CHAPTER 5: INSTALLATION AND STRUCTURAL EVALUATION*

5.0 INTRODUCTION

The HI-STORE CIS facility utilizes the subterranean canister storage system referred to as HI-STORM UMAX certified in NRC Docket #72-1040 [1.0.6]. As the safety determination in this chapter shows, from the structural standpoint, the HI-STORM UMAX design can be adopted in its entirety from its native docket for the HI-STORE CIS facility without the need for any modification. The basis for this adoption, as elaborated in this chapter, is supported by the existing structural qualifications of the HI-STORM UMAX system that have been previously reviewed by the NRC and which *uniformly* bound all HI-STORE CIS site-specific loadings.

However, while the safety analyses for HI-STORM UMAX can be adopted for HI-STORE, that is not the case for the ancillary systems, structures and components (SSCs) needed to operate the facility. These ancillaries are listed and their operational roles are summarized in Subsection 1.2.7. In this chapter, the structural safety qualification of each ancillary envisaged to be used at HI-STORE CIS, showing its compliance with its Design Criteria (presented in Chapter 4), is documented. The computed design margin for the ancillary SSCs under their respective design basis loads along with the safety analyses in the HI-STORM UMAX FSAR for the certified storage system underpins the safety case for the HI-STORE site.

The HI-STORM UMAX system as licensed in Docket # 72-1040 allows for a variable depth canister storage cavity to accommodate canisters of different heights. At the HI-STORE CIS site, all the storage cavities will be built to the same fixed depth, which is within the design limits of the licensed HI-STORM UMAX system. The structural qualification of HI-STORM UMAX in Docket # 72-1040 is based on the tallest and heaviest MPC-37 canisters (South Texas) because they define the bounding inertia loads. The Licensing Drawings in Section 1.5 of this SAR contain the depictions of the fixed depth HI-STORM UMAX cavity adapted from Docket #72-1040. For structural purposes, the deepest cavity to store the longest and heaviest canister defines the governing configuration. In Table 5.0.1, a comparison of the Design Basis Loads (DBLs) in its generic FSAR [1.0.6] and their site specific loading counterparts is presented to demonstrate that the Design Basis structural loads bound the site specific loads (SSLs) *in every instance*. Therefore, fresh qualifying analyses for the storage system at the HI-STORE installation, in addition to those in [5.4.7], are not necessary.

The bounding weights for the various dry cask storage components and ancillary equipment used at the HI-STORE CIS facility are listed in Table 5.0.2.

Finally, to facilitate convenient access to the referenced material, a list of sections germane to this chapter is provided in a tabular form. Table 5.0.3 provides a listing of the material adopted in this chapter by reference from other licensed dockets.

* All references are placed within square brackets in this report and are compiled in Chapter 19 of this report.

Table 5.0.1: Comparison of DBLs for HI-STORM UMAX System and Site-Specific Loads for HI-STORE CIS Facility		
Load Category	Design Basis Value	Site-Specific Value
Earthquake	Top of the Grade (Ground surface) spectra per Figure 2.4.1 of [1.0.6] with horizontal ZPA, a_H, and vertical ZPA, a_V scaled as follows: $a_H = 1.0g$ $a_V = 0.75g$ and foundation surface pad spectra per Figure 2.4.2 of [1.0.6] with horizontal ZPA, a_H, and vertical ZPA, a_V of: $a_H = 0.93g$ $a_V = 0.71g$	Top of the Grade spectra corresponding to 5% damped RG 1.60 earthquake [4.3.2] scaled to 0.25g (bounding) in three orthogonal directions (see Table 4.3.3)
Tornado	Per Table 2.3.4 of [1.0.6]	Consistent with NRC Regulatory Guide 1.76 [2.7.1], ANSI 57.9 [2.7.2], and ASCE 7-05 [4.6.1]
Flood	Floodwater depth of 125 feet.	Floodwater depth less than 1 foot
Snow Load	100 psf	See Chapter 2

Table 5.0.2: Bounding Weights for Cask Components and Ancillary Equipment	
Component	Bounding Weight, lbf
Loaded MPC	110,000
HI-TRAC CS Transfer Cask - Empty - Loaded with MPC	(b)(4)
HI-STAR 190 Transport Cask - Empty w/o Impact Limiters - Loaded w/o Impact Limiters - Loaded w/ Impact Limiters	 261,000 371,000 414,800
HI-TRAC CS Lift Yoke	(b)(4)
Transport Cask Lift Yoke	
Transport Cask Horizontal Lift Beam	
Transport Cask Tilt Frame	
MPC Lift Attachment	
MPC Lifting Device Extension	
HI-TRAC CS Lift Links (set of 2)	
VCT	

Notes:
1) All structural analyses presented in Chapter 5 use the bounding weights per this table as input. Higher values may be used for additional conservatism.
2) Assumed based on standard tracked crawler design used at various nuclear plants in U.S.

Table 5.0.3: Material Incorporated by Reference in this Chapter

Information Incorporated by Reference	Source of the Information	Location in this SAR where Material is Incorporated	Technical Justification of Applicability to HI-STORM UMAX at HI-STORE CIS
MPC-37 and MPC-89 Structural Evaluation	Section 3.4 HI-STORM FW FSAR [1.3.7]	Subsection 5.1.4	The canister is identical to the one described in the HI-STORM FW FSAR and originally approved in the referenced FSAR.
HI-STORM UMAX ISFSI Pad and SFP Structural Evaluation	Paragraph 3.4.4.1 HI-STORM UMAX FSAR [1.0.6]	Paragraph 5.3.1.4	The ISFSI Pad and SFP are identical to that described in HI-STORM UMAX FSAR and originally approved in the referenced FSAR. Also, the Design Basis Loads for the HI-STORM UMAX bound the site-specific loads applicable to the HI-STORE site as shown in Table 5.0.1.
HI-STORM UMAX VVM Structural Evaluation	Paragraph 3.4.4.1 HI-STORM UMAX FSAR [1.0.6]	Paragraph 5.4.1.4	The HI-STORM UMAX VVM is identical to that described in HI-STORM UMAX FSAR and originally approved in the referenced FSAR. Also, the Design Basis Loads for the HI-STORM UMAX bound the site-specific loads applicable to the HI-STORE site as shown in Table 5.0.1.

5.1 CONFINEMENT STRUCTURES, SYSTEMS, AND COMPONENTS

The only confinement SSC that is utilized at the HI-STORE CIS facility is the Multi-Purpose Canister (MPC). There are two types of MPCs that are permitted to be stored at the HI-STORE site, namely MPC-37 and MPC-89, both of which have been previously licensed by the NRC as part of the HI-STORM FW dry storage system (Docket # 72-1032). The structural design basis for MPC-37 and MPC-89, which are used to store PWR and BWR fuel, respectively, are described in complete detail in Chapters 2 and 3 of the HI-STORM FW FSAR [1.3.7]. A brief summary of their structural design basis is provided below.

5.1.1 Description of Structural Design

The MPC enclosure vessels are cylindrical weldments with identical and fixed outside diameters. Each MPC is an assembly consisting of a honeycomb fuel basket, a baseplate, a canister shell, a lid, and a closure ring. The number of SNF storage locations in an MPC depends on the type of fuel assembly (PWR or BWR) to be stored in it. The required characteristics of the fuel assemblies to be stored in the MPC are limited in accordance with Section 4.1 of the SAR.

The MPC enclosure vessel is a fully welded enclosure, which provides the confinement for the stored fuel and radioactive material. The MPC baseplate and shell are made of stainless steel. The lid is a two-piece construction, with the top structural portion made of Alloy X. The confinement boundary is defined by the MPC baseplate, shell, lid, port covers, and closure ring. Drawings for the MPCs are provided in Section 1.5.

The MPC-37 and MPC-89 fuel baskets are assembled using interlocking Metamic-HT panels, as shown in the Licensing Drawings in Section 1.5.

5.1.2 Design Criteria

The MPC is classified as important-to-safety. The MPC structural components include the fuel basket and the enclosure vessel. The MPC enclosure vessel is designed and fabricated as a Class 1 pressure vessel in accordance with Section III, Subsection NB of the ASME Code, with certain necessary alternatives, as discussed in Section 2.2 of [1.3.7]. The MPC fuel basket is a non-Code

Compliance with the ASME Code, with respect to the design and fabrication of the MPC, and the associated justification are discussed in Section 2.2 of [1.3.7]. The MPC design is analyzed for all design basis normal, off-normal, and postulated accident conditions, as defined in Section 2.2 of [1.3.7], which bound the conditions at the HI-STORE site.

5.1.3 Material Properties

The MPC shell, baseplate and lid are made of stainless steel (Alloy X, see Appendix 1.A of [1.3.7]). The properties for Alloy X are listed in Table 3.3.1 of the HI-STORM FW FSAR [1.3.7]. The minimum strength properties for Metamic-HT, which is used to fabricate the fuel baskets, are provided in Table 1.2.8 of the HI-STORM FW FSAR [1.3.7].

5.1.4 Structural Analyses

The structural analyses for the MPC for all design basis normal, off-normal, and postulated accident conditions are documented in Chapter 3 of the HI-STORM FW FSAR [1.3.7] and further supplemented by the seismic response analysis of the MPC inside the HI-STORM UMAX presented in Subparagraph 3.4.4.1.2 of the HI-STORM UMAX FSAR [1.0.6].

The fatigue evaluations for the HI-STORM FW and HI-STORM UMAX Systems, which are found in Subsection 3.1.2.5 of their respective FSARs, remain valid for the proposed 40-year storage term at the HI-STORE CIS Facility. This is because the passive nature and the large thermal inertia of these storage systems protect the MPC enclosure vessel from significant stress cycling. In fact, the amplitude of the stress cycles is well below the endurance limit of the stainless steel MPC, which means that the MPC has infinite fatigue life under long-term storage conditions.

Moreover, as shown in Table 6.3.1 of the HI-STORE SAR, the maximum MPC heat loads and the ambient temperature conditions applicable to the HI-STORE CIS Facility are less demanding than the corresponding values for which the HI-STORM UMAX System is certified. This reduces stress amplitudes in the MPC at the HI-STORE CIS Facility and ensures that the ASME Code required fatigue evaluations that were originally performed for the UMAX and FW systems remain valid for 40 years of storage at the HI-STORE CIS Facility.

5.2 POOL AND POOL CONFINEMENT FACILITIES

There are no pools at the HI-STORE CIS facility.

5.3 REINFORCED CONCRETE STRUCTURES

The HI-STORE CIS facility includes the following reinforced concrete structures:

- HI-STORM UMAX ISFSI Pad and Support Foundation Pad (SFP)
- Cask Transfer Building (CTB) Slab
- Canister Transfer Facility (CTF) Foundation

Each of these components is discussed in more detail, including their description, design criteria, material properties, and structural analyses, in the following subsections.

5.3.1 HI-STORM UMAX ISFSI Pad and Support Foundation Pad

5.3.1.1 Description of Structural Design

The HI-STORM UMAX ISFSI pad and Support Foundation Pad (SFP) are integral parts of the HI-STORM UMAX underground dry storage system, which has already been licensed in accordance with 10CFR72 requirements under NRC Docket # 72-1040. As described in Section 1.2 of this SAR, the structural performance objectives for the ISFSI pad are to provide a riding surface for the cask transporter and to serve as a missile barrier. The SFP is the foundation mat for the HI-STORM UMAX structure, and it also serves as the resting surface for the VVM array. As shown on the Licensing Drawing in Section 1.5, the SFP is a continuous concrete pad of uniform thickness, whereas the ISFSI pad fills the interstitial space between the VVM at the top of grade level.

5.3.1.2 Design Criteria

The SFP and the ISFSI pad are categorized as important-to-safety (ITS) structures as indicated in Table 4.2.1. ACI 318-05 [5.3.1] is specified as the reference code for the design qualification of the SFP and the ISFSI pad using the load combinations specified in Table 2.4.3 of [1.0.6].

5.3.1.3 Material Properties

The ISFSI pad and SFP are reinforced concrete structures with their properties defined in Table 2.3.2 of the HI-STORM UMAX FSAR [1.0.6].

5.3.1.4 Structural Analysis

The seismic and structural qualification of the HI-STORM UMAX storage system, including the ISFSI pad and SFP, is performed in Chapter 3 of [1.0.6]. As shown in Table 5.0.1 above, the design basis loads analyzed in the HI-STORM UMAX FSAR completely bound the site-specific loads applicable to the HI-STORE site, and therefore no new structural analysis is required to qualify the ISFSI pad or the SFP for this application.

5.3.2 Cask Transfer Building Slab

5.3.2.1 Description of Structural Design

The Cask Transfer Building (CTB) slab is a reinforced concrete slab, which serves as the structural foundation for the railway and the CTB Crane, provides a riding surface for the VCT inside the CTB, and acts as laydown area for the HI-TRAC CS and other ancillary equipment. The general layout and key dimensions of the CTB slab are shown on the Licensing Drawing in Section 1.5.

5.3.2.2 Design Criteria

The structural design criteria for the CTB slab, including the governing load combinations, are provided in Subsection 4.6.2 of this SAR.

5.3.2.3 Material Properties

The material properties for the CTB slab are summarized in Table 5.3.1.

5.3.2.4 Structural Analysis

The analysis of the CTB slab is carried out using classical solutions for a slab on grade, which are obtained from [5.3.2], to determine the internal forces and moments acting on the CTB slab for the governing load combinations in Subsection 4.6.2.

The analysis of the slab considers the live loads associated with the freestanding HI-TRAC CS, the VCT, the CTB crane, the tilt frame (loaded with HI-STAR 190 with impact limiters), and the loaded rail car. The load acting on the CTB slab due to the CTB crane and the rail car are applied as concentrated forces at the wheel locations. The VCT load is applied as a uniform distributed pressure over the footprint area of its tracks/wheels. The load on the tilt frame assembly is also applied as a uniformly distributed pressure.

For the seismic load combination, the weight of each component (e.g., VCT) is amplified by the vertical ZPA for the Design Basis Earthquake (DBE), which is given in Table 4.3.3. The use of the ZPA value is justified since the DBE is a low-intensity earthquake that does not cause any of the above mentioned equipment to rock/uplift (i.e., no incipient tipping).

The calculated results for each load combination are compared with the ACI Code compliant section capacities to demonstrate the structural adequacy of the CTB slab. All calculated safety factors for the CTB slab are greater than 1.0 as shown in Table 5.3.2. The complete details of the CTB slab analysis are provided in the Structural Calculation Package [5.4.6].

5.3.3 Canister Transfer Facility Foundation

5.3.3.1 Description of Structural Design

The Canister Transfer Facility (CTF) is a below-ground structure used to carry out vertical MPC transfers from the transport cask to the HI-TRAC CS (or vice versa). The design enables a transport cask to be lowered into the CTF cavity (see Figure 3.1.1 (g)). With the transport cask in place, the HI-TRAC CS is then positioned above the CTF cavity opening and anchor bolts are installed to secure the HI-TRAC CS to the CTB slab at the CTF location, after which the MPC can be vertically lifted from the transport cask into the HI-TRAC CS using the VCT. The general layout and key dimensions of the CTF are shown on the Licensing Drawing in Section 1.5.

At the base of the CTF cavity is a reinforced concrete slab that acts as the supporting surface for the transport cask during transfer operations. This below-grade slab is referred to as the CTF foundation, and its construction is identical to the CTB slab with respect to thickness, strength, and reinforcement details.

5.3.3.2 Design Criteria

The design criteria for the CTF foundation, which is an ITS component, are the same as the criteria for the CTB slab, which are provided in Subsection 4.6.2.

5.3.3.3 Material Properties

The material properties for the CTF foundation are identical to those for the CTB slab, which are given in Table 5.3.1.

5.3.3.4 Structural Analysis

The results for the structural analysis of the CTB slab, which are discussed above in Paragraph 5.3.2.4, are also bounding for the CTF foundation for the following reasons:

a) The construction of the CTB slab and the CTF foundation are identical in terms of their thickness, reinforcement details, and minimum strength properties.

b) The bounding weight of a loaded HI-TRAC CS (which rests vertically on the CTB slab), used in the structural evaluation [5.4.6], is greater than the bounding weight of a loaded HI-STAR 190 transport cask without impact limiters (which rests vertically on CTF foundation). See Table 5.0.2 for bounding weight comparison.

c) The contact footprint of the HI-TRAC CS alignment shield ring is smaller than that of the HI-STAR 190 bottom forging. The outer diameter is nearly equal but the alignment shield ring is an annular ring whereas the HI-STAR 190 bottom forging is a solid cylinder.

Based on the above, the minimum calculated safety factor for the CTB slab given in Table 5.3.2 is also a lower bound safety factor for the CTF foundation.

Table 5.3.1: Material Properties for CTB Slab & CTF Foundation	
Description	Value
Min. concrete compressive strength	4,500 psi
Min. rebar yield strength	60 ksi
Rebar size and spacing	See Licensing Drawing

Table 5.3.2: Key Results of CTB Slab Analysis			
Item	Max. Demand	Capacity	Safety Factor
Bending moment in CTB slab (kip-ft)	14,680	28,679	1.95
Shear force in CTB slab (kip)	2,011	3,899	1.94
Bearing load on CTB slab (kip)	304	383	1.26
Punching shear in CTB slab (kip)	304	1,093	3.60
Notes: 1) Reported values are worst-case results from all three load combinations (see Subsection 4.6.2).			

5.4 OTHER SSCs IMPORTANT TO SAFETY

The HI-STORE CIS facility includes the following other SSCs that are classified as important to safety:

- HI-STORM UMAX Vertical Ventilated Module (VVM)
- HI-TRAC CS
- Cask Transfer Building Crane
- Transport Cask Lift Yoke
- MPC Lift Attachment
- Special Lifting Devices
- Cask Transfer Facility Steel Structure

Each of these components is discussed in more detail, including their description, design criteria, material properties, and structural analyses, in the following subsections.

5.4.1 HI-STORM UMAX VVM

5.4.1.1 Description of Structural Aspects

The HI-STORM UMAX VVM is a central component of the HI-STORM UMAX dry storage system, which has been previously licensed in accordance with 10CFR72 requirements under NRC Docket # 72-1040. The VVM provides for storage of the MPC in a vertical configuration inside a subterranean cylindrical cavity entirely below the top-of-grade (TOG) of the ISFSI pad. The VVM is comprised of the Cavity Enclosure Container (CEC) and the Closure Lid, which are both shown on the Licensing Drawing in Section 1.5. A full description of the VVM, including its subcomponents, is provided in Section 1.2 of the HI-STORM UMAX FSAR [1.0.6]. The HI-STORM UMAX VVM is licensed as a variable height system in [1.0.6]. For the HI-STORE CIS facility, however, there will be one uniform depth for all VVMs as shown on the Licensing Drawing in Section 1.5. The HI-STORM UMAX FSAR also provides for multiple design options with respect to the seismic restraints and the closure lid design. The specific set of options selected for the HI-STORE CIS facility are shown on the Licensing Drawing in Section 1.5. This design variant of the HI-STORM UMAX, which is to be deployed at the HI-STORE CIS facility, is referred to as the HI-STORM UMAX Version C.

5.4.1.2 Design Criteria

To serve its intended function, the HI-STORM UMAX VVM, including the CEC and Closure Lid, shall ensure physical protection, biological shielding, and allow the retrieval of the MPC under all conditions of storage (10 CFR 72.122(l)). Because the VVM is an in-ground structure, drops and tip-over of the VVM are not credible events and, therefore, do not warrant analysis. The design bases and criteria for the VVM are fully defined in Chapter 2 of the HI-STORM UMAX FSAR [1.0.6]. The load cases germane to establishing the structural adequacy of the VVM pursuant to 10 CFR 72.24(c) are compiled in Table 2.4.1 of [1.0.6].

5.4.1.3 Material Properties

The material properties for the VVM are provided in Section 3.3 of the HI-STORM UMAX FSAR [1.0.6] in conjunction with the Licensing Drawing in Section 1.5.

5.4.1.4 Structural Analysis

The design basis structural analyses for the VVM for all applicable normal, off-normal, and accident loadings are presented in Chapter 3 of the HI-STORM UMAX FSAR [1.0.6]. As shown in Table 5.0.1 above, the design basis loads analyzed in the HI-STORM UMAX FSAR completely bound the site-specific loads applicable to the HI-STORE site, and therefore minimal structural analyses are required to qualify the VVM for this application.

