36 (MPC-24)
Cask Environment During the Postulated Fire Event (EF)	Accident	1475
HI-STORM 100 Overpack Fire Duration (seconds)	Accident	217
HI-TRAC Transfer Cask Fire Duration (minutes)	Accident	4.8
Maximum submergence depth due to flood (ft)	Accident	125
Flood water velocity (ft/s)	Accident	15
Maximum Horizontal ZPA (Zero Period Acceleration) for HI-STORM†	Accident	0.40 (w/1.0 vertical) 0.43 (w/0.75 vertical) 0.44 (w/0.667 vertical) 0.47 (w/0.5 vertical)
HI-STORM 100 Overpack Vertical Lift Height Limit (in.)	Accident	11
HI-TRAC Transfer Cask Horizontal Lift Height Limit (in.)	Accident	42

† The maximum horizontal ZPA is specified as the vector sum of the g-loading in two orthogonal directions as a function of the vertical acceleration multiplier which is the maximum vertical ZPA divided by the maximum horizontal ZPA for a single orthogonal direction for the site.

Table 2.2.9

CHARACTERISTICS OF REFERENCE ISFSI PAD[†]

Concrete thickness	≤ 36 inches
Concrete Compressive Strength	≤ 4,200 psi at 28 days
Reinforcement Top and Bottom (both directions)	Reinforcing bar shall be 60 ksi Yield Strength ASTM Material
Subgrade Soil Effective Modulus of Elasticity[††]	≤ 28,000 psi (measured prior to ISFSI pad installation)
Top Concrete Surface	A static coefficient of friction of ≥ 0.53 between the ISFSI pad and the bottom of the overpack shall be verified by test. The test procedure shall follow the guidelines included in the Sliding Analysis in TSAR Subsection 3.4.7.1

† The characteristics of this pad are identical to the pad considered by Lawrence Livermore Laboratory (see Appendix 3.A).

†† An acceptable method of defining the soil effective modulus of elasticity applicable to the drop and tipover analysis is provided in Table 13 of NUREG/CR-6608 with soil classification in accordance with ASTM-D2487 Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System USCS) and density determination in accordance with ASTM-D1586 Standard Test Method for Penetration Test and Split/Barrel Sampling of Soils.

9. Pre-service examination requirements

10. In-use inspection and maintenance requirements

11. Number and magnitude of repetitive loading significant to fatigue

12. Insulation and enclosure requirements (on electrical motors and machinery)

13. Applicable Reg. Guides and NUREGs.

14. Welding requirements

15. Painting, marking, and identification requirements

16. Design Report documentation requirements

17. Operational and Maintenance (O&M) Manual information requirements

All design documentation shall be subject to a review, evaluation, and safety assessment process in accordance with the provisions of the QA program described in Chapter 13.

Users may effectuate the inter-cask transfer of the MPC between the HI-TRAC transfer cask and either the HI-STORM 100 or the HI-STAR 100 overpack in a location of their choice, depending upon site-specific needs and capabilities. For those users choosing to perform the MPC inter-cask transfer outside of a facility governed by the regulations of 10 CFR Part 50 (e.g., fuel handling or reactor building), a Cask Transfer Facility (CTF) is required. The CTF is a stand-alone facility located on-site, near the ISFSI that incorporates or is compatible with lifting devices designed to lift a loaded or unloaded HI-TRAC transfer cask, place it atop the overpack, and transfer the loaded MPC to or from the overpack. The detailed design criteria which must be followed for the design and operation of the CTF are set down in Paragraphs A through R below.

The inter-cask transfer operations consist of the following potential scenarios of MPC transfer:

- Transfer between a HI-TRAC transfer cask and a HI-STORM 100 overpack
- Transfer between a HI-TRAC transfer cask and a HI-STAR 100 overpack

In both scenarios, HI-TRAC is mounted on top of the overpack (HI-STAR 100 or HI-STORM 100) and the MPC transfer is carried out by opening the transfer lid doors located at the bottom of the HI-TRAC transfer cask and by moving the MPC vertically to the cylindrical cavity of the recipient cask. However, the devices utilized to lift the HI-TRAC cask to place it on the overpack and to vertically transfer the MPC may be of stationary or mobile type.

The specific requirements for the CTF employing stationary and mobile lifting devices are somewhat different. The requirements provided in the following specification for the CTF apply to *both* types of lifting devices, unless explicitly differentiated in the text.

A. General Specifications:

i. The cask handling functions which may be required of the Cask Transfer Facility include:

a. Upending and downending of a HI-STAR 100 overpack on a flatbed rail car or other transporter (see Figure 2.3.1 for an example).

b. Upending and downending of a HI-TRAC transfer cask on a heavy-haul transfer trailer or other transporter (see Figure 2.3.2 for an example)

c. Raising and placement of a HI-TRAC transfer cask on top of a HI-STORM 100 overpack for MPC transfer operations (see Figure 2.3.3).

d. Raising and placement of a HI-TRAC transfer cask on top of a HI-STAR 100 overpack for MPC transfer operations (see Figure 2.3.4).

e. MPC transfer between the HI-TRAC transfer cask and the HI-STORM 100 overpack.

f. MPC transfer between the HI-TRAC transfer cask and the HI-STAR 100 overpack.

ii. Other Functional Requirements:

The CTF should possess facilities and capabilities to support cask operations such as :

a. Devices and areas to support installation and removal of the HI-STORM 100 lid.

b. Devices and areas to support installation and removal of the HI-STORM 100 shield block inserts.

c. Devices and areas to support installation and removal of the HI-STAR 100 closure plate.

ii. Design Report: A QA-validated design report documenting full compliance with the provisions of this specification shall be prepared and archived for future reference in accordance with the provisions of Chapter 13 of this TSAR.

2.3.3.2 Instrumentation

As a consequence of the passive nature of the HI-STORM 100 System, instrumentation which is important to safety is not necessary. No instrumentation is required or provided for HI-STORM 100 storage operations, other than normal security service instruments and TLDs.

However, in lieu of performing the periodic inspection of the HI-STORM overpack vent screens, temperature elements may be used in an minimum of two of the overpack exit vents to monitor the air temperature. If the temperature elements and associated temperature monitoring instrumentation are used, they shall be designated important to safety as specified in Table 2.2.6.

The temperature elements and associated temperature monitoring instrumentation provided to monitor the air outlet temperature shall be suitable for a temperature range of -40°F to 500°F. At a minimum, the temperature elements and associated temperature monitoring instrumentation shall be calibrated for the temperatures of 32°F (ice point), 212°F (boiling point), and 449°F (melting point of tin) with an accuracy of +/- 4°F.

2.3.4 Nuclear Criticality Safety

The criticality safety criteria stipulates that the effective neutron multiplication factor, k_{eff}, including statistical uncertainties and biases, is less than 0.95 for all postulated arrangements of fuel within the cask under all credible conditions.

2.3.4.1 Control Methods for Prevention of Criticality

The control methods and design features used to prevent criticality for all MPC configurations are the following:

a. Incorporation of permanent neutron absorbing material (Boral™) in the MPC fuel basket walls.

b. Favorable geometry provided by the MPC fuel basket

Administrative controls specified as Technical Specifications are provided in Chapter 12 and shall be used to ensure that fuel placed in the HI-STORM 100 System meets the requirements described in Chapters 2 and 6. All appropriate criticality analyses are presented in Chapter 6.

2.3.4.2 Error Contingency Criteria

Provision for error contingency is built into the criticality analyses performed in Chapter 6. Because biases and uncertainties are explicitly evaluated in the analysis, it is not necessary to introduce additional contingency for error.

2.3.4.3 Verification Analyses

In Chapter 6, critical experiments are selected which reflect the design configurations. These critical experiments are evaluated using the same calculation methods, and a suitable bias is incorporated in the reactivity calculation.

3.A.11 References

[3.A.1] Witte, M., et al., "Evaluation of Low-Velocity Impacts Tests of Solid Steel Billet onto Concrete Pads.", Lawrence Livermore National Laboratory, UCRL-ID-126274, Livermore, California, March 1997.

[3.A.2] Witte, M., et al., "Evaluation of Low-Velocity Impacts Tests of Solid Steel Billet onto Concrete Pads, and Application to Generic ISFSI Storage Cask for Tipover and Side Drop.", Lawrence Livermore National Laboratory, UCRL-ID-126295, Livermore, California, March 1997.

[3.A.3] Tang, D.T., Raddatz, M.G., and Sturz, F.C., "NRC Staff Technical Approach for Spent Fuel Cask Drop and Tipover Accident Analysis", SFPO, USNRC (1997).

[3.A.4] Simulescu, I., "Benchmarking of the Holtec LS-DYNA3D Model for Cask Drop Events", Holtec Report HI-971779, September 1997.

[3.A.5] LS-DYNA3D, Version 936-03, Livermore Software Technology Corporation, September 1996.

[3.A.6] Whirley, R.G., "DYNA3D, A Nonlinear, Explicit, Three-Dimensional Finite element Code for Solid and Structural Mechanics - User Manual.", Lawrence Livermore National Laboratory, UCRL-MA-107254, Revision 1, 1993.

Table 3.A.1: Essential Variables for Reference ISFSI Pad Data (from [3.A.2] and [3.A.4])

Thickness of concrete	36 inches
Nominal compressive strength of concrete	4,200 psi at 28 days
Concrete mass density	2.097E-04 lb-sec^2/in^4
Concrete Poisson's ratio	0.22
Mass density of the soil	1.872E-04 lb.-sec^2/in^4
Effective modulus of elasticity of the subgrade soil	28,000 psi
Poisson's ratio of the soil	0.4

Note 1: The concrete Young's Modulus is derived from the American Concrete Institute recommended formula $57000(f)^{1/2}$ where f is the nominal compressive strength of the concrete (psi).

Note 2: The effective modulus of elasticity of the subgrade soil is to be measured by an appropriate "plate test" before pouring of the concrete ISFSI pad.

Note 3: The pad thickness of 36", concrete compressive strength of 4200 psi (nom.) at 28 days of curing, and the subgrade soil effective modulus of 28000 psi are the upper bound values to ensure that the deceleration limits under the postulated impact events set forth in Table 3.1.2 are satisfied.

Table 3.A.2: Essential Steel Material Properties for HI-STORM 100 Overpack

Steel Type	Parameter	Value
SA-516-70 at T = 350 deg. F	E	2.800E + 07
	S_y	3.315E+04 psi
	S_u	7.000E+04 psi
	ϵ_u	0.21
	ν	0.30

Note that the properties of the steel components, except for the radial channels used to position the MPC, do not affect the results reported herein since the HI-STORM 100 is eventually assumed to behave as a rigid body (by internal constraint equations automatically computed by DYNA3D upon issue of a "make rigid" command). In Section 3.4, however, stress and strain results for an additional tip-over analysis, performed using the actual material behavior ascribed to the storage overpack, are presented for the sole purpose of demonstrating ready retrievability of the MPC after the tip-over.

Table 3.A.3: Key Input Data in Drop Analyses

Overpack weight	267,664 lb
Radial Concrete weight	163,673 lb
Length of the cask	231.25 inches
Diameter of the bottom plate	132.50 inches
Inside diameter of the cask shell	72.50 inches
Outside diameter of the cask shells	132.50 inches
MPC weight (including fuel)	88,857 lb
MPC height	190.5 inches
MPC diameter	68.375 inches
MPC bottom plate thickness	2.5 inches
MPC top plate thickness	9.5 inches

Table 3.A.4: Results

Drop Event	Max. Displ (in)	Impact Velocity (in/sec)	Max. Acc. (g's)	Acc. Pulse Duration (msec.)
End-11"	0.696	92.20	44.13	2.96
Tipover Cask Top[1]	4.903	341.3	48.41	9.76
Tipover (Basket Top)	4.368	304.03	43.12	--
Tipover (with Increased Initial Clearance) Cask Top[1]	4.998	341.3	48.52	10.0
Tipover (with Increased Initial Clearance) (Basket Top)	4.452	304.03	43.22	--

1 The distance of the top of the fuel basket is 206" from the pivot point. The distance of the top of the cask is 231.25" from the pivot point. Therefore, all displacements, velocities, and accelerations at the top of the fuel basket are 89.08% of those at the cask top (206"/231.25").

