2.1 SPENT FUEL TO BE STORED

2.1.1 Determination of the Design Basis Fuel

A central object in the design of the HI-STORM FW System is to ensure that all SNF discharged from the U.S. reactors and not yet loaded into dry storage systems can be stored in a HI-STORM FW MPC. Publications such as references [2.1.1] and [2.1.2] provide a comprehensive description of fuel discharged from U.S. reactors.

The cell openings in the fuel baskets have been sized to accommodate BWR and PWR assemblies. The cavity length of the MPC will be determined for a specific site to accord with the fuel assembly length used at that site, including non-fuel hardware and damaged fuel containers, as applicable.

Table 2.1.1 summarizes the authorized contents for the HI-STORM FW System. Tables 2.1.2 and 2.1.3, which are referenced in Table 2.1.1, provide the fuel characteristics of all groups of fuel assembly types determined to be acceptable for storage in the HI-STORM FW System. Any fuel assembly that has fuel characteristics within the range of Tables 2.1.2 and 2.1.3 and meets the other limits specified in Table 2.1.1 is acceptable for storage in the HI-STORM FW System. The groups of fuel assembly types presented in Tables 2.1.2 and 2.1.3 are defined as "array/classes" as described in further detail in Chapter 6. Table 2.1.4 lists the BWR and PWR fuel assembly designs which are found to govern for three qualification criteria, namely reactivity, shielding, and thermal, or that are used as reference assembly design is those analyses. Additional information on the design basis fuel definition is presented in the following subsections.

2.1.2 Undamaged SNF Specifications

Undamaged fuel is defined in the Glossary.

2.1.3 Damaged SNF and Fuel Debris Specifications

Damaged fuel and fuel debris are defined in the Glossary.

Damaged fuel assemblies and fuel debris will be loaded into damaged fuel containers (DFCs) (Figure 2.1.6) that have mesh screens or perforated plates on the top and bottom. The DFC will have a removable lid to allow the fuel assembly to be inserted. In storage, the lid will be latched in place. DFC's used to move fuel assemblies will be designed for lifting with either the lid installed or with a separate handling lid. DFC's used to handle fuel and the associated lifting tools will designed in accordance with the requirements of NUREG-0612. The DFC will be fabricated from structural aluminum or corrosion resistant alloy steel. For damaged fuel assemblies that can be handled by normal means and whose structural integrity is such that geometric rearrangement of fuel is not expected, the use of a Damaged Fuel Isolator (DFI)

(Figure 2.1.7) can be substituted for the use of the DFC. The DFI is a set of specially designed barriers at the top and bottom of a storage cell space used to prevent the migration of fissile material from those cells. The DFI is made of corrosion resistant alloy steel and includes mesh screens or perforated plates at the top and bottom. DFI storage locations are limited to the same locations defined for DFCs. The appropriate structural, thermal, shielding, criticality, and confinement evaluations, as applicable, have been performed to account for damaged fuel and fuel debris and are described in their respective chapters that follow. The limiting design characteristics for damaged fuel assemblies and restrictions on the number and location of damaged fuel containers authorized for loading in each MPC model are provided in this chapter.

2.1.3.1 Damaged Fuel Isolator

If the damaged fuel assembly can be handled by normal means and its structural integrity is such that geometric rearrangement of fuel is not expected, then the device known as the Damaged Fuel Isolator (DFI) can be used in place of the DFC. Like the DFC, the DFI prevents the migration of fissile material in bulk or coarse particulate form from the nuclear fuel stored in its cellular storage cavity. The DFI can be used only if the fuel can be handled by normal means but is classified as damaged because of physical defect, viz., a breach in the fuel cladding or a structural failure in the grid strap assembly, etc., as explained in ISG-1. Damaged fuel stored utilizing the DFI may contain missing or partial fuel rods and/or fuel rods with known or suspected cladding defects greater than hairline cracks or pinhole leaks as long as the fuel assembly can be handled by normal means.

The DFI is made up of two end caps that, along with the four basket cell walls, comprise the fuel isolation space. The essential attributes of the DFI are:

[Proprietary Information Withheld in Accordance with 10 CFR 2.390]

[Proprietary Information Withheld in Accordance with 10 CFR 2.390]

2.1.4 Structural Parameters for Design Basis SNF

The main physical parameters of an SNF assembly applicable to the structural evaluation are the fuel assembly length, cross sectional dimensions, and weight. These parameters, which define the mechanical and structural design, are specified in Subsection 2.1.8. An appropriate axial clearance is provided to prevent interference due to the irradiation and thermal growth of the fuel assemblies.

2.1.5 Thermal Parameters for Design Basis SNF

The principal thermal design parameter for the stored fuel is the fuel's peak cladding temperature (PCT) which is a function of the maximum decay heat per assembly and the decay heat removal capabilities of the HI-STORM FW System.

To ensure the permissible PCT limits are not exceeded, Subsection 1.2 specifies the maximum allowable decay heat per assembly for each MPC model in the three-region configuration (see also Table 1.2.3 and 1.2.4).

The fuel cladding temperature is also affected by the heat transfer characteristics of the fuel assemblies. The design basis fuel assembly for thermal calculations for both PWR and BWR fuel is provided in Table 2.1.4.

Finally, the axial variation in the heat generation rate in the design basis fuel assembly is defined based on the axial burnup distribution. For this purpose, the data provided in references [2.1.3] and [2.1.4] are utilized and summarized in Table 2.1.5 and Figures 2.1.3 and 2.1.4. These distributions are representative of fuel assemblies with the design basis burnup levels considered. These distributions are used for analyses only, and do not provide a criteria for fuel assembly acceptability for storage in the HI-STORM FW System.