The only loading event for the VVM that is not generically analyzed in the HI-STORM UMAX FSAR is a postulated earthquake during MPC transfer operations at the VVM, wherein the HI-TRAC CS is vertically stacked on top of the VVM and securely fastened in place at four anchor bolt locations. The analysis of this stack-up configuration is performed herein using the time history analysis method implemented in LS-DYNA [5.4.2]. The finite element model used for this analysis is shown in Figure 5.4.1.

(b)(4)

5.4.2 HI-TRAC CS

5.4.2.1 Description of Structural Aspects

The HI-TRAC CS is a steel and concrete transfer cask, which is used for all on-site canister transfers. It has a cylindrical body delimited by carbon steel inner and outer shells with densified concrete occupying the space between the shells. The HI-TRAC CS has two trunnions near the top of the cask for lifting, and two rotation trunnions near its base for upending (or down ending) the cask. The bottom lid of the HI-TRAC CS, which is also referred to as the shield gate, is split into two halves such that they can be slid open in a symmetric manner to allow the MPC to pass through the opening (see Figure 1.2.3a). A complete description of the HI-TRAC CS is provided in Subsection 1.2.4.

5.4.2.2 Design Criteria

The design criteria for the HI-TRAC CS, which is an ITS component, are fully provided in Subsection 4.3.3.

The structural steel components of the HI-TRAC CS are designed to meet the stress limits of Section III, Subsection NF of the ASME Code [4.5.1] for all operating modes. The embedded trunnions for lifting and handling of the transfer cask are designed in accordance with the requirements of NUREG-0612 [1.2.7] for interfacing lift points.

Table 4.3.4 lists the loading scenarios for HI-TRAC CS for which its structural qualification must be performed.

5.4.2.3 Material Properties

The fabrication materials for the HI-TRAC CS are the same as those for the HI-STORM FW and the HI-TRAC VW. Therefore, the material properties for the HI-TRAC CS can be obtained from the summary tables in Section 3.3 of the HI-STORM FW FSAR [1.3.7], which are sourced from the Section II, Part D of ASME Code [4.6.3].

5.4.2.4 Structural Analysis

The loads on the HI-TRAC CS that are structurally significant are listed in Table 4.3.4, and the structural analysis for each of these loads is described below.

5.4.2.4.1 Lifting Analysis

(b)(4)

(b)(4)

The results for the above lifting analyses are summarized in Table 5.4.2, which shows that all calculated stresses are less than their applicable stress limits. The complete details of the HI-TRAC CS lifting analysis are provided in the Structural Calculation Package [5.4.6].

5.4.2.4.2 Seismic Analysis at CTF

The seismic analysis of the HI-TRAC CS while it is mounted atop a HI-STORM UMAX VVM is discussed in Subsection 5.4.1.4, and the results are summarized in Table 5.4.1. The anchorage design used to secure the HI-TRAC CS to the CTF is the same design used to anchor the HI-TRAC CS at a HI-STORM UMAX VVM location. The only difference between stack-up configurations at the CTF versus the HI-STORM UMAX VVM is the anchor bolts used to secure the HI-TRAC CS are longer for the latter configuration. The longer free length of the bolts introduces more flexibility into the system, which in turn may lead to larger rocking displacements and internal loads acting on the stack under seismic conditions. In light of this, plus the fact that the stack-up analysis for the HI-STORM UMAX VVM is conservatively performed using the most limiting earthquake condition (i.e., DECE), the results for the HI-TRAC CS in Table 5.4.1 are also bounding for the stack-up configuration at the CTF.

5.4.2.4.3 Tornado Missile Analysis

When the HI-TRAC CS is in use at the HI-STORE site, it is potentially exposed to tornado generated missiles. Although the threat of a tornado is relatively low at the HI-STORE site (see Section 2.3), the HI-TRAC CS is conservatively analyzed for the same tornado missiles as previously analyzed for the HI-STORM FW system and the HI-STORM UMAX system. These bounding tornado missiles are listed in Table 2.7.2.

(b)(4)

The complete details of the tornado missile analysis are provided in the Structural Calculation Package [5.4.6].

5.4.2.4.4 Seismic Stability Analysis of Freestanding HI-TRAC CS

The general stability of a freestanding HI-TRAC CS (empty and fully loaded) under the SSE is evaluated for the possibility of incipient tipping and sliding, where simple dynamic equations are formulated based on force and moment equilibrium. Table 5.4.7 summarizes both the bounding parameters used as input to the seismic stability analysis and the results. As seen from the table, the cask does not uplift or slide under the SSE event. A similar analysis has also been performed for the HI-STAR 190, and the results are likewise summarized in Table 5.4.7.

5.4.2.4.5 CTB Collapse Analysis

As discussed in Section 4.6.1, the walls and roof structure of the CTB are designed to meet the requirements of IBC [4.6.4] and ASCE 7-10 [4.6.2], and they are designated as not important to safety (NITS). This means that they are not designed to withstand seismic or tornado loads. Therefore, HI-TRAC CS (as well as HI-STAR 190) has been structurally analyzed to evaluate the damage due to a potential building collapse. (b)(4)

(b)(4)

The complete details of the CTB collapse analysis are provided in the Structural Calculation Package [5.4.6].

5.4.2.4.6 Fatigue Evaluation

The HI-TRAC CS will be used repeatedly at the HI-STORE CIS facility to transfer canisters from arriving transport casks to VVM storage cavities. As a result, the HI-TRAC CS will be subject to both thermal and mechanical cyclic loading, which must be evaluated from a fatigue life standpoint. A fatigue life evaluation for all load bearing members of HI-TRAC CS has been performed in [5.4.6], and the results are presented in Table 5.4.8. The maximum stress in the trunnions is conservatively set at the allowable stress limit per [1.2.7] times a stress concentration factor of 4.0 for the material. The use of stress concentration factor of 4.0 is consistent with HI-STAR 100 SAR [1.3.5]. The maximum stress in all other load bearing members of HI-TRAC CS, designed to stress limits in [4.5.1], is conservatively set at the ultimate strength of the material. The fatigue life of all load bearing materials is calculated by comparing the maximum stress value with the material cycle life curves defined in Appendix I of ASME Code [17.3.2]. A safety factor of 2.0 on the permissible loading cycles is imposed for additional conservatism per Subsection 4.5.3.9.

5.4.3 Cask Transfer Building Crane

5.4.3.1 Description of Structural Aspects

The Cask Transfer Building (CTB) Crane consists of a gantry crane, trolley, and hoist(s). The CTB Crane is electrically driven and rides on crane rails, which are mounted to the CTB slab in the Cask Receiving Area. The trolley rides on crane rails mounted to the top of the crane girders and has at least one electric wire rope hoist for load lifting. The hoist hook will be used to lift various loads and shall interface with the required rigging and below the hook lifting devices as required for the process. Figure 3.1.1 (b-c) is an illustration of the CTB Crane loading/unloading a transport package to/from a transport vehicle.

5.4.3.2 Design Criteria

The CTB Crane shall be a single failure proof load handling device designed and built in accordance with the provisions of ASME NOG-1 [3.0.1]. The design criteria and operational requirements for the CTB Crane are further discussed in Subsection 4.5.2 of this SAR.

The applicable Design Basis loadings on the CTB Crane are set down in Table 4.5.1.

5.4.3.3 Structural Analysis

The structural analysis of the CTB Crane shall demonstrate compliance with the applicable requirements of ASME NOG-1 for the specified loadings in Table 4.5.1.

5.4.4 Transport Cask Lift Yoke

5.4.4.1 Description of Structural Aspects

The Transport Cask Lifting Device is used to lift the HI-STAR 190 transport cask inside the CTB. As shown on the Licensing Drawing in Section 1.5, the Transport Cask Lifting Device has two lift arms that connect to the pair of lifting trunnions on the HI-STAR 190 and a main strongback assembly that connects to the CTB Crane hook.

5.4.4.2 Design Criteria

The design criteria that apply to lifting devices are fully described in Section 4.5. The Transport Cask Lift Yoke is a non-redundant special lifting device, which is designed to meet the increased safety factors per ANSI N14.6 [1.2.4].

5.4.4.3 Material Properties

As shown on the Licensing Drawing in Section 1.5, the major structural components of the Transport Cask Lift Yoke are the strongback plates, the lift arms, the actuator plates, the main pins, and the actuator pins. The strongback plates, lift arms, and actuator plates are fabricated from high-strength alloy steel (A514 or equivalent). The main pins and actuator pins are fabricated from hardened nickel alloy bar material (SB-637 N07718). The minimum strength properties for these components are obtained directly from the applicable ASTM specification or from Section II, Part D of the ASME Code [4.6.3], and they are summarized in Table 5.4.10.

5.4.4.4 Structural Analysis

The load bearing members of the Transport Cask Lift Yoke are analyzed using a combination of formulae from ASME BTH-1 [5.4.3] and strength of materials principles. The lifted load considered in the analysis is equal to the bounding weight of the loaded HI-STAR 190 transport cask from Table 5.0.2. The lifted load and the self-weight of the lifting device are further amplified by 15% to account for dynamic effects in accordance with the guidance in CMAA-70 [4.5.2] for low speed lifts. The results of the structural analysis for the Transport Cask Lift Yoke are summarized in Table 5.4.4, which shows that all calculated safety factors are greater than 1.0. The complete details of the structural analysis of the Transport Cask Lift Yoke are provided in the Structural Calculation Package [5.4.6].

5.4.5 MPC Lift Attachment

5.4.5.1 Description of Structural Aspects

The MPC Lift Attachment is a one-piece lifting device (or lug) that is bolted directly to threaded anchor locations on the top surface of the MPC closure lid using a total of eight bolts (see Licensing Drawing in Section 1.5). The MPC Lift Attachment allows raising or lowering of the MPC during canister transfer operations using either the CTB Crane or the VCT.

5.4.5.2 Design Criteria

The design criteria that apply to lifting devices are fully described in Section 4.5. The MPC Lift Attachment is a non-redundant special lifting device, which is designed to meet the increased safety factors per ANSI N14.6 [1.2.4].

5.4.5.3 Material Properties

As described above, the MPC Lift Attachment consists of the lifting lug and eight attachment bolts. The lifting lug is fabricated from an alloy steel forging (A336-F6NM). The attachment bolts are fabricated from hardened nickel alloy bar material (SB-637 N07718). The minimum strength properties for these components are obtained directly from the applicable ASTM specification or from Section II, Part D of the ASME Code [4.6.3], and they are summarized in Table 5.4.10.

5.4.5.4 Structural Analysis

The load bearing members of the MPC Lift Attachment are analyzed using strength of materials principles together with formulae from ASME BTH-1 [5.4.3]. The lifted load considered in the analysis is equal to the bounding weight of a loaded MPC from Table 5.0.2. The lifted load and the self-weight of the lifting device are further amplified by 15% to account for dynamic effects in accordance with the guidance in CMAA-70 [4.5.2] for low speed lifts. The results of the structural analysis for the MPC Lift Attachment are summarized in Table 5.4.5, which shows that all calculated safety factors are greater than 1.0. The complete details of the structural analysis of the MPC Lift Attachment are provided in the Structural Calculation Package [5.4.6].

5.4.6 Other Special Lifting Devices

5.4.6.1 Description of Structural Aspects

In addition to the Transport Cask Lift Yoke and MPC Lift Attachment discussed in the preceding subsections, there are other special lifting devices that will be used to connect the cask or canister to the CTB Crane or VCT at the HI-STORE CIS facility. These other special lifting devices include:

- HI-TRAC CS Lift Yoke
- HI-TRAC CS Lift Link
- Transport Cask Horizontal Lift Beam
- MPC Lifting Device Extension

All special lifting devices that will be used at the HI-STORE CIS facility are shown on the Licensing Drawings in Section 1.5.

5.4.6.2 Design Criteria

The design criteria that apply to lifting devices are fully described in Section 4.5. Special lifting devices are designed to meet the increased safety factors per ANSI N14.6 [1.2.4].

5.4.6.3 Material Properties

The fabrication materials for the special lifting devices listed above are specified on the Licensing Drawings in Section 1.5. The minimum strength properties for these materials are obtained directly from the applicable ASTM specification or from Section II, Part D of the ASME Code [4.6.3] in accordance with the Licensing Drawings. The strength properties used to support the structural evaluations for the special lifting devices are summarized in Table 5.4.10.

5.4.6.4 Structural Analysis

5.4.6.4.1 Lifting Analysis

The load bearing members of special lifting devices are analyzed using a combination of methods, including the finite element approach, formulae from ASME BTH-1 [5.4.3], and strength of materials principles. The lifted loads considered in the analyses are equal to the bounding weights of the loaded HI-STAR 190 transport cask, the loaded MPC, or the loaded HI-TRAC CS from Table 5.0.2, as applicable. The lifted load and the self-weight of the lifting device are further amplified by 15% to account for dynamic effects in accordance with the guidance in CMAA-70 [4.5.2] for low speed lifts. The minimum calculated safety factors for the special lifting devices, other than the Transport Cask Lift Yoke and the MPC Lift Attachment, are summarized in Table 5.4.6. The complete details of the structural analysis of the special lifting devices are provided in the Structural Calculation Package [5.4.6].

5.4.6.4.2 Fatigue Evaluation

The special lifting devices will be used repeatedly at the HI-STORE CIS facility to transfer canisters from arriving transport casks to VVM storage cavities. As a result, the special lifting devices will be subject to both thermal and mechanical cyclic loading, which must be evaluated from a fatigue life standpoint. A fatigue life evaluation for all special lifting devices has been performed in [5.4.6], and the results are presented in Table 5.4.9. The maximum stress in the special lifting devices is conservatively set at the allowable stress limit per [1.2.4] times a stress concentration factor of 4.0 for the material. The use of stress concentration factor of 4.0 is consistent with HI-STAR 100 SAR [1.3.5]. The fatigue life of all load bearing materials is calculated by comparing the maximum stress value with the material cycle life curves defined in Appendix I of ASME Code [17.3.2]. A safety factor of 2.0 on the permissible loading cycles is imposed for additional conservatism per Subsection 4.5.3.9.

5.4.7 Cask Transfer Facility Steel Structure

5.4.7.1 Description of Structural Aspects

A general description of the Cask Transfer Facility (CTF) is provided in Subsection 5.3.3.1. The steel components essentially serve as concrete forms during initial construction of the CTF. The CTF steel structure is also equipped with four threaded anchor blocks, as shown on the Licensing Drawing in Section 1.5, which are used to secure the HI-TRAC CS above the CTF cavity during MPC transfer operations.

5.4.7.2 Design Criteria

The structural steel components of the CTF are designed to meet the stress limits of Section III, Subsection NF of the ASME Code [4.5.1] for all operating modes.

5.4.7.3 Material Properties

The fabrication materials for the CTF steel structure are specified on the Licensing Drawing in Section 1.5. The minimum strength properties for these materials are obtained directly from the applicable ASTM specification or from Section II, Part D of the ASME Code [4.6.3].

5.4.7.4 Structural Analysis

Under normal operating conditions, the loads on the CTF steel structure are minimal since the dead and live loads are supported by the CTB floor slab and the CTF foundation slab. The carbon steel shell and base plate that define the CTF cavity space merely act as shim plates and transfer the loads from the Transport Cask to the underlying concrete via direct thru-wall compression.

The most limiting load condition for the CTF steel structure is the accident condition wherein the site design basis earthquake is postulated to occur while the loaded HI-TRAC CS is bolted to the CTF following MPC transfer operations, which is referred to as the stack-up configuration. The analysis of this accident event, which is referred to herein as the “stack-up” analysis, is fully discussed in Subsection 5.4.1.4, and the results of the analysis, including the loads on the CTF steel structure, are summarized in Table 5.4.1. All calculated safety factors are greater than 1.0.

Table 5.4.1: Key Results of Stack-up Analysis at HI-STORM UMAX VVM/CTF

(b)(4)

[redacted]

Table 5.4.2: Key Results of HI-TRAC CS Lifting Analysis

(b)(4)

Table 5.4.3: Key Results of Tornado Missile Analysis for HI-TRAC CS

(b)(4)

Table 5.4.4: Key Results of Structural Analysis for Transport Cask Lift Yoke

(b)(4)

Table 5.4.5: Key Results of Structural Analysis for MPC Lift Attachment

(b)(4)

Table 5.4.6: Minimum Calculated Safety Factors for Other Special Lifting Devices

(b)(4)

Table 5.4.7: Bounding Input Parameters and Final Results of HI-TRAC CS and HI-STAR 190 Seismic Stability Analyses

(b)(4)

Table 5.4.8: Fatigue Life of HI-TRAC CS	
Item	Maximum Number of Loading Cycles
Lifting Trunnions (SB-637 N07718)	8,000
Lifting Trunnions (SB-637 N07718)	7,500
Inner Shell, Outer Shell and Other Load Bearing Members	6,000

Table 5.4.9: Fatigue Life of Lifting Ancillaries	
Item	Maximum Number of Loading Cycles
HI-TRAC CS Lift Yoke	3,500
Transport Cask Lift Yoke	3,500
Horizontal Lift Beam for Transport Cask	3,500
MPC Lift Attachment	3,500
MPC Lift Attachment Connector	3,500
HI-TRAC CS Lift Links	70,000

Table 5.4.10: Mechanical Properties for Lifting Device Materials (Note 1)		
Temperature, °F	Yield Strength, ksi	Tensile Strength, ksi
	A514 (≤ 2.5" Thk.)	
200	95.5	110
300	92.5	110
400	88.75	110
	SB-637 N07718	
200	144	177.6
500	136.8	168.7
	A336-F6NM	
500	65.35	103.87
	Weldox 900E (Note 2)	
70	130 [120]	136 [123]
300	110.5 [102]	136 [123]
	A500 Grade B	
200	42.17	58
	A53 Grade B	
200	32.08	60

Notes:
1) All tabulated values are obtained from [5.4.6].
2) Strength properties are dependent on thickness of material. Values not shown in brackets ([]) are applicable to thicknesses less than or equal to 2 inches. Bracketed values are applicable to thicknesses greater than 2 inches.

(b)(4)

Figure 5.4.1: LS-DYNA Model of Stack-up Configuration at VVM

(b)(4)

Figure 5.4.2: Free Body Diagram of HI-TRAC CS Subject Tornado Wind and Large Missile Impact

(b)(4)

Figure 5.4.3: LS-DYNA Model of HI-TRAC CS for CTB Collapse Analysis

(b)(4)

Figure 5.4.4: Contour Plot of Plastic Strain in HI-TRAC CS due to CTB Collapse

(b)(4)

Figure 5.4.5: LS-DYNA Model of HI-STAR 190 for CTB Collapse Analysis

(b)(4)

Figure 5.4.6: Contour Plot of Plastic Strain in HI-STAR 190 due to CTB Collapse

5.5 OTHER SSCs

The HI-STORE CIS facility includes the following other SSCs:

- Transport Cask Tilt Frame
- Vertical Cask Transporter
- CTB Steel Structure

Each of these components is discussed in more detail, including their description, design criteria, material properties, and structural analyses, in the following subsections.

5.5.1 Transport Cask Tilt Frame

5.5.1.1 Description of Structural Aspects

The Transport Cask Tilt Frame is used in conjunction with the CTB Crane and its special lifting devices to upend or down end the HI-STAR 190 transport cask between the vertical and horizontal orientations. The Transport Cask Tilt Frame consists of a set of trunnion support stanchions and a cask support saddle. The trunnion support stanchions engage the cask's rotation trunnions and provide a low-friction rotation point for cask tilting (see Figures 3.1.1(c-f) for illustration). The cask support saddle contacts the upper portion of the cask when the cask reaches the horizontal orientation. The trunnion support stanchion assembly is bolted to the CTB slab at its base while in use.

5.5.1.2 Design Criteria

The Transport Cask Tilt Frame is not a lifting device since it is a stationary device that provides support to the cask from below. Also, during upending or down ending operations, the cask always remains connected to the single failure proof CTB Crane via a special lifting device. Therefore, the Cask Tilt Frame is an ITS component, which is designed accordingly to meet the stress limits per ASME Section III, Subsection NF [4.5.1] for Class 3 plate- and shell-type supports.

The staging of the HI-STAR 190, without impact limiters, on the Transport Cask Tilt Frame is a short-term operation, and therefore as discussed in Subsection 4.3.6, the Transport Cask Tilt Frame is seismic-exempt. In the event that the HI-STAR 190 must remain on Transport Cask Tilt Frame for an extended period of time (i.e., more than one shift), then the impact limiters shall be re-installed on the HI-STAR 190 cask.

5.5.1.3 Material Properties

As shown on the Licensing Drawing in Section 1.5, the Transport Cask Tilt Frame is fabricated from carbon steel material (SA-516 Gr. 70, A572, A500 Gr. B). The minimum strength properties for these materials are obtained directly from the applicable ASTM specification or from Section II, Part D of the ASME Code [4.6.3].