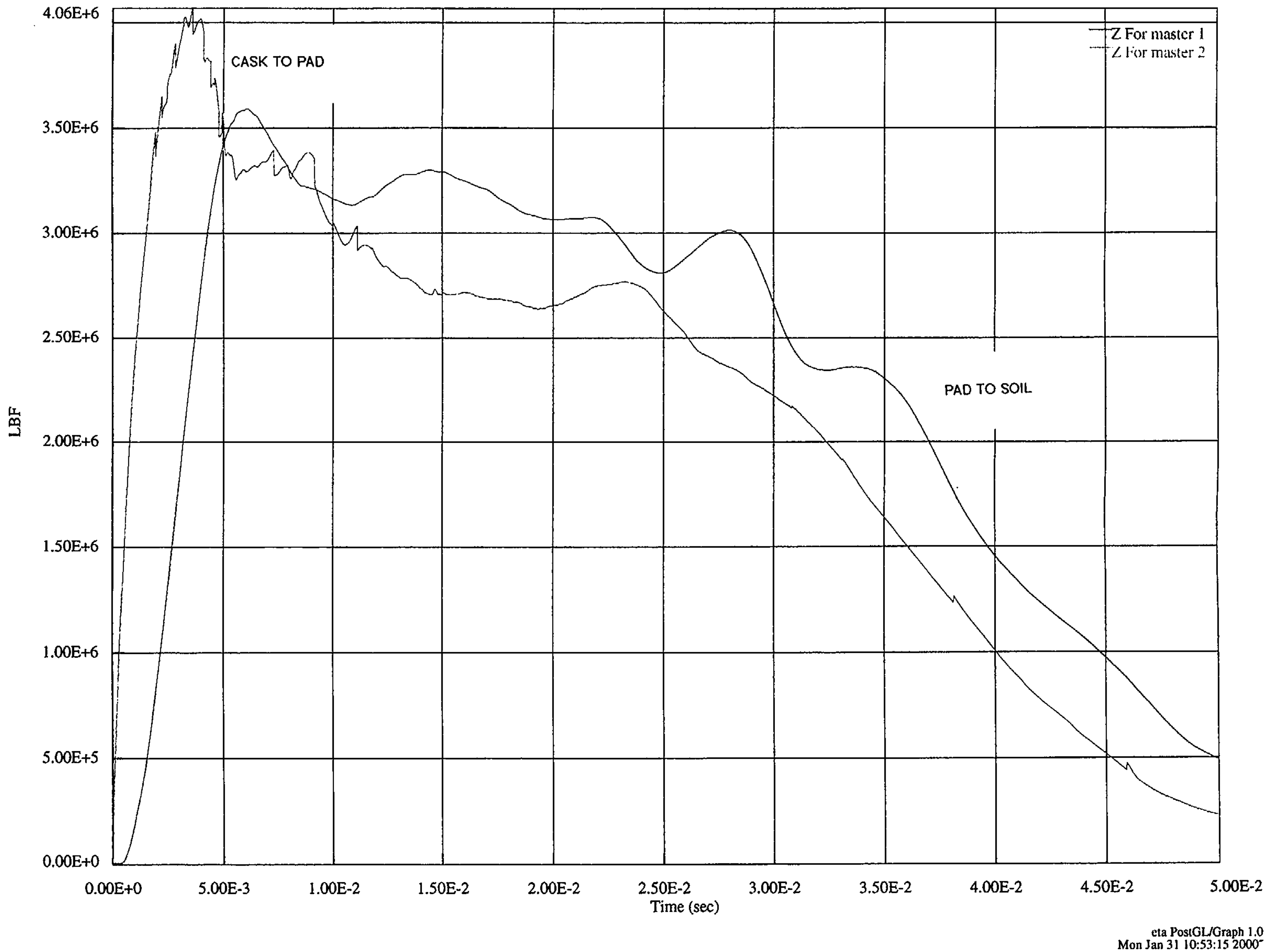


FIG. 3.A.19 Tipover Scenario: Impact Force Time Histories

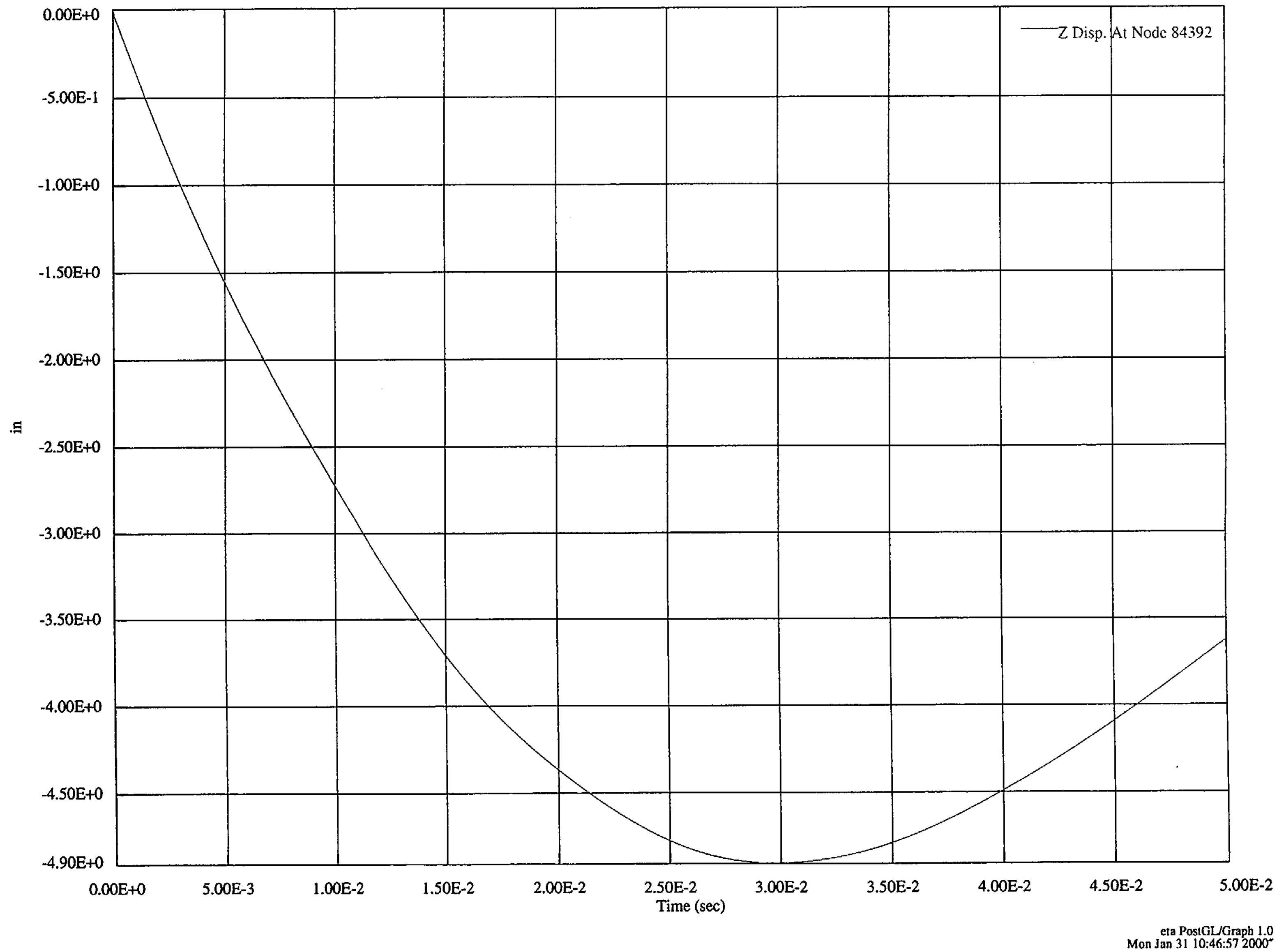


FIG. 3.A.20 Tipover Scenario: Channel A2 Displacement Time History

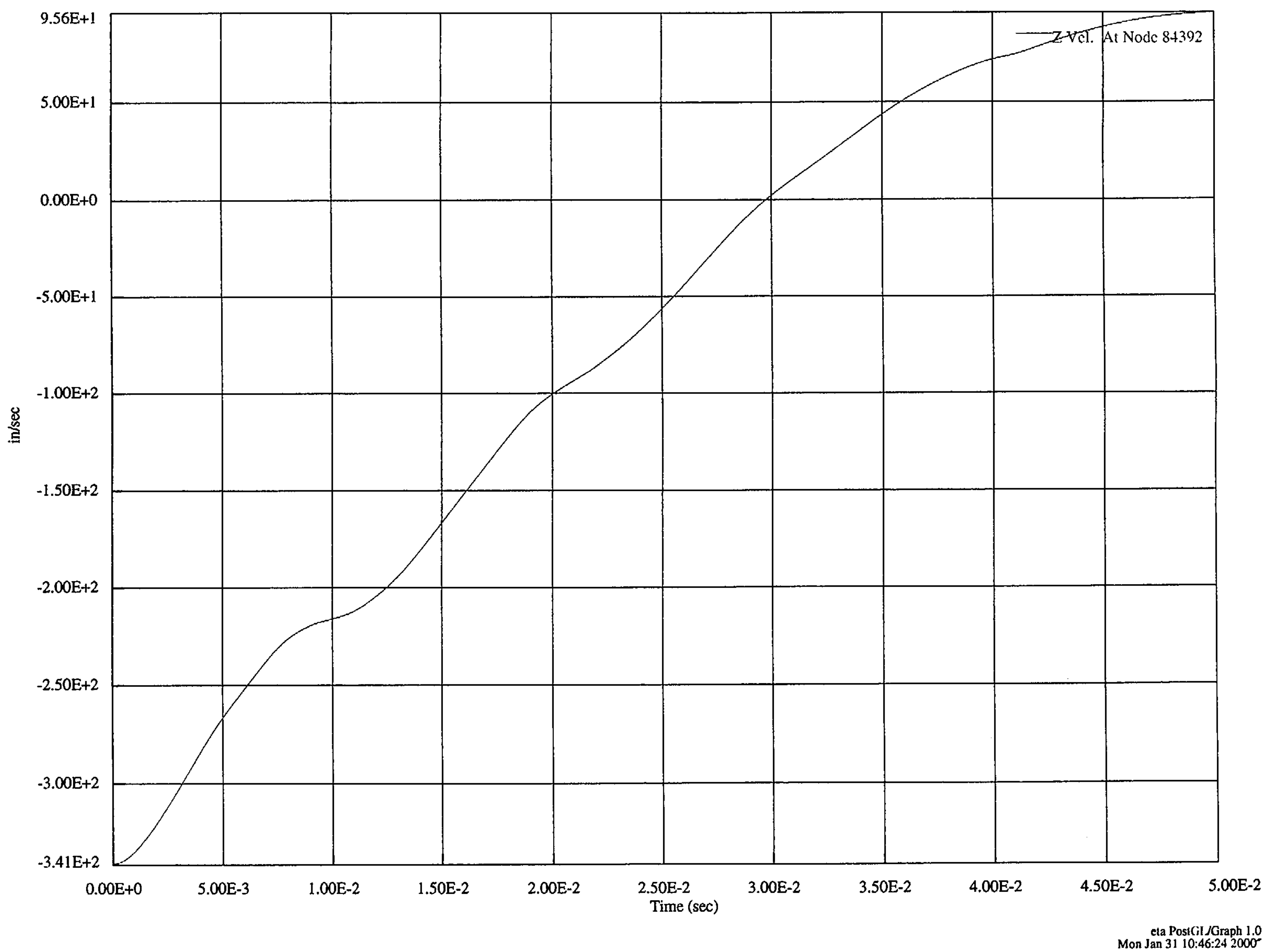


FIG 3.A.21 Tipover Scenario: Channel A2 Velocity Time History

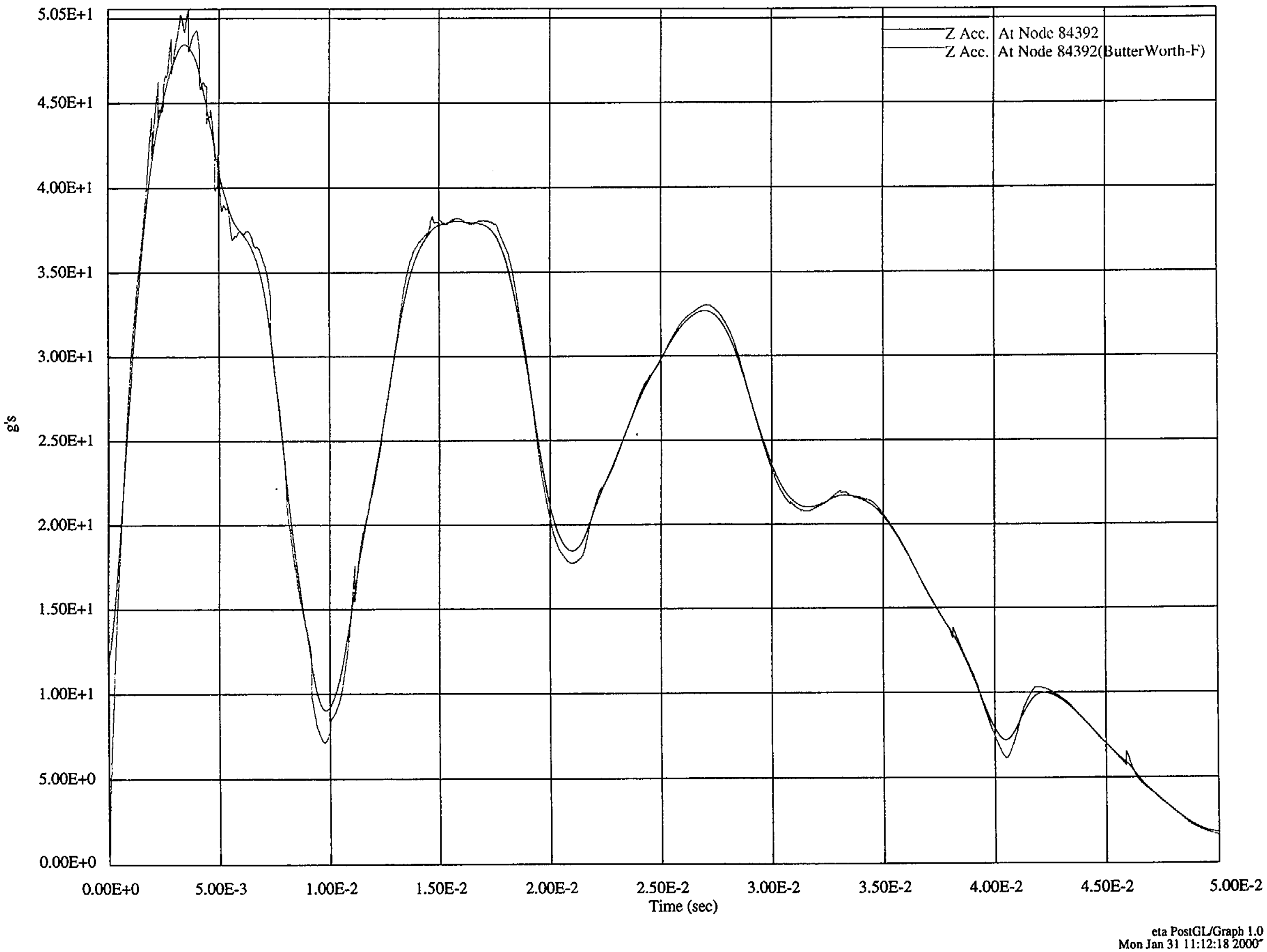


FIG 3A.22 Tipover Scenario: Channel A2 Deceleration Time Histories

Table 4.4.20

MPC-24 DESIGN-BASIS MAXIMUM HEAT LOAD[1]
VERSUS FUEL AGE AT LOADING

Fuel Age At Loading (years)	Permissible Heat Load (kW)
5	20.88
6	20.17
7	18.18
10	17.72
15	17.17

1 The cask heat load limits (Q_τ) presented in this table pertain to loading the MPC with uniformly aged fuel assemblies emitting heat at the design basis maximum rate (q_τ), where "τ" is the age of the fuel at the start of dry storage. For a cask loaded with a mix of fuel ages, the cask heat load limit shall be the sum of the individual assembly decay heat limits (as a function of τ) as specified in the Appendix B to COC 1014.