TABLE 2.1.8
BURNUP CREDIT CONFIGURATIONS

Configuration	Description
Configuration 1	Spent UNDAMAGED fuel assemblies are placed in all positions of the basket
Configuration 2	Fresh UNDAMAGED fuel assemblies are placed in locations 3-4, 3-5, 3-12, and 3-13 (see Figure 2.1.1); spent UNDAMAGED fuel assemblies are placed in the remaining positions
Configuration 3	Damaged Fuel Containers (DFCs) and/or Damaged Fuel Isolators (DFIs) with spent DAMAGED fuel assemblies are placed in locations 3-1, 3-3, 3-4, 3-5, 3-6, 3-7, 3-10, 3-11, 3-12, 3-13, 3-14, and 3-16 (see Figure 2.1.1); spent UNDAMAGED fuel assemblies are placed in the remaining positions
Configuration 4	DFCs with Damaged Fuel and/or fresh FUEL DEBRIS are placed in locations 3-1, 3-7, 3-10, and 3-16 with locations 2-1, 2-5, 2-8, and 2-12 (see Figure 2.1.1) empty; spent UNDAMAGED fuel assemblies are placed in the remaining positions

TABLE 2.1.9
DAMAGED FUEL ISOLATOR CRITICAL CHARACTERISTICS

[Proprietary Information Withheld in Accordance with 10 CFR 2.390]

[Proprietary Information Withheld in Accordance with 10 CFR 2.390]

Figure 2.1.7: Damaged Fuel Isolator (Typical)
Example configuration. Final configuration may vary with fuel type.

[Proprietary Information Withheld in Accordance with 10 CFR 2.390]

Figure 2.1.7 (Continued): Damaged Fuel Isolator (Typical)
Example configuration. Final configuration may vary with fuel type.

Table 2.2.3

TEMPERATURE LIMITS

HI-STORM FW Component	Normal Condition and Design Temperature Limits (°F)	Short Term Events†† Temperature Limits (°F)	Off-Normal and Accident Condition Temperature Limits † (°F)
MPC shell	600*	800*	800*
MPC basket	752	932	932
MPC basket shims	752	932	932
MPC lid	600*	800*	800*
MPC closure ring	500*	800*	800*
MPC baseplate	400*	800*	800*
HI-TRAC VW inner shell	-	600	700
HI-TRAC VW outer shell	-	500	700
HI-TRAC VW bottom lid	-	500	700
HI-TRAC VW water jacket shell	-	500	700**
HI-TRAC VW top flange	-	500	650
HI-TRAC VW bottom lid seals	-	400	N/A
HI-TRAC VW bottom lid bolts	-	400	800
HI-TRAC VW bottom flange	-	400	700
HI-TRAC VW radial neutron shield	-	311	N/A
HI-TRAC VW radial lead gamma shield	-	600	600
HI-TRAC VW Version V2 NSC steel	-	400	600
HI-TRAC VW Version V2 NSC	-	300	350

†† Short term operations include, but are not limited to, MPC drying and onsite transport. The 1058°F temperature limit applies to MPCs containing all moderate burnup fuel. The limit for MPCs containing one or more high burnup fuel assemblies is 752°F.

* Temperature limits in Table 1.A.6 shall take precedence if duplex stainless steels are used for the fabrication of confinement boundary components, as described in Appendix 1.A.

** For fire accidents, the steel structure is required to remain physically stable similar to HI-STORM overpack.

† For accident conditions that involve heating of the steel structures and no mechanical loading (such as the blocked air duct accident), the permissible metal temperature of the steel parts is defined by Table 1A of ASME Section II (Part D) for Section III, Class 3 materials as 700°F. For the fire event, the structure is required to remain physically stable (no specific temperature limits apply)

General Note: The normal condition temperature limits are used in the design basis structural evaluations for MPC and HI-STORM. The short-term condition temperature limits are used in the design basis structural evaluations for HI-TRAC. All other short-term, off-normal, and accident condition structural evaluations are based on bounding temperatures from thermal evaluations presented in Chapter 4.

TABLE 2.2.14
List of ASME Code Alternatives for Multi-Purpose Canisters (MPCs)

			clearances are satisfied. The dimensions required to be met in fabrication are chosen to meet the functional requirements of the dry storage components. Thus, although the post-forming Code cylindricity requirements are not evaluated for compliance directly, they are indirectly satisfied (actually exceeded) in the final manufactured components.
MPC Enclosure Vessel	NB-4122	Implies that with the exception of studs, bolts, nuts and heat exchanger tubes, CMTRs must be traceable to a specific piece of material in a component.	MPCs are built in lots. Material traceability on raw materials to a heat number and corresponding CMTR is maintained by Holtec through markings on the raw material. Where material is cut or processed, markings are transferred accordingly to assure traceability. As materials are assembled into the lot of MPCs being manufactured, documentation is maintained to identify the heat numbers of materials being used for that item in the multiple MPCs being manufactured under that lot. A specific item within a specific MPC will have a number of heat numbers identified as possibly being used for the item in that particular MPC of which one or more of those heat numbers (and corresponding CMTRS) will have actually been used. All of the heat numbers identified will comply with the requirements for the particular item.
MPC Lid and Closure Ring Welds	NB-4243	Full penetration welds required for Category C Joints (flat head to main shell per NB-3352.3)	MPC lid and closure ring are not full penetration welds. They are welded independently to provide a redundant seal.
MPC Closure Ring, Vent and Drain Cover Plate Welds	NB-5230	Radiographic (RT) or ultrasonic (UT) examination required.	Root (if more than one weld pass is required) and final liquid penetrant examination to be performed in accordance with NB-5245. The closure ring provides independent redundant closure for vent and drain cover plates. Vent and drain port cover plate welds are helium leakage tested.
MPC Lid to Shell Weld	NB-5230	Radiographic (RT) or ultrasonic (UT) examination required.	Only progressive liquid penetrant (PT) examination is permitted. PT examination will include the root and final weld layers and each approx. 3/8" of weld depth.

2.3 SAFETY PROTECTION SYSTEMS

2.3.1 General

The HI-STORM FW System is engineered to provide for the safe long-term storage of spent nuclear fuel (SNF). The HI-STORM FW will withstand all normal, off-normal, and postulated accident conditions without release of radioactive material or excessive radiation exposure to workers or members of the public. Special considerations in the design have been made to ensure long-term integrity and confinement of the stored SNF throughout all cask normal and off-normal operating conditions and its retrievability for further processing or ultimate disposal in accordance with 10 CFR 72.122(l) and ISG-2 [2.3.1].