5.5.1.4 Structural Analysis

The Transport Cask Title Frame is analyzed using the finite element code ANSYS [5.5.1] and supplemented by manual calculations using strength of materials principles. (b)(4) [redacted]

(b)(4) [redacted]

The results of the structural analysis for the Transport Cask Tilt Frame are summarized in Table 5.5.1, which shows that all of the calculated safety factors are above 1.0. The complete details of the structural analysis of the Transport Cask Tilt Frame are provided in the Structural Calculation Package [5.4.6].

5.5.2 Vertical Cask Transporter

5.5.2.1 Description of Structural Aspects

The Vertical Cask Transporter (VCT) is the principal load handling device used for MPC transfer operations at the HI-STORE CIS. Used in conjunction with the HI-TRAC CS lift links, it provides the critical lifting and handling functions associated with the canister transfer operations. It is a custom-designed equipment consisting of a set of caterpillars or multiple wheels, a diesel engine with a robust gear train and transmission housed in a rugged structural frame that also supports a set of hydraulically-actuated lifting towers. Figure 1.2.4 illustrates the general configuration of a VCT. The VCT uses the same controls and redundant drop protection features used to prevent an unplanned lowering of the critical load under a loss-of-power or hydraulic system failure as used at other ISFSIs in the United States where the VCT is used in canister transfer operations.

5.5.2.2 Design Criteria

The design criteria that apply to lifting devices, including the VCT, are fully described in Section 4.5 of this SAR. The detailed criteria that govern the design of the VCT are set down in Subsection 4.5.3.

The Design Basis loadings on the VCT are given in Table 4.5.3.

5.5.2.3 Structural Analysis

The seismic stability of the VCT (unloaded and carrying empty or fully loaded HI-TRAC CS) under the most severe DECE loading is evaluated for the possibility of incipient tipping and sliding, where simple dynamic equations are formulated based on force and moment equilibrium.

(b)(4)

The stress analysis of the VCT shall demonstrate compliance with the structural design criteria in Subsection 4.5.3 for the specified loadings in Table 4.5.3. The stress analysis of the VCT can be performed via calculations using strength of materials principles, finite element analysis, or a combination thereof.

5.5.3 CTB Steel Structure

5.5.3.1 Description of Structural Aspects

The CTB is a conventional sheet metal building consisting of a thick load bearing concrete slab and a set of knee-high concrete walls, which support the steel frame that serves as the backbone for the building. Corrugated sheet metal panels are fastened to the steel frame to create the lateral enclosure system. An overhead truss provides the framework to support the roof, which is also made of corrugated sheet metal.

Since the CTB steel structure serves as a weather enclosure, and it does not serve any safety related function, it is designated as a NITS structure. Accordingly, the HI-TRAC CS and HI-STAR 190 are analyzed in Subparagraph 5.4.2.4.5 for a hypothetical building collapse.

5.5.3.2 Design Criteria

The design criteria for the CTB, including the concrete slab and the above ground steel structure, are provided in Subsection 4.6.1.

5.5.3.3 Structural Analysis

Table 4.6.1 provides loading data for designing the CTB walls and roof structure; this data shall be used, along with the specified design criteria, to carry out the strength calculations for the CTB steel structure.

Table 5.5.1: Key Results of Structural Analysis for Transport Cask Tilt Frame

(b)(4)

Table 5.5.2: Bounding Input Parameters and Final Results of VCT Seismic Stability Analysis

(b)(4)

(b)(4)

Figure 5.5.1: ANSYS Model of Transport Cask Tilt Frame

5.6 REGULATORY COMPLIANCE

The structural compliance pursuant to the provisions of NUREG-1567 [1.0.3] for deployment of canisters certified in the HI-STORM UMAX Docket # (72-1040) has been demonstrated in this chapter. As the canisters will arrive at the HI-STORE site loaded in the transport package, the Short Term Operations on the (dry) canisters to place them in the HI-STORM UMAX VVMs and their interim storage in the HI-STORM UMAX VVMs are the subjects of safety analysis in this chapter. The information presented in this chapter confirms that:

i. The description of confinement structures, systems and components, reinforced concrete structures, and other SSCs important to safety meet the requirements of 10CFR72.24(a) and (b), 10CFR72.82(c)(2), and 10CFR72.106(a), (b), and (c).

ii. Suitable material properties for use in the design and construction of the SSCs, reinforced concrete structures, and other SSCs important to safety meet the requirements of 10CFR 72.24(c)(3).

iii. The analytical and/or test reports ensuring the structural integrity of the SSCs, reinforced concrete structures, and other SSCs important to safety meet the requirements of 10CFR72.24 (d)(1), (d)(2), and (i), and 10CFR72.122 (b)(1), (b)(2), and (b)(3), (c), (d), (f), (g), (h), (i), (j), (k), and (l).

It is therefore concluded that all applicable regulatory requirements and guidelines germane to the integrity of the stored fuel and the HI-STORM UMAX storage system have been addressed and satisfied in this chapter.

CHAPTER 6: THERMAL EVALUATION*

6.0 INTRODUCTION

HI-STORM UMAX, certified in the USNRC docket # 72-1040 is an underground vertical ventilated system with openings for air ingress and egress and internal air flow passages for ventilation cooling of loaded MPC. The licensing drawing package for the HI-STORM UMAX applicable to the HI-STORE CIS facility is provided in Section 1.5. Thermal design requirements are presented in Chapter 4.

As stated in Chapter 4, the thermal evaluation in this chapter seeks to establish that the peak fuel cladding temperature in the canisters stored in the HI-STORE CIS facility will remain below the ISG-11 Rev 3 [4.0.1] limit. Another object of the safety demonstration is that under all short-term operations summarized in Subsection 3.1.4, the peak fuel cladding temperature limit set forth in ISG-11 Rev 3 will be satisfied with robust margins.

With respect to normal storage in the HI-STORM UMAX cavities at HI-STORE, it is recognized that the maximum heat load in any canister cannot exceed the limit in the transport cask that will be used to bring the canisters to the HI-STORE CIS site. As the heat removal capacity of the ventilated HI-STORM UMAX system is substantially in excess of the (unventilated) transport cask (viz., HI-STAR 190 [1.3.6]) that will be used to transport the canisters, the ISG-11 temperature limit under the normal, off-normal and accident conditions of storage is axiomatically satisfied.

The short term operations at the HI-STORE facility involve a new transfer cask, HI-TRAC CS, which is not certified in the HI-STORM UMAX docket. As described in Subsection 1.2.4, HI-TRAC CS utilizes high density concrete (in lieu of lead, water or Holtite) to achieve enhanced structural ruggedness and for an improved dose attenuation profile. Because HI-TRAC CS is not submerged in a pool, its heat dissipation capabilities are significantly better than other HI-TRAC models that are subject to pool submergence (and hence must have a hydraulically leak-proof joint at the bottom lid suppressing the option of convective cooling of the canister). The limiting thermal scenarios with the canister in HI-TRAC CS are considered in this chapter. As described in Chapter 3, the short term operations that are performed at HI-STORE also include transfer of canisters from transportation cask (HI-STAR 190) to the HI-TRAC CS transfer cask in the Canister Transfer Facility (CTF). This thermal scenario is also considered in this chapter.

Since the Design Basis heat load is significantly lower than that in HI-STORM UMAX Docket [1.0.6] (see Table 6.3.1), the safety analyses summarized in this chapter demonstrate rather large margins to the allowable limits under all operational modes. Minor changes to the design parameters that inevitably occur during the product's life cycle and are ascertained to have an insignificant effect on the computed safety factors may not prompt a formal reanalysis and revision of the results and associated data in the tables of this chapter unless the cumulative effect of all such unquantified changes on the reduction of any of the computed safety margins cannot be deemed to be insignificant. For purposes of this determination, unconditionally safe threshold (UST) is defined as an acceptance criterion set at the smaller of 25% of the safety

* All references are in placed within square brackets in this report and are compiled in Chapter 19 of this report.

margin to the limit or 10 deg. C. for all operational modes. To ensure rigorous configuration control, the information in the Licensing Drawings in Section 1.5 should be treated as the authoritative source for safety analysis at all times.

To facilitate convenient access to the material incorporated by reference, a list of sections germane to this chapter is provided in a tabular form in Table 6.0.1. Table 6.0.1 provides a listing of the material adopted in this chapter by reference from other licensed dockets.

Table 6.0.1: Material Incorporated by Reference in this Chapter

Information Incorporated by Reference	Source of the Information	Location in this SAR where Material is Incorporated	Technical Justification of Applicability to HI-STORM UMAX at HI-STORE CIS
Thermal Properties of materials in MPC, VVM and transfer cask	Section 4.2 of HI-STORM UMAX FSAR [1.0.6]	Subsection 6.4.1	Materials used in MPC, VVM and HI-TRAC CS transfer cask are the same as those used in HI-STORM UMAX FSAR and are therefore incorporated by reference.
MPC-37 and MPC-89 Thermal Model and Methodology	Subsection 4.4.1 of HI-STORM UMAX FSAR [1.0.6]	Paragraph 6.4.2.2	The canister is identical to the one described in the HI-STORM UMAX FSAR. So the approach, general assumptions and models established for MPCs in the HI-STORM UMAX FSAR are fully applicable to the HI-STORM UMAX utilized for HI-STORE facility. Therefore, the MPC thermal models are incorporated by reference.
HI-STORM UMAX VVM Thermal Model and Methodology	Subsection 4.4.1 of HI-STORM UMAX FSAR [1.0.6]	Paragraph 6.4.2.3	The HI-STORM UMAX VVM is identical to that described in the HI-STORM UMAX FSAR with minor differences in design details like it has two fixed cavity heights instead of variable cavity height. The thermal performance is unaffected for tallest MPC and improved for shortest MPC. Additional details of the differences and technical justification for the same are provided in Paragraph 6.4.2.3. So the approach, general assumptions and models established in the HI-STORM UMAX FSAR are fully applicable to the HI-STORM UMAX utilized for HI-STORE facility.

Information Incorporated by Reference	Source of the Information	Location in this SAR where Material is Incorporated	Technical Justification of Applicability to HI-STORM UMAX at HI-STORE CIS
Minimum Temperatures	Subsection 4.4.4 of HI-STORM UMAX FSAR [1.0.6]	Paragraph 6.4.3.3	The minimum ambient temperature is bounded by that specified in the HI-STORM UMAX FSAR [1.0.6]. Accordingly the low-service temperature evaluation presented in HI-STORM UMAX FSAR [1.0.6] is applicable to the HI-STORM UMAX evaluated in this SAR and is therefore incorporated by reference.
Engineered Clearances	Subsection 4.4.6 of HI-STORM UMAX FSAR [1.0.6]	Paragraph 6.4.3.4	As the fuel, component temperatures and MPC cavity pressure during long-term storage in Subsection 6.4.3 are bounded by that presented in Subsection 4.4.4(i) of HI-STORM UMAX FSAR [1.0.6], the differential thermal expansions presented in Subsection 4.4.6 of the HI-STORM UMAX FSAR [1.0.6] is bounding and is therefore incorporated by reference.
Evaluation of Sustained Wind	Subsection 4.4.9 of HI-STORM UMAX FSAR [1.0.6]	Paragraph 6.4.3.5	The HI-STORM UMAX design is the same as the one described in the HI-STORM UMAX FSAR [1.0.6]. The effect of sustained wind on cask arrays evaluated under a worst case co-incidence of wind direction and speed is applicable to the HI-STORM UMAX evaluated in this SAR and is therefore incorporated by reference.
Off-Normal Environment Temperature	Paragraph 4.6.1.1 of HI-STORM UMAX FSAR [1.0.6]	Sub-section 6.5.1	The off-normal ambient temperature at the site is bounded by that specified in the HI-STORM UMAX FSAR [1.0.6] (see Table 6.3.1). So the temperatures and MPC cavity pressures presented in

Information Incorporated by Reference	Source of the Information	Location in this SAR where Material is Incorporated	Technical Justification of Applicability to HI-STORM UMAX at HI-STORE CIS
			HI-STORM UMAX FSAR are bounding and are therefore incorporated by reference.
Partial Blockage of Air Inlets	Paragraph 4.6.1.2 of HI-STORM UMAX FSAR [1.0.6]	Sub-section 6.5.1	Since the decay heat, fuel, component temperatures and MPC cavity pressure during long-term storage in Subsection 6.4.3 are bounded by that presented in Subsection 4.4.4(i) of HI-STORM UMAX FSAR [1.0.6], this scenario presented in Paragraph 4.6.1.2 of the HI-STORM UMAX FSAR [1.0.6] is bounding and is therefore incorporated by reference.
Extreme Environment Temperature	Paragraph 4.6.2.2 of HI-STORM UMAX FSAR [1.0.6]	Paragraph 6.5.2.4	The extreme ambient temperature at the site is the bounded by that specified in the HI-STORM UMAX FSAR [1.0.6] (see Table 6.3.1). So the temperatures and MPC cavity pressures presented in HI-STORM UMAX FSAR are bounding and is therefore incorporated by reference.
100% Blockage of Air Inlets and Outlet	Paragraph 4.6.2.3 of HI-STORM UMAX FSAR [1.0.6]	Paragraph 6.5.2.5	Since the decay heat, fuel, component temperatures and MPC cavity pressure during long-term storage in Section 6.4.3 are bounded by that presented in Section 4.4 of HI-STORM UMAX FSAR [1.0.6], this scenario presented in Paragraph 4.6.2.3 of the HI-STORM UMAX FSAR [1.0.6] is bounding.

Information Incorporated by Reference	Source of the Information	Location in this SAR where Material is Incorporated	Technical Justification of Applicability to HI-STORM UMAX at HI-STORE CIS
Flood	Paragraph 4.6.2.5 of HI-STORM UMAX FSAR [1.0.6]	Paragraph 6.5.2.6	The Design Basis Flood used to qualify the VVM in the HI-STORM UMAX FSAR (up to 5 inch) exceeds the most severe projection of flood at the ELEA site (up to 4.8 inch (see Subsection 2.4.3). Therefore, flood evaluation presented in Paragraph 4.6.2.5 of HI-STORM UMAX FSAR [1.0.6] is bounding and is therefore incorporated by reference.

6.1 DECAY HEAT REMOVAL SYSTEMS

Rejection of heat from the used nuclear fuel at the HI-STORE CIS facility occurs through three types of casks, namely:

i. The HI-STAR 190 transport cask

ii. The HI-TRAC CS transfer cask

iii. The HI-STORM UMAX vertical ventilated module

The heat dissipation mechanisms in each of the above cask systems are summarized below:

(i) The HI-STAR 190 transport cask: The HI-STAR 190 transport cask is used only during the short term operations at the HI-STORE site. The HI-STAR 190 transport cask, illustrated in Figure 6.4.1, is a metal cask whose safety analysis is summarized in the SAR [1.3.6] in NRC Docket# 71-9373. HI-STAR rejects the decay heat produced by its contents through natural convection from its external surface and by radiation. In its standard transport configuration, HI-STAR 190 is horizontally disposed. Its thermal performance in the horizontal orientation is documented in the cask's SAR [1.3.6].

(ii) At the HI-STORE facility, however, the HI-STAR cask is staged vertically inside the Canister Transfer Facility (CTF) which is a subterranean pit with a set of inlet vents located near its bottom. The heat dissipation mechanism inside the CTF is evidently different from that in the transport mode analyzed in [1.3.6]. Therefore, a thermal analysis of this configuration is required. A thermal model of this configuration is constructed and details are provided in Section 6.4.2.

(iii) The HI-TRAC CS transfer cask: The HI-TRAC is used only during the short term operations at the HI-STORE facility. The HI-TRAC CS transfer cask, illustrated in Figure 6.4.2 and described in Section 1.2, is a ventilated dual shell steel weldment with high density concrete installed in its inter-shell space for neutron and gamma shielding. HI-TRAC CS is not intended for use in fuel pool service; it is used solely for dry handling of the canisters arriving at the HI-STORE facility. As described in Chapter 3, the loaded canister is transferred to the HI-TRAC CS transfer cask in the Canister Transfer Facility (CTF) through a vertical stack up process. As shown in Figure 6.4.3, in this configuration, the canister is cooled by a direct convective action of ventilation air over a tall column of the stack. This convection effect would be much less pronounced when the canister is installed in the transfer cask and its retractable segmented shield gate is fully closed (Figure 1.2.3a). An examination of the canister loading steps outlined in Subsection 1.2.5 indicates that the limiting thermal condition involves the scenario where the canister is loaded in the transfer cask and its shield gate is closed. Figures 1.2.3a, 1.2.3b and 6.4.2 show the retractable shield gate in perspective view. As can be seen from this figure, HI-TRAC CS has a built-in ventilation feature which provides for limited ventilation even when the shield gate is fully closed. The thermal analysis in this chapter seeks to quantify the margins to the fuel cladding temperature and other material limits for this thermally limiting configuration. A thermal model of this configuration is constructed and details are provided in Section 6.4.2.

(iv) The HI-STORM UMAX VVMs: The interim storage of the canisters will occur in the HI-STORM UMAX VVMs. The thermal-hydraulic configuration of the HI-STORM UMAX VVMs at HI-STORE is essentially identical to that certified in the HI-STORM UMAX docket. Therefore, its heat rejection capacity would be virtually identical under identical conditions to that analyzed and certified in [1.0.6] under all operation modes. However, as can be inferred from Table 6.3.1, the Design Basis heat load and the ambient temperature metrics for the HI-STORE ISFSI are less challenging than those for which the system is certified in [1.0.6]. Therefore, it is concluded that the heat rejection performance of the canisters at the HI-STORE ISFSI will have even greater margins to the regulator-prescribed limit than that established in [1.0.6]. To ascertain this, long-term storage of canisters in HI-STORM UMAX with site-specific conditions from Table 6.3.1 is evaluated in this chapter. A thermal model of the HI-STORM UMAX VVM containing MPC is constructed and details are provided in Section 6.4.2.

The decay heat removal of HI-STORM UMAX VVMs under normal, off-normal and accident conditions is evaluated in this chapter. Similarly, thermal performance of HI-TRAC CS transfer cask and HI-STAR 190 cask under short-term and accident conditions are also evaluated in this chapter.

6.2 MATERIAL TEMPERATURE LIMITS

Material temperature limits are provided in Section 4.4 of Chapter 4. All material considerations including material degradation modes applicable to HI-STORM UMAX are evaluated in Chapter 17 of this SAR. If the canister arrives at HI-STORE at a date greater than 20 years from the date of first being placed on a storage pad, the canister is added to the list of canisters undergoing aging management immediately, a more detailed description of which is provided in Chapter 18 of this SAR.

6.3 THERMAL LOADS AND ENVIRONMENTAL CONDITIONS

The thermal loads and applicable environmental conditions are summarized in Table 6.3.1. This table also contains the corresponding values for which the HI-STORM UMAX system is certified in its FSAR [1.0.6]. It can be noted from this table that the site normal, off-normal and accident ambient temperatures are lower than that adopted on a generic basis in the HI-STORM UMAX FSAR [1.0.6]. The design basis normal ambient temperature used in this SAR will be exceeded only for brief periods as suggested by the ambient temperature data in Chapter 2. 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 site. Previously licensed cask systems have employed yearly averaged normal temperatures (USNRC Dockets 72-1014, 72-1032 and 72-1040) for evaluation of long-term storage.

Table 6.3.1: Thermally Significant Parameters for the HI-STORM UMAX ISFSI at HI-STORE and Corresponding Certified Value in the System FSAR [1.0.6]

Thermally significant ISFSI parameter	Certified value from the HI-STORM UMAX FSAR and table reference		Value applicable to the HI-STORE ISFSI and reference source	
	Data	Table I.D.	Data	Source
Maximum Aggregate Heat Load for MPC-37, kW	37.06*	Table 2.1.8 of [1.0.6]	32.09	Table 4.1.1
MPC-37 Initial Helium Backfill Specification at 70°F reference temperature, psig	39 – 46	Table 4.4.6 of [1.0.6]	39 – 46	Table 4.1.3
Maximum Aggregate Heat Load for MPC-89, kW	36.72*	Table 2.1.9 of [1.0.6]	32.15	Table 4.1.2
Initial Helium Backfill Specification at 70°F reference temperature, psig	39 – 46†	Table 4.4.6 of [1.0.6]	39 – 47.5†	Table 4.1.3
Normal Ambient Temperature (See Glossary), °F	80	Table 2.3.6 of [1.0.6]	62	Table 2.7.1
Minimum Ambient Temperature (See Glossary), °F	-40	Table 2.3.6 of [1.0.6]	-11	Table 2.3.1
Off-normal Ambient Temperature (See Glossary), °F	100	Table 2.3.6 of [1.0.6]	91	Table 2.7.1
Accident Ambient Temperature (See Glossary), °F	125	Table 2.3.6 of [1.0.6]	108	Table 2.7.1

* The maximum total heat load permissible in the HI-STORM UMAX 72-1040 CoC is presented herein. The actual total heat load adopted for thermal evaluations in the HI-STORM UMAX FSAR [1.0.6] is significantly higher.