Table 4.4.21

MPC-68 DESIGN-BASIS MAXIMUM HEAT LOAD[1]
VERSUS FUEL AGE AT LOADING

Fuel Age At Loading (years)	Permissible Heat Load (kW)
5	21.52
6	20.31
7	18.41
10	17.95
15	17.45

1 The cask heat load limits (Q_τ) presented in this table pertain to loading the MPC with uniformly aged fuel assemblies emitting heat at the design basis maximum rate (q_τ), where "τ" is the age of fuel at the start of dry storage. For a cask loaded with a mix of fuel ages, the cask heat load limit shall be the sum of the individual assembly decay heat limits (as a function of fuel age) as specified in the Appendix B to COC 1014.

7.2 REQUIREMENTS FOR NORMAL AND OFF-NORMAL CONDITIONS OF STORAGE

The MPC uses multiple confinement barriers provided by the fuel cladding and the MPC enclosure vessel to assure that there is no release of radioactive material to the environment. Chapter 3 shows that all confinement boundary components are maintained within their Code-allowable stress limits during normal storage conditions. Chapter 4 shows that the peak confinement boundary component temperatures and pressures are within the design basis limits for all normal conditions of storage. Since the MPC confinement vessel remains intact, and the design bases temperatures and pressure are not exceeded, the design basis leakage rate is not exceeded during normal conditions of storage.

7.2.1 Release of Radioactive Material

The MPC is closed by the MPC lid, the vent and drain port cover plates, and the MPC closure ring. Weld examinations, including multiple surface examinations, volumetric examination, hydrostatic testing, and leakage rate testing on the MPC lid weld, and multiple surface examinations and leakage rate testing of the vent and drain port cover plate welds, assure the integrity of the MPC closure. The MPC is a strength-welded pressure vessel designed to meet the stress criteria of the ASME Code, Section III, Subsection NB [7.1.1]. The all-welded construction of the MPC with redundant closure provided by the fully welded MPC closure ring and extensive inspections and testing ensures that no release of fission gas or crud for normal storage and transfer conditions will occur. The above discussion notwithstanding, an analysis is performed in Section 7.2.7 to calculate the annual dose at 100 meters based on an assumed leakage rate of $5x10^{-6}$ atm-cm^3/sec under normal and off-normal conditions of storage.

7.2.2 Pressurization of the Confinement Vessel

The loaded and sealed MPC is drained, vacuum dried, and backfilled with helium gas. This process provides a chemically non-reactive environment for storage of spent fuel assemblies. First, air in the MPC is displaced with water and then the water is displaced by helium or nitrogen gas during MPC blowdown. The MPC is then vacuum dried, and backfilled with a predetermined mass of helium as specified in the Technical Specifications. Chapter 8 describes the steps of these processes and the Technical Specifications provide the acceptance criteria. This drying and backfilling process ensures that the resulting inventory of oxidizing gases in the MPC remains below 0.25% by volume, and that the MPC pressure is maintained within the design limitations. In addition, the MPC basket fluid contact areas are stainless steel alloy material or aluminum of extremely high corrosion and erosion resistance. The aluminum oxide layer on the aluminum components (e.g., heat conduction elements and Boral neutron absorption plates) ensures that there is no reaction during the short duration of exposure to the fuel pool water. Carbon steels are not employed in the construction of the MPCs. Therefore, no protective coatings which could interact with borated spent fuel pool water are used.

The only means of pressure increase in the MPC is from the temperature rise due to normal heat-up to normal operating temperatures and the release of backfill and fission gas contents from fuel rods into the MPC cavity. Under the most adverse conditions of normal ambient temperature, full insolation, and design basis decay heat, the calculated pressure increase assuming 1% fuel rod failure is well below the system design pressure as shown in Chapter 4. For off-normal conditions of storage, failure of up to 10% of the fuel rods has been analyzed and would result in an MPC internal pressure below the value specified as the normal design pressure.

7.2.3 Confinement Integrity During Dry Storage

There is no credible mechanism or event that results in a release of radioactive material from the MPC under normal conditions. Since the MPC remains structurally intact and provides redundant welded closures as discussed above, the postulated leakage of radioactive material from the MPC will be limited to a leakage rate equivalent to the acceptance test criteria specified for the MPC helium leak tests. Leakage from the MPC during normal conditions of storage could result in the release of gaseous fission products, fines, volatiles and airborne crud particulates as discussed in Section 7.3.1. The conservative assumption is made that 1% of the fuel inventory is available for release for normal conditions of storage and 10% of the fuel inventory is available for release under off-normal conditions of storage. The maximum cavity internal operating pressure with 10% fuel rod failure reported in Table 4.4.14 is bounded by the use of an internal cavity pressure of 80 psia (5.44 ATM), which is assumed as an initial condition for this evaluation.

The following doses to an individual at the site boundary (100 meters) as a result of an assumed effluent release under normal and off-normal conditions of storage were determined; the inhaled committed dose equivalent for critical organs and tissues (gonad, breast, lung, red marrow, bone surface, thyroid, skin, lens of the eye), the effective dose from external submersion in the plume, and the resulting Total Effective Dose Equivalent (TEDE). These doses were determined for each type of MPC. The ISFSI controlled area boundary must be at least 100 meters from the nearest loaded HI-STORM 100 System in accordance with 10CFR72.106(b) [7.0.1]. The doses are compared to the regulatory limits specified in 10CFR72.104 [7.0.1].

Confinement boundary welds performed at the fabricator's facility are inspected by volumetric and liquid penetrant examination methods as detailed in Section 9.1. Field welds are performed on the MPC lid, the MPC vent and drain port covers, and MPC closure ring. The weld of the MPC lid-to-shell is liquid penetrant examined on the root and final pass, volumetrically (or multilayer liquid penetrant) examined, hydrostatically tested, and leak rate tested. The vent and drain port cover plates are liquid penetrant examined on the root and final pass and leak rate tested. The MPC closure ring welds are inspected by the liquid penetrant examination method on the root and final pass. In Chapter 11, the MPC lid-to-shell weld is postulated to fail to confirm the safety of the HI-STORM 100 confinement boundary. The failure of the MPC lid weld is equivalent to the MPC drain or vent provided on the spread sheets included as Appendix 7.A.

7.2.7.7 Occupancy Time

An occupancy time of 8,760 hours is used for the analysis [7.0.2]. This conservatively assumes that the individual is exposed 24 hours per day for 365 days at the minimum controlled area boundary of 100 meters.

7.2.7.8 Breathing Rate

A breathing rate of 3.3×10^{-4} m^3/sec for a worker is used for the analysis [7.0.2]. This assumption is in accordance with the guidance provided in NUREG-1536 [7.0.2] for a worker.

7.2.8 Postulated Doses Under Normal and Off-Normal Conditions of Storage

The following doses to an individual at the site boundary (100 meters) as a result of an assumed effluent release under normal and off-normal conditions of storage were determined; the inhaled committed dose equivalent for critical organs and tissues (gonad, breast, lung, red marrow, bone surface, thyroid, skin, lens of the eye), the effective dose from external submersion in the plume, and the resulting Total Effective Dose Equivalent (TEDE). These doses are determined for each type of MPC and for each condition of storage (i.e., normal and off-normal). The postulated doses as a result of exposure to soil with ground surface contamination and soil contaminated to a depth of 15 cm were also determined. The resultant doses were negligible compared to the those resulting from submersion in the plume and are therefore not reported.

The doses were determined using spreadsheet software. The resultant doses are summarized for each MPC type in Tables 7.3.2, 7.3.3, and 7.3.4 of the HI-STORM TSAR. Example spread sheets used for the dose estimates are presented in Appendix 7.A.

7.2.8.1 Whole Body Dose (Total Effective Dose Equivalent)

The whole body dose is the sum of the inhaled committed effective dose equivalent (CEDE) and the external exposure from submersion in the plume. The postulated doses were determined using spreadsheet software. Example spread sheets are provided in Appendix 7.A.

The CEDE is the product of radionuclide release rate, the atmospheric dispersion factor, the occupancy time, the breathing rate, and the effective dose conversion factor.

External exposure from submersion is the product of the nuclide release rate, the atmospheric dispersion factor, the occupancy time, and the effective dose conversion factor.

7.2.8.2 Critical Organ Dose

The dose to the critical organ (or tissue) is the sum of the committed dose equivalent to the critical organ or tissue from inhalation and the dose equivalent to the organ or tissue from submersion in the plume. The postulated doses as a result of exposure to soil with ground surface contamination and soil contaminated to a depth of 15 cm were also determined. The resultant doses were negligible compared to the those resulting from submersion in the plume and are therefore not reported.

The committed dose equivalent to the organ or tissue from inhalation is the product of radionuclide release rate, the atmospheric dispersion factor, the occupancy time, the breathing rate, and the organ/tissue dose conversion factor. The dose equivalent to the organ or tissue from submersion in the plume is the product of the nuclide release rate, the atmospheric dispersion factor, the occupancy time, and the organ/tissue dose conversion factor.

The doses for tissues and organs other than lens of the eye were determined using spreadsheet software. The dose to the lens of the eye as a result of submersion in the plume was estimated using guidance from Dr. James Turner in his book, *Atoms, Radiation, and Radiation Protection* [7.3.10]]. Dr. Turner states that alpha particles and low-energy beta particles, such as those from tritium, cannot penetrate to the lens of the eye (at a depth of 3 mm). The discussion continues that many noble gases emit photons and energetic beta particles, which in turn must be considered in the dose estimate. Dr. Turner states that the dose-equivalent rate to tissues near the surface of the body (e.g., lens of the eye) is more than 130 times the dose-equivalent rate in the lung from gases contained in the lung. The estimated dose to the lens of the eye is greatest using the accident condition of storage for the MPC-68. Section 7.3.4.2 presents the detailed discussion of the dose to the lens of the eye.

7.2.9 Assumptions

The following presents a summary of assumptions for the normal condition confinement analysis of the HI-STORM 100 System.

- The distance from the cask to the site boundary is 100 meters.
- Under normal conditions of storage, 1% of the fuel rods have ruptured. This assumption is in accordance with NUREG-1536 for normal storage conditions.
- Under off-normal conditions of storage, 10% of the fuel rods have ruptured. This assumption is in accordance with ISG-5 and NUREG-1536 for off-normal storage conditions.
- Unchoked flow correlations were used as the unchoked flow correlations better approximate the true measured flow rate for the leakage rates.

- For conservatism, the upstream pressure at test conditions (inside of the MPC) is assumed to be 2 ATM and the down stream pressure (outside of the MPC) is assumed to be 1 ATM.

- The temperature at test conditions is assumed to be equal to a temperature, 212° F based on the maximum temperature achievable by the water in the MPC during performance of the leak test. This is conservative because the leak hole diameter computed from test conditions is larger.

- Normal storage conditions (i.e., MPC cavity at a pressure of 80 psia (5.44 ATM) at MPC cavity average temperature of 510 K) are postulated for this analysis as these condition bound the off-normal conditions of storage.

- The capillary length required for Equation 7-3 was conservatively chosen to be the MPC lid closure weld which is 1.9 cm.

- The majority of the activity associated with crud is due to ^{60}Co. This assumption follows from the discussion provided in NUREG/CR-6487 [7.3.2].

- The normal and off-normal condition leakage rate persists for one year without a decrease in the rate or nuclide concentration.

- The individual at the site boundary is exposed for 8,760 hours [7.0.2]. This conservatively assumes that the individual is exposed 24 hours per day for 365 days.

- A breathing rate of 3.3×10^{-4} m^3/sec for a worker is used for the analysis [7.0.2]. This assumption is in accordance with the guidance provided in NUREG-1536 for a worker.

- All fuel stored in the MPC is of the design basis type with a bounding burnup and cooling time.

- Exposure to dose conversion factors for inhalation reported in EPA Federal Guidance Report No. 11, Table 2.1 [7.3.5] were selected by lung clearance class which reports the most conservative values.

- For conservativism, the maximum possible leakage rate is assumed to be $7.5\text{x}10^{-6}$ atm-cm^3/s, which is 150% of the test leak rate of $5.0\text{x}10^{-6}$ atm-cm^3/s

PWR
Surface area per Assy = 3.0E+05 cm^2
140 $\mu Ci/cm^2$ x 3.0E+05 cm^2 = 42.0 Ci

BWR
Surface area per Assy = 1.0E+05 cm^2
1254 $\mu Ci/cm^2$ x 1.0E+05 cm^2 = 125.4 Ci

$^{60}Co(t) = {}^{60}Co_0\, e^{-(ët)}$, where ë = $\ln 2/t_{1/2}$, t = 5 years (for the MPC-24 and MPC-68), t = 18 years (MPC-68F), $t_{1/2}$ = 5.272 years for ^{60}Co [7.3.3]

MPC-24

$^{60}Co(5) = 42.0\ Ci\ e^{-(\ln 2/5.272)(5)}$
$^{60}Co(5) = 21.77\ Ci$

MPC-68

$^{60}Co(5) = 125.4\ Ci\ e^{-(\ln 2/5.272)(5)}$
$^{60}Co(5) = 64.98\ Ci$

MPC-68F

$^{60}Co(18) = 125.4\ Ci\ e^{-(\ln 2/5.272)(18)}$
$^{60}Co(18) = 11.76\ Ci$

A summary of the ^{60}Co inventory available for release is provided in Table 7.3.1.