2.3.2 Protection by Multiple Confinement Barriers and Systems

2.3.2.1 Confinement Barriers and Systems

The radioactivity which the HI-STORM FW System must confine originates from the spent fuel assemblies and, to a lesser extent, any radioactive particles from contaminated water in the fuel pool which may remain inside the MPC. This radioactivity is confined by multiple engineered barriers.

Contamination on the outside of the MPC from the fuel pool water is minimized by preventing contact, removing the contaminated water, and decontamination. An inflatable seal in the annular gap between the MPC and HI-TRAC VW, and the elastomer seal in the HI-TRAC VW bottom lid (see Chapter 9) prevent the fuel pool water from contacting the exterior of the MPC and interior of the HI-TRAC VW while submerged for fuel loading.

The MPC is a seal welded enclosure which provides the confinement boundary. The MPC confinement boundary is defined by the MPC baseplate, MPC shell, MPC lid, closure ring, port cover plates, and associated welds.

The MPC confinement boundary has been designed to withstand any postulated off-normal operations, accident conditions, or external natural phenomena. Redundant closure of the MPC is provided by the MPC closure ring welds which provide a second barrier to the release of radioactive material from the MPC internal cavity. Therefore, no monitoring system for the confinement boundary is required.

Confinement is discussed further in Chapter 7. MPC field weld examinations, helium leakage testing of the port cover plate welds, and pressure testing are performed to verify the confinement function. Fabrication inspections and tests are also performed, as discussed in Chapter 10, to verify the integrity of the confinement boundary.

extreme temperature is assumed to last for a sufficient duration to allow the HI-STORM FW system to reach steady state conditions. Because of the large mass of the HI-STORM FW system, with its corresponding large thermal inertia and the limited duration for the extreme temperature, this assumption is conservative. Starting from a baseline condition evaluated in Section 4.4 (normal ambient temperature and limiting fuel storage configuration) the temperatures of the HI-STORM FW system are conservatively assumed to rise by the difference between the extreme and normal ambient temperatures (45°F). The HI-STORM FW extreme ambient temperatures computed in this manner are reported in Table 4.6.4. The co-incident MPC pressure is also computed (Table 4.6.7) and compared with the accident design pressure (Table 2.2.1), which shows a positive safety margin. The result is confirmed to be below the accident limit.

4.6.2.4 100% Blockage of HI-STORM Air Inlets

This event is defined as a complete blockage of all eight bottom inlets for a significant duration (32 hours). The immediate consequence of a complete blockage of the air inlets is that the normal circulation of air for cooling the MPC is stopped. An amount of heat will continue to be removed by localized air circulation patterns in the overpack annulus and outlet ducts, and the MPC will continue to radiate heat to the relatively cooler storage overpack. As the temperatures of the MPC and its contents rise, the rate of heat rejection will increase correspondingly. Under this condition, the temperatures of the overpack, the MPC and the stored fuel assemblies will rise as a function of time.

As a result of the considerable inertia of the storage overpack, a significant temperature rise is possible if the inlets are substantially blocked for extended durations. This accident condition is, however, a short duration event that is identified and corrected through scheduled periodic surveillance. Nevertheless, this event is conservatively analyzed assuming a substantial duration of blockage. The HI-STORM FW thermal model is the same 3-Dimensional model constructed for normal storage conditions (see Section 4.4) except for the bottom inlet ducts, which are assumed to be impervious to air. Using this model, a transient thermal solution of the HI-STORM FW system starting from normal storage conditions is obtained. The results of the blocked ducts transient analysis are presented in Table 4.6.5 and compared against the accident temperature limits (Table 2.2.3). The co-incident MPC pressure (Table 4.6.7) is also computed and compared with the accident design pressure (Table 2.2.1). All computed results are well below their respective limits.

4.6.2.5 Burial Under Debris (Load Case AG in Table 2.2.13)

Burial of the HI-STORM FW system under debris is not a credible accident. During storage at the ISFSI there are no structures that loom over the casks whose collapse could completely bury the casks in debris. Minimum regulatory distances from the ISFSI to the nearest ISFSI security fence precludes the close proximity of substantial amount of vegetation. There is no credible to block air flow through the bottom ducts, the lower region of the MPC will be submerged in the water. Although heat transport through air circulation is cut off in this scenario, the reduction is substantially offset by flood water cooling.

The MPCs are equipped with the thermosiphon capability, which brings the heat emitted by the fuel to the bottom region of the MPC as the circulating helium flows along the downcomer space around the basket. This places the heated helium in close thermal communication with the flood water, further enhancing convective cooling via the flood water.

The most adverse flood condition exists when the flood waters are high enough to block the inlet ducts but no higher. In this scenario, the MPC surface has minimum submergence in water and the ventilation air is completely blocked. In fact, as the flood water begins to accumulate on the ISFSI pad, the air passage size in the inlet vents is progressively reduced. Therefore, the rate of floodwater rise with time is necessary to analyze the thermal-hydraulic problem. For the reference design basis flood (DBF) analysis in this FSAR, the flood waters are assumed to rise instantaneously to the height to block the inlet vents and stay at that elevation for 32 hours. The consequences of the DBF event is bounded by the 100% blocked ducts events evaluated in Section 4.6.2.4. If the duration of the flood blockage exceeds the DBF blockage duration then a site specific evaluation shall be performed in accordance with the methodology presented in this Chapter and evaluated for compliance with Subsection 2.2.3 criteria.

4.6.2.7 100% Blockage of HI-TRAC VW Version V2 Air Inlet

As illustrated in the Licensing drawings of HI-TRAC VW Versions V and V2 listed in Section 1.5, the inlet flow passages in HI-TRAC ("the Cask") are not discrete vents; rather they are radially symmetric passages. The outlet is essentially an unhindered annular opening to ambient air above the cask as the design does not require a cover or lid that would otherwise restrict air exit. The ventilation action through the MPC/Cask annulus is entirely by natural convection. It is not credible to postulate that these circumferentially extant passages can be entirely blocked during the transport of the cask from the Fuel Building to the ISFSI pad. However, as a study to support a defense-in depth approach, an evaluation is presented below assuming that inlet flow passages are 100% blocked. As a result of the considerable inertia of the storage overpack, a significant temperature rise is possible if the inlets are substantially blocked for extended durations. This accident condition is, however, a short duration event that is identified and corrected through scheduled periodic surveillance.