† It is recognized that the initial helium backfill specification are consistent with the limits in the transport cask [1.3.6] that will be used to bring the canisters to the HI-STORE CIS site.

6.4 APPLICABLE SYSTEMS, ANALYTICAL METHODS, MODELS AND CALCULATIONS

6.4.1 Applicable Systems

As explained in Subection 1.2.1, HI-STORM UMAX Version C is deployed at HI-STORE CIS. This design is identical to the design licensed in HI-STORM UMAX docket# 72-1040 except the following:

- The ultra-high earthquake-resistant options, referred to as MSE options, are not present.
- The storage cavity depth is made fixed (not variable, as permitted in the general certification) at two discrete dimensions and are referred to as types SL and XL (see drawing Section 1.5).

As a result of the above, the thermal performance of the system remains either unaffected or improved depending on the height of the canister being stored. The safety analysis of the HI-STORM UMAX ISFSI at HI-STORE will be bounded by the generic analysis in the HI-STORM UMAX docket [1.0.6] since the Design Basis heat load and the ambient temperature metrics for the HI-STORE ISFSI are less challenging than those for which the system is certified in [1.0.6] (see Table 6.3.1). To provide further assurance, a thermal evaluation of normal long-term storage of HI-STORM UMAX Version C VVMs under governing scenario is performed in this section to demonstrate safety compliance.

Additionally, there are two safety analyses that pertain to short term operations that warrant quantification of their safety margin. These are:

(i) The HI-STAR 190 transport cask situated in the CTF illustrated in Figure 6.4.1: The HI-STAR 190 cask is analyzed in its Part 71 docket [1.3.6] wherein its compliance with the ISG-11 Rev 3 thermal limit under transport is demonstrated. A similar demonstration for the configuration in Figure 6.4.1 is provided in Subsection 6.4.2.

(ii) HI-TRAC CS transfer cask containing a loaded canister with its shield gates closed: In this configuration, as shown in Figure 6.4.2, the canister inside the transfer cask has limited ventilation assistance. In comparison, the configuration wherein the transfer cask is mounted on top of the HI-STORM UMAX cavity or HI-STAR 190 cavity with its shield gates wide open (see Figure 6.4.3) has maximum ventilation cooling action and is therefore ruled out as a governing thermal condition. Thermal model and analysis methodology of normal onsite transfer in HI-TRAC CS is described in Subsection 6.4.2.

Table 6.4.1 provides the principal input data used in the thermal analysis performed for the above two short term operation scenarios. Thermal properties of materials used in MPC and VVM storage system are incorporated by reference from Section 4.2 of HI-STORM UMAX FSAR [1.0.6]. Materials present in HI-TRAC CS transfer cask include steel and concrete, thermal properties of which are also provided in Section 4.2 of HI-STORM UMAX FSAR [1.0.6]. Similarly properties of materials used in HI-STAR 190 cask are incorporated by reference from Section 3.3 of HI-STAR 190 SAR [1.3.6].

6.4.2 Analysis Methodology

6.4.2.1 Computer Code

The analysis vehicle for prediction of thermal performance of the systems in this SAR is the computer code FLUENT [6.4.1]. FLUENT has been benchmarked and validated for use in cask systems [6.4.2] since 1990s and has been used in the thermal qualification of every storage and transport cask developed by Holtec since 1995. A summary of pre-qualification benchmarking of FLUENT is included in Appendix 6.A herein for reference purposes. In Table 6.4.2, a listing of the licenses or license amendments issued by the USNRC and other regulatory authorities on both transport and ventilated cask types that utilize FLUENT is summarized. Several cask models listed in Table 6.4.2 have received numerous licensing amendments over the years. Thus, from this table, it can be inferred that Holtec's FLUENT models for simulating ventilated and metal casks have been repeatedly endorsed by the NRC and other national regulatory authorities.

As in all other HI-STORM dockets, the FLUENT solutions reported in this SAR have been vetted for numerical stability and grid sensitivity [6.4.3, 6.4.4] (Subsection 4.4.2 of the HI-STORM UMAX FSAR [1.0.6]).

6.4.2.2 MPC Thermal Model

The thermal analysis model of MPC is incorporated by reference from Section 4.4 of the HI-STORM UMAX FSAR [1.0.6].

6.4.2.3 HI-STORM UMAX VVM Thermal Model

The HI-STORM UMAX storage VVM used in HI-STORE CIS is slightly modified compared to the version documented in the HI-STORM UMAX FSAR [1.0.6]. A geometrically accurate 3D thermal model of the HI-STORM UMAX VVM Version C is constructed in the manner of HI-STORM UMAX in docket # 72-1040. The scenario of short MPC-37 placed in HI-STORM UMAX Version C Type SL is thermally governing for the following reasons and is therefore evaluated in this chapter:

a. As demonstrated in Section 4.4 of HI-STORM UMAX FSAR [1.0.6], thermal evaluations of MPC-89 are bounded by MPC-37. Since the heat load patterns provided in Section 4.1 of this SAR are bounded by those adopted in the generic HI-STORM UMAX FSAR [1.0.6] for both MPCs, MPC-37 is the governing canister at HI-STORE also.

b. MPC-37 with short fuel results in highest PCT and component temperatures as demonstrated in Section 4.4 of HI-STORM UMAX FSAR [1.0.6].

c. Active fuel height of short PWR fuel is lowest among short, reference and long fuel assemblies. For the same heat load, lower active height results in higher heat load density.

The thermal modeling of the HI-STORM UMAX VVM is incorporated by reference from Section 4.4 of HI-STORM UMAX FSAR [1.0.6]. The quarter symmetric model for the VVM assembly seeks to represent the essential geometry details of the physical system as depicted in the Licensing Drawings in Section 1.5 and utilizes the same conservative assumptions as summarized in Section 4.4 of [1.0.6].

Sectional and isometric views of the HI-STORM UMAX VVM quarter symmetric 3D thermal model are presented in Figures 6.4.4 and 6.4.5 respectively.

(b)(4)

6.4.2.4 HI-STAR 190 Thermal Model

(b)(4)

To accommodate all PWR and BWR canisters, the HI-STAR 190 cask is available in two discrete lengths – version SL (standard length) and version XL (extended length), as described in Chapter 1 of HI-STAR 190 SAR [1.3.6]. The HI-STAR 190 Version XL has a larger external surface area for heat dissipation than that of HI-STAR 190 Version SL. Therefore, the thermal performance of HI-STAR 190 Version XL is bounded by that of HI-STAR 190 Version SL. The thermal performance of short MPC-37 bounds that of MPC-89 for similar decay heats as has been demonstrated in Section 3.3 of HI-STAR 190 SAR [1.3.6], Sections 4.4 of the HI-STORM UMAX FSAR [1.0.6] and HI-STORM FW FSAR [1.3.7].

(b)(4)

used in its native docket (10CFR71-9373 [1.3.6]). Thermal model of HI-STAR 190 placed inside the CTF has the following attributes:

(b)(4)
[redacted]

Table 6.4.1 provides the principal input data used in the thermal analysis performed for this short term operation scenario. Sectional and isometric views of the HI-STAR 190 in CTF quarter symmetric 3D thermal model are presented in Figures 6.4.6 and 6.4.7 respectively. The computational results for this scenario are presented in Subsection 6.4.3.

6.4.2.5 HI-TRAC CS Transfer Cask Thermal Model

The HI-TRAC CS is a dry use only cask designed specifically for the HI-STORE CIS facility. HI-TRAC CS has large cavities to accommodate various heights of MPCs. As described above, short MPC-37 is the governing thermal scenario and is therefore evaluated to demonstrate safety. Its thermal model, implemented on FLUENT has the following key attributes:

(b)(4)
[redacted]

(b)(4)

[redacted]

Sectional and isometric views of the HI-TRAC quarter symmetric 3D thermal model are presented in Figures 6.4.8 and 6.4.9 respectively. The computational results for this scenario are presented in Subsection 6.4.3.

6.4.3 Calculations and Results

6.4.3.1 Maximum Temperatures

A steady state thermal analysis of the governing "thermal configurations" (meaning the combination of canister type, regionalized loading pattern and fuel type that produces highest fuel cladding temperature) was performed using the 3-D FLUENT model described in Subsection 6.4.2 to quantify the thermal margins under long term storage conditions. Thermal analyses of the MPC-37 with short fuel under heat load pattern 1 specified in Table 4.1.1 is performed.

The maximum spatial values of the computed temperatures of the fuel cladding, the fuel basket material, the divider shell, the closure lid concrete, the MPC lid, the MPC shell and the average air outlet temperature are summarized in Table 6.4.3. The following conclusions are reached from the solution data:

a. The PCT is below the temperature limit set forth in ISG-11 Rev 3 [4.0.1].
b. The maximum temperatures of all MPC and VVM constituent parts are below their respective limits set down in Section 4.4.
c. The temperatures are below the licensed temperatures obtained and presented in Chapter 4 of HI-STORM UMAX FSAR [1.0.6].

It is therefore concluded that the HI-STORM UMAX system provides a thermally acceptable storage environment for the eligible MPCs.

Thermal evaluations in Section 3.3.5 of HI-STAR 190 SAR [1.3.6] demonstrate that the predicted temperatures and cavity pressures under sub-design basis heat loads[*] is bounded by those under design basis maximum heat loads. Therefore, the safety conclusions made for design basis heat loads also remain applicable to sub-design basis heat loads also.

6.4.3.2 MPC Cavity Pressures

The MPC from HI-STAR 190 is already filled with dry pressurized helium. During normal storage in HI-STORM UMAX VVM and during short-term operations in HI-TRAC CS and HI-STAR 190, the gas temperature within the MPC rises to its maximum operating basis temperature. The gas pressure inside the MPC will also increase with rising temperature. The pressure rise is determined using the ideal gas law. The MPC gas pressure is also subject to substantial pressure rise under hypothetical rupture of fuel rods.

The MPC maximum gas pressure is computed for a postulated release of fission product gases from fuel rods into this free space. For these scenarios, the amounts of each of the release gas constituents in the MPC cavity are summed and the resulting total pressures determined from the ideal gas law. A concomitant effect of rod ruptures is the increased pressure and molecular weight of the cavity gases with enhanced rate of heat dissipation by internal helium convection and lower cavity temperatures. As these effects are substantial[1] under large rod ruptures the 100% rod rupture accident is conservatively evaluated without credit for increased heat dissipation under increased pressure and molecular weight of the cavity gases. Based on fission gases release fractions (NUREG 1567 criteria), rods' net free volume and initial fill gas pressure, maximum gas pressures with 1% (normal), 10% (off-normal) and 100% (accident condition) rod rupture are given in Table 6.4.4. The maximum calculated gas pressures reported in Table 6.4.4

[*] MPC helium initial backfill specification and sub-design basis heat load is defined in Table 4.1.4.

[1] Rod rupture gases boost helium density and coincident mass of internal convection flows by virtue of their large molecular weights (Argon, Krypton and Xenon are 10, 21 and 33 times heavier than helium). As internal convection cooling is an effective means of dissipating heat relative to conduction heat transfer in gases it more than offsets reduced conductivity of helium due to rod rupture gases.

are all below the MPC internal design pressures for normal, off-normal and accident conditions specified in Chapter 4.

6.4.3.3 Minimum Temperatures

The minimum temperature evaluation for HI-STORM UMAX at HI-STORE is bounded by that in Subsection 4.4.4 of the HI-STORM UMAX FSAR [1.0.6] due to the following:

- The minimum ambient temperature at HI-STORE site is bounded by that defined in HI-STORM UMAX FSAR [1.0.6] (see Table 6.3.1).

Therefore, Subsection 4.4.4(ii) of the HI-STORM UMAX FSAR [1.0.6] is incorporated by reference into this document.

6.4.3.4 Engineered Clearances to Eliminate Thermal Interfaces

The differential thermal expansion between MPC and cask components for HI-STORM UMAX at HI-STORE is bounded by that in Sub-section 4.4.6 of the HI-STORM UMAX FSAR [1.0.6] due to the following:

- The MPC and VVM component temperatures at HI-STORE are lower than that presented for the same MPC presented in Section 4.4.4(i) of the HI-STORM UMAX FSAR under normal long-term storage condition [1.0.6].

Therefore, Subsection 4.4.6 of the HI-STORM UMAX FSAR [1.0.6] is incorporated by reference into this document.

6.4.3.5 Evaluation of Sustained Wind

This scenario corresponds to a postulated event where a sustained wind of *a fixed velocity in a fixed direction* acts for a sufficiently long time to bring the array of HI-STORE storage systems to thermal equilibrium. The horizontal wind has two potential thermal-hydraulic effects on the HI-STORE Systems:

Effect #1: Horizontal wind may decrease the ventilating air flow entering the passageway inside HI-STORM UMAX cavity.

Effect #2: Horizontal wind may blow the heated air exiting the upwind modules into the inlet vents of down-stream modules, thus increasing their air inlet temperature.

Because of the (unmanageably) large size of the CFD model, two separate models are used to quantify the effect of the two above mentioned impacts:

(1) For the HI-STORM UMAX VVM located in the front row of ISFSI array, a half-symmetric model is constructed to analyze the HI-STORM UMAX VVM subject to the direct aerodynamic effect of the wind on the inlet and outlet openings. The half-symmetric model is augmented from the quarter symmetric model described in Section 6.4.2.

A series of steady state computations are performed for different wind speeds and results are tabulated in Table 6.4.7. The results show that fuel cladding temperature increases from the quiescent condition with wind speed upto 5mph, and then decreases as the wind speed increases beyond 5 mph. Table 6.4.7 also presents the effect of different wind speeds on the HI-STORM UMAX standard design evaluated in Section 4.4.9 of the UMAX FSAR [1.0.6]. The results from Table 6.4.7 conclude that HI-STORE UMAX Version C design is less susceptible to the effects of sustained wind. Therefore, the UMAX version evaluated in UMAX FSAR [1.0.6] is thermally limiting design under wind conditions.

(2) To properly evaluate the effect of wind on mass flow rate and pre-heating the inlet air of HI-STORM UMAX modules located inside an ISFSI array, an array model is evaluated. Based on the conclusions from the evaluations of Effect#1 described above, array model of the limiting UMAX version described in Section 4.4.9 of the UMAX FSAR [1.0.6] is incorporated by reference. To consider the effects of neighboring casks in a conservative manner, a linear array of UMAX Systems is modeled with reflecting lateral walls at mid-pitch. The walls block lateral dissipation of heated air and reflecting boundary blocks and redirects radiation energy dissipation back onto the casks. The linear cask array model computed results [6.4.8] support following observations:

- Maximum air inlet temperature observed in module #7 indicating that temperature rise stabilized at module #7 and that the eight-module deep model is adequate for its intended purpose. The maximum air inlet temperature increase from the quiescent model is 11^{o}F.
- minimum air flow rate observed in module #1 (front module facing the wind)

As illustrated from the results in Section 4.4.9 of the UMAX FSAR, one by eight array with lateral symmetry boundaries is reasonably sufficient to evaluate limiting module in an ISFSI array with 500 casks.

To compute MPC internal temperatures under the worst-case effects evaluated above, limiting version of HI-STORM UMAX is solved under most adverse wind and maximum inlet air temperature (Section 4.4.9 of UMAX FSAR [1.0.6]). The combined effects results in a temperature rise tabulated in Table 6.4.8. Due to reasons outlined above, the same temperature rise is conservatively adopted for all components of HI-STORE UMAX and results presented in Table 6.4.9. The results tabulated in Table 6.4.9 support the following conclusions:

a. The PCT complies with temperature limit set forth in ISG-11 Rev 3 [4.0.1] with robust margins.

b. The maximum temperatures of all MPC and VVM constituent parts are well below their respective limits set down in Section 4.4.

c. The temperatures are below the licensed temperatures in Chapter 4 of HI-STORM UMAX FSAR [1.0.6].

d. The MPC pressures are below the design pressures under normal, off-normal and accident conditions specified in Chapter 4.

6.4.3.6 Evaluation of HI-STAR 190 in CTF

The calculations performed [6.4.7] using the 3-D FLUENT model described in Subsection 6.4.2 provided steady state results that are summarized in Table 6.4.5. By comparing the results in the above tables with the acceptable limits in Chapter 4 yield the following conclusions:

i) The peak cladding temperature is considerably below the limit corresponding to short term operations.

ii) There is a large margin to the limit for the metal temperature of the steel in the cask.

iii) The temperatures of the gamma and neutron blockage materials in the transport cask have considerable margins to their respective limits.

iv) MPC cavity pressure during this short-term operation is below the design pressure limit (see Chapter 4).

In summary, the temperatures of all HI-STAR 190 components are well within their prescribed limits.

6.4.3.7 Evaluation of Normal Onsite Transfer in HI-TRAC CS

The calculations performed using the 3-D FLUENT model described in Subsection 6.4.2 provided steady state results that are summarized in Table 6.4.6. By comparing the results in the above tables with the acceptable limits in Chapter 4 yield the following conclusions:

(i) The peak cladding temperature is considerably below the limit corresponding to short term operations.

(ii) There is a large margin to the limit for the metal temperature of the steel in the cask.

(iii) The section average temperature of shielding concrete in HI-TRAC CS is also well within the permitted limit.

(iv) MPC cavity pressure during this short-term operation is below the design pressure limit (see Chapter 4).

In summary, the temperatures in every constituent part of HI-TRAC CS are well within their prescribed regulatory limits.

Table 6.4.1: Thermal Input Data for Analysis of Governing Scenarios During Short Term Operations		
PARAMETER	**HI-STAR 190**	**HI-TRAC CS**
Ambient Temperature, ^{o}F (Note 1)	91	91
Ambient pressure, psia (Note 2)	12.2	12.2
Canister (Note 3)	Short MPC-37	Short MPC-37
Nominal Cask Cavity Height, inch	190.81 (Note 4)	215.25
Heat Load, kW	(Note 5)	(Note 5)
Location	Canister Transfer Building	Inside or Outside Canister Transfer Building
Configuration	Figure 6.4.1	Figure 6.4.2

Note 1: The 3-day average ambient temperature is defined in Table 2.7.1.
Note 2: The ambient pressure is assumed to be based on an altitude of 5000 feet above the Mean Sea Level [6.4.5]; the actual elevation cited in Table 2.7.1, is much lower.
Note 3: The thermal analyses reported in Section 4.1 of HI-STORM UMAX FSAR [1.0.6] shows that short MPC-37 with PWR fuel provides the most challenging thermal case.
Note 4: The cavity height of short SL version reported herein.
Note 5: The thermal analyses reported in Section 3.3 of HI-STAR 190 SAR [1.3.6] shows that Heat Load Pattern 1 specified in Appendix 7.C of HI-STAR 190 SAR [1.3.6] is the governing heat load distribution and is adopted herein for thermal evaluations.

Table 6.4.2: List of Holtec's Licensing Basis FLUENT Models Previously Used in Storage and Transport Casks			
Cask name	**Type**	**Regulator**	**Docket No.**
HI-STAR 100	Metal transport cask	USNRC	71-9261
HI-STAR 100	Metal storage cask	USNRC	72-1008
HI-STORM 100	Ventilated storage cask	USNRC	72-1014
HI-STAR 180	Metal transport cask	USNRC	71-9325
HI-STAR 60	Metal transport cask	USNRC	71-9336
HI-STAR 180D	Metal transport cask	USNRC	71-9367
HI-STORM FW	Ventilated storage cask	USNRC	72-1032
HI-STORM UMAX	Ventilated storage cask	USNRC	72-1040

Table 6.4.3: Normal Long-Term Storage Temperatures for MPC-37 in HI-STORM UMAX at HI-STORE CIS	
Component	**Temperature, ºF**
Fuel Cladding	613
Fuel Basket	552
Basket Shims	435
MPC Shell	372
MPC Lid[2]	369
MPC Baseplate[1]	304
Divider Shell	273
CEC Shell	111
Closure Lid Concrete[1]	156
Average Air Outlet	153
Note: MPC cavity pressures under normal long term storage tabulated in Table 6.4.4.	

[2] Maximum section average temperature is reported.