7.3.3 Release of Contents Under Non-Mechanistic Accident Conditions of Storage

7.3.3.1 Seal Leakage Rate

The helium leak rate testing performed on the MPC confinement boundary verifies the helium leak rate to be less than or equal to $5x10^{-6}$ atm-cm^3/s [1] as required by the Technical Specifications As demonstrated by analysis, the MPC confinement boundary is not compromised as a result of normal, off-normal, and accident conditions. Based on the robust nature of the MPC confinement boundary, the NDE inspection of the welds, and the measurement of the helium leakage rate, there is essentially no leakage. However, it is conservatively assumed that the maximum possible leakage rate from the confinement vessel is $7.5x10^{-6}$ atm-cm^3/s.

Equation B-1 of ANSI N14.5 (1997) [7.3.8] is used to express this mass-like helium flow rate (Q_u) measured in atm-cm^3/s as a function of the upstream volumetric leakage rate (L_u) as follows:

[1] According to ANSI N14.5 (1997), the mass-like leakage rate specified herein is often used in leakage testing. This is defined as the rate of change of the pressure-volume product of the leaking fluid at test conditions.

Equation 7-2

$$Q_u = L_u * P_u \quad \text{atm-cm}^3\text{/sec (Equation B-1 from ANSI N14.5(1997))}$$

$$L_u = Q_u/P_u \quad \text{cm}^3\text{/sec}$$

where:

L_u is the upstream volumetric leakage rate [cm^3/s],
Q_u is the mass-like helium leak rate [atm cm^3/s], and
P_u is the upstream pressure [ATM]

The corresponding leakage rate at accident conditions is determined using the following methodology. For conservatism, unchoked flow correlations were used as the unchoked flow correlations better approximate the true measured flowrate for the leakage rates. Using the equations for molecular and continuum flow, Equation B-5 provided in ANSI N14.5-1997 [7.3.8], the corresponding capillary diameter, D, was calculated. For conservatism, the upstream pressure at test conditions (inside of the MPC) is assumed to be 2 ATM (minimum) and the down stream pressure (outside of the MPC) is assumed to be 1 ATM (at 298 K), therefore, the average pressure is 1.5 ATM. The evaluation was performed using the helium gas temperature at test conditions of both 70°F and 212°F. These temperatures are representative of the possible temperature of the helium gas in the confinement vessel during the helium leak test. The 212°F helium temperature is the upper bound because the water inside the MPC is shown not to boil in Chapter 4 as long as the "time-to-boil" time limit is not exceeded. From the two calculations using the two temperatures, it was determined that the higher temperature (212°F) results in a greater capillary diameter. The capillary length required for Equation 7-3 was conservatively chosen to be the minimum MPC lid closure weld which is 1.9 cm. Table 7.3.6 provides a summary of the parameters used in the calculation.

Equation 7-3

$$L_u \quad [\frac{2.49x10^6 \; D^4}{a \; u} \quad \frac{3.81x10^3 \; D^3 \sqrt{\frac{T}{M}}}{a \; P_a}][P_u \quad P_d][\frac{P_a}{P_u}]$$

annual 25 mrem whole body limit imposed by 10 CFR 72.104(a). The estimated thyroid dose (0.11 mrem/yr) is a small fraction of the annual 75 mrem thyroid limit imposed by 10 CFR 72.104(a). Additionally, the dose estimates to other critical organs are small fractions of the annual 25 mrem critical organ limit imposed by 10 CFR 72.104(a). The highest of the "other critical organs" is 8.65 mrem to the bone surface.

7.3.6 Assumptions

The following presents a summary of assumptions for the accident condition confinement analysis of the HI-STORM 100 System.

The distance from the cask to the site boundary is 100 meters.

100% of the fuel rods have ruptured. This assumption is conservative because it results in the greatest potential release of radioactive material.

Unchoked flow correlations were used as the unchoked flow correlations better approximate the true measured flowrate for the leakage rates associated with transportation packages.

For conservatism, the upstream pressure at test conditions (inside of the MPC) is assumed to be 2 and the down stream pressure (outside of the MPC) is assumed to be 1 .

The temperature at test conditions is assumed to be equal to an ambient reference temperature, 212° F based on the maximum temperature achievable by the water in the MPC during performance of the leak test. This is conservative because the leak hole diameter computed from test conditions is larger.

Bounding accident conditions (i.e., MPC cavity at design pressure (125 psig) at peak cladding temperature limit (570° C)) are postulated for this analysis.

The capillary length required for Equation 7-3 was conservatively chosen to be the MPC lid closure weld which is 1.9 cm.

The majority of the activity associated with crud is due to ^{60}Co. This assumption follows from the discussion provided in NUREG/CR-6487 [7.3.2].

The accident condition leakage rate persists for 30 days without a decrease in the rate or nuclide concentration.

The individual at the site boundary is exposed for 720 hours (30 days). This conservatively assumes that the individual is exposed 24 hours per day for 30 days.

- A breathing rate of 3.3 x 10^{-4} m^3/sec for a worker is used for the analysis [7.0.2]. This assumption is in accordance with the guidance provided in NUREG-1536 for a worker.

- All fuel stored in the MPC is of the design basis type with a bounding burnup and cooling time.

- Exposure to dose conversion factors for inhalation reported in EPA Federal Guidance Report No. 11, Table 2.1 [7.3.5] were selected by lung clearance class which reports the most conservative values.

- For conservativism, the maximum possible leakage rate is assumed to be 7.5×10^{-6} atm-cm^3/s, which is 150% of the test leak rate of 5.0×10^{-6} atm-cm^3/s.

CHAPTER 8: OPERATING PROCEDURES†

8.0 INTRODUCTION:

This chapter outlines the loading, unloading, and recovery procedures for the HI-STORM 100 System for storage operations. The procedures provided in this chapter are prescriptive to the extent that they provide the basis and general guidance for plant personnel in preparing detailed, written, site-specific, loading, handling, storage and unloading procedures. Users may add or delete steps as necessary provided that the intent of this guidance is met. The information provided in this chapter meets all requirements of NUREG-1536 [8.0.1].

Section 8.1 provides the guidance for loading the HI-STORM 100 System in the spent fuel pool. Section 8.2 provides the procedures for ISFSI operations and general guidance for performing maintenance and responding to abnormal events. Responses to abnormal events that may occur during normal loading operations are provided with the procedure steps. Section 8.3 provides the procedure for unloading the HI-STORM 100 System in the spent fuel pool. Section 8.4 provides the guidance for MPC transfer to the HI-STAR 100 Overpack for transport or storage. Section 8.4 can also be used for recovery of a breached MPC for transport or storage. Section 8.5 provides the guidance for transfer of the MPC into HI-STORM from the HI-STAR 100 transport overpack. The Technical Specifications in Appendix A to CoC 72-1014 provide Limiting Conditions of Operation (LCO), Surveillance Requirements (SR's), as well as administrative information, such as Use and Application. Appendix B to COC 72-1014 provides the approved contents and design features applicable to the HI-STORM 100 System. TSAR Appendix 12.A includes the Bases for the LCOs. The Technical Specifications impose restrictions and requirements that must be applied throughout the loading and unloading process. Equipment specific operating details such as Vacuum Drying System valve manipulation and Transporter operation are not within the scope of this TSAR and will be provided to users based on the specific equipment selected by the users and the configuration of the site.

The procedures contained herein describe acceptable methods for performing HI-STORM 100 loading and unloading operations. Users may alter these procedures to allow alternate methods and operations to be performed in parallel or out of sequence as long as the general intent of the procedure is met. In the figures following each section, acceptable configurations of rigging, piping, and instrumentation are shown. In some cases, the figures are artists rendition. Users may select alternate configurations, equipment and methodology to accommodate their specific needs. All rigging should be approved by the user's load handling authority prior to use. User-developed procedures and the design and operation of any alternate equipment must be reviewed by the Certificate holder prior to implementation.

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† This chapter has been prepared in the format and section organization set forth in Regulatory Guide 3.61. However, the material content of this chapter also fulfills the requirements of NUREG 1536. Pagination and numbering of sections, figures, and tables are consistent with the convention set down in Chapter 1, Section 1.0, herein. Finally, all terms-of-art used in this chapter are consistent with the terminology of the glossary (Table 1.0.1) and component nomenclature of the Bill-of-Materials (Section 1.5).

Licensees (Users) will utilize the procedures provided in this chapter, the Technical Specifications in Appendix A to CoC 72-1014, the conditions of the Certificate of Compliance, equipment-specific operating instructions, and plant working procedures and apply them to develop the site specific written, loading and unloading procedures.

The loading and unloading procedures in Section 8.1 and 8.3 can also be appropriately revised into written site-specific procedures to allow dry loading and unloading of the system in a hot cell or other remote handling facility. The Dry Transfer Facility (DTF) loading and unloading procedures are essentially the same with respect to loading and vacuum drying, inerting, and leakage testing of the MPC. The dry transfer facility shall develop the appropriate site-specific procedures as part of the DTF facility license.

Tables 8.1.1 through 8.1.4 provide the handling weights for each of the HI-STORM 100 System major components and the loads to be lifted during various phases of the operation of the HI-STORM 100 System. Users shall take appropriate actions to ensure that the lift weights do not exceed user-supplied lifting equipment rated loads. Table 8.1.5 provides the HI-STORM 100 System bolt torque and sequencing requirements. Table 8.1.6 provides an operational description of the HI-STORM 100 System ancillary equipment along with its safety designation and QA category, where applicable. Fuel assembly selection and verification shall be performed by the licensee in accordance with written, approved procedures which ensure that only SNF assemblies authorized in the Certificate of Compliance and as defined in the Appendix B to CoC 72-1014 are loaded into the HI-STORM 100 System.

In addition to the requirements set forth in the CoC, users will be required to develop or modify existing programs and procedures to account for the operation of an ISFSI. Written procedures will be required to be developed or modified to account for such things as nondestructive examination (NDE) of the MPC welds, handling and storage of items and components identified as Important to Safety, 10CFR72.48 [8.1.1] programs, specialized instrument calibration, special nuclear material accountability at the ISFSI, security modifications, fuel handling procedures, training and emergency response, equipment and process qualifications. Users are required to take necessary actions to prevent boiling of the water in the MPC. This may be accomplished by performing a site-specific analysis to identify a time limitation to ensure that water boiling will not occur in the MPC prior to the initiation of draining operations. Chapter 4 of the TSAR provides some sample time limits for the time to initiation of draining for various spent fuel pool water temperatures using design basis heat loads.

Table 8.1.7 summarizes some of the instrumentation used to load and unload the HI-STORM 100 System. Other instrumentation that meets the requirements of the Technical Specifications is also acceptable. Tables 8.1.8, 8.1.9, and 8.1.10 provide sample receipt inspection checklists for the HI-STORM 100 overpack, the MPC, and the HI-TRAC Transfer Cask, respectively. Users shall develop site-specific receipt inspection checklists, as required for their equipment. Fuel handling, including the handling of fuel assemblies in the Damaged Fuel Container (DFC) shall be performed in accordance with written site-specific procedures. DFCs shall be loaded in the spent fuel pool racks prior to placement into the MPC.

Technical and Safety Basis for Loading and Unloading Procedures

The procedures herein (Sections 8.1.2 through 8.1.5) are developed for the loading, storage, unloading, and recovery of spent fuel in the HI-STORM 100 System. The activities involved in loading of spent fuel in a canister system, if not carefully performed, may present risks. The design of the HI-STORM 100 System, including these procedures, the ancillary equipment and the Technical Specifications, serve to minimize risks and mitigate consequences of potential events. To summarize, consideration is given in the loading and unloading systems and procedures to the potential events listed in Table 8.0.1.

The primary objective is to reduce the risk of occurrence and/or to mitigate the consequences of the event. The procedures contain Notes, Warnings, and Cautions to notify the operators to upcoming situations and provide additional information as needed. The Notes, Warnings and Cautions are purposely bolded and boxed and immediately precede the applicable steps.

In the event of an extreme abnormal condition (e.g., cask drop or tip-over event) the user shall have appropriate procedural guidance to respond to the situation. As a minimum, the procedures shall address establishing emergency action levels, implementation of emergency action program, establishment of personnel exclusions zones, monitoring of radiological conditions, actions to mitigate or prevent the release of radioactive materials, and recovery planning and execution and reporting to the appropriate regulatory agencies, as required.

Table 8.0.1
OPERATIONAL CONSIDERATIONS

POTENTIAL EVENTS	METHODS USED TO ADDRESS EVENT	COMMENTS/ REFERENCES
Cask Drop During Handling Operations	Cask lifting and handling equipment is designed to ANSI N14.6. Procedural guidance is given for cask handling, inspection of lifting equipment, and proper engagement to the trunnions. Technical Specifications limit the cask and overpack lift height outside the fuel building.	See Section 8.1.2. See Technical Specifications in Appendix A to CoC 72-1014 for HI-TRAC and HI-STORM lift height limitations.
Cask Tip-Over Prior to welding of the MPC lid	The Lid Retention System is available to secure the MPC lid during movement between the spent fuel pool and the cask preparation area.	See Section 8.1.5 Step 1. See Figure 8.1.15.
Contamination of the MPC external shell	The annulus seal, pool lid, and Annulus Overpressure System minimize the potential for the MPC external shell to become contaminated from contact with the spent fuel pool water. Technical Specifications require surveys of certain components of the HI-STORM 100 System to monitor for removable contamination.	See Figures 8.1.13 and 8.1.14. See Technical Specifications in Appendix A to CoC 72-1014.
Contamination spread from cask process system exhausts	Processing systems are equipped with exhausts that can be directed to the plant's processing systems.	See Figures 8.1.19-8.1.22.
Damage to fuel assembly cladding from oxidation/thermal shock	Fuel assemblies are never subjected to air or oxygen during loading and unloading operations. Cool-Down System brings fuel assembly temperatures to below water boiling temperature prior to flooding.	See Section 8.1.5 Step 24b, Section 8.3.3 Step 8 and LCO 3.1.3.
Damage to Vacuum Drying System vacuum gauges from positive pressure	Vacuum Drying System is separate from pressurized gas and water systems.	See Figure 8.1.22 and 8.1.23.

a. If used, fill the Annulus Overpressure System lines and reservoir with demineralized water and close the reservoir valve. Attach the Annulus Overpressure System to the HI-TRAC via the quick disconnect. See Figure 8.1.14.

b. Engage the lift yoke to HI-TRAC lifting trunnions and position HI-TRAC over the cask loading area with the basket aligned to the orientation of the spent fuel racks.