For this purpose, an exceedingly conservative analysis that ignores heat rejection from the cask is considered. Under this scenario, the contents of the cask will undergo a transient heat up under an assumed adiabatic condition. The minimum available time ($\Delta\tau$) for the most limiting component (Table 4.5.23) to reach the accident limit depends on the following: (i) thermal inertia of the cask, (ii) the cask initial conditions, (iii) the spent nuclear fuel decay heat generation and (iv) the margin between the component temperature and the accident temperature limit. To obtain a lowerbound value of $\Delta\tau$, the cask thermal inertia (item i) is understated. A set of conservatively postulated input parameters for items (i) through (iv) are summarized in Table 4.6.8. Using these input parameters for items (i) through (iv), $\Delta\tau$ is computed as follows:

$$\Delta\tau = \frac{I \times \Delta T}{Q}$$

where:

- $\Delta\tau$ = maximum available time under 100% duct blockage (hr)
- I = Thermal Inertia of the cask (Btu/^{o}F)
- ΔT = Permissible temperature rise (^{o}F)
- Q = Decay heat load (Btu/hr)

Using the parameters in Table 4.6.8, the maximum available time under this accident is computed. A conservatively lowerbound allowable duration is identified for scheduled periodic surveillance and is presented in Table 4.6.9. The computed component temperatures are summarized in Table 4.6.10. The MPC cavity pressure result is presented in Table 4.6.7. The temperature and pressure results show that the accident temperature and pressure limits are met with adequate margins.

Alternatively, the FLUENT thermal model described in Section 4.5 can be adopted on a site-specific basis to evaluate the transient temperature rise of the components of the HI-TRAC VW Versions V and V2 casks, by blocking the air flow at the inlet vents.

Thus, the allowable time under this accident condition can then be computed using the conservative method described above or via using the FLUENT thermal model with site-specific parameters (for example heat load).

Table 4.6.7 OFF-NORMAL AND ACCIDENT CONDITION MAXIMUM MPC PRESSURES	
Condition	**Pressure (psig)**
Off-Normal Conditions	
Off-Normal Pressure[8]	110.0
Partial Blockage of Inlet Ducts	99.9
Accident Conditions	
HI-TRAC VW fire accident	103.3
Extreme Ambient Temperature	101.7
100% Blockage of Air Inlets	116.4
Burial Under Debris	130.8
HI-TRAC VW Jacket Water Loss	109.5
100% Blockage of HI-TRAC VW V2 Air Inlets[Note 1]	105.8
Note 1: HI-TRAC VW Version V2 bounds Version V.	

8 The off-normal pressure event defined in Section 4.6.1.1 bounds the off-normal ambient temperature event (Section 4.6.1.2)

Table 4.6.8 SUMMARY OF INPUTS FOR 100% BLOCKAGE OF HI-TRAC VW VERSION V2 INLET VENTS Note 1	
Cask Thermal Inertia (I)	17160 Btu/^{o}F
Initial Temperature (T_{init})	279^{o}F (Note 2)
Temperature Rise (ΔT)	70^{o}F (Note 3)
Decay Heat (Q)	1.54x10^5 Btu/hr
Note 1: HI-TRAC VW Version V2 bounds Version V. Note 2: The component (NSC Holtite) with least margins to temperature limits is adopted from Table 4.5.23. Note 3: A conservatively lower temperature rise is adopted.	

Table 4.6.9 ALLOWABLE TIME AND TEMPERATURE RISE UNDER 100% BLOCKAGE OF HI-TRAC VW VERSION V2 INLET VENTS	
Duration	6 hours (Note 1)
Temperature Rise	54^{o}F
Note: Allowable time conservatively lower than that computed from input values in Table 4.6.8.	

Table 4.6.10

TEMPERATURE RESULTS UNDER POSTULATED 100% BLOCKAGE OF HI-TRAC VW VERSION V2 INLET VENTS

Component	**Temperature** [Note 1]**, °F**
Fuel Cladding	786
MPC Basket	759
Aluminum Basket Shims	612
MPC Shell	550
HI-TRAC VW Inner Shell	388
NSC Inner Shell	333
NSC Holtite	333

Note 1: The components temperatures tabulated herein are obtained by adding the temperature rise computed in Table 4.6.9 to the values reported in Table 4.5.23.

CHAPTER 7*: CONFINEMENT

7.0 INTRODUCTION

Confinement of all radioactive materials in the HI-STORM FW system is provided by the MPC. The design of the HI-STORM FW MPC assures that there are no credible design basis events that would result in a radiological release to the environment. The HI-STORM FW overpack and HI-TRAC VW transfer cask are designed to provide physical protection to the MPC during normal, off-normal, and postulated accident conditions to assure that the integrity of the MPC is maintained. The dry inert atmosphere in the MPC and the passive heat removal capabilities of the HI-STORM FW also assure that the SNF assemblies remain protected from long-term degradation.

A detailed description of the confinement structures, systems, and components important to safety is provided in Chapter 2. The structural adequacy of the MPC is demonstrated by the analyses documented in Chapter 3. The physical protection of the MPC provided by the overpack and the HI-TRAC Transfer Cask is demonstrated by the structural analyses documented in Chapter 3 for off-normal and postulated accident conditions that are considered in Chapter 11. The heat removal capabilities of the HI-STORM FW system are demonstrated by the thermal analyses documented in Chapter 4. Materials evaluation in Chapter 8 demonstrates the compatibility and durability of the MPC materials for long term spent fuel storage.

This chapter describes the HI-STORM FW confinement design and describes how the design satisfies the confinement requirements of 10CFR72 [7.0.1]. It also provides an evaluation of the MPC confinement boundary as it relates to the criteria contained in Interim Staff Guidance (ISG)–18 [7.0.2] and applicable portions of ANSI N14.5-1997 [7.0.3] as justification for reaching the determination that leakage from the confinement boundary is not credible and, therefore, a quantification of the consequence of leakage from the MPC is not required. This chapter is in general compliance with NUREG-1536 [7.0.4] as noted in Chapter 1.