Table 6.4.4: MPC Cavity Pressure During Normal Long-Term Storage in HI-STORM UMAX VVM		
Component	**Pressure, psig**	**Cavity Average Temperature [°F]**
Normal Condition - No Rod Rupture - 1% Rod Rupture	 88.2 89.2	439
Off-Normal Condition (10% Rod Rupture)	98.3	
Accident Condition (100% Rod Rupture)	188.7	

Table 6.4.5: Maximum Component Temperatures and MPC Cavity Pressure for HI-STAR 190 in CTF Short-Term Operation	
Component	**Temperature, °F**
Fuel Cladding	716
Fuel Basket	667
Basket Shims	558
MPC Shell	504
MPC Lid[3]	495
MPC Baseplate[1]	396
Containment Shell	385
Holtite	385
Enclosure Shell	336
Closure Lid[1]	252
Containment Bottom Forging[4]	320
Containment Top Forging[2]	264
MPC Cavity Average Temperature	561
	Pressure, psig
MPC Cavity Pressure	102.3

[3] Maximum section average temperature is reported.

[4] Bulk average temperature is reported.

Table 6.4.6: Normal On-Site Transfer Temperatures and MPC Cavity Pressure in HI-TRAC CS	
Component	**Temperature, °F**
Fuel Cladding	669
Fuel Basket	615
Basket Shims	507
MPC Shell	461
MPC Lid[5]	416
MPC Baseplate[1]	343
HI-TRAC Inner Shell	352
HI-TRAC Concrete[1]	271
HI-TRAC Outer Shell	200
MPC Cavity Average Temperature	507°F
	Pressure, psig
MPC Cavity Pressure	96.0

[5] Maximum section average temperature is reported.

Table 6.4.7: Effects of Wind on Peak Cladding Temperature in a Single HI-STORM UMAX System

Wind Speed MPH	UMAX FSAR Notes 1,3 °F	HI-STORE UMAX Notes 2,3 °F
2	7	3
5	18	9
7	19	7
9	21	-4 (Note 4)
10	18	-9 (Note 4)

Note 1: PCT rise due to sustained wind obtained for the standard UMAX version from Table 4.4.12 of the UMAX FSAR [1.0.6].
Note 2: PCT rise due to sustained wind obtained for UMAX Version C presented in Section 1.5.
Note 3: Effect of wind calculated at conservatively higher decay heat load than that presented in Table 4.1.1.
Note 4: Negative temperature rise in PCT indicate wind has a positive impact i.e. it results in decrease in PCT compared to no wind scenario.

Table 6.4.8: Combined Effect of Wind on Component Temperatures in HI-STORM UMAX System	
PCT Rise (Notes 1,2)	34°F
Note 1: PCT rise due to sustained wind obtained for the standard UMAX version from Tables 4.4.15 and 4.4.2 of the UMAX FSAR [1.0.6]. Note 2: PCT rise is conservatively adopted as the temperature rise for all MPC and VVM components in HI-STORE UMAX. Note 3: Combined effect of wind obtained at conservatively higher decay heat load than that presented in Table 4.1.1.	

Table 6.4.9: Maximum HI-STORE Long-Term Storage Temperatures and Pressures Under Wind Conditions	
Component	**Temperature, °F**
Fuel Cladding	647
Fuel Basket	586
Basket Shims	469
MPC Shell	406
MPC Lid[6]	403
MPC Baseplate[1]	338
Divider Shell	307
CEC Shell	145
Closure Lid Concrete[1]	190
Average Air Outlet	187
MPC Cavity Average Temperature	473
	Pressure, psig
Normal Condition - No Rod Rupture - 1% Rod Rupture	 92.2 93.2
Off-Normal Condition (10% Rod Rupture)	102.6
Accident Condition (100% Rod Rupture)	196.4
Note 1: Temperatures obtained by conservatively adding temperature rise due to wind effects (Table 6.4.8) to Table 6.4.3.	

[6] Maximum section average temperature is reported.

(b)(4)

Figure 6.4.1: HI-STAR 190 in the Thermally-Restricted Environment in the CTF

(b)(4)

Figure 6.4.2: Loaded HI-TRAC CS with its Shield Gates Closed

(b)(4)

Figure 6.4.3: Ventilation Path when the HI-TRAC CS is Arrayed on Top of the CTF

(b)(4)

Figure 6.4.4: Sectional View of the HI-STORM UMAX VVM Quarter Symmetric 3D Thermal Model

(b)(4)

Figure 6.4.5: Isometric View of the HI-STORM UMAX VVM Quarter Symmetric 3D Thermal Model

(b)(4)

Figure 6.4.6: Sectional View of the HI-STAR 190 in CTF Quarter Symmetric 3D Thermal Model

(b)(4)

Figure 6.4.7: Isometric View of the HI-STAR 190 in CTF Quarter Symmetric 3D Thermal Model

(b)(4)

Figure 6.4.8: Sectional View of the HI-TRAC CS Quarter Symmetric 3D Thermal Model

(b)(4)

Figure 6.4.9: Isometric View of the HI-TRAC CS Quarter Symmetric 3D Thermal Model

6.5 SAFETY UNDER OFF-NORMAL AND ACCIDENT EVENTS

6.5.1 Off-Normal Events

To support evaluation of off-normal events in Section 15.2, the following off-normal events are evaluated herein:

i) Off-Normal Environment Temperature

ii) Partial Blockage of Air Inlets

iii) Off-Normal Pressure

Thermal evaluations of off-normal events (i) and (ii) are bounded by the evaluations reported in Sub-section 4.6.1 of the HI-STORM UMAX FSAR [1.0.6] since that the PCT and component temperatures of MPC stored in HI-STORM UMAX at HI-STORE are lower than that of the same MPC presented in Section 4.4.4(i) of the HI-STORM UMAX FSAR under normal long-term storage condition [1.0.6]. Therefore, Subsection 4.6.1 of the HI-STORM UMAX FSAR [1.0.6] is incorporated by reference into this document.

Thermal evaluation of off-normal event (iii) is presented in Subsection 6.4.3. The off-normal MPC cavity pressure is below the limit defined in Table 4.3.1 with positive margins.

6.5.2 Accident Events

6.5.2.1 Bounding Fire Event

(a) <u>HI-STORM UMAX Fire Accident</u>: The FSARs of both the HI-STORM UMAX [1.0.6] and the HI-STORM FW system [1.3.7] contain the fire consequence analysis for a 50 gallon fire at a generic ISFSI and demonstrate that all of the safety metrics of the storage system will be met. However, since a transporter with potentially larger volume of combustibles is used on site to transfer MPCs from HI-TRAC CS transfer cask to HI-STORM UMAX VVM storage module, a conservative fire event has been considered herein. The amount of combustibles is conservatively considered equal to that specified in Table 6.5.1. Thermal evaluation of an all engulfing fire of the aboveground HI-STORM FW System for the same amount of combustibles is presented in a Holtec report [6.5.3]. The results demonstrate that the fuel and MPC confinement integrity is assured under this severe fire accident. Based on this, it is safe to conclude that the MPC and its contents are also safe in HI-STORM UMAX at HI-STORE under transporter fire accident due to the following:

- The initial PCT and component temperatures of MPC stored in HI-STORM UMAX at HI-STORE are lower than that of the same MPC in the HI-STORM FW system [6.5.3].
- MPC decay heat is significantly lower in HI-STORM UMAX.
- HI-STORM UMAX system has much lesser surface directly exposed to fire than that of above-ground system.

Consequently, the conclusion that PCT and components' temperatures and MPC pressure are below temperature and pressure limits for transporter fire event drawn in Holtec report [6.5.3] remain valid for the HI-STORM UMAX system at HI-STORE site.

(b) <u>HI-TRAC CS Fire Accident</u>: The case of fire in the Cask Transfer Building (CTB) where the HI-TRAC CS cask is used to handle the arriving canister, however, is not addressed in the above referenced FSARs. While the probability of a fire event in the CTB is quite low due to the lack of combustible materials, except the fuel in the Vertical Cask Transporter's tank (procedurally limited to 50 gallons), a conservative fire event has been assumed herein and analyzed. Under a postulated fuel tank fire, the outer layers of HI-TRAC CS cask will be heated for the duration of fire by the incident thermal radiation and forced convection heat fluxes.

To make the fire event even more severe, the quantity of combustible fluid in the VCT has been conservatively increased to as adopted in Table 6.5.1. The fuel tank fire is conservatively assumed to surround the HI-TRAC CS cask thus exposing the entire external to heating by radiation and convection heat transfer. Following the 10 CFR 71 guidelines [1.3.2], the following fire parameters are assumed:

(b)(4)

(b)(4)

The results of the fire and post-fire events are reported in Table 6.5.2. These results demonstrate the following:

- The fire event has a minor effect on the fuel cladding temperature. The peak cladding temperature remains below the applicable ISG-11 Rev 3 [4.0.1] limit.
- The internal pressure in the canister remains below its accident condition limit.
- Localized regions of shielding concrete in the body of HI-TRAC CS up to less than 0.25 inch depth are exposed to temperatures in excess of accident temperature limit set forth in Chapter 4, Table 4.4.1. The bulk of the concrete remains well below the accident temperature limit.
- The metal temperature of the steel weldment of the HI-TRAC CS cask is also well within the applicable limit in Table 4.4.1.

It is thus concluded that the suitability of the HI-TRAC CS cask to render its canister transfer function will remain essentially unimpaired after the bounding fire event postulated in the foregoing.

(c) HI-STAR 190 Fire Accident: All loading/lifting operations related to HI-STAR 190 transport cask after arriving at the facility is performed using CTB crane (see Section 10.3). The CTB crane does not have sources of combustibles to cause a potential fire hazard. The HI-TRAC CS transfer cask is also operated using the crane and placed on the CTF alignment plate for MPC transfer from HI-STAR 190 to HI-TRAC CS. The transporter is only used for transfer operations with HI-TRAC CS, which is always distant from the CTF or HI-STAR 190 cask. Any potential hazard from transporter fire is bounded by the 30 minute fire evaluation in Section 3.4 of the HI-STAR 190 SAR [1.3.6] and is therefore incorporated by reference.

(d) Potential Fire Hazards: Site survey in Subsection 2.1.2 yields potential hazards which are evaluated herein. These are the presence of an oil recovery facility and underground run natural gas pipelines at the facility. There are no active oil wells on the site and there are no plans to use any of the plugged and abandoned wells on site. This section reviews the potential fire hazards from these sources that could affect spent fuel storage operations at storage pad and/or cask transfer operations along the haul path. The identified hazards from oil well and natural gas pipelines are evaluated for credibility and severity.

As stated in Table 2.1.4, the oil recovery facility or oil well is at a substantial distance from any cask structure either on the storage pad or haul path to cause a significant impact on fuel cladding temperature or cask structures. In an unlikely event oil well catches fire, emergency response plans are in place to mitigate the fire. If the oil well catches fire during transfer of MPC in HI-TRAC CS on the haul path, transfer cask shall be moved either to the storage pad or the cask transfer building.

The temporary flexible pipelines that run aboveground through the center of the site will be moved prior to or during the early construction phases of the CIS facility, as described in Subsection 2.1.2. Therefore, they do not present a fire hazard. The natural gas pipelines that run underground along the north-south axis to the east of the site do not present a real fire hazard.

(e) Range-Land Fires and Fire-Jump Hazards: Rangeland fires do not pose a credible threat to the safety of spent nuclear fuel stored at the HI-STORE CIS facility as justified below:

- Fuel stored in an underground cavity having no line of sight for radiation heating.
- The HI-STORE CIS facility is designed and operated as a vegetation-free storage area within the controlled area boundary.
- The ISFSI layout includes a substantial distance (over 500 ft) from the storage pads to the controlled area boundary.
- Site includes suitable width of vegetation cleared land around the controlled area boundary.
- Due to large distances separating potential vegetation fires and UMAX storage modules fire heating reasonably bounded by design basis fire accidents evaluated herein as all-engulfing fires.
- As evaluated above the HI-STORE CIS designed as a vegetation free facility renders fire-jump hazards non-credible.

6.5.2.2 Explosion Event

There are no credible internal explosive events at the HI-STORE ISFSI since all materials are compatible with the various operating environments, as discussed in Chapter 17, or appropriate preventive measures are taken to preclude internal explosive events (see Table 4.3.1). The canister is composed of non-explosive materials and maintains an inert gas environment. Thus explosion during long term storage is not credible. Likewise, the mandatory use of the protective measures at the HI-STORE site to prevent fires and explosions and the absence of any need for an explosive material during loading and unloading operations eliminates the scenario of an explosion as a credible event. Furthermore, because the MPC is internally pressurized, any short-term external pressure from explosion will act to reduce the tensile state of stress in the enclosure vessel. Nevertheless, a design basis external pressure (Table 4.3.1) has been defined as a design basis loading event wherein the internal pressure is non-mechanistically assumed to be absent. The ability of the canister to withstand loads due to an explosion event is evaluated in Chapter 3 of HI-STORM FW FSAR [1.3.7].

6.5.2.3 Burial under Debris

(a) Burial of HI-STORM UMAX VVM

There are no structures that loom over the HI-STORE HI-STORM UMAX ISFSI whose collapse could bury the VVMs in debris. A substantial distance from the ISFSI to the nearest ISFSI security fence (see Drawing in Section 1.5) precludes the close proximity of substantial amount of vegetation (native vegetation is low lying scrub). Thus, there is no credible mechanism for the HI-STORM UMAX system to become completely buried under debris.

(b) Collapse of the CTB

The CTB is a non-load bearing Butler building made of corrugated aluminum. The building does not support any crane or other loads and is designed to withstand the maximum wind applicable to the HI-STORE site. It is nevertheless assumed that the roof of the CTB will fall and cover the canister bearing casks that are in use within the CTB. The governing burial scenarios are shown in Figures 6.4.1 and 6.4.2 that involve the HI-STAR 190 metal cask (unventilated) and the HI-TRAC CS cask (ventilated), respectively. Because of the corrugated shape of the debris and the physical restrictions, it is assumed that the debris restricts the exiting air flow to only 10% of the unobstructed (normal) condition. A FLUENT analysis of the restricted flow in Figures 6.4.1 and 6.4.2 is performed. The steady state results for this accident on HI-TRAC CS and HI-STAR 190 when it is in the CTF are summarized in Tables 6.5.3 and 6.5.4. The results demonstrate integrity on fuel cladding and MPC confinement boundary are assured under a postulated CTB collapse accident.

6.5.2.4 Extreme Environmental Temperature

The extreme environmental accident evaluation for HI-STORM UMAX at HI-STORE is bounded by that in Paragraph 4.6.2.2 of the HI-STORM UMAX FSAR [1.0.6] due to the following:

- The PCT and component temperatures of MPC stored in HI-STORM UMAX at HI-STORE are lower than that of the same MPC presented in Section 4.4.4(i) of the HI-STORM UMAX FSAR under normal long-term storage condition [1.0.6].
- The extreme environment temperature at HI-STORE site is lower than that defined in HI-STORM UMAX FSAR [1.0.6] (see Table 6.3.1).

Therefore, Paragraph 4.6.2.2 of the HI-STORM UMAX FSAR [1.0.6] is incorporated by reference into this document.

6.5.2.5 100% Blockage of Air Vents

Thermal evaluation of 100% blockage of air vents accident event is bounded by that in Paragraph 4.6.2.3 of the HI-STORM UMAX FSAR [1.0.6] due to the following:

- The initial condition of the PCT and component temperatures of MPC stored in HI-STORM UMAX at HI-STORE is lower than that of the same MPC presented in Section 4.4.4(i) of the HI-STORM UMAX FSAR under normal long-term storage condition [1.0.6].
- Design basis heat load is lower in HI-STORM UMAX at HI-STORE (see Table 6.3.1) which results in lower heat-up rate.

Therefore, Paragraph 4.6.2.3 of the HI-STORM UMAX FSAR [1.0.6] is incorporated by reference into this document. The amount of heat removed from the MPC external surfaces by natural circulation of air is reduced to less than 1% of that under normal conditions (i.e. when inlet and outlet vents completely unblocked). Therefore, in an event of complete blockage of both inlet and outlet vents, that small additional heat removal capability by air through outlet vents is also lost. This will result in a small temperature rise compared to the large available temperature margins established from the transient study of complete inlet vents blockage in Paragraph 4.6.2.3 of the HI-STORM UMAX FSAR [1.0.6]. This accident condition is, however, a short duration event that is identified and corrected through scheduled periodic surveillance. The periodic surveillance time requirement is adopted the same as that in HI-STORM UMAX FSAR [1.0.6].

6.5.2.6 Flood

The flood accident evaluation is bounded by that in Paragraph 4.6.2.5 of the HI-STORM UMAX FSAR [1.0.6] due to the following:

- The Design Basis Flood used to qualify the VVM in the HI-STORM UMAX FSAR [1.0.6] (up to 5 inch) exceeds the most severe projection of flood at the ELEA site i.e. up to 4.8 inch (see Subsection 2.4.3).
- The initial condition of the PCT and component temperatures of MPC stored in HI-STORM UMAX at HI-STORE is lower than that of the same MPC presented in Section 4.4.4(i) of the HI-STORM UMAX FSAR under normal long-term storage condition [1.0.6].

Therefore, Paragraph 4.6.2.5 of the HI-STORM UMAX FSAR [1.0.6] is incorporated by reference into this document.

6.5.3 SSCs Important to Safety Guidance for Fire Protection Program

There are no combustible or explosive materials associated with the HI-STORM UMAX System. Combustible materials will not be stored within an ISFSI. However, for conservatism, a hypothetical fire accident has been analyzed as a bounding condition for HI-STORM UMAX System. The evaluation of the HI-STORM UMAX System fire accident is discussed in Subsection 6.5.2. Similarly, there are no credible internal explosive events at the HI-STORE ISFSI since all materials are compatible with the operating environments, or appropriate preventive measures are taken to preclude explosions. The canister is composed of non-explosive materials and maintains an inert gas environment. Thus explosion during long term storage is not credible. Likewise, the mandatory use of the protective measures at the HI-STORE site to prevent fires and explosions and the absence of any need for an explosive material during loading and unloading operations eliminates the scenario of an explosion as a credible event. An emergency response plan is in place as described in emergency response plan report [10.5.1]. The Holtec CISF Emergency Response Plan [10.5.1] evaluates and describes the necessary and sufficient emergency response capabilities for managing fire emergency conditions associated with the operation of the HI-STORE facility. The plan meets all requirements of 10CFR72.32 (a).

Measures for fire prevention, fire detection, fire suppression, and fire containment for the protection of the spent fuel assemblies and cask structures important to safety are provided in emergency response plan [10.5.1]. The fire detection and suppression systems are contained within the Canister Transfer Building. The construction materials of the Canister Transfer Building do not support combustion, and the fire-prone materials are limited to diesel fuel. Fires are analyzed for all casks in Subsection 6.5.2 of this SAR. The area surrounding the storage pads and Canister Transfer Building includes a gravel-covered fire break with vegetation control to limit potential fuel for fires. The nonflammable nature of the materials of construction, other passive design features, and the limited fuel sources at the Facility lead to the conclusion that the fire detection and suppression systems are correctly classified as not important to safety.

The design of the Facility is such that all structures, systems, and components are located within a region covered with crushed rock. Therefore, there is no credible wildfire load on structures, systems, and components important to safety. A range of onsite fire scenarios has been evaluated. Bounding fire events are based on the volume of combustibles in the transporter, as given in Table 6.5.1. Operational restrictions are in place to ensure that these levels are not exceeded. The cask structures are designed so that they can continue to perform their safety functions under credible fire and explosion exposure conditions. Additionally, the cask structures containing spent fuel are located at significant distances from potential fire hazards identified on site.

Table 6.5.1: Cask Transporter Combustible Quantities and Fire Duration

Description	Value
Volume of Combustibles, gallon	430
Fuel Area around HI-TRAC CS Cask, ft^2	291.6
Depth of Combustibles, inch	2.366
Fuel consumption rate, in/min [6.5.1]	0.15
Fire Duration, seconds	946 (Note 1)

Note 1: Thermal evaluations of HI-TRAC CS fire conservatively performed for a larger duration.

Table 6.5.2: HI-TRAC CS Fire and Post-Fire Accident Results		
Component	**Temperature, °F**	
	End of Fire	**Post-Fire Note 1**
Fuel Cladding	670	701
Fuel Basket	615	650
Basket Shims	508	537
MPC Shell	512	512
MPC Lid[7]	474	474
MPC Baseplate[1]	426	527
HI-TRAC Inner Shell	886	886
HI-TRAC Concrete	1380 (Note 2)	1380 (Note 2)
HI-TRAC Outer Shell[8]	1092	1092
MPC Cavity Average Temperature	509	543
	Pressure, psig	
MPC Cavity Pressure	96.2	100.2
Note 1: Maximum temperatures are reported during the fire event. Note 2: An extremely small area of concrete skin towards the top of the HI-TRAC is unavailable for shielding since it exceeds the temperature limit specified in Table 4.4.1.		