> **ALARA Note:**
> Wetting the components that enter the spent fuel pool may reduce the amount of decontamination work to be performed later.

c. Wet the surfaces of HI-TRAC and lift yoke with plant demineralized water while slowly lowering HI-TRAC into the spent fuel pool.

d. When the top of the HI-TRAC reaches the elevation of the reservoir, open the Annulus Overpressure System reservoir valve. Maintain the reservoir water level at approximately 3/4 full the entire time the cask is in the spent fuel pool.

e. Place HI-TRAC on the floor of the cask loading area and disengage the lift yoke. Visually verify that the lift yoke is fully disengaged. Remove the lift yoke from the spent fuel pool while spraying the crane cables and yoke with plant demineralized water.

f. Observe the annulus seal for signs of air leakage. If leakage is observed (by the steady flow of bubbles emanating from one or more discrete locations) then immediately remove the HI-TRAC from the spent fuel pool and repair or replace the seal.

8.1.4 MPC Fuel Loading

> **Note:**
> An underwater camera or other suitable viewing device may be used for monitoring underwater operations.

1. Perform a fuel assembly selection verification using plant fuel records to ensure that only fuel assemblies that meet all the conditions for loading as specified in Appendix B to CoC 72-1014 have been selected for loading into the MPC.

2. Load the pre-selected fuel assemblies into the MPC in accordance with the approved fuel loading pattern.

3. Perform a post-loading visual verification of the assembly identification to confirm that the serial numbers match the approved fuel loading pattern.

8.1.5 MPC Closure

> **Note:**
> The user may elect to use the Lid Retention System (See Figure 8.1.15) to assist in the installation of the MPC lid and lift yoke, and to provide the means to secure the MPC lid in the event of a drop accident during loaded cask handling operations outside of the spent fuel pool. The user is responsible for evaluating the additional weight imposed on the cask, lift yoke, crane and floor prior to use. See Tables 8.1.1 through 8.1.4 as applicable.

1. Visually inspect the MPC lid rigging or Lid Retention System in accordance with site-approved rigging procedures. Attach the MPC lid to the lift yoke so that MPC lid, drain line and trunnions will be in relative alignment. Raise the MPC lid and adjust the rigging so the MPC lid hangs level as necessary.

2. Install the drain line to the underside of the MPC lid. Ensure that the reducer is fully seated against the bottom of the MPC lid. See Figure 8.1.17.

3. Align the MPC lid and lift yoke so the drain line will be positioned in the MPC drain location and the cask trunnions will also engage. See Figure 8.1.11 and 8.1.17.

> **ALARA Note:**
> Pre-wetting the components that enter the spent fuel pool may reduce the amount of decontamination work to be performed later.

4. Slowly lower the MPC lid into the pool and insert the drain line into the drain access location and visually verify that the drain line is correctly oriented. See Figure 8.1.12.

5. Lower the MPC lid while monitoring for any hang-up of the drain line. If the drain line becomes kinked or disfigured for any reason, remove the MPC lid and replace the drain line.

> **Note:**
> The outer diameter of the MPC lid will seat flush with the top edge of the MPC shell when properly installed.

6. Seat the MPC lid in the MPC and visually verify that the lid is properly installed.

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

8. Apply a slight tension to the lift yoke and visually verify proper engagement of the lift yoke to the lifting trunnions.

> **ALARA Note:**
> Activated debris may have settled on the top face of HI-TRAC and MPC during fuel loading. The cask top surface should be kept under water until a preliminary dose rate scan clears the cask for removal. Users are responsible for any water dilution considerations.

Note:

The Lid-to-Shell weld may be examined by either volumetric examination (UT) or multi-layer liquid penetrant examination. If volumetric examination is used, it shall be the ultrasonic method and shall include a liquid penetrant (PT) of the root and final weld layers. If PT alone is used, at a minimum, it must include the root and final weld layers and each 3/8-inch of weld depth.

For all liquid penetrant examinations in this procedure, ASME Boiler and Pressure Vessel Code [8.1.3], Section V, Article 6 provides the liquid penetrant examination methods. The acceptance standards for liquid penetrant examination shall be in accordance with ASME Boiler and Pressure Vessel Code, Section III, Subsection NB, Article NB-5350 as specified on the Design Drawings. ASME Code, Section III, Subsection NB, Article NB-4450 provides acceptable requirements for weld repair. NDE personnel shall be qualified per the requirements of Section III and V of the Code or site-specific program.

Volumetric examination of the MPC Lid-to-Shell weld by ultrasonic test method is defined in ASME Boiler and Pressure Vessel Code, Section V, Article 5. The acceptance standards for UT examination are per Section III, Subsection NB, Article NB-5332 for UT as defined on the Design Drawings. NDE personnel shall be qualified per the requirements of Section III and V of the Code or site-specific program.

g. Lay the root weld.

h. Perform a liquid penetrant examination of the weld root.

i. Complete the MPC lid welding performing intermediate PTs as required.

j. Perform a liquid penetrant examination on the MPC lid final pass.

26. Perform hydrostatic and MPC leakage rate testing as follows:

ALARA Note:
The leakage rates are determined before the MPC is drained for ALARA reasons. A weld repair is a lower dose activity if water remains inside the MPC.

a. Attach the drain line to the vent port and route the drain line to the spent fuel pool or the plant liquid radwaste system. See Figure 8.1.20 for the hydrostatic test arrangement.

ALARA Warning:
Water flowing from the MPC may carry activated particles and fuel particles. Apply appropriate ALARA practices around the drain line.

b. Fill the MPC with either spent fuel pool water or plant demineralized water until water is observed flowing out of the vent port drain hose.

c. Perform a hydrostatic test of the MPC as follows:

1. Close the drain valve and pressurize the MPC to 125 +5/-0 psig.

2. Close the inlet valve and monitor the pressure for a minimum of 10 minutes. The pressure shall not drop during the performance of the test.

3. Following the 10-minute hold period, visually examine the MPC lid-to-shell weld for leakage of water. The acceptance criteria is no observable water leakage.

d. Release the MPC internal pressure, disconnect the water fill line and drain line from the vent and drain port RVOAs leaving the vent and drain port caps open.

   Repeat the liquid penetrant examination on the MPC lid final pass.

e. Attach a regulated helium supply (pressure set to 10+10/-0 psig) to the vent port and attach the drain line to the drain port as shown on Figure 8.1.21.

f. Reset the totalizer on the drain line.

g. Verify the correct pressure (pressure set to 10+10/-0 psig) on the helium supply and open the helium supply valve. Drain approximately twenty gallons as measured by the totalizer.

h. Close the drain port valve and pressurize the MPC to 10+10/-0 psig helium.

i. Close the vent port.

Note:
The leakage detector may detect residual helium in the atmosphere. If the leakage tests detects a leak, the area should be flushed with nitrogen or compressed air and the location should be retested.

j. Perform a helium sniffer probe leakage rate test of the MPC lid-to shell weld in accordance with the Mass Spectrometer Leak Detector (MSLD) manufacturer's instructions and ANSI N14.5 [8.1.2]. The MPC Helium Leak Rate shall be $\leq$ 5.0E-6 atm cc/sec (He). See Technical Specification LCO 3.1.1.

k. Repair any weld defects in accordance with the site's approved weld repair procedures. Reperform the Ultrasonic (if necessary), PT, Hydrostatic and Helium Leakage tests if weld repair is performed.

27. Drain the MPC as follows:

Note:
It is necessary to completely fill the MPC with water to get an accurate measurement of the MPC internal free space.

Note:
ASME Boiler and Pressure Vessel Code [8.1.3], Section V, Article 6 provides the liquid penetrant inspection methods. The acceptance standards for liquid penetrant examination shall be in accordance with ASME Boiler and Pressure Vessel Code, Section III, Subsection NB, Article NB-5350 as specified on the Design Drawings. ASME Code, Section III, Subsection NB, Article NB-4450 provides acceptable requirements for weld repair. NDE personnel shall be qualified per the requirements of Section V of the Code or site-specific program.

j. Perform a liquid penetrant examination on the vent port cover weld.

k. Repeat Steps 30.a through 30.j for the drain port cover plate.

31. Perform a leakage test of the MPC vent and drain port cover plates as follows:

Note:
The leakage detector may detect residual helium in the atmosphere from the helium injection process. If the leakage tests detects a leak, the area should be blown clear with compressed air or nitrogen and the location should be retested.

a. Flush the area around the vent and drain cover plates with compressed air or nitrogen to remove any residual helium gas.

b. Perform a helium leakage rate test of vent and drain cover plate welds in accordance with the Mass Spectrometer Leak Detector (MSLD) manufacturer's instructions and ANSI N14.5 [8.1.2]. The MPC Helium Leak Rate acceptance criteria is provided in the Technical Specification LCO 3.1.1.

c. Repair any weld defects in accordance with the site's approved code weld repair procedures. Reperform the leakage test as required.

32. Weld the MPC closure ring as follows:

ALARA Note:
The closure ring is installed by hand. No tools are required.

a. Install and align the closure ring. See Figure 8.1.8.

b. Tack weld the closure ring to the MPC shell and the MPC lid.

c. Visually inspect the tack welds.

d. Lay the root weld between the closure ring and the MPC shell.

e. Lay the root weld between the closure ring and the MPC lid.

f. Lay the root weld connecting the two closure ring segments.

Note:
ASME Boiler and Pressure Vessel Code [8.1.3], Section V, Article 6 provides the liquid penetrant inspection methods. The acceptance standards for liquid penetrant examination shall be in accordance with ASME Boiler and Pressure Vessel Code, Section III, Subsection NB, Article NB-5350 as specified on the Design Drawings. ASME Code, Section III, Subsection NB, Article NB-4450 provides acceptable requirements for weld repair. NDE personnel shall be qualified per the requirements of Section V of the Code or site-specific program.

g. Perform a liquid penetrant examination on the closure ring root welds.

h. Complete the closure ring welding.

Note:
ASME Boiler and Pressure Vessel Code [8.1.3], Section V, Article 6 provides the liquid penetrant inspection methods. The acceptance standards for liquid penetrant examination are contained in the ASME Boiler and Pressure Vessel Code, Section III, Subsection NB, Article NB-5350. ASME Code, Section III, Subsection NB, Article NB-4450 provides acceptable requirements for weld repair. NDE personnel shall be qualified per the requirements of Section V of the Code or site-specific program.

i. Perform a liquid penetrant examination on the closure ring final weld.

j. Remove the Automated Welding System.

k. If necessary, remove the AWS baseplate shield. See Figure 8.1.7 for rigging.

8.1.6 Preparation for Storage

ALARA Warning:
Dose rates will rise around the top of the annulus as water is drained from the annulus. Apply appropriate ALARA practices.

Remove the annulus shield and store it in an approved plant storage location

a. 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.

b. Install HI-TRAC Top Lid as follows:

Warning:
When traversing the MPC with the HI-TRAC top lid, 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.

1. Install HI-TRAC Top Lid. Inspect the bolts for general condition. Replace worn or damaged bolts with new bolts.

2. Install and torque the Top Lid bolts. See Table 8.1.5 for torque requirements.

3. Inspect the lift cleat bolts for general condition. Replace worn or damaged bolts with new bolts.

4. Install the MPC lift cleats and MPC support stays to the MPC lid and torque the bolts. See Figure 8.1.24 and 8.1.25. See Table 8.1.5 for torque requirements.

5. Drain the Temporary Shield Ring, if used. Remove the ring segments (or site-supplied temporary shielding) and store them in an approved plant storage location.

2. Replace the pool lid with the transfer lid as follows:

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 glide rails, rollers, transfer step and carriage. The transfer slide carriage and jacks are powered and operated by remote control. The carriage consists of four 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 support stays.

a. Lower the lift yoke and attach the MPC support stays to the lift yoke. See Figure 8.1.25.

b. Rise the lift yoke and engage the lift yoke to the HI-TRAC lifting trunnions.

Note:
The MPC lift cleats and support stays provide redundant support of the MPC during the bottom lid replacement.

c. If necessary, position the transfer step and transfer lid adjacent to one another on the transfer slide carriage. See Figure 8.1.26. See Figure 8.1.9 for transfer step rigging.

d. Test the travel and lift features of the transfer slide to ensure its operability.

e. Position HI-TRAC with the pool lid centered over the transfer step approximately one inch above the transfer step.

f. Raise the transfer slide carriage so the transfer step is supporting the pool lid bottom. Remove the bottom lid bolts and store them temporarily.

ALARA Warning:
Clear all personnel away from the immediate operations area. The transfer slide carriage and jacks are remotely operated. The carriage has fine adjustment features to allow precise positioning of the lids.

g. Lower the transfer carriage and position the transfer lid under HI-TRAC.

h. Raise the transfer slide carriage to place the transfer lid against the HI-TRAC bottom lid bolting flange.

i. Inspect the transfer lid bolts for general condition. Replace worn or damaged bolts with new bolts.

j. Install the transfer lid bolts. See Table 8.1.5 for torque requirements.

k. Raise and remove the HI-TRAC from the transfer slide.

l. Disconnect the MPC support stays and store them in an approved plant storage location.

Note:
HI-STORM receipt inspection may be performed independent of procedural sequence.

3. 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, 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 truck bay 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 as described in the Technical Specifications are not exceeded. The licensee is responsible for assessing and controlling floor loading conditions during the MPC transfer operations.

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 deenergized air pad, on a roller skid, or on a flatbed trailer. If necessary, remove the exit vent screens and gamma shield cross plates 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.

18. Perform a transport route walkdown to ensure that the cask transport conditions are met. See Technical Specification for the on-site cask handling limitations.

    a. Transfer the HI-STORM to its designated storage location at the appropriate pitch. See Figure 8.1.35.

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

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

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

19. Install the HI-STORM inlet vent gamma shield cross plates and vent screens. See Table 8.1.5 for torque requirements. See Figure 8.1.34.