It should be observed that the configuration of the confinement boundary of the MPCs covered by this FSAR is identical to that used in the MPCs in Docket No. 72-1014 (HI-STORM 100 system), including weld joint details and weld types and weld sizes. Therefore, it is reasonable to conclude that the safety evaluation conducted to establish confinement integrity in Docket No. 72-1014 is also applicable herein.

*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.

After the MPC lid weld is ensured to be acceptable the vent and drain port cover plates are welded in place, examined by the liquid penetrant method and a helium leakage test of each of the vent and drain port cover plate welds is performed. These welds are tested in accordance to the leakage test methods and procedures of ANSI N 14.5 [7.0.3] to the “leaktight” criterion of the standard. Finally, the MPC closure ring which also covers the vent and drain cover plates is installed, welded, and inspected by the liquid penetrant method. Chapters 9, 10, and 13 provide procedural guidance, acceptance criteria, and operating controls, respectively, for performance and acceptance of non-destructive examination of all welds made in the field.

After moisture removal and prior to sealing the MPC vent and drain ports, the MPC cavity is backfilled with helium. The helium backfill provides an inert, non-reactive atmosphere within the MPC cavity that precludes oxidation and hydride attack on the SNF cladding. Use of a helium atmosphere within the MPC contributes to the long-term integrity of the fuel cladding, reducing the potential for release of fission gas or other radioactive products to the MPC cavity. Helium also aids in heat transfer within the MPC and helps reduce the fuel cladding temperatures. The inert atmosphere in the MPC, in conjunction with the thermal design features of the MPC and storage cask, assures that the fuel assemblies are sufficiently protected against degradation, which might otherwise lead to gross cladding ruptures during long-term storage.

The confinement boundary welds completed at the fabrication facility (i.e., the MPC longitudinal and circumferential shell welds and the MPC shell to baseplate weld) are referred to as the shop welds. After visual and liquid penetrant examinations, the shop welds are volumetrically inspected by radiography. The MPC shop welds are multiple-pass (6 to 8 passes) austenitic stainless steel welds. Helium leakage testing of the shop welds is performed as described in Table 10.1.1.

7.1.2 Confinement Penetrations

Two penetrations (the MPC vent and drain ports) are provided in the MPC lid for MPC draining, moisture removal and backfilling during MPC loading operations, and also for MPC re-flooding during unloading operations. No other confinement penetrations exist in the MPC.

The MPC vent and drain ports are sealed by cover plates that are integrally welded to the MPC lid. No credit is taken for the sealing action provided by the vent and drain port cap joints. The MPC closure ring covers the vent and drain port cover plate welds and the MPC lid-to-shell weld, providing the redundant closure of these penetrations. The redundant closure of the MPC satisfies the requirements of 10CFR72.236(e) [7.0.1].

7.1.3 Seals and Welds

Section 7.1.1 describes the design of the confinement boundary welds. The welds forming the confinement boundary is summarized in Table 7.1.1.

The use of multi-pass welds with surface liquid penetrant inspection of root, intermediate, and

11. Install the inflatable annulus seal around the MPC.

12. To the extent practicable, apply waterproof tape over any empty bolt holes or locations where water may create a decontamination issue.

Note:
Canister filling and draining operations vary by site. Instructions are provided on a site-specific basis.

13. Fill the MPC with water to approximately 12 inches below the top of the MPC shell. Refer to LCO 3.3.1 for boron concentration requirements.

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

14. Place HI-TRAC VW in the designated cask loading area.

15. If used, the DFC can be installed in those cells where damaged fuel or fuel debris will be stored. If used, the bottom DFI can be installed in those cells where damaged fuel which can be handled by normal means and meeting the criteria of section 2.1.3.1, will be stored.

16. Verify spent fuel pool for boron concentration requirements in accordance with LCO 3.3.1. Testing must be completed within four hours prior to loading and every 48 hours after in accordance with the LCO. Two independent measurements shall be taken to ensure that the requirement of 10 CFR 72.124(a) is met.

9.2.3 MPC Fuel Loading

Note:
When loading an MPC requiring soluble boron, the boron concentration of the water shall be checked in accordance with LCO 3.3.1 before and during operations with fuel and water in the MPC.

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 the Approved Contents Section of Appendix B to the CoC, have been selected for loading into the MPC. Perform a verification of the types, amounts, and location of non-fuel hardware using plant fuel records to ensure that only non-fuel hardware that meet the conditions for loading, as specified in the Approved Contents Section of Appendix B to the CoC, have been selected for loading into the MPC.

Note:
The demoisturizer module must maintain the temperature of the helium exiting the FHD below the Technical Specification limits continuously from the end of the drying operations until the MPC has been backfilled and isolated. If the temperature of the gas exiting the FHD exceeds the temperature limit, the dryness test must be repeated and the backfill re-performed.

Continue operation of the FHD system with the demoisturizer on.

While monitoring the temperatures into and out of the MPC, adjust the helium pressure in the MPC to provide a fill pressure as required by LCO 3.1.1.

Open the FHD bypass line and Close the vent and drain port RVOAs.

Warning:

A HI-TRAC VW Version V or V2 containing an MPC loaded with spent fuel assemblies shall NOT be left unattended to ensure that blockage of the air flow paths does not occur. The HI-TRAC vents shall be monitored to be free from blockage once every 4 hours.

For HI-TRAC VW Versions V and V2, deflate the lower inflatable annulus seal and remove the annulus shield to establish air flow through the annulus.

Shutdown the FHD system and disconnect it from the RVOAs.

Remove the vent and drain port RVOAs.

9. Weld the vent and drain port cover plates and perform NDE in accordance with the licensing drawings using approved procedures. Repair any weld defects in accordance with the applicable code and re-perform the NDE until the weld meets the required acceptance criteria.

10. Perform a leakage test of the MPC vent port cover plate and drain port cover plate in accordance with the following and site-approved procedures:

If necessary, remove the cover plate set screws.