[7] Maximum section average temperature is reported.

[8] Bulk temperature is reported.

Table 6.5.3: HI-TRAC CS Maximum Temperatures due to Cask Blockage from Debris (CTB Collapse Accident)	
Component	**Temperature, °F**
Fuel Cladding	918
Fuel Basket	869
Basket Shims	757
MPC Shell	718
MPC Lid[9]	649
MPC Baseplate[1]	642
HI-TRAC Inner Shell	642
HI-TRAC Concrete	640
HI-TRAC Outer Shell	351
MPC Cavity Average Temperature	766
	Pressure, psig
MPC Cavity Pressure	125.8

[9] Maximum section average temperature is reported.

Table 6.5.4: Maximum Temperatures of HI-STAR 190 when Placed in CTF during CTB Collapse Accident	
Component	**Temperature, ^{o}F**
Fuel Cladding	862
Fuel Basket	813
Basket Shims	709
MPC Shell	664
MPC Lid[10]	630
MPC Baseplate[1]	531
Containment Shell	592
Enclosure Shell	550
Closure Lid[1]	475
MPC Cavity Average Temperature	703
	Pressure, psig
MPC Cavity Pressure	118.6

[10] Maximum section average temperature is reported.

6.6 REGULATORY COMPLIANCE

The thermal compliance pursuant to the provisions of NUREG-1567 [1/0/3] and ISG-11 [4.0.1] for deployment of canisters certified in the HI-STORM UMAX docket number (72-1040) has been demonstrated in this chapter. As the canisters will arrive at the HI-STORE site loaded in the transport package, the Short Term Operations on the (dry) canisters to place them in the HI-STORM UMAX VVMs and their interim storage in the VVMs are the subjects of safety analysis in this chapter.

Following the guidance of ISG-11 [4.0.1], the fuel cladding temperature at the beginning of dry storage at HI-STORE will be below the anticipated damage-threshold temperatures for normal conditions of storage for the licensed life of the HI-STORM UMAX System. Maximum fuel cladding temperatures for long-term storage conditions are reported in Section 6.4. The large margin to the ISG-11 limit for the fuel cladding temperature at the HI-STORE ISFSI provides added assurance that the breach of fuel cladding in storage is extremely unlikely.

Following the guidance of NUREG-1567, the system is passively cooled. All heat rejection mechanisms described in this chapter, including conduction, natural convection, and thermal radiation, are completely passive.

During Short Term Operations, the ISG-11 requirement to ensure that maximum cladding temperatures be below 400^{o}C (752^{o}F) for high burnup fuel and below 570^{o}C (1058^{o}F) for moderate burnup fuel is satisfied with ample margin.

Events of extremely low probability such as an enveloping fire and an extreme environmental phenomenon leading to burial of the transfer or transport cask in debris have been analyzed for their compliance with the temperature limits set down for fuel cladding, structural weldments and shielding materials. The results show ample margins of safety against regulatory limits.

It is therefore concluded that all applicable regulatory requirements and guidelines germane to the integrity of the stored fuel and the HI-STORM UMAX storage system have been addressed and satisfied in this chapter.

APPENDIX 6A: HOLTEC VALIDATION OF FLUENT FOR CASK APPLICATIONS

6A.1 INTRODUCTION

(b)(4)

6A.2 CODE DEVELOPER VALIDATION

(b)(4)

(b)(4)

6A.3 HOLTEC VALIDATION

(b)(4)

Table 6A.1: Summary of Fluent Code Validation Cases

(b)(4)

Table 6A.2: Comparison of FLUENT Predictions with Benchmark Results for Friction Factor and Nusselt Number

(b)(4)

(b)(4)

Figure 6A.1: Comparison of FLUENT and Experimental Temperature Profiles and Heat Fluxes in a Heated Annulus

(b)(4)

Figure 6A.2: Vertical Cross-Section View of the TN-24P Cask

(b)(4)

Figure 6.A.3: Horizontal Cross-Section View of the TN-24P Cask

(b)(4)

Figure 6A.4: Vacuum Condition FLUENT Temperature Profile Comparison with Measured TN-24P Data

(b)(4)

Figure 6A.5: Horizontal Nitrogen FLUENT Temperature Profile Comparison with Measured Temperature Data

(b)(4)

Figure 6A.6: Horizontal Helium FLUENT Temperature Profile Comparison with Measured Temperature Data

(b)(4)

Figure 6A.7: Vertical Nitrogen FLUENT Temperature Profile Comparison with Measured Temperature Data

(b)(4)

Figure 6A.8: Vertical Helium FLUENT Temperature Profile Comparison with Measured Temperature Data

CHAPTER 7: SHIELDING EVALUATION*

7.0 INTRODUCTION

The shielding evaluations for the HI-STORE CIS Facility are presented in this chapter, including dose and dose rate calculations to show that the facility is in compliance with the applicable regulatory requirements.

Specifically, evaluations and calculations are presented here for the following conditions and configurations:

- Owner Controlled Area boundary, with dose rates and annual dose for the location closest to the ISFSI. An ISFSI with 500 loaded HI-STORM UMAX VVMs, consistent with the description in Section 1.1, is used for the evaluations, and conservative assumptions on the content of each canister.
- Occupational dose rates at the surface and 1 meter from a single HI-STORM UMAX.
- Occupational dose rates at the surface, 0.5 meters, 1 meter, and 2 meters from the HI-TRAC CS

The HI-STORE CIS Facility utilizes the HI-STORM UMAX storage system (Docket #72-1040), and only canisters approved for that system and listed in Table 1.0.3 are permitted for storage in the facility. Therefore, the principal calculational approach, including principal assumptions and methodologies, are directly taken from the HI-STORM UMAX FSAR, and are incorporated by reference. Table 7.0.1 lists all sections from the HI-STORM UMAX FSAR that are incorporated by reference, together with a technical justification. However, some additional shielding evaluation that is different from that in the HI-STORM UMAX FSAR is required specifically for the HI-STORE CIS Facility, due to site-specific considerations. These additional shielding evaluations are clearly identified in the following sections. In brief, they contain the following:

- The dose analyses in the HI-STORM UMAX FSAR focus on dose rates around a single VVM, and only a few hypothetical ISFSI configurations were analyzed. In the evaluations presented here, the full ISFSI as described in Section 1.1 is used as the basis of the evaluation.
- The HI-STORM UMAX storage VVM used here is slightly modified compared to the version documents in the HI-STORM UMAX FSAR [1.0.6], with lower doses and other improvements not related to the shielding analyses. General details of this version are presented in Section 1.2. This is considered in the dose evaluations presented here.
- The HI-STORM UMAX FSAR assumes the use of a generic transfer cask (HI-TRAC VW) suitable for canister loading in a spent fuel pool. Since wet loading of canisters is not part of the operation of the HI-STORE CIS facility, a different HI-TRAC, termed HI-TRAC CS, with improved shielding and improved operational characteristics is used.

* All references are in placed within square brackets in this report and are compiled in Chapter 19 (References)

Details of this HI-TRAC CS are presented in Section 1.2. Dose rate evaluations for this transfer cask are presented in this chapter.

- The dose estimates for loading operations consider the operational sequence for canister loading at the HI-STORE facility, which includes the unloading of the transport cask, stackup operation between the transport cask and the HI-TRAC CS, transfer movement to the HI-STORM UMAX VVM ISFSI, and downloading of the canister into the HI-STORM UMAX VVM.

Table 7.0.1: Material Incorporated by Reference in this Chapter				
Information Incorporated by Reference	**Source of the Information**	**NRC Approval of Material Incorporated by Reference**	**Location in this SAR where Material is Incorporated**	**Technical Justification of Applicability to HI-STORM UMAX**
HI-STORM UMAX Evaluation Methodologies	Sections 5.1, 5.2, 5.3, and 5.4; Reference [1.0.6]	SER HI-STORM UMAX Amendments 0, 1, and 2 References [7.0.1, 7.0.2, 7.0.3]	Sections 7.1, 7.2, and 7.4	The general HI-STORM UMAX design is the same from a shielding perspective as the one described in the HI-STORM UMAX FSAR with minor differences in design details, so the approaches, general assumptions and methods established in the HI-STORM UMAX FSAR are fully applicable to the HI-STORM UMAX utilized for the HI-STORE facility. Note that the HI-STORM UMAX FSAR includes references to the HI-STORM FW FSAR, since both share the same canister models. However, since the HI-STORM UMAX FSAR includes relevant excerpts from the HI-STORM FW FSAR, no part of the HI-STORM FW FSAR needs to be incorporated by reference into the HI-STORE SAR in this chapter.

7.1 CONTAINED RADIATION SOURCES

7.1.1 General Specification and Approach for Neutron and Gamma Sources

The HI-STORE CIS Facility is designed for spent fuel and associated hardware in sealed canisters. The principal description of the source terms for the fuel, together with the calculations methodologies, is presented in Section 5.2 of the HI-STORM UMAX FSAR [1.0.6], which is incorporated here by reference. The only additional discussion needed here is the justification of the design basis assembly assumption presented below.

7.1.2 Design Basis Assemblies

The design basis assemblies in [1.0.6] are industry standard 17x17 PWR assemblies, with a burnup, enrichment and cooling time combination specified in Table 5.0.1 of [1.0.6]. These parameters while conservative for HI-STORM UMAX systems loaded on ISFSIs at Nuclear Power Plant sites, far exceed the allowable heat load of the HI-STAR 190 (Table 7.C.7 of Reference [1.3.6]) and other transportation casks that would be used to transport canisters to the HI-STORE CIS Facility. Therefore, a conservative but more realistic set of burnup, cooling time, and initial enrichment parameters as shown in Table 7.1.1 that have a heat load comparable to Table 4.1.1 are used for site-specific HI-STORE CIS Facility shielding calculations.

A number of conservative assumptions are applied throughout the HI-STORE CIS Facility shielding calculations. These assumptions assure that actual dose rates will always be below the calculated dose rates, and below regulatory limits. Selected key assumptions are:

(b)(4)

(b)(4)

- Assemblies with higher burnups
  - Those would also have correspondingly higher cooling times to meet transport requirements
- PWR fuel assemblies that differ from HI-STORM UMAX FSAR [1.0.6] design basis fuel assemblies
- The MPC-89 canister with BWR fuel.
  - Calculations for the HI-STORM FW [1.3.7] show that the results for the MPC-37 and MPC-89 are comparable

Table 7.1.1: HI-STORE CIS FACILITY DESIGN BASIS FUEL - BURNUP, COOLING TIME, AND ENRICHMENT FOR DOSE EVALUATION			
MPC TYPE	**BURN- UP (GWD/MTU)**	**COOLING TIME (YEARS)**	**ENRICHMENT (Wt % U-235)**
MPC-37	45	8	3.2

Table 7.1.2 CALCULATED PWR FUEL GAMMA SOURCE PER ASSEMBLY FOR DESIGN BASIS BURNUP AND COOLING TIME			
Lower Energy	**Upper Energy**	**45,000 MWD/MTU 8-Year Cooling**	
(MeV)	(MeV)	(MeV/s)	(Photons/s)
0.45	0.7	1.42E+15	2.47E+15
0.7	1.0	2.67E+14	3.15E+14
1.0	1.5	8.49E+13	6.80E+13
1.5	2.0	5.85E+12	3.34E+12
2.0	2.5	5.94E+11	2.64E+11
2.5	3.0	3.97E+10	1.44E+10
Total		1.78E+15	2.86E+15

Table 7.1.3

SCALING FACTORS USED IN CALCULATING THE ^{60}Co SOURCE

Region	PWR
Handle	N/A
Upper End Fitting	0.1
Gas Plenum Spacer	0.1
Expansion Springs	N/A
Gas Plenum Springs	0.2
Incore Grid Spacer	1.0
Lower End Fitting	0.2

Table 7.1.4

CALCULATED ^{60}Co SOURCE PER ASSEMBLY

FOR DESIGN BASIS

FUEL AT DESIGN BASIS BURNUP AND COOLING TIME

Location	45,000 MWD/MTU and 8-Year Cooling (curies)
Lower End Fitting	57.51
Gas Plenum Springs	11.21
Gas Plenum Spacer	7.96
Incore Grid Spacers	238.81
Upper End Fitting	38.26

Table 7.1.5

CALCULATED PWR NEUTRON SOURCE PER ASSEMBLY

FOR 45,000 MWD/MTU BURNUP AND 8 YEAR COOLING

Lower Energy (MeV)	**Upper Energy (MeV)**	**45,000 MWD/MTU 8-Year Cooling (Neutrons/s)**
1.0e-01	4.0e-01	3.25E+07
4.0e-01	9.0e-01	7.08E+07
9.0e-01	1.4	7.06E+07
1.4	1.85	5.64E+07
1.85	3.0	1.05E+08
3.0	6.43	9.55E+07
6.43	20.0	9.11E+06
Totals		4.40E+08

7.2 STORAGE AND TRANSFER SYSTEMS

7.2.1 Design Criteria

The design criteria, namely the relevant regulatory dose and dose rate, and ALARA requirements are presented in Chapter 4.

7.2.2 Design Features

7.2.2.1 Storage System

The version of the HI-STORM UMAX storage system used here is slightly different from that described in [1.0.6]. However, the differences are minor, and do not affect the principal design features of the system. A discussion of the shielding design features of the storage system see Subsection 5.1.1 in [1.0.6]. This Subsection is incorporated here by reference.

The storage system design is based on a metal canister that is sealed by welding for spent fuel confinement, preventing release of radionuclides from inside the canister. Radioactive effluents are thus precluded by design. This meets the intent of 10CFR72.24(e) and 10CFR72.126(d) [1.0.5], which requires that the ISFSI design provide means to limit the release of radioactive materials in effluents during normal operations to levels that are ALARA. There are no radioactive effluents released from the CIS Facility during normal operations. This passive system design also requires minimum maintenance and surveillance requirements by personnel.

7.2.2.2 Transfer Cask HI-TRAC CS

As discussed before, the HI-STORE facility uses a different transfer cask, HI-TRAC CS, than used in the operation of the generic HI-STORM UMAX and HI-STORM FW system. Instead of lead and steel for gamma shielding, and water for neutron shielding, it uses steel and concrete for both gamma and neutron shielding, and has an integrated bottom door for operational purposes. A detailed description of the HI-TRAC CS design is presented in Subsection 1.2.4. With its higher weight and integrated bottom shield gates, it provides significant advantages in dose rates and operational doses compared to the lead and water design.

7.3 SHIELDING COMPOSITION AND DETAILS

7.3.1 Composition and Material Properties

The composition and material properties for the concrete and soil used in the MCNP model of the HI-STORM UMAX System is provided in Table 7.3.1. The material compositions and material properties of the storage system are provided in Subsection 5.3.2 and Table 5.3.2 in [1.0.6]. This section and table are incorporated by reference into this document.

The material compositions and properties for the materials used for the HI-TRAC CS are the same as those for the corresponding materials in Table 5.3.2 in [1.0.6], except for the concrete in the transfer cask body, which is specified in Table 7.3.1 at the end of this subsection.

7.3.2 Shielding Details

For shielding details of the canisters see Section 5.3 in [1.0.6]. This section is incorporated by reference into this document.

Chapter 1 provides the drawings that describe the HI-STORM UMAX System including the HI-TRAC CS transfer cask. These drawings, using nominal dimensions, were used to create the MCNP models used in the radiation transport calculations for the transfer cask. Figure 7.4.1 shows a cross sectional view of the HI-TRAC CS with the MPC-37. Figure 7.4.2 shows the HI-STORM UMAX Version C as modeled in MCNP. These figures were created in the visual editor provided with MCNP, and are drawn to scale.

Conservatively the walls of the HI-TRAC CS are shorter than the dimensions shown in Section 1.5 Licensing Drawings and the optional Annulus Shield Ring is not credited.

Table 7.3.1 (Sheet 1 of 3)

COMPOSITION OF THE MATERIALS – HI-STORE CIS FACILITY

Component	Density (g/cm^3)	Elements	Mass Fraction (%)
HI-TRAC CS Concrete	Normal Conditions 3.05 Accident Conditions 2.40 Ground (Concrete below HI-TRAC CS) 2.30	O	53.2
		Si	33.7
		Ca	4.4
		Al	3.4
		Na	2.9
		Fe	1.4
		H	1.0
HI-STORM UMAX Concrete	Lid 2.40 C.E.C Plenum Shield 2.16 ISFSI Pad 2.16 Support Foundation Pad 1.92	O	53.2
		Si	33.7
		Ca	4.4
		Al	3.4
		Na	2.9
		Fe	1.4
		H	1.0
Soil	Ground 1.92 Beneath VVM 1.7	H	0.962
		O	54.361
		Al	12.859
		Si	31.818

Table 7.3.1 (Sheet 2 of 3)

COMPOSITION OF THE MATERIALS - HI-STORE CIS FACILITY

Component	Density (g/cm^3)	Elements	Mass Fraction (%)
Metamic-HT	2.61	B-10	1.3
		B-11	5.75
		Al	91.0
		C	1.96
Carbon steel	7.82	Fe	99.0
		C	1.0
SS304	7.94	Cr	19.0
		Mn	2.0
		Fe	69.5
		Ni	9.5

Table 7.3.1 (Sheet 3 of 3)

COMPOSITION OF THE MATERIALS – HI-STORE CIS FACILITY

Component	**Density (g/cm^3)**	**Elements**	**Mass Fraction (%)**
PWR Fuel Region Mixture	3.769 (5.0 wt% U-235)	^{235}U	3.709
		^{238}U	70.474
		O	9.972
		Zr	15.565
		Cr	0.016
		Fe	0.033
		Sn	0.230
Lower End Fitting (PWR)	1.849	SS304	100
Gas Plenum Springs (PWR)	0.23626	SS304	100
Gas Plenum Spacer (PWR)	0.33559	SS304	100
Upper End Fitting (PWR)	1.8359	SS304	100

7.4 SHIELDING ANALYSES METHODS AND RESULTS

7.4.1 Computational Methods and Data

Computational methods and associated data is provided in Section 5.4 in [1.0.6]. This section is incorporated by reference into this document.

For doses and does rates from the entire ISFSI, the contribution from each individual VVM is calculated, considering the distance of the VVM to the selected dose location, and then the results for all VVMs are added.

7.4.2 Dose and Dose Rate Estimates

7.4.2.1 Normal Conditions

Dose rates around a HI-TRAC CS and around a single HI-STORM UMAX storage module, loaded with the MPC-37 and design basis fuel, are presented in Table 7.4.1 and 7.4.2 respectively. It can be concluded from the shielding analysis and results that the HI-TRAC CS and HI-STORM UMAX provide suitable shielding in accordance with 10CFR72.128(a)(2) [1.0.5].

Dose rates, and annual dose from 500 loaded HI-STORM UMAX VVMs at the ISFSI for various distances are presented in Table 7.4.3. Figure 7.4.3 shows ISFSI dose rates as a function of distance. The site specific geometry used in the shielding calculation is provided in Figure 7.4.4.

The maximum controlled area boundary dose rate (assuming an occupancy of 2,000 hours per year) is below the 25 mrem annual dose limit of 10CFR72.104 [1.0.5].

The nearest residence is 1.5 miles from the HI-STORE CIS Facility. The dose calculations conservatively assume a full-time resident (8760 hours/year) is only 1000 meters from the nearest loaded HI-STORM UMAX VVM. In the case of this nearest residence, the dose is calculated to be below the 25 mrem annual dose limit prescribed in 10CFR72.104 [1.0.5].

Operations inside the Canister Transfer Building would not contribute significantly to dose rates at the Controlled Area Boundary since the loaded canisters are shielded at all times by a shipping or transfer cask. The operational steps to load a single storage module, together with the estimated duration and dose rate for each step, and the cumulative crew dose for the entire operation, is presented in Chapter 11 (Radiation Protection).

Occupational doses to individuals are administratively controlled to ensure that they are maintained below 10CFR20.1201(a)(1) annual limits [7.4.1] i.e. the more limiting of:

i. The total effective dose equivalent being equal to 5 rem (0.05 Sv); or

ii. The sum deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rem (0.5 Sv).