20. Perform an air temperature rise test as follows for the first HI-STORM 100 System placed in service:

Note:
The air temperature rise test shall be performed between 5 and 7 days after installation of the HI-STORM 100 lid to allow thermal conditions to stabilize. The purpose of this test is to confirm the initial performance of the HI-STORM 100 ventilation system.

    a. Measure the inlet air (or screen surface) temperature at the center of each of the four vent screens. Determine the average inlet air (or surface screen) temperature.

    b. Measure the outlet air (or screen surface) temperature at the center of each of the four vent screens. Determine the average outlet air (or surface screen) temperature.

    c. Determine the average air temperature rise by subtracting the results of the average inlet screen temperature from the average outlet screen temperature.

    d. Report the results to the certificate holder.

Table 8.1.1

HI-STORM 100 SYSTEM COMPONENT AND HANDLING WEIGHTS
125-TON HI-TRAC

Component	MPC-24	MPC-68	Case† Applicability					
			1	2	3	4	5	6
Empty HI-STORM 100 overpack (without lid)	245,040	245,040					1	
HI-STORM 100 lid (without rigging)	23,963	23,963					1	
Empty MPC (without lid or closure ring including drain line)	29,845	29,302	1	1	1	1	1	1
MPC lid (without fuel spacers or drain line)	9677	10,194	1	1	1	1	1	1
MPC Closure Ring	145	145			1	1	1	1
Fuel (design basis)	40,320	47,600	1	1	1	1	1	1
Damaged Fuel Container (Dresden 1)	0	150						
Damaged Fuel Container (Humboldt Bay)	0	120						
MPC water (with fuel in MPC)	17,630	16,957	1	1				
Annulus Water	256	256	1	1				
HI-TRAC Lift Yoke (with slings)	3600	3600	1	1	1			
Annulus Seal	50	50	1	1				
Lid Retention System	2300	2300						
Transfer frame	6700	6700						1
Empty HI-TRAC (without Top Lid, neutron shield jacket water, or bottom lids)	118,470	118,470	1	1	1			1
HI-TRAC Top Lid	2730	2730			1			1
HI-TRAC Pool Lid (with bolts)	12,031	12,031	1	1				
HI-TRAC Transfer Lid (with bolts)	21,679	21,679			1			1
HI-TRAC Neutron Shield Jacket Water	9757	9757		1	1			1
MPC Stays (total of 2)	200	200						
MPC Lift Cleat	480	480			1	1		1

† See Table 8.1.2.

TABLE 8.1.2
MAXIMUM HANDLING WEIGHTS
125-TON HI-TRAC

Caution:
The maximum weight supported by the 125-Ton HI-TRAC lifting trunnions cannot exceed 250,000 lbs. Users must take actions to ensure that this limit is not exceeded.

Note:
The weight of the fuel spacers and the damaged fuel container are less than the weight of the design basis fuel assembly for each MPC and are therefore not included in the maximum handling weight calculations. Fuel spacers are determined to be the maximum combination weight of fuel + spacer. Users should determine their specific handling weights based on the MPC contents and the expected handling modes.

Case No.	**Load Handling Evolution**	**Weight (lbs)**	
		MPC-24	**MPC-68**
1	Loaded HI-TRAC removal from spent fuel pool (neutron tank empty)	231,879	238,460
2	Loaded HI-TRAC removal from spent fuel pool (neutron tank full)	241,636	248,217
3	Loaded HI-TRAC During Movement through Hatchway	236,703	243,957
4	MPC during transfer operations	80,467	87,721
5	Loaded HI-STORM in storage	348,990	356,244
6	Loaded HI-TRAC and transfer frame during on site handling	239,803	247,057

Table 8.1.3
HI-STORM 100 SYSTEM COMPONENT AND HANDLING WEIGHTS
100-TON HI-TRAC

Component	Weight (lbs)		Case† Applicability					
	MPC-24	MPC-68	1	2	3	4	5	6
Empty HI-STORM 100 overpack (without lid)	245,040	245,040					1	
HI-STORM 100 lid (without rigging)	23,963	23,963					1	
Empty MPC (without lid or closure ring including drain line)	29,845	29,302	1	1	1	1	1	1
MPC lid (without fuel spacers or drain line)	9677	10,194	1	1	1	1	1	1
MPC Closure Ring	145	145			1	1	1	1
Fuel (design basis)	40,320	47,600	1	1	1	1	1	1
Damaged Fuel Container (Dresden 1)	0	150						
Damaged Fuel Container (Humboldt Bay)	0	120						
MPC water (with fuel in MPC)	17,630	16,957	1	1				
Annulus Water	256	256	1	1				
HI-TRAC Lift Yoke (with slings)	3200	3200	1	1	1			
Annulus Seal	50	50	1	1				
Lid Retention System	2300	2300						
Transfer frame	6700	6700						1
Empty HI-TRAC (without Top Lid, neutron shield jacket water, or bottom lids)	84,031	84,031	1	1	1			1
HI-TRAC Top Lid	1202	1202			1			1
HI-TRAC Pool Lid (with bolts)	7,915	7,915	1	1				
HI-TRAC Transfer Lid (with bolts)	16,425	16,425			1			1
HI-TRAC Neutron Shield Jacket Water	7556	7556		1	1			1
MPC Stays (total of 2)	200	200						
MPC Lift Cleat	480	480			1	1		1

† See Table 8.1.4.

Table 8.1.4
MAXIMUM HANDLING WEIGHTS
100-TON HI-TRAC

Caution:
The maximum weight supported by the 100-Ton HI-TRAC lifting trunnions cannot exceed 200,000 lbs. Users must take actions to ensure that this limit is not exceeded.

Note:
The weight of the fuel spacers and the damaged fuel container are less than the weight of the design basis fuel assembly and therefore not included in the maximum handling weight calculations. Fuel spacers are determined to be the maximum combination weight of fuel + spacer. Users should determine the handling weights based on the contents to be loaded and the expected mode of operations.

Case No.	Load Handling Evolution	Weight (lbs)	
		MPC-24	MPC-68
1	Loaded HI-TRAC removal from spent fuel pool (neutron tank empty)	193,180	199,505
2	Loaded HI-TRAC removal from spent fuel pool (neutron tank full)	200,736	207,061
3	Loaded HI-TRAC During Movement through Hatchway	193,137	200,135
4	MPC during transfer operations	80,467	87,721
5	Loaded HI-STORM in storage	348,990	356,244
6	Loaded HI-TRAC and transfer frame during on site handling	196,637	203,635

Table 8.1.5
HI-STORM 100 SYSTEM TORQUE REQUIREMENTS

Fastener†	**Torque (ft-lbs)** ††	**Pattern**†††
HI-TRAC Top Lid Bolts†	39 ft-lbs	Figure 8.1.37
HI-TRAC Pool Lid Bolts†	58 ft-lbs	Figure 8.1.37
100-Ton HI-TRAC Transfer Lid Bolts†	203 ft-lbs	Figure 8.1.37
125-Ton HI-TRAC Transfer Lid Bolts†	270 ft-lbs	Figure 8.1.37
MPC Lift Cleats Bolts†	453 ft-lbs	None
MPC Lift Hole plugs†	Hand tight	None
Threaded Fuel Spacers	Hand Tight	None
HI-STORM Lid Nuts †	100 ft-lbs	None
Door Locking Pins	Hand Tight + 1/8 to 1/2 turn	None
HI-STORM 100 Vent Screen/Thermocouple Screws	Hand Tight	None

† Bolts shall be cleaned and inspected for damage or excessive thread wear (replace if necessary) and coated with a light layer of Fel-Pro Chemical Products, N-5000, Nuclear Grade Lubricant (or equivalent).

†† Unless specifically specified, torques have a +/- 5% tolerance.

††† No detorquing pattern is needed.

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

Equipment	Important To Safety Classification	Reference Figure†	Description
HI-TRAC Upending Frame	Not Important To Safety	8.1.4	Optional. A welded steel frame used to support HI-TRAC during on-site movement and upending/downending operations.
Cask Primary Lifting Device	Important to Safety Category A.	8.1.28 and 8.1.32	An optional auxiliary (Non-Part 50) cask lifting device used for cask upending and downending and HI-TRAC raising for positioning on top of HI-STORM to allow MPC transfer. The device may consist of a crane, lifting platform, gantry system or any other suitable device used for such purpose.
Inflatable Annulus Seal	Not Important To Safety	8.1.13	Used to prevent spent fuel pool water from contaminating the external MPC shell and baseplate surfaces during in-pool operations.
Lid Retention System	Safety Related Status determined by each licensee. MPC lid lifting portions of the Lid Retention System shall meet the requirements of ANSI N14.6.	8.1.15, 8.1.17	Optional. The Lid Retention System provides three functions; it guides the MPC lid into place during underwater installation, establishes lift yoke alignment with the HI-TRAC trunnions, and locks the MPC lid in place during cask handling operations between the pool and decontamination pad.
MPC Lift Cleats	Important To Safety – Category A. MPC Lift Cleats shall requirements of ANSI N14.6.	8.1.24	Used to secure the MPC inside HI-TRAC during bottom lid replacement and support the MPC during MPC transfer from HI-TRAC into HI-STORM and vice versa. MPC cleats consist of the cleats and attachment bolts. Requires use of the MPC stays. The cleats are supplied as solid steel components that contain no welds.
Hydrostatic Test System	Not Important to Safety	8.1.20	Used to hydrostatically test the MPC lid-to-shell weld.
MPC Downloader	Important To Safety – Category A (MPC supporting members only). MPC Downloader Shall meet the requirements of Technical Specification 4.9.	8.1.28 and 8.1.32	MPC Downloader is a single-failure proof hydraulic lifting device used for raising and lowering the MPC during MPC transfer operations.

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

Equipment	Important To Safety Classification	Reference Figure†	Description
MPC Drain Line	Not Important To Safety	8.1.21	Used for MPC water raising and lowering operations. Consists of the drain hose and adapter for the MPC drain and vent RVOAs.
MPC Fill Pump System	Not Important To Safety	Not shown	Large pump used for filling the MPC with spent fuel pool water prior to cask insertion into the spent fuel pool. Also used for emptying of the MPC for unloading operations.
MPC Support Stays	Important To Safety – Category A – Stays shall meet requirements of ANSI N14.6.	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 single pin or dual pin crane hook configuration. Requires special lift yoke-to-crane hook pin(s). The stays may be removed for inspection, load testing and replacement.
MPC Upending Frame	Not Important to Safety	8.1.6	A welded steel frame used to evenly support the MPC during upending operations. The frame consists of the main frame, five MPC support saddles, two rigging bars, five wrap around-straps, and five strap attachment lugs.
MSLD (Helium Leakage Detector)	Not Important To Safety	Not shown	Used for helium leakage testing of the MPC closure welds.
MSLD Calibration Sources.	Not Important To Safety	Not shown	Traceable leakage sources for periodic calibration of the MSLD.
Small Water Pump	Not Important To Safety	8.1.19	Used for lowering the MPC water level prior to lid welding.
Temporary Shield Ring	Not Important To Safety	8.1.18	A water-filled segmented tank that fits on the cask neutron shield around the upper forging and provides supplemental shielding to personnel performing cask loading and closure operations. Shield segments are installed by hand, no tools are required.
Vacuum Drying System	Not Important To Safety	8.1.22	Used for removal of residual moisture from the MPC following water draining. Used for evacuation of the MPC to support backfilling operations. Used to support test volume samples for MPC unloading operations.
Vent and Drain RVOAs	Not Important To Safety	8.1.16	Used to drain, dry, inert and fill the MPC through 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.

9.1 ACCEPTANCE CRITERIA

This section provides the workmanship inspections and acceptance tests to be performed on the HI-STORM 100 System prior to and during first loading of the system. These inspections and tests provide assurance that the HI-STORM 100 System has been fabricated, assembled, inspected, tested, and accepted for use under the conditions specified in this TSAR and the Certificate of Compliance issued by the NRC in accordance with the requirements of 10CFR72 [9.0.1].

These inspections and tests are also intended to demonstrate that the operation of the HI-STORM 100 System complies with the applicable regulatory requirements and the Technical Specifications contained in Appendix A to CoC 72-1014. Noncompliances encountered during the required inspections and tests shall be corrected or dispositioned to bring the item into compliance with this TSAR. Identification and resolution of noncompliances shall be performed in accordance with the Holtec International Quality Assurance Program as described in Chapter 13 of this TSAR, or the licensee's NRC-approved Quality Assurance Program.

The testing and inspection acceptance criteria applicable to the MPCs, the HI-STORM 100 overpack, and the 100-ton HI-TRAC and 125-ton HI-TRAC transfer casks are listed in Tables 9.1.1, 9.1.2, and 9.1.3, respectively, and discussed in more detail in the sections that follow. Chapters 8 and 12 provide details on operating procedures and the bases for the Technical Specifications, respectively. These inspections and tests are intended to demonstrate that the HI-STORM 100 System has been fabricated, assembled, and examined in accordance with the design criteria contained in Chapter 2 of this TSAR.

This section summarizes the test program required for the HI-STORM 100 System.

9.1.1 Fabrication and Nondestructive Examination (NDE)

The design, fabrication, inspection, and testing of the HI-STORM 100 System is performed in accordance with the applicable codes and standards specified in Tables 2.2.6 and 2.2.7 and on the Design Drawings. Additional details on specific codes used are provided below.

The following fabrication controls and required inspections shall be performed on the HI-STORM 100 System, including the MPCs, overpacks, and HI-TRAC transfer casks, in order to assure compliance with this TSAR and the Certificate of Compliance.

1. Materials of construction specified for the HI-STORM 100 System are identified in the drawing Bills-of-Material in Chapter 1 and shall be procured with certification and supporting documentation as required by ASME Code [9.1.1] Section II (when applicable); the requirements of ASME Section III (when applicable); Holtec procurement specifications; and 10CFR72, Subpart G. Materials and components shall be receipt inspected for visual and dimensional acceptability, material conformance to specification requirements, and traceability markings, as applicable. Controls shall be in place to assure material traceability is maintained throughout fabrication. Materials for the confinement boundary (MPC baseplate, lid, closure

ring, port cover plates and shell) shall also be inspected per the requirements of ASME Section III, Article NB-2500.