Flush the cavity with helium to remove the air and immediately install the set screws recessed approximately ¼ inch below the top of the cover plate.

Plug weld the recess above each set screw to complete the penetration closure welding in accordance with the licensing drawings using approved procedures. Repair any weld defects in accordance with the applicable code and re-perform the NDE until the weld meets the required acceptance criteria.

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

Warning:
A HI-TRAC VW Version V or V2 containing an MPC loaded with spent fuel assemblies shall NOT be left unattended when the MPC does not contain water. The HI-TRAC vents shall be monitored to be free from blockage once every 4 hours.

6. Disconnect the bottom lid and open the mating device drawer.
7. Attach the ends of the MPC sling to the lifting device.
8. Raise the MPC into HI-TRAC VW.
9. Verify the MPC is in the full-up position.
10. Close the mating device.
11. Attach the bottom lid to the HI-TRAC VW.
12. Lower the MPC onto the bottom lid.
13. Disconnect the MPC lift rigging from the MPC lid.
14. Remove HI-TRAC VW from the top of the HI-STORM FW.

9.4.3 Preparation for Unloading

1. Prepare for MPC cool-down as follows:

Warning:
At the start of annulus filling, the annulus fill water may flash to steam due to high MPC shell temperatures. Users may select the location and means of performing the annulus fill. Users may also elect the source of water for the annulus. Water addition should be performed in a slow and controlled manner until water steam generation has ceased. Ensure vent seal is inflated prior to filling the annulus with water.

2. If necessary, set the annulus water level to approximately 4 inches below the top of the MPC shell and install the annulus shield. Cover the annulus and HI-TRAC VW top surfaces to protect them from debris produced when removing the MPC lid weld.

3. Access the MPC as follows:

ALARA Note:
The following procedures describe weld removal using a machine tool head. Other methods may also be used. The metal shavings may need to be periodically removed.

ALARA Warning:
Weld removal may create an airborne radiation condition. Weld removal must be performed under the direction of the user's Radiation Protection organization.

10.1.1.4 Weld Examination

The examination of the HI-STORM FW system welds shall be performed in accordance with the drawing package in Section 1.5 and the applicable codes and standards.

All code weld inspections shall be performed in accordance with written and approved procedures by personnel qualified in accordance with SNT-TC-1A. All required inspections, examinations, and tests shall become part of the final quality documentation package.

The following specific weld requirements shall be followed in order to verify fabrication in accordance with the provisions of this FSAR.

1. Confinement Boundary welds including any attachment welds (and temporary welds to the Confinement Boundary) shall be examined in accordance with ASME Code Section V, with acceptance criteria per ASME Code Section III, Subsection NB, Article NB-5300. Examinations, Visual (VT), Radiographic (RT), and Liquid Penetrant (PT), apply to these welds as defined by the code. These welds shall be repaired in accordance with the requirements of the ASME Code Section III, Article NB-4450 and examined after repair in the same manner as the original weld.

2. Basket welds, although they are conservatively not credited in structural analysis, shall be examined and repaired in accordance with NDE specified in the drawing package and with written and approved procedures developed specifically for welding Metamic-HT with acceptance criteria per ASME Section V, Article 1, Paragraph T-150 (2007 Edition). The basket welds, made by the Friction Stir Weld process, are classified as Category C per NG-3351.3 and belonging to Type III (by virtue of being corner joint with a thru-thickness “stir zone”) in Table NG-3352-1. These weld requirements are not applicable to welds identified as NITS on the drawing package.

3. Non-code welds shall be examined and repaired in accordance with written and approved procedures as defined in the system Manufacturing Manual.

10.1.1.5 MPC Surface Peening Procedure Qualification

Peening shall be performed using a QA validated procedure that is qualified to deliver the expected surface enhancement on a repeatable basis while maintaining the structural integrity of the MPC. The essential variables of the process shall be identified by the peening service provider and their acceptable range identified in the procedure.

Testing shall be performed to confirm that the peening process maintains all MPC safety functions. Testing shall use sample coupons that simulate the surface condition of the Confinement Boundary and/or MPC Confinement Boundary welds that are to be peened. Table 10.1.9 specifies the required testing that must precede the first peening operation carried out on a production MPC to confirm the efficacy of the peening procedure for a specific MPC fabrication

Table 10.1.4
HI-STORM FW MPC NDE REQUIREMENTS

Weld Location	**NDE Requirement**	**Applicable Code**	**Acceptance Criteria (Applicable Code)**
Shell longitudinal seam	RT PT (surface)	ASME Section V, Article 2 (RT) ASME Section V, Article 6 (PT)	RT: ASME Section III, Subsection NB, Article NB-5320 PT: ASME Section III, Subsection NB, Article NB-5350
Shell circumferential seam	RT PT (surface)	ASME Section V, Article 2 (RT) ASME Section V, Article 6 (PT)	RT: ASME Section III, Subsection NB, Article NB-5320 PT: ASME Section III, Subsection NB, Article NB-5350
Baseplate-to-shell	RT PT (surface)	ASME Section V, Article 2 (RT) ASME Section V, Article 6 (PT)	RT: ASME Section III, Subsection NB, Article NB-5320 PT: ASME Section III, Subsection NB, Article NB-5350
Lid-to-shell	PT (root and final pass) and multi-layer PT. PT (surface following pressure test)	ASME Section V, Article 6 (PT)	PT: ASME Section III, Subsection NB, Article NB-5350
Closure ring-to-shell	PT (final pass)	ASME Section V, Article 6 (PT)	PT: ASME Section III, Subsection NB, Article NB-5350
Closure ring-to-lid	PT (final pass)	ASME Section V, Article 6 (PT)	PT: ASME Section III, Subsection NB, Article NB-5350
Closure ring radial welds	PT (final pass)	ASME Section V, Article 6 (PT)	PT: ASME Section III, Subsection NB, Article NB-5350
Port cover plates-to-lid	PT (root and final pass)	ASME Section V, Article 6 (PT)	PT: ASME Section III, Subsection NB, Article NB-5350
Lift lug and lift lug baseplate	PT (surface)	ASME Section V, Article 6 (PT)	PT: ASME Section III, Subsection NB, Article NB-5350
Vent and drain port cover plate plug welds	PT (surface)	ASME Section V, Article 6 (PT)	PT: ASME Section III, Subsection NB, Article NB-5350

FW System for the extreme environmental temperature and the dose calculations are to the same as those for normal condition dose rates.