Operational controls ensure the total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem (1 mSv) in accordance with

10CFR20.1301(a)(1) [7.4.1] and that the dose in any unrestricted area from external sources does not exceed 2 mrem (0.02 mSv) in any one hour 10CFR20.1301(a)(2) [7.4.1].

TLDs are located at the Restricted Area fence and at the Controlled Area Boundary in accordance with 10CFR20.1302 [7.4.1] to show compliance with the annual dose limit in 10CFR20.1301 [7.4.1].

7.4.2.2 Off-Normal and Accident Conditions

The only off-normal or accident condition applicable to the HI-STORM UMAX storage system is the missile impact during construction next to a loaded canister. This condition is analyzed and modeled in Section 5.1 and 5.3 of the HI-STORM UMAX FSAR [1.0.6]. The evaluation of this missile impact event shows that the regulatory dose limits are met for this condition. The respective sections are hereby incorporated by reference into this document.

The HI-TRAC CS is always carried with single failure proof equipment when loaded with a canister, hence any drop accident that could result in an increase in does rates is not credible. Further, unlike the HI-TRAC VW used in the HI-STORM UMAX FSAR, the HI-TRAC CS does not contain any water as neutron absorber. A loss of water accident is therefore not possible. However, under the fire accident condition, the outside of the cask would heat up significantly, and while the outer steel shell would assure the overall integrity of the cask, and hence prevent any significant loss of shielding function, the outer area of the shielding concrete may experience some degradation. To model this in an analysis, shielding calculations are performed in which the density of the HI-TRAC CS concrete is assumed to be substantially degraded as shown in Table 7.3.1. Results of the analyses are presented in Table 7.4.4, with the resulting accident dose (assuming a 30 day accident duration) at 100 m from the cask showing compliance with the requirements of 10CFR72.106 [1.0.5].

Table 7.4.1: Dose Rates from the HI-TRAC CS MPC-37 Design Basis Fuel 45,000 MWD/MTU and 8-Year Cooling			
Dose Point Location[1]	**Gamma Dose Rate[2] (mrem/hr)**	**Neutron Dose Rate (mrem/hr)**	**Total Dose Rate (mrem/hr)**
Surface of HI-TRAC CS			
Bottom Duct	58	56	**114**
60 inches below Mid-Height	57	2	**58**
Mid-Height	58	2	**60**
60 inches above Mid-Height	47	1	**48**
Center of Top Lid	860	164	**1024**
0.5 meters from HI-TRAC CS			
Bottom Duct	24	11	**35**
60 inches below Mid-Height	35	2	**36**
Mid-Height	37	1	**38**
60 inches above Mid-Height	27	1	**27**
1 meter from HI-TRAC CS			
Bottom Duct	18	6	**24**
60 inches below Mid-Height	24	2	**25**
Mid-Height	26	1	**27**
60 inches above Mid-Height	18	1	**19**
2 meters from HI-TRAC CS			
Bottom Duct	14	3	**17**
60 inches below Mid-Height	14	1	**15**
Mid-Height	17	1	**17**
60 inches above Mid-Height	11	1	**12**

[1] Refer to Figure 7.4.1.
[2] Dose rate from gammas include gammas generated by neutron capture, fuel gammas, Co-60 gammas and BPRA gammas.

Table 7.4.2: Dose Rates Adjacent to and 1 Meter from the HI-STORM UMAX Module for Normal Conditions MPC-37 Design Basis Zircaloy Clad Fuel			
Dose Point Location[1]	**Gamma Dose Rate[2] (mrem/hr)**	**Neutron Dose Rate (mrem/hr)**	**Total Dose Rate (mrem/hr)**
Surface of Closure Lid			
1	10.62	2.59	13.21
2	3.23	1.52	4.75
3	2.71	0.78	3.49
4	4.35	1.60	5.96
5	13.63	3.57	17.20
One Meter from Closure Lid			
1	0.40	0.31	0.72
2	0.37	0.23	0.60
3	0.91	0.37	1.27
4	1.04	0.30	1.34
5	0.31	0.20	0.51

[1] Refer to Figure 7.4.2 for dose point locations.
[2] Dose rate from gammas include gammas generated by neutron capture, fuel gammas, Co-60 gammas, and BPRA gammas.

Table 7.4.3: Dose Rates as a Function of Distance from 500 Loaded HI-STORM UMAX VVMs for Fuel Assemblies with a Burnup of 45,000 MWD/MTU, an Initial U-235 Enrichment of 3.2 wt%, and a Cooling Time of 8 Years

Distance (m)	Total Dose Rate (mrem/hr)	2000 hour/year Occupancy	8760 hour/year Occupancy
		Total Dose (mrem/yr)	Total Dose (mrem/yr)
10	6.34E-01	1.27E+03	5.55E+03
20	4.32E-01	8.63E+02	3.78E+03
30	3.22E-01	6.43E+02	2.82E+03
40	2.48E-01	4.97E+02	2.18E+03
50	1.96E-01	3.91E+02	1.71E+03
75	1.14E-01	2.28E+02	9.99E+02
100	7.07E-02	1.41E+02	6.19E+02
150	3.03E-02	6.07E+01	2.66E+02
200	1.43E-02	2.85E+01	1.25E+02
250	7.08E-03	1.42E+01	6.20E+01
300	3.68E-03	7.35E+00	3.22E+01
350	1.98E-03	3.95E+00	1.73E+01
400	1.10E-03	2.19E+00	9.61E+00
450	6.29E-04	1.26E+00	5.51E+00
500	3.71E-04	7.43E-01	3.25E+00
600	1.40E-04	2.80E-01	1.22E+00
700	6.09E-05	1.22E-01	5.34E-01
800	2.88E-05	5.75E-02	2.52E-01
900	1.41E-05	2.83E-02	1.24E-01
1000	1.01E-05	2.02E-02	8.87E-02

Table 7.4.4
Dose at 100 Meters from a Single HI-TRAC CS with MPC-37 Loaded with Design Basis Fuel for Accident Condition[1]

Dose (Rem)
0.083

[1] Accident duration is assumed to be 30 days.

(b)(4)

Figure 7.4.1 Dose Locations for the HI-TRAC CS

(b)(4)

Figure 7.4.2. Dose Locations for the HI-STORM UMAX Version C (Sheet 1 of 2)

(b)(4)

Figure 7.4.2. Dose Locations for the HI-STORM UMAX Version C (Sheet 2 of 2)

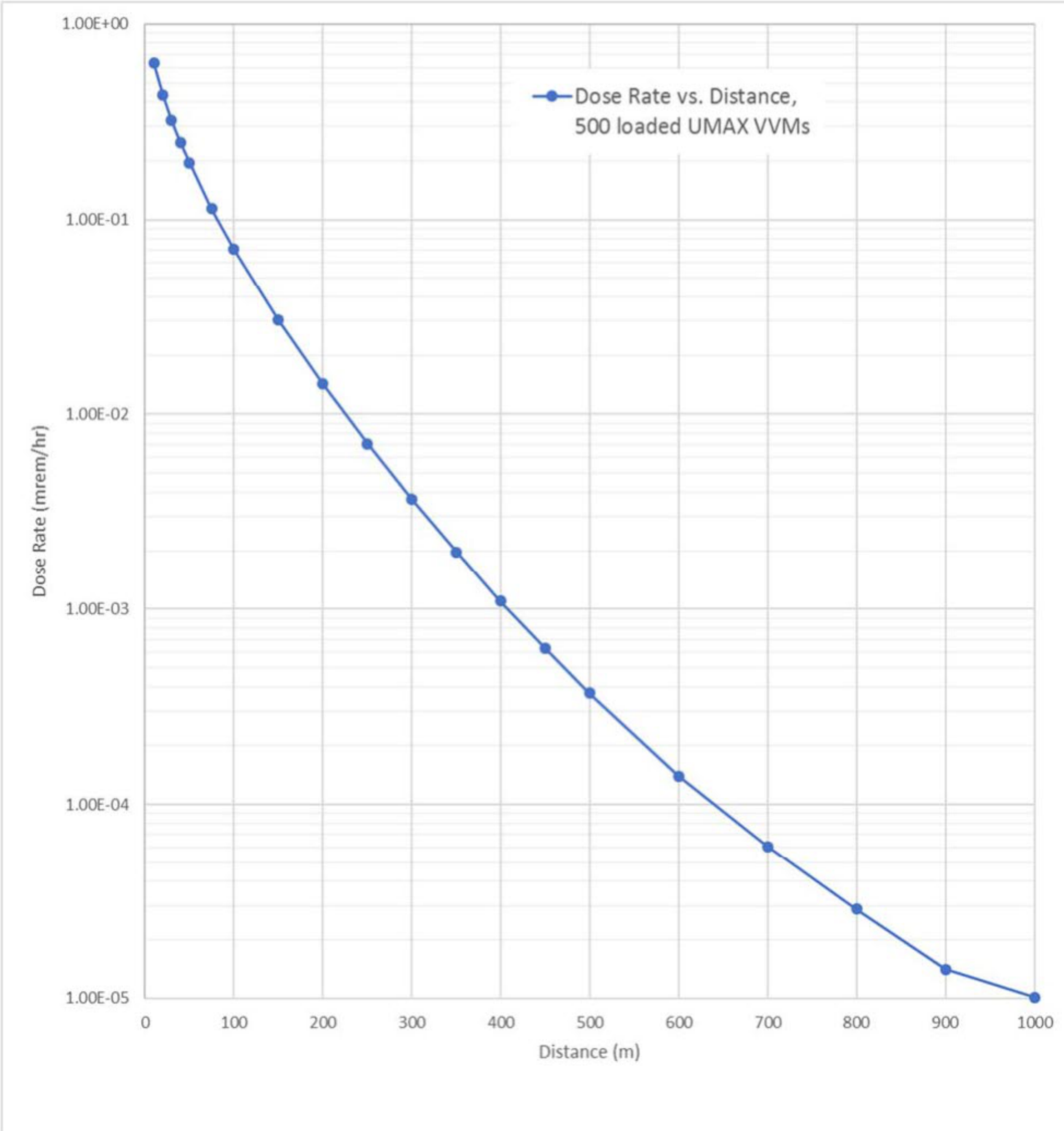


Figure 7.4.3. HI-STORE CIS Facility HI-STORM UMAX VVM ISFSI Dose Rates as a Function of Distance (500 loaded HI-STORM UMAX VVMs)

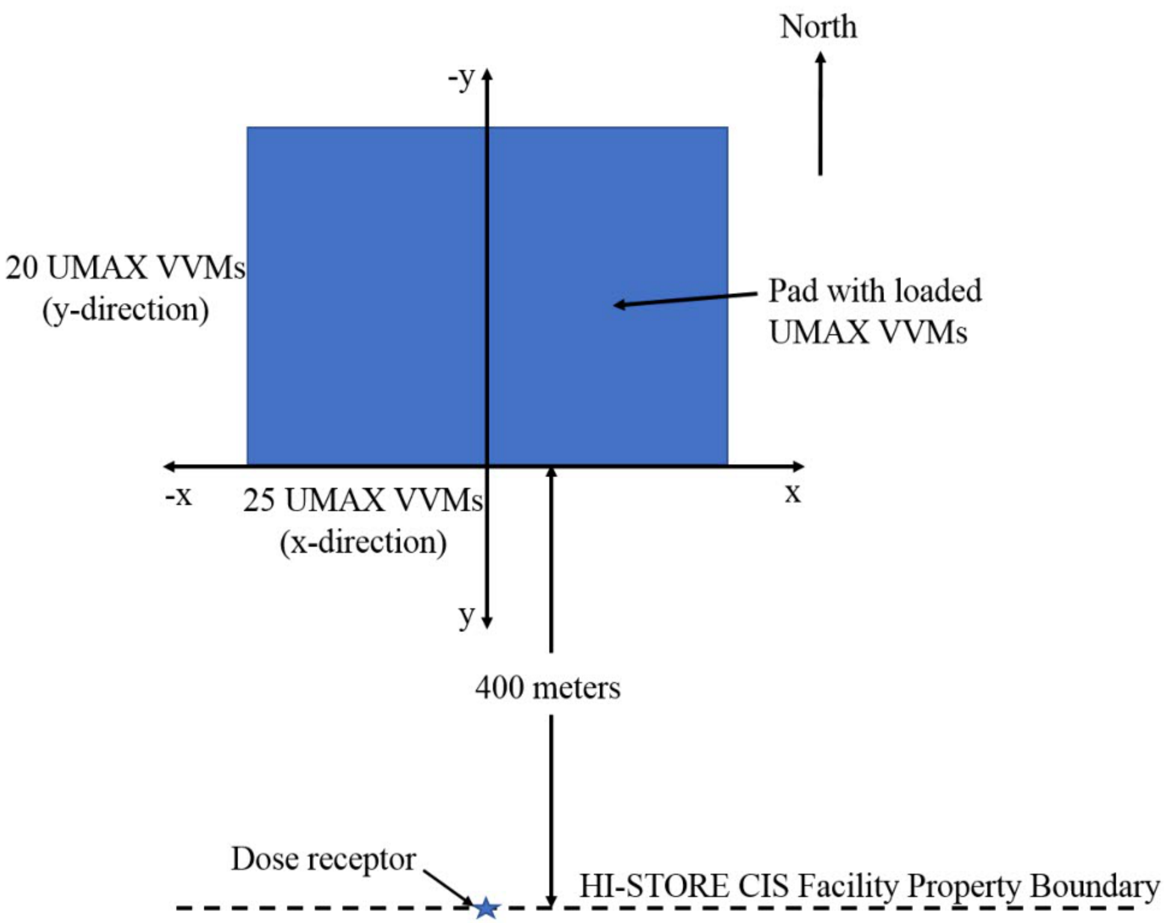


Figure 7.4.4. HI-STORE CIS Facility Layout - 500 Loaded HI-STORM UMAX VVMs considered in Dose vs. Distance Shielding Analysis

Notes:

1. UMAX VVM center-to-center inter-cavity pitch is provided in Table 1.1.1.
2. Dose receptor pictured in Figure 7.4.4 indicates location of maximum dose rates at the property boundary for the given ISFSI geometry. Maximum dose rates at various distances (for any orientation) are reported in Table 7.4.3. The dose receptor pictured in Figure 7.4.4 is at the coordinate pair (0, 400), with modeling and calculational details provided in Reference [7.4.2].

7.5 SUMMARY

In summary, the design of the facility satisfies all regulatory criteria and limits for radiological protection, and provides acceptable means for limiting the exposure of the public to direct and scattered radiation.

CHAPTER 8: CRITICALITY EVALUATION*

8.0 INTRODUCTION

The criticality safety qualification of the canisters for installation at the HI-STORE CIS facility is considered in this chapter. An essential commitment in this SAR is that only those canisters that have been certified and loaded under the HI-STORM UMAX docket (#72-1040) may be stored at the HI-STORE facility. Reactivity of the stored fuel in a canister depends foremost on the configuration of the fuel basket and to a lesser extent on the circumscribing Enclosure Vessel around the basket. Because the canister shipped from the originating site has already been designed, built, loaded and certified to an NRC-issued Technical Specification, the subcriticality of the canister is pre-established. Thus, for example, for the canisters denoted as MPC-37 and MPC-89, the substantiating criticality safety demonstration is in the HI-STORM FW FSAR [1.3.7]. This qualification as also been utilized in the regulatory review and certification for storage in the HI-STORM UMAX system in docket # 72-1040. Since the same HI-STORM UMAX system is proposed to be deployed at HI-STORE, the criticality safety determination by the NRC in docket # 72-1040 remains applicable. This axiomatic qualification of the canisters will remain valid unless the canister and its fuel basket are physically altered during their transport or handling to the HI-STORE facility which will summarily disqualify them from storage under the HI-STORE CIS docket.

* All references are placed within square brackets in this report and are compiled in Chapter 19 (last chapter)

Table 8.0.1: Material Incorporated by Reference in this Chapter

Information Incorporated by Reference	Source of the Information	NRC Approval of Material Incorporated by Reference	Location in this SAR where Material is Incorporated	Technical Justification of Applicability to HI-STORM UMAX
MPC-37 and MPC-89 Criticality Evaluation	Sections 6.1, 6.2, 6.3, 6.4, and 6.5; Appendices 6.A and 6.B of Reference [1.3.7]	SER HI-STORM FW Amendments 0, 1, and 2 References [8.0.1, 8.0.2, and 8.0.3]	Sections 8.1, 8.3, and 8.4	The canister is the same as the one described in the FW FSAR and originally approved in the referenced SER. There is no change to the fuel basket, and canister integrity is ensured by the acceptance test criteria established in this SAR.
Applicability of HI-STORM FW criticality evaluation to HI-STORM UMAX system	Section 6.2 of Reference [1.0.6]	SER HI-STORM UMAX Amendments 0, 1, and 2 References [7.0.1, 7.0.2, 7.0.3]	Sections 8.3, and 8.4	The HI-STORM UMAX design is the same from a criticality perspective as the one described in the HI-STORM UMAX FSAR and so the conclusions established therein that the HI-STORM FW criticality analysis is fully applicable to the HI-STORM UMAX, remain unchanged in this SAR.

8.1 CRITICALITY DESIGN CRITERIA AND FEATURES

8.1.1 Criteria

The acceptance criteria for criticality evaluations for the HI-STORM UMAX system utilized at the HI-STORE facility are presented in Chapter 4 of this SAR.

8.1.2 Features

Section 6.1 of the HI-STORM FW FSAR [1.3.7] is incorporated by reference into this SAR, and describes all the criticality design features of the canisters which maintain the stored fuel in a sub-critical condition.

8.2 STORED MATERIAL SPECIFICATIONS

The fuel assemblies allowable for storage in the HI-STORM UMAX VVMs at the HI-STORE facility are described in Section 4.1.

8.3 EVALUATION

During storage conditions in the HI-STORM UMAX system, the maximum k_{eff} will be significantly below the limiting maximum k_{eff} since the MPC is internally dry. Under this condition, the configuration is very similar in all other HI-STORM models, which consists of an internally dry MPC, an air gap between the MPC and the overpack, a steel shell or shells and concrete (above-ground) or soil (underground). Results for the HI-STORM UMAX VVM would therefore be practically identical to the results listed for storage conditions in Chapter 6 of the canister's native FSAR (such as the HI-STORM FW FSAR [1.3.7] for the canisters subsequently certified under the HI-STORM UMAX FSAR [1.0.6], which are now included in this site-specific license. Any small differences in results would not affect the principal conclusions, since the maximum k_{eff} under storage conditions (dry inert environment) is substantially below the regulatory limit. It should be noted that the analysis for the canisters in the various HI-STORM models conservatively assumes that the gap between the canister and the HI-STORM is flooded with water, thus increasing the neutron reflection compared to a dry cavity [8.0.1, Section 7]. Flooding under accident conditions of the HI-STORM UMAX is therefore also covered by the calculations for the HI-STORM FW (see also Subsection 8.3.2 below). All other normal, off-normal and accident conditions in the HI-STORM UMAX system at HI-STORE are identical to or less severe than invoked for certification in the generic dockets (such as HI-STORM FW) which consider bounding loadings for the entire continental United States.

In summary, the limiting condition for storage of the canisters certified in the generic docket for HI-STORM UMAX (Docket # 72-1040) is identical to their storage in HI-STORM UMAX at HI-STORE from a criticality perspective, and all other normal, off-normal and accident conditions are identical or equivalent between the two dockets from a criticality perspective. Therefore, the criticality safety of the canisters certified in docket # 72-1040 is *a priori* ensured for storing those canisters at HI-STORE. No additional calculations to demonstrate criticality safety are required for storing such canisters in the HI-STORM UMAX system at HI-STORE.

8.3.1 Model Configuration

The model configuration including material properties for the criticality analysis is incorporated by reference from Section 6.3 of [1.3.7], as described in Table 8.0.1 of this SAR.

8.3.2 Accidental Criticality

10CFR72.124(a) requires that at least two unlikely events (changes) must occur before a criticality accident is possible. The HI-STORM UMAX implementation at the HI-STORE facility would in fact require three such events before an accident is possible, and is therefore in compliance with the abovementioned regulation. The three unlikely events applicable to the facility are as follows

- The site is in a dry area with no flood plains (see [1.0.4], Subsection 3.5.4). Even the 100,000 year flood is estimated to be only 4.8 inches (see [1.0.4], Subsection 4.5.3), and at that level the design of the systems would prevent any flooding of the CECs, since the lowest points of the air inlets or outlets are higher above the ground than this value. Further, the pads are designed and constructed so that rainwater will run off and not accumulate. A water spray was performed on the first HI-STORM UMAX systems installed at a site to demonstrate this after installation. Based on this, a flooding of the CECs is unlikely, in fact considered not credible.