2. The MPC confinement (helium retention) boundary shall be fabricated and inspected in accordance with ASME Code, Section III, Subsection NB, with exceptions as noted below. The MPC basket and basket supports shall be fabricated and inspected in accordance with ASME Code, Section III, Subsection NG, with exceptions as noted below. Metal components of the HI-TRAC transfer cask and the HI-STORM overpack, as applicable, shall be fabricated and inspected in accordance with ASME Code, Section III, Subsection NF, Class 3 or AWS D1.1, as shown on the Design Drawings, with exceptions as noted below.

   NOTE: Exceptions to these Code requirements are provided in TSAR Chapter 2 and in Table 3-1 of Appendix B to CoC 72-1014.

3. ASME Code welding shall be performed using welders and weld procedures that have been qualified in accordance with ASME Code Section IX and the applicable ASME Section III Subsections (e.g., NB, NG, or NF, as applicable to the SSC). AWS code welding may be performed using welders and weld procedures that have been qualified in accordance with applicable AWS requirements or in accordance with ASME Code Section IX

4. Welds shall be visually examined in accordance with ASME Code, Section V, Article 9 with acceptance criteria per ASME Code, Section III, Subsection NF, Article NF-5360, except the MPC fuel basket cell plate-to-cell plate welds and fuel basket support-to-canister welds which shall have acceptance criteria to ASME Code Section III, Subsection NG, Article NG-5360, (as modified by the Design Drawings). Table 9.1.4 identifies additional nondestructive examination (NDE) requirements to be performed on specific welds, and the applicable codes and acceptance criteria to be used in order to meet the inspection requirements of the applicable ASME Code, Section III. Acceptance criteria for NDE shall be in accordance with the applicable Code for which the item was fabricated. These additional NDE criteria are also specified on the Design Drawings provided in Chapter 1 for the specific welds. Weld inspections shall be detailed in a weld inspection plan which shall identify the weld and the examination requirements, the sequence of examination, and the acceptance criteria. The inspection plan shall be reviewed and approved by Holtec in accordance with its QA program. NDE inspections shall be performed in accordance with written and approved procedures by personnel qualified in accordance with SNT-TC-1A [9.1.2] or other site-specific, NRC-approved program for personnel qualification.

5. Machined surfaces of the metal components of the HI-STORM 100 System shall be visually examined in accordance with ASME Section V, Article 9, to verify they are free of cracks and pin holes.

If a hydrostatic retest is required and fails, a nonconformance report shall be issued and a root cause evaluation and appropriate corrective actions taken before further repairs and retests are performed.

Test results shall be documented. The documentation shall become part of the final quality documentation package.

9.1.2.2.2 MPC Confinement Boundary

Hydrostatic testing of the MPC confinement boundary shall be performed in accordance with the requirements of the ASME Code Section III, Subsection NB, Article NB-6000, when field welding of the MPC lid-to-shell weld is completed. The hydrostatic pressure for the test is 125 +5,-0 psig, which is 125% of the design pressure of 100 psig. The MPC vent and drain ports will be used for pressurizing the MPC cavity. The loading procedures in TSAR Chapter 8 define the test equipment arrangement. The calibrated test pressure gage installed on the MPC confinement boundary shall have an upper limit of approximately twice that of the test pressure. Following completion of the 10-minute hold period at the hydrostatic test pressure, and while maintaining a minimum test pressure of 125 psig, the surface of the MPC lid-to-shell weld shall be visually examined for leakage and then re-examined by liquid penetrant examination in accordance with ASME Code, Section III, Subsection NB, Article NB-5350 acceptance criteria. Any evidence of cracking or deformation shall be cause for rejection, or repair and retest, as applicable. The performance and sequence of the test is described in TSAR Section 8.1 (loading procedures).

If a leak is discovered, the test pressure shall be reduced, the MPC cavity water level lowered, the MPC cavity vented (to the pool or the licensee's off-gas system), and the weld shall be examined to determine the cause of the leakage and/or cracking. Repairs to the weld shall be performed in accordance with written and approved procedures prepared in accordance with the ASME Code, Section III, Subsection NB, NB-4450.

The MPC confinement boundary hydrostatic test shall be repeated until all visual and liquid penetrant examinations are found to be acceptable in accordance with the acceptance criteria. Test results shall be documented and maintained as part of the loaded MPC quality documentation package.

9.1.2.3 Materials Testing

The majority of materials used in the HI-TRAC transfer cask and a portion of the material in the HI-STORM overpack are ferritic steels. ASME Code, Section II and Section III require that certain materials be tested in order to assure that these materials are not subject to brittle fracture failures.

Materials of the HI-TRAC transfer cask and HI-STORM overpack, as required, shall be Charpy V-notch tested in accordance with ASME Section IIA and/or ASME Section III, Subsection NF, Articles NF-2300, and NF-2430. The materials to be tested include the components identified in Table 3.1.18 and applicable weld materials. Table 3.1.18 provides the test temperatures and test acceptance criteria to be used when performing the material testing specified above.

The concrete utilized in the construction of the HI-STORM overpack shall be mixed, poured, and tested as described in TSAR Appendix 1.D in accordance with written and approved procedures. Testing shall verify the composition, compressive strength, and density meet design requirements.

Concrete testing shall be performed for each lot of concrete. Concrete testing shall comply with ACI 349, as described in Table 1.D.2. Test specimens shall be in accordance with ASTM C39.

Test results shall be documented and become part of the final quality documentation package.

9.1.3 Leakage Testing

Leakage testing shall be performed in accordance with the requirements of ANSI N14.5 [9.1.5]. Testing shall be performed in accordance with written and approved procedures.

At completion of welding the MPC shell to the baseplate, an MPC confinement boundary weld helium leakage test shall be performed using a helium mass spectrometer leak detector (MSLD). A temporary test closure lid is used in order to provide a sealed MPC. The confinement boundary welds shall have indicated helium leakage rates less than or equal to 5×10^{-6} atm cm^3/s (helium). If a leakage rate exceeding the acceptance criterion is detected, then the area of leakage shall be determined and the area repaired per ASME Code Section III, Subsection NB, Article NB-4450 requirements. Re-testing shall be performed until the leakage rate acceptance criteria is met.

If failure of the leakage rate retest occurs after initial repairs are completed, a nonconformance report shall be issued, and a root cause evaluation and appropriate corrective actions taken before further repairs and retest are performed.

Leakage testing of the field welded MPC lid-to-shell weld shall be performed following the successful completion of the MPC hydrostatic test performed per Section 9.1.2.2.2. Leakage testing of the vent and drain port cover plate welds shall be performed after welding of the cover plates and subsequent NDE. The description and procedures for these field leakage tests are provided in TSAR Section 8.1, and the acceptance criteria are defined in the Technical Specifications in Appendix A to CoC 72-1014.

Leak testing results for the MPC shall be documented and shall become part of the quality record documentation package.

9.1.4 Component Tests

9.1.4.1 Valves, Rupture Discs, and Fluid Transport Devices

There are no fluid transport devices or rupture discs associated with the HI-STORM 100 System. The only valve-like components in the HI-STORM 100 System are the specially designed caps installed in the MPC lid for the drain and vent ports. These caps are recessed inside the MPC lid and covered by the fully-welded vent and drain port cover plates. No credit is taken for the caps' ability to confine helium or radioactivity. After completion of drying and backfill operations, the drain and the water jacket. The purpose of the gamma scanning test is to demonstrate that the gamma shielding of the transfer cask body, pool lid, and transfer lid doors is at least as effective as that of a lead and steel test block. For the test block, the steel thickness shall be equivalent to the minimum design thickness of steel in the transfer cask component and the lead thickness shall be 5 percent lower than the minimum design thickness of lead in the transfer cask component (see the Design Drawings for the design values). Data shall be recorded on a 6-inch by 6-inch (nominal) grid pattern over the surfaces to be scanned. Should the measured gamma dose rates exceed those established with the test block, the shielding of that transfer cask component shall be deemed unacceptable. Corrective actions shall be taken as appropriate and the testing re-performed until successful results are achieved. Gamma scanning shall be performed in accordance with written and approved procedures. Dose rate measurements shall be documented and shall become part of the quality documentation package.

Following the first fuel loading of each HI-STORM 100 System (HI-TRAC transfer cask and HI-STORM storage overpack), a shielding effectiveness test shall be performed at the loading facility site to verify the effectiveness of the radiation shield. This test shall be performed after the HI-STORM overpack and HI-TRAC transfer cask have been loaded with an MPC containing spent fuel assemblies and the MPC has been drained, vacuum dried, and backfilled with helium.

Operational neutron and gamma shielding effectiveness tests shall be performed after fuel loading using written and approved procedures. Calibrated neutron and gamma dose rate meters shall be used to measure the actual neutron and gamma dose rates at the surface of the HI-STORM overpack and HI-TRAC. Measurements shall be taken at the locations specified in the Technical Specifications in Appendix A to CoC 72-1014 and, if necessary, average dose rates computed for comparison against the prescribed limits. The results of the dose rate measurements shall be compared to the limits specified in the Technical Specifications. The test is considered acceptable if the dose rate readings are less than or equal to limits in the Technical Specifications. If dose rates are higher than the limits, the Required Actions provided in the Technical Specifications shall be completed. Dose rate measurements shall be documented and shall become part of the quality documentation package.

9.1.5.3 Neutron Absorber Tests

After manufacturing, a statistical sample of each lot of Boral shall be tested using wet chemistry and/or neutron attenuation techniques to verify a minimum ^{10}B content (areal density) at the ends of the panel. Any panel in which ^{10}B loading is less than the minimum allowed shall be rejected. Testing shall be performed using written and approved procedures. Results shall be documented and become part of the cask quality records documentation package.

Installation of Boral panels into the fuel basket shall be performed in accordance with written and approved instructions. Travelers and quality control procedures shall be in place to assure each required cell wall of the MPC basket contains a Boral panel in accordance with Design Drawings in Chapter 1. These quality control processes, in conjunction with Boral manufacturing testing, provide the necessary assurances that the Boral will perform its intended function. No additional testing or in-service monitoring of the Boral will be required.

9.1.6 Thermal Acceptance Tests

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

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

9.1.7 Cask Identification

Each MPC, HI-STORM overpack, and HI-TRAC transfer cask shall be marked with a model number, identification number (to provide traceability back to documentation), and the empty weight of the item in accordance with the marking requirements specified in the Design Drawings in Chapter 1.

12.1 PROPOSED OPERATING CONTROLS AND LIMITS

12.1.1 NUREG-1536 (Standard Review Plan) Acceptance Criteria

12.1.1.1 This portion of the TSAR establishes the commitments regarding the HI-STORM 100 System and its use. Other 10CFR72 [12.1.2] and 10CFR20 [12.1.3] requirements in addition to the Technical Specifications may apply. The conditions for a general license holder found in 10CFR72.212 [12.1.2] shall be met by the licensee prior to loading spent fuel into the HI-STORM 100 System. The general license conditions governed by 10CFR72 [12.1.2] are not repeated with these Technical Specifications. Licensees are required to comply with all commitments and requirements.

12.1.1.2 The Technical Specifications provided in Appendix A to CoC 72-1014 and the authorized contents and design features provided in Appendix B to Co 72-1014 are primarily established to maintain subcriticality, confinement boundary integrity, shielding and radiological protection, heat removal capability, and structural integrity under normal, off-normal and accident conditions. Table 12.1.1 addresses each of these conditions respectively and identifies the appropriate Technical Specification(s) designed to control the condition. Table 12.1.2 provides the list of Technical Specifications for the HI-STORM 100 System.

Table 12.1.1

HI-STORM 100 SYSTEM CONTROLS

Condition to be Controlled	Applicable Technical Specifications[1]
Criticality Control	Refer to Appendix B to Certificate of Compliance 72-1014 for fuel specifications and design features
Confinement Boundary Integrity	3.1.1 Multi-Purpose Canister (MPC)
Shielding and Radiological Protection	Refer to Appendix B to Certificate of Compliance 72-1014 for fuel specifications and design features 3.1.1 Multi-Purpose Canister (MPC) 3.1.3 Fuel Cool-Down 3.2.1 TRANSFER CASK Average Surface Dose Rates 3.2.2 TRANSFER CASK Surface Contamination 3.2.3 OVERPACK Average Surface Dose Rates
Heat Removal Capability	Refer to Appendix B to Certificate of Compliance 72-1014 for fuel specifications and design features 3.1.1 Multi-Purpose Canister (MPC) 3.1.2 SFSC Heat Removal System
Structural Integrity	3.5 Cask Transfer Facility (CTF) (CoC 72-1014, Appendix B – Design Features) 5.5 Cask Transport Evaluation Program

[1] Technical Specifications are located in Appendix A to CoC 72-1014

Table 12.1.2

HI-STORM 100 SYSTEM TECHNICAL SPECIFICATIONS

NUMBER	TECHNICAL SPECIFICATION
1.0	USE AND APPLICATION 1.1 Definitions 1.2 Logical Connectors 1.3 Completion Times 1.4 Frequency
2.0	Not Used. Refer to Appendix B to CoC 72-1014 for fuel specifications.
3.0	LIMITING CONDITION FOR OPERATION (LCO) APPLICABILITY SURVEILLANCE REQUIREMENT (SR) APPLICABILITY
3.1.1	Multi-Purpose Canister (MPC)
3.1.2	SFSC Heat Removal System
3.1.3	Fuel Cool-Down
3.2.1	TRANSFER CASK Average Surface Dose Rates
3.2.2	TRANSFER CASK Surface Contamination
3.2.3	OVERPACK Average Surface Dose Rates
Table 3-1	MPC Model-Dependent Limits
4.0	Not Used. Refer to Appendix B to CoC 72-1014 for design features.
5.0	ADMINSTRATIVE CONTROLS AND PROGRAMS
5.1	Training Program
5.2	Pre-Operational testing and Training Exercise
5.3	Special Requirements For First System In Place
5.4	Radioactive Effluent Control Program
5.5	Cask Transport Evaluation Program
Table 5-1	TRANSFER CASK and OVERPACK Lifting Requirements

12.2 DEVELOPMENT OF OPERATING CONTROLS AND LIMITS

This section provides a discussion of the operating controls and limits for the HI-STORM 100 System to assure long-term performance consistent with the conditions analyzed in this TSAR. In addition to the controls and limits provided in the Technical Specifications contained in Appendix A to Certificate of Compliance 72-1014 and the Approved Contents and Design Features in Appendix B to Certificate of Compliance 72-1014, the licensee shall ensure that the following training and dry run activities are performed.