12.2.15.4 Extreme Environmental Temperature Corrective Action

There are no consequences of this accident that require corrective action.

12.2.16 100% Blockage of HI-TRAC VW Version V or V2 Air Vents

12.2.16.1 Cause of 100% Blockage of HI-TRAC VW Version V or V2 Air Vents

This event is defined as 100% blockage of air flow through the HI-TRAV VW Version V or V2 air vents. The inlet flow vents in the HI-TRAC are not discrete vent; rather they are radially symmetric passages. The outlet is an essentially an unhindered opening to ambient air above the cask. It is not credible to postulate that these passages can be entirely blocked; however, this event is evaluated as a defense in depth approach.

12.2.16.2 100% Blockage of HI-TRAC VW Version V or V2 Air Vents Analysis

The immediate consequence of a blockage of the air inlet and/or outlet openings is that the normal circulation of air for cooling the MPC is reduced. An amount of heat will continue to be removed by localized air circulation patterns in the overpack annulus, and the MPC will continue to radiate heat to the relatively cooler transfer cask. As the temperatures of the MPC and its contents rise, the rate of heat rejection will increase correspondingly. Under this condition, the temperatures of the HI-TRAC VW Version V or V2 transfer cask, the MPC and the stored fuel assemblies will rise as a function of time.

As a result of the considerable inertial of the TRANSFER CASK, a significant temperature rise is possible if the inlets are substantially blocked for extended durations. This accident condition is a short duration event that will be identified by the ISFSI staff, at worst, during scheduled periodic surveillance and corrected using the site’s ISFSI operating procedures. The TRANSFER CASK is not left unattended and any blockage is expected to be recognized within a short period of time.

i. Structural

There are no structural consequences as a result of this event.

ii. Thermal

A thermal analysis is performed in Subsection 4.6.2 to determine the effect of a complete blockage of all inlets for an extended duration. For this event, a significant temperature rise is possible if the inlet or outlet vents are substantially blocked for extended durations. For this event, both the fuel cladding and component temperatures remain below their accident temperature limits. The MPC internal pressure for this event is evaluated in Subsection 4.6.2 and is bounded by the design basis internal pressure for accident conditions (Table 2.2.1).

iii. Shielding

There is no effect on the shielding performance of the system as a result of this event, since the shielding component temperatures remain below their design accident limits provided in Table 2.2.3.

iv. Criticality

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

v. Confinement

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

vi. Radiation Protection

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

Based on the above evaluation, it is concluded that the 100% blockage of HI-TRAC VW Version V or V2 air inlets accident does not affect the safe operation of the HI-TRAC transfer casks, as the plant's emergency response process required to act to remove the blockage is the first priority activity.

12.2.16.3 100% Blockage of HI-TRAC VW Version V or V2 Air Inlets Dose Calculations

As shown in the analysis of the 100% blockage of air inlets accident, the shielding capabilities of the HI-TRAC VW Version V or V2 cask are unchanged because the shielding material's peak temperatures do not exceed its accident condition design temperature. The elevated temperatures will not cause the breach of the confinement system and the accident fuel cladding temperature limit is not exceeded. Therefore, there is no radiological impact.

12.2.16.4 100% Blockage of HI-TRAC VW Version V or V2 Air Vents Accident Corrective Action

Analysis of the 100% blockage of air inlet and/or outlet accident shows that the temperatures for cask system components and fuel cladding are within the accident temperature limits if the blockage is cleared within the maximum elapsed period between scheduled surveillance inspections. Upon detection of the complete blockage of the air vent openings, the plant owner shall activate its emergency response procedure to remove the blockage with mechanical and manual means as necessary. After clearing the cask openings, the cask shall be visually and radiologically inspected for any damage.

For an accident event that completely blocks the air vents for greater than the analyzed duration, a site-specific evaluation or analysis may be performed to whether adequate heat removal for the duration of the event would occur. Adequate heat removal is defined as the minimum rate of heat dissipation that ensures cladding temperatures limits are met and structural integrity of the MPC and overpack is not compromised. For those events where an evaluation or analysis is not performed or is not successful in showing that cladding temperatures remain below their short term temperature limits, the site's emergency plan shall include provisions to address removal of the material blocking the air inlet openings and to provide alternate means of cooling prior to exceeding the time when the fuel cladding temperature reaches its short-term temperature limit. Alternate means of cooling could include, for example, spraying water into the air outlet opening using pumps or fire-hoses or blowing air into the air outlet opening, to directly cool the MPC .

Table 13.1.1

HI-STORM FW SYSTEM CONTROLS

Condition to be Controlled	**Applicable Technical Specifications**†
Criticality Control	3.3.1 Boron Concentration
Confinement boundary integrity and integrity of cladding on undamaged fuel	3.1.1 Multi-Purpose Canister (MPC)
Shielding and radiological protection	3.1.1 Multi-Purpose Canister (MPC) 3.1.3 MPC Reflooding 3.2.1 TRANSFER CASK Surface Contamination 5.1 Radioactive Effluent Control Program 5.3 Radiation Protection Program
Heat removal capability	3.1.1 Multi-Purpose Canister (MPC) 3.1.2 SFSC Heat Removal System 3.1.4 TRANSFER CASK Heat Removal System
Structural integrity	5.2 Transport Evaluation Program

† Technical Specifications are located in Appendix A to the CoC. Authorized contents are specified in this FSAR in Subsection 2.1.8

Table 13.1.2

HI-STORM FW 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
3.0	LIMITING CONDITION FOR OPERATION (LCO) APPLICABILITY SURVEILLANCE REQUIREMENT (SR) APPLICABILITY
3.1	SFSC Integrity
3.1.1	Multi-Purpose Canister (MPC)
3.1.2	SFSC Heat Removal System
3.1.3	Fuel Cool-Down
3.1.4	TRANSFER CASK Heat Removal System
3.2	SFSC Radiation Protection
3.2.1	TRANSFER CASK Surface Contamination
3.3	SFSC Criticality Control
3.3.1	Boron Concentration
Table 3-1	MPC Cavity Drying Limits
Table 3-2	MPC Helium Backfill Limits
4.0	Not Used
5.0	ADMINSTRATIVE CONTROLS
5.1	Radioactive Effluent Control Program
5.2	Transport Evaluation Program
5.3	Radiation Protection Program

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B 3.1 SFSC Integrity

B 3.1.4 TRANSFER CASK Heat Removal System

BASES	
BACKGROUND	The HI-TRAC VW Version V or V2 Heat Removal System is a passive, air-cooled, convective heat transfer system that ensures heat from the MPC canister is transferred to the environs by the chimney effect. Relatively cool air is drawn into the annulus between the TRANSFER CASK and the MPC through the inlet air ducts. The MPC transfers its heat from the canister surface to the air via natural convection. The buoyancy created by the heating of the air creates a chimney effect and the air is forced back into the environs through the outlet air ducts at the top of the TRANSFER CASK.
APPLICABLE SAFETY ANALYSIS	The thermal analyses of the HI-TRAC VW Version V or V2 take credit for the decay heat from the spent fuel assemblies being ultimately transferred to the ambient environment surrounding the TRANSFER CASK. Transfer of heat away from the fuel assemblies ensures that the fuel cladding and other TRANSFER CASK component materials temperatures do not exceed applicable limits. Under normal storage conditions, the inlet and outlet air ducts are unobstructed and full air flow (i.e., maximum heat transfer for the given ambient temperature) occurs. Any blockage of the inlet air ducts reduces normal air cooling of the MPC. The MPC will continue to radiate heat to the relatively cooler TRANSFER CASK. With the reduction or loss of normal air cooling, the fuel temperature and TRANSFER CASK component materials temperatures will increase toward their respective short-term temperature limits. To prevent the fuel cladding from reaching temperature limits over the duration of the analyzed event, time limits for removal of the blockage are implemented with the LCO.

(continued)

BASES	
LCO	The HI-TRAC VW Version V or V2 Heat Removal System must be verified to be operable to preserve the assumptions of the thermal analyses. Operability is defined as 100% of the inlet and outlet air ducts available for air flow (i.e., unblocked). Operability of the heat removal system ensures that the decay heat generated by the stored fuel assemblies is transferred to the environs at a sufficient rate to maintain fuel cladding and other TRANSFER CASK component materials temperatures within design limits. The intent of this LCO is to address air duct blockage that can be reasonably anticipated to occur. (i.e., Design Event I and II class events per ANSI/ANS-57.9). These events are of the type where corrective actions can usually be accomplished within one 8-hour operating shift to restore the heat removal system to operable status (e.g., removal of loose debris). This LCO is not intended to address low frequency, unexpected Design Event III and IV class events (ANSI/ANS-57.9) such as design basis accidents and extreme environmental phenomena that could potentially block one or more of the air ducts for an extended period of time (i.e., longer than the total Completion Time of the LCO). This class of events is addressed site-specifically as required by Section 3.4.10 of Appendix B to the CoC.
APPLICABILITY	The LCO is applicable when a loaded MPC is in the HI-TRAC VW Version V or V2 TRANSFER CASK and MPC drying operations have completed. Once drying operations of a loaded MPC have completed, the TRANSFER CASK heat removal system must be operable to ensure adequate dissipation of the decay heat from the fuel assemblies.
ACTIONS	A note has been added to the ACTIONS which states that, Transfer of the MPC out of the TRANSFER CASK and into an OVERPACK is permitted with the TRANSFER CASK heat removal system inoperable.

(continued)

BASES

ACTIONS (continued)

A.1

The heat removal system is inoperable. The blockage should be cleared within 6 hours to remove the obstructions in the air flow path and maintain fuel temperature and TRANSFER CASK component materials temperatures within design limits. The Completion Time is consistent with the thermal analyses of this event, which show that fuel temperature and all TRANSFER CASK component materials temperatures remain below their temperature limits up to 6 hours after event initiation.

A.2

If the heat removal system blockage can not be cleared within the allowable completion time or if the site chooses, a site-specific evaluation can be completed to verify fuel cladding temperature limits and TRANSFER CASK component materials temperature limits are met. This calculation can be used to extend the completion time to clear the TRANSFER CASK blockage.

B.1

If the heat removal system cannot be restored to operable status within the 8 hours, the fuel or the TRANSFER CASK materials, may experience elevated temperatures. The fuel temperature limits are not expected to be exceeded; however, the TRANSFER CASK component materials temperature limits may be exceeded with the heat removal system inoperable. Efforts must continue to restore the heat removal system to operable status by removing the air flow obstructions.

B.2

In addition to Required Action B.1, Supplemental Cooling to the TRANSFER CASK may be provided to protect the integrity of the TRANSFER CASK component materials. If the completion time has been exceeded, an engineering evaluation must be performed to determine if deterioration of the TRANSFER CASK component materials, which prevents it from performing its design function has occurred. If the evaluation is successful and the air flow obstructions have been cleared, the TRANSFER CASK heat removal system may be considered operable.

Transfer of the MPC into an OVERPACK removes the TRANSFER CASK from the LCO Applicability.

BASES

SURVEILLANCE REQUIREMENTS	SR 3.1.4 The short-term integrity of the fuel in the HI-TRAC VW Version V or V2 is dependent on the ability of the TRANSFER CASK to reject heat from the MPC to the environment. Visual observation of all inlet and outlet air ducts are unobstructed ensures that air flow past the MPC is occurring and heat transfer is taking place. Any amount of blockage renders the heat removal system inoperable and this LCO is not met. The Frequency of 4 hours is reasonable, based on the time necessary for fuel cladding and TRANSFER CASK components to heat up to unacceptable temperatures, assuming design basis heat loads, and allowing for corrective actions to take place upon discovery of blockage of air ducts.
REFERENCES	1. FSAR Chapter 4 2. ANSI/ANS 57.9-1992