12.2.1 Training Modules

Training modules are to be developed under the licensee's training program to require a comprehensive, site-specific training, assessment, and qualification (including periodic re-qualification) program for the operation and maintenance of the HI-STORM 100 Spent Fuel Storage Cask (SFSC) System and the Independent Spent Fuel Storage Installation (IFSI). The training modules shall include the following elements, at a minimum:

1. HI-STORM 100 System Design (overview);
2. ISFSI Facility Design (overview);
3. Systems, Structures, and Components Important to Safety (overview)
4. HI-STORM 100 System Topical Safety Analysis Report (overview);
5. NRC Safety Evaluation Report (overview);
6. Certificate of Compliance conditions;
7. HI-STORM 100 Technical Specifications, Approved Contents, Design Features and other Conditions for Use;
8. HI-STORM 100 Regulatory Requirements (e.g., 10CFR72.48, 10CFR72, Subpart K, 10CFR20, 10CFR73);
9. Required instrumentation and use;
10. Operating Experience Reviews

11. HI-STORM 100 System and ISFSI Procedures, including

- Procedural overview
- Fuel qualification and loading
- MPC /HI-TRAC/overpack rigging and handling, including safe load pathways
- MPC welding operations
- HI-TRAC/overpack closure
- Auxiliary equipment operation and maintenance (e.g., draining, vacuum drying, helium backfilling, and cooldown)
- MPC/HI-TRAC/overpack pre-operational and in-service inspections and tests
- Transfer and securing of the loaded HI-TRAC/overpack onto the transport vehicle
- Transfer and offloading of the HI-TRAC/overpack
- Preparation of MPC/HI-TRAC/overpack for fuel unloading
- Unloading fuel from the MPC/HI-TRAC/overpack
- Surveillance
- Radiation protection
- Maintenance
- Security
- Off-normal and accident conditions, responses, and corrective actions

12.2.2 Dry Run Training

A dry run training exercise of the loading, closure, handling, and transfer of the HI-STORM 100 System shall be conducted by the licensee prior to the first use the system to load spent fuel assemblies. The dry run shall include, but is not limited to the following:

1. Receipt inspection of HI-STORM 100 System components.
2. Moving the HI-STORM 100 MPC/HI-TRAC into the spent fuel pool.
3. Preparation of the HI-STORM 100 System for fuel loading.
4. Selection and verification of specific fuel assemblies to ensure type conformance.
5. Locating specific assemblies and placing assemblies into the MPC (using a dummy fuel assembly), including appropriate independent verification.

6. Remote installation of the MPC lid and removal of the MPC/HI-TRAC from the spent fuel pool.

7. Replacing the HI-TRAC pool lid with the transfer lid.

8. MPC welding, NDE inspections, hydrostatic testing, draining, vacuum drying, helium backfilling and leakage testing (for which a mockup may be used).

9. HI-TRAC upending/downending on the horizontal transfer trailer or other transfer device, as applicable to the site's cask handling arrangement.

10. Placement of the HI-STORM 100 System at the ISFSI.

11. HI-STORM 100 System unloading, including cooling fuel assemblies, flooding the MPC cavity, and removing MPC welds (for which a mock-up may be used).

12.2.3 Functional and Operating Limits, Monitoring Instruments, and Limiting Control Settings

The controls and limits apply to operating parameters and conditions which are observable, detectable, and/or measurable. The HI-STORM 100 System is completely passive during storage and requires no monitoring instruments. The user may choose to implement a temperature monitoring system to verify operability of the overpack heat removal system in accordance with Technical Specification Limiting Condition for Operation (LCO) 3.1.2.

12.2.4 Limiting Conditions for Operation

Limiting Conditions for Operation specify the minimum capability or level of performance that is required to assure that the HI-STORM 100 System can fulfill its safety functions.

12.2.5 Equipment

The HI-STORM 100 System and its components have been analyzed for specified normal, off-normal, and accident conditions, including extreme environmental conditions. Analysis has shown in this TSAR that no credible condition or event prevents the HI-STORM 100 System from meeting its safety function. As a result, there is no threat to public health and safety from any postulated accident condition or analyzed event. When all equipment is loaded, tested, and placed into storage in accordance with procedures developed for the ISFSI, no failure of the system to perform its safety function is expected to occur.

12.2.6 Surveillance Requirements

The analyses provided in this TSAR show that the HI-STORM 100 System fulfills its safety functions, provided that the Technical Specifications in Appendix A to CoC 72-1014 and the Authorized Contents and Design Features in Appendix B to CoC 72-1014 are met. Surveillance requirements during loading, unloading, and storage operations are provided in the Technical Specifications.

12.2.7 Design Features

This section describes HI-STORM 100 System design features that are Important to Safety. These features require design controls and fabrication controls. The design features, detailed in this TSAR and in Appendix B to CoC 72-1014, are established in specifications and drawings which are controlled through the quality assurance program presented in Chapter 13. Fabrication controls and inspections to assure that the HI-STORM 100 System is fabricated in accordance with the design drawings and the requirements of this TSAR are described in Chapter 9.

12.2.8 MPC

a. Basket material composition, properties, dimensions, and tolerances for criticality control.

b. Canister material mechanical properties for structural integrity of the confinement boundary.

c. Canister and basket material thermal properties and dimensions for heat transfer control.

d. Canister and basket material composition and dimensions for dose rate control.

12.2.9 HI-STORM 100 Overpack

a HI-STORM 100 overpack material mechanical properties and dimensions for structural integrity to provide protection of the MPC and shielding of the spent nuclear fuel assemblies during loading, unloading and handling operations.

b. HI-STORM 100 overpack material thermal properties and dimensions for heat transfer control.

c. HI-STORM 100 overpack material composition and dimensions for dose rate control

12.3 TECHNICAL SPECIFICATIONS

Technical Specifications for the HI-STORM 100 System are provided in Appendix A to Certificate of Compliance 72-1014. Authorized Contents (i.e., fuel specifications) and Design Features are provided in Appendix B to CoC 72-1014. Bases applicable to the Technical Specifications are provided in TSAR Appendix 12.A. The format and content of the HI-STORM 100 System Technical Specifications and Bases are that of the Improved Standard Technical Specifications for power reactors, to the extent they apply to a dry spent fuel storage cask system. NUMARC Document 93-03, "Writer's Guide for the Restructured Technical Specifications" [12.3.1] was used as a guide in the development of the Technical Specifications and Bases.

12.4 REGULATORY EVALUATION

Table 12.1.2 lists the Technical Specifications for the HI-STORM 100 System. The Technical Specifications are detailed in Appendix A to Certificate of Compliance 72-1014. The Authorized Contents (i.e., fuel specifications) and Design Features are provided in Appendix B to CoC 72-1014.

The conditions for use of the HI-STORM 100 System identify necessary Technical Specifications, limits on authorized contents (i.e., fuel), and cask design features to satisfy 10 CFR Part 72, and the applicable acceptance criteria have been satisfied. Compliance with these Technical specifications and other conditions of the Certificate of Compliance provides reasonable assurance that the HI-STORM 100 System will provide safe storage of spent fuel and is in compliance with 10 CFR Part 72, the regulatory guides, applicable codes and standards, and accepted practices.

HI-STORM 100 SYSTEM TSAR

APPENDIX 12.A

TECHNICAL SPECIFICATION BASES

FOR THE HOLTEC HI-STORM 100 SPENT FUEL STORAGE CASK SYSTEM

(36 PAGES, INCLUDING THIS PAGE)

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BASES

ACTIONS

C.2 (continued)

evaluation performed under Required Action C.1, different recovery strategies may be necessary. Since an elevated helium leak rate represents a challenge to heat removal rates and off-site doses, reasonably rapid action is required. The Completion Time is sufficient to develop and initiate the corrective actions commensurate with the safety significance of the CONDITION.

D.1

If the MPC fuel cavity cannot be successfully returned to a safe, analyzed condition, the fuel must be placed in a safe condition in the spent fuel pool. The Completion Time is reasonable based on the time required to replace the transfer lid with the pool lid, perform fuel cooldown operations, re-flood the MPC, cut the MPC lid welds, move the TRANSFER CASK into the spent fuel pool, remove the MPC lid, and remove the spent fuel assemblies in an orderly manner and without challenging personnel.

SURVEILLANCE REQUIREMENTS

SR 3.1.1.1, SR 3.1.1.2, and SR 3.1.1.3

The long-term integrity of the stored fuel is dependent on storage in a dry, inert environment. Cavity dryness is demonstrated by evacuating the cavity to a very low absolute pressure and verifying that the pressure is held over a specified period of time. A low vacuum pressure is an indication that the cavity is dry. Having the proper helium backfill density ensures adequate heat transfer from the fuel to the fuel basket and surrounding structure of the MPC. Meeting the helium leak rate limit ensures there is adequate helium in the MPC for long term storage and the leak rate assumed in the confinement analyses remains bounding for off-site dose.

(continued)

BASES

SURVEILLANCE REQUIREMENTS

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

The leakage rate acceptance limit is specified in units of atm-cc/sec. This is a mass-like leakage rate as specified in ANSI N14.5 (1997). This is defined as the rate of change of the pressure-volume product of the leaking fluid at test conditions. This allows the leakage rate as measured by a mass spectrometer leak detector (MSLD) to be compared directly to the acceptance limit without the need for unit conversion from test conditions to standard, or reference conditions.

All three 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. TSAR Sections 4.4, 7.2, 7.3 and 8.1

BASES

ACTIONS	B.1 (continued) assemblies must be placed in a safe condition in the spent fuel pool. The Completion Time is reasonable based on the time required to replace the transfer lid with the pool lid, perform fuel cooldown operations, re-flood the MPC, cut the MPC lid welds, move the TRANSFER CASK into the spent fuel pool, remove the MPC lid, and remove the spent fuel assemblies in an orderly manner and without challenging personnel.
SURVEILLANCE REQUIREMENTS	SR 3.2.1.1 This SR ensures that the TRANSFER CASK average surface dose rates are within the LCO limits prior to TRANSPORT OPERATIONS. The surface dose rates are measured approximately at the locations indicated on Figure 3.2.1-1 following standard industry practices for determining average dose rates for large containers. The SR requires specific locations for taking dose rate measurements to ensure the dose rates measured are indicative of the average value around the cask.
REFERENCES	1. 10 CFR Parts 20 and 72. 2. TSAR Sections 5.1 and 8.1.6.

B 3.2 SFSC Radiation Protection

B 3.2.2 TRANSFER CASK Surface Contamination

BASES

BACKGROUND

A TRANSFER CASK is immersed in the spent fuel pool in order to load the spent fuel assemblies. As a result, the surface of the TRANSFER CASK may become contaminated with the radioactive material in the spent fuel pool water. This contamination is removed prior to moving the TRANSFER CASK to the ISFSI, or prior to transferring the MPC into the OVERPACK, whichever occurs first, in order to minimize the radioactive contamination to personnel or the environment. This allows dry fuel storage activities to proceed without additional radiological controls to prevent the spread of contamination and reduces personnel dose due to the spread of loose contamination or airborne contamination. This is consistent with ALARA practices.

APPLICABLE SAFETY ANALYSIS

The radiation protection measures implemented during MPC transfer and transportation using the TRANSFER CASK are based on the assumption that the exterior surfaces of the TRANSFER CASKs have been decontaminated. Failure to decontaminate the surfaces of the TRANSFER CASKs could lead to higher-than-projected occupational doses.

LCO

Removable surface contamination on the TRANSFER CASK exterior surfaces and accessible surfaces of the MPC is limited to 1000 dpm/100 cm^2 from beta and gamma sources and 20 dpm/100 cm^2 from alpha sources. These limits are taken from the guidance in IE Circular 81-07 (Ref. 2) and are based on the minimum level of activity that can be routinely detected under a surface contamination control program using direct survey methods. Only loose contamination is controlled, as fixed contamination will not result from the TRANSFER CASK loading process. Experience has shown that these limits are low enough to prevent the spread of contamination to clean areas and are significantly less than the levels which would cause significant personnel skin dose.

(continued)

BASES

LCO (continued)	LCO 3.2.2 requires removable contamination to be within the specified limits for the exterior surfaces of the TRANSFER CASK and accessible portions of the MPC. The location and number of surface swipes used to determine compliance with this LCO are determined based on standard industry practice and the user's plant-specific contamination measurement program for objects of this size. Accessible portions of the MPC means the upper portion of the MPC external shell wall accessible after the inflatable annulus seal is removed and before the annulus shield ring is installed. The user shall determine a reasonable number and location of swipes for the accessible portion of the MPC. The objective is to determine a removable contamination value representative of the entire upper circumference of the MPC, while implementing sound ALARA practices.
APPLICABILITY	Verification that the TRANSFER CASK and MPC surface contamination is less than the LCO limit is performed during LOADING OPERATIONS. This occurs before TRANSPORT OPERATIONS, when the LCO is applicable. Measurement of the TRANSFER CASK and MPC surface contamination is unnecessary during UNLOADING OPERATIONS as surface contamination would have been measured prior to moving the subject TRANSFER CASK to the ISFSI.
ACTIONS	A note has been added to the ACTIONS which states that, for this LCO, separate Condition entry is allowed for each TRANSFER CASK. This is acceptable since the Required Actions for each Condition provide appropriate compensatory measures for each TRANSFER CASK not meeting the LCO. Subsequent TRANSFER CASKs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions. <u>A.1</u> If the removable surface contamination of a TRANSFER CASK

(continued)