- However, even if a CEC would be flooded, the internal cavity of the canister with the basket and fuel would remain dry, and hence the reactivity would remain very low. The canister is seal-welded, and the integrity of the canister is verified during the acceptance tests when it enters the site. For the initially licensed period of each canister, this gives assurance that a leak of the canister that would allow ingress of water is unlikely. For longer storage times beyond the initially licensed period, an aging management program is applied, designed to detect and mitigate any such leaks, making water inleakage also an unlikely event.
- Finally, the fact that canisters are not loaded on-site, but always be delivered to the site in a 10CFR71 approved transportation cask, together with the acceptance tests for each transport cask, presents the third barrier, which would prevent a criticality accident even in the unlikely event that both the CEC and the canister would be flooded:
    - The transport regulations require that the package remains subcritical under normal conditions when flooded with pure water.
        - For BWR fuel that is essentially met by default, since canisters are loaded in a pool with fresh water
        - For PWR fuel, the requirements for transportation in the HI-STAR 190 require burnup credit so that the same requirement is met, i.e. subcriticality when flooded with fresh water
    - The transportation cask to be used for the approved canisters (HI-STAR 190) will also be qualified for High Burnup Fuel, where fuel damage is possible. In that case, the criticality safety evaluation for the package does not assume flooding of the canister. However, the acceptance tests for the acceptance of the canister on site excludes canisters from transports that have undergone any accident condition, as described in the Facility Technical Specifications. This scenario is therefore not applicable here.

Based on this, even for a flooded canister, accidental criticality is unlikey.

Overall, at least three unlikely (or non-credible) events would be required before accidental criticality could be possible at the HI-STORE facility. The facility is therefore in compliance with 10CFR72.124(a).

8.4 APPLICANT CRITICALITY ANALYSIS

The criticality analysis for the MPC-37 and MPC-89 is incorporated by reference from Section 6.4 of [1.3.7], as described in Table 8.0.1 of this SAR, including the computer program utilized, multiplication factor, and benchmark comparison. The discussion of how these HI-STORM FW results apply to the HI-STORM UMAX system is incorporated by reference from Section 6.2 of [1.0.6]. The configuration and confinement of the canisters are unchanged based on the discussion in Chapter 9, so the existing analysis is fully applicable to the HI-STORE CIS Facility.

8.5 CRITICALITY MONITORING

10CFR72.124(c) requires criticality monitoring during operations unless the fuel is already packaged in the storage configuration. At the HI-STORE facility, no wet fuel operations are performed, and fuel will always be in the dry and sealed canisters, i.e. in the storage configuration. Hence criticality monitoring per 10CFR72.124(c) is not required.

CHAPTER 9: CONFINEMENT EVALUATION*

9.0 INTRODUCTION

The confinement safety of the HI-STORE CIS facility is considered in this chapter. In accordance with NUREG-1567 [1.0.3] the following areas are addressed

- Potential of the release of radioactive material
- Monitoring systems
- Protection of stored materials from degradation

The evaluation of any potential release considers both the storage systems and the operational activities.

Additionally, for the storage systems, aspects of receipt inspections for systems delivered to the site, and long-term aging are briefly addressed, with full details presented in other chapters of this SAR and referenced appropriately.

With respect to the storage systems themselves, only radioactive materials in seal-welded canisters are accepted and placed into storage in this facility. Further, this is limited to those canisters that are certified for storage in the HI-STORM UMAX docket (Docket #72-1040). The HI-STORM UMAX FSAR references the HI-STORM FW docket (Docket # 72-1032). Hence this chapter contains references to sections of the FSAR of the HI-STORM UMAX and sections of FSAR of the HI-STORM FW. The sections that are included by reference from the HI-STORM UMAX FSAR and HI-STORM FW are listed in Table 9.0.1.

* All references are in placed within square brackets in this report and are compiled in Chapter 19 (last chapter)

Table 9.0.1: Material Incorporated by Reference in this Chapter

Information Incorporated by Reference	Source of the Information	NRC Approval of Material Incorporated by Reference	Location in this SAR where Material is Incorporated	Technical Justification of Applicability to HI-STORM UMAX
HI-STORM UMAX Confinement Evaluation HI-STORM FW Confinement Evaluation	Chapter 7 of [1.0.6] Chapter 7 of [1.3.7]	SER HI-STORM UMAX Amendments 0, 1, and 2 References [7.0.1, 7.0.2, 7.0.3] SER HI-STORM FW Amendments 0, 1, and 2 References [8.0.1, 8.0.2, 8.0.3]	Section 9.2.1 Section 9.2.1	Only canisters approved for use in HI-STORM UMAX under its certificate are permitted for storage in the HI-STORE facility. Further, the storage system used for storage of the canisters at the HI-STORE CIS is principally the same as that in the HI-STORM UMAX FSAR. Additionally, the conditions, namely the environmental temperatures, and canister heat loads, for the HI-STORE facility are bounded by the values that the canisters are qualified for in the HI-STORM UMAX FSAR. Hence the containment evaluation in the HI-STORM UMAX FSAR is fully applicable to the HI-STORM UMAX utilized for the HI-STORE facility. The details of the canisters approved for use in the HI-STORM UMAX, confinement design and requirements, for normal, off-normal and accident conditions are provided in the HI-STORM FW FSAR .

9.1 ACCEPTANCE CRITERIA

The acceptance criteria for confinement evaluations are referenced in Section 4.3 of this SAR.

9.2 CONFINEMENT OF RADIOACTIVE MATERIALS

9.2.1 Storage Systems

Continued Storage

Only canisters approved for use in HI-STORM UMAX under its certificate are permitted for storage in the HI-STORE facility. Table 1.0.4 identifies the canisters approved for storage in this docket. Further details on the canisters and the applicability of the containment evaluations from the HI-STORM UMAX FSAR to the HI-STORE facility are discussed below.

Confinement of all radioactive materials in all HI-STORM vertical ventilated modules is provided by the canister's Enclosure Vessel which has no mechanical joints, flanges, gaskets and the like that may be subject to leakage. The confinement boundary as defined in Paragraph 2.3.3.4 in the HI-STORM UMAX FSAR[1.0.6] consists of the MPC shell, MPC baseplate, MPC lid, port cover plates, closure ring, and associated welds. The pressure boundary of the canister consists of radiographed weld seams and ultrasonically tested plate and forging stock. Only high ductility stainless steel alloy with excellent fracture strength properties at low service temperatures are used in the manufacture of the canisters eligible for storage at HI-STORE.

All normal, off-normal and accident conditions relevant to confinement integrity for which the canister is certified in the HI-STORM UMAX docket are equal to or less severe at the HI-STORE facility. Therefore, there are no new conditions for the HI-STORE CIS facility that would require additional confinement analyses. With respect to the applicability of the containment evaluation from the HI-STORM UMAX note that the continued confinement integrity of a canister is influenced by the stress field that exists in its Enclosure Vessel during its storage state and by the occurrence of any stress-inducing mechanical loading event. These are discussed below:

- The stresses that the canister will experience at the HI-STORE facility will be bounded by those for which it is certified in the HI-STORM UMAX docket because:
  - The Design Basis Heat load (see Tables 4.1.1 and 4.1.2) for all canisters eligible for storage in HI-STORE is lower than that for the canisters certified in Docket # 72-1040 (see Tables 2.1.8 and 2.1.9 in the HI-STORM UMAX FSAR[1.0.6]). It follows that the internal gas temperature in the former will be less than the latter. Therefore, it follows that the pressure in the canisters and hence any pressure-induced stresses will be lower in HI-STORE canisters than their certification-basis in the HI-STORM UMAX FSAR.
  - The canisters in the HI-STORM UMAX docket are certified for the entire range of ambient temperatures that exist in the lower 48 states in the United States. Therefore, the licensing-basis ambient temperature range applicable to the canister's general certification in the HI-STORM UMAX docket bounds the conditions at the HI-STORE site.
- As in the HI-STORM UMAX FSAR, all lifting and handling operations involving canisters at the HI-STORE facility are performed with single failure proof equipment. Hence there are no additional mechanical loading events that would affect the confinement function of the canisters.

In summary, the storage conditions at the HI-STORE site are identical to, or more benign (less challenging) than the certification-basis conditions for the canisters in the generic HI-STORM UMAX docket (# 72-1040). Therefore, the safety conclusions reached with respect to the system confinement integrity in the HI-STORM UMAX FSAR [1.0.6] also apply to the canisters stored at HI-STORE.

Confinement safety of the canisters in this docket is therefore demonstrated by reference to the confinement determination reached in the HI-STORM UMAX FSAR [1.0.6].

<u>Receipt Inspection</u>

The canister must meet the following criteria that pertain to its continued condition of no-credible-leakage upon arrival at the HI-STORE facility:

- The canister records must be provided to the HI-STORE facility personnel prior to shipment of a canister. These records must be reviewed and any applicable 10CFR72.48 screenings or evaluations written against the canister's original licensing basis evaluated against the HI-STORE site specific license to determine if a change requiring NRC approval is necessary.
- The canister was not subject to any incident beyond the normal conditions which the package has been qualified to pursuant to 10CFR71.71.
- The canister passes the leak test and other receipt inspections set forth in Chapter 10 of this SAR at the HI-STORE receiving area.

A canister that meets the above conditions is deemed to continue to meet the no-credible-leakage criteria to which it has been certified in the HI-STORM UMAX docket (# 72-1040). Although the HI-STORM UMAX confinement boundary includes the MPC lid to shell weld, this weld is covered with a redundant closure ring. Therefore, the leak testing described is performed on that redundant closure ring and the confinement boundary lid to shell weld together. However, due to the restrictions on no transport incident and the fact that the storage conditions have been demonstrated to pose no challenge to the confinement boundary, confirmation that the combination of closure ring and lid to shell weld is intact provides reasonable assurance that the inner lid-to-shell weld remains a fully qualified confinement boundary.

Prior to shipment, the canister storage operation is bounded by the onsite storage system FSAR. During transportation to the HI-STORE, canister transportation operations are bounded by the HI STAR 190 SAR, Chapter 4 (Sections 4.5 – 4.7) [1.3.6]. Adherence to these criteria demonstrates confinement safety prior to receipt at the HI-STORE.

<u>Long Term Storage and Aging Management</u>

While a canister is still within its originally licensed period in accordance with the certificate it was originally approved to, no further confinement considerations are necessary, since the canister retains its no-credible-leakage status based on the original confinement evaluation and the receipt inspection discussed above. However, it is expected that canisters will be stored at the HI-STORE CIS facility beyond this initial period. Any canister where the storage life exceeds 20 years will need to comply with the aging management requirements outlined in Chapter 18 of this SAR. Compliance with these requirements will ensure that any conditions that could be detrimental to the confinement function of the canister will be identified, and, if necessary, mitigated.

9.2.2 Operational Activities

With respect to the confinement of the radioactive material, the operational activities can be grouped into the following three steps/conditions

- MPC is still inside the intact containment boundary of the transportation cask that it is delivered in
- Receipt inspection activities on each canister, and, if the inspection criteria are met, opening of the transport cask containment boundary.
- Operational activities to place the accepted canister into storage

These steps are discussed in further detail below.

While the canister is still inside the transportation cask, the canister is still considered the confinement boundary for the material. However, the receipt inspections need to be passed to confirm that the confinement boundary has not degraded during the transport phase. Until this is concluded, the containment boundary of the transportation cask serves as an additional measure to assure confinement of the material in the canisters.

During the receipt inspection and opening of each transportation cask, the activities that are performed, and the possibility (or lack thereof) of any release of radioactive material is as follows:

- The transportation cask's closure lid access port is opened to allow access to the small free volume between the canister and the cask. For this activity, the port is covered by appropriate means, so that in the unlikely event that the volume would contain any radioactive material, it would not be released into the local work area (transfer building), but appropriately collected.
- A gas sample is taken from this volume and tested for the presence of fission products, namely Krypton-85.
  - If any fission products are detected, the port will be resealed, and the cask will be classified as "not acceptable". All gas samples containing fission products will be collected and tracked in accordance with Section 10.3. Cask transfer operations will be terminated for casks not meeting the acceptance criteria. For further processing of casks that are not acceptable see Section 10.3.
  - Full details of the receipt inspection test including instrumentation and acceptance criteria are outlined in Section 10.3.
  - If the acceptance criteria outlined in Section 10.3. are not met the transportation cask is not opened and is not accepted at the HI-STORE facility
- If no fission products are detected, the free volume is evacuated, flushed with nitrogen and then tested for traces of helium that could be an indication of any leakage of the helium-filled canister in the cask.

- If the leak tightness of the canister cannot be ascertained the port will be resealed and the cask will be classified as “not acceptable”. For further processing of casks that are not acceptable see Subsection 10.3.3.

From this step, even in the unlikely event that fission products were detected, these would only be small amounts from the small free space between the cask and the canisters, and the process is designed to ensure that those are collected. A release into the building or the environment is therefore not considered credible.

As discussed in Subsection 9.2.1 above, all radioactive material is stored and handled in seal welded canisters, and as presented in Chapter 1, all handling operations are performed either with single-failure-proof cranes, or using suitable impact limiters. Hence once the canisters have passed the receipt inspection, also discussed in Subsection 9.2.1, there is no credible normal, off-normal, or accident conditions that could challenge the integrity of the canister confinement system and result in a release of any radioactivity.

Overall, from all operational activities, no credible events are identified that would result in a release of any radioactive materials into the work areas or the environment.

9.3 POOL AND WASTE MANAGEMENT FACILITIES

9.3.1 Pool Facilities

HI-STORE CIS contains no pool or any other water-based storage or handling facility.

9.3.2 Waste Management Facilities

No specific facilities are needed for the management of radioactive waste at the HI-STORE facility, since no, or only insignificant amounts of, radioactive waste is generated in the facility, as discussed in the following:

- All fuel is handled in seal-welded canisters with no credible leakage, and all activities and operations with the canisters are designed to maintain this condition
- The transportation casks received with the canisters at the site would almost certainly have been loaded with canisters in a dry facility, hence contamination of the casks is not expected.
    - Nevertheless, transport casks are checked for contamination upon receipt and during processing and extraction of the canisters, and in the unlikely event that any contamination would be detected, this would be removed with standard methods, and any materials related to this operation would be separately collected, and transported off-site for appropriate disposal.
- Small gas samples are taken during the receipt inspection of the canisters. The samples will be kept in closed containers until the measurements have confirmed the absence of any fission gases. In the unlikely event that fission gases would be detected, the gas samples will be transported off-site for appropriate disposal.
- There is no other radioactive material that is being handled openly throughout the facility.

9.4 CONFINEMENT MONITORING

9.4.1 Storage Confinement Systems

9.4.1.1 Closure Seal Monitoring System

All radioactive material is stored in seal-welded canisters, and consistent with its operation and approval under the initial certificate that those canisters are loaded under, no monitoring of the closure seals is required for the initial licensing period. The continuous confinement of the canisters beyond their initial licensing period is addressed in the Aging Management Program in Chapter 18, which uses a Canister Aging Management Program to inspect and monitor, as described in Section 18.5.

9.4.1.2 Continuous Monitoring System

All material at the ISFSI is stored in seal welded canisters, qualified to have no credible leakage per ISG-18. Hence no monitoring of airborne radiation is needed in and around the storage area.

For the canister transfer inside the CTB, there is also no expectation that any release of radioactivity would occur, so no monitoring of airborne radiation is required. Nevertheless, radiation detectors able to detect airborne radiation may be used in the CTB as additional measure.

9.4.2 Effluents

The HI-STORE CIS facility does not generate any radioactive effluent hence no effluent monitoring system is required.

Additionally, in the absence of any effluent, there is no potential for transport of radioactive materials to the environment through any aquifer under the site.

9.5 PROTECTION OF STORED MATERIALS FROM DEGRADATION

9.5.1 Confinement Casks or Systems

All radioactive material is stored in seal-welded canisters, in an inert atmosphere, and consistent with its operation and approval under the initial certificate that those canisters are loaded under, no degradation of its content is to be expected. Any potential degradation beyond the previously approved canister licensed life is addressed in the Aging Management Program in Sections 18.5, 18.11, 18.12 and 18.14.

9.5.2 Pool and Waste Management Systems

HI-STORE CIS contains no pool or any other water-based storage or handling facility.

9.6 SUMMARY

In summary,

- This chapter describes confinement structures, systems and components, and their evaluation and effectiveness.
- The confinement of all radioactive material is provided by seal-welded canisters, loaded and closed under their original certificates. The confinement is verified upon receipt inspection through leak testing to the leaktight criteria in accordance with Section 10.3.
- The operation of the HI-STORE CIS facility generates no radioactive effluents. There is no potential for transport of radioactive materials to the environment through any aquifer.
- No release of any radioactive material is expected from the facility and its operation, hence no additional dose from released material is considered in the evaluations in Chapter 11.
- No radiation monitoring system is required.
- The stored material is protected against degradation due to its storage in an inert atmosphere.
- The confinement systems will reasonably maintain confinement under normal, off-normal and accident conditions.

CHAPTER 10: CONDUCT OF OPERATIONS EVALUATION*

10.0 INTRODUCTION

This chapter discusses the organization and procedures established by Holtec International (Holtec) for the operation and decommissioning of an Independent Spent Fuel Storage Installation (ISFSI) at the HI-STORE CIS site. Included are descriptions of organizational structure, testing, training programs, normal operations, emergency planning, and security safeguards.

* All references are placed within square brackets in this report and are compiled in Chapter 19 of this report.

10.1 ORGANIZATIONAL STRUCTURE

This section describes the organization that is responsible for long term storage of spent nuclear fuel at the HI-STORE CIS facility. Lines of authority, responsibility, and communication shall be defined and established throughout highest management levels, intermediate levels, and all operating organization positions. These relationships shall be documented and updated, as appropriate, in organizational charts, functional descriptions of departmental responsibilities and relationships, and job descriptions for key personnel positions, or in equivalent forms of documentation. This chapter is included in this SAR to fulfill the requirements in 10CFR72.24(h) and 72.28(c).

10.1.1 Corporate and On-Site Organization

The Holtec Corporate Executive responsible for the HI-STORE CIS facility (hereafter referred to as the Corporate Executive) has overall responsibility for safe operation of the site.

The Holtec HI-STORE CIS Site Manager (hereafter referred to as the Site Manager) reports to the Corporate Executive. The Site Manager is responsible for safe operation of the site, maintaining personnel trained and qualified in accordance with the HI-STORE Site Specialist Training Program [10.1.1], day-to-day implementation of the Holtec Quality Assurance Manual [12.0.1], and operation of all HI-STORE CIS facility structures, systems and components that are important to safety. This position provides direction for the safe operation, maintenance, radiation protection, training and qualification, and security of the site and personnel.

To assure continuity of operation and organizational responsiveness to off-normal situations, a normal order of succession and delegation of authority will be established. The Site Manager will designate, in writing, personnel who are qualified to act in his/her absence.

The organization charts shown in Figures 10.4.1 and 10.4.2 represent the planned organizational relationships throughout the life of the facility.

10.1.2 Support Staff (ISFSI Specialists)

Support staff will be available by either corporate staff, on-site staff or contract personnel to provide support and expertise to the Site Manager in the following areas:

- Quality Assurance: Responsible for the implementation of the requirements of the Holtec Quality Assurance Manual [12.0.1], including the maintenance of appropriate records. The staff will ensure that the appropriate steps are added to site procedures for operation and maintenance to ensure that all activities are performed in accordance with the site license;
- Engineering: The site nuclear compliance engineer is responsible for the oversight of the facility modifications. Engineering support staff, either on or off-site, is provided to support the site nuclear engineer.
- Radiation Protection Manager: Responsible for radiation safety at the HI-STORE CIS facility, for the planning and direction of the facility radiation protection and ALARA programs and procedures, as well as the operation of the health physics laboratory.

- Operating Personnel: Responsible for the receipt, inspection and transfer of canisters arriving onsite in accordance with site procedures.
- Maintenance: Responsible for mechanical, electrical and instrument maintenance for buildings, fencing, mechanical equipment and all other site equipment. Also provide operations coverage for those periods of time in which loaded canisters are handled and routine site maintenance and surveillance when canisters are not being handled. May also provide maintenance as needed for operation of railroad locomotives from the railroad mainline. Shall be responsible for ensuring that appropriate records are maintained in accordance with Subsection 10.3.2 of this Chapter and the site licensing requirements.
- Security: Responsible to maintain the security of special nuclear materials that are within the physical confines of the site, including providing initial responses to security intrusions as described in the Site Security Plan [3.1.1].
- Records: Responsible for the maintenance of records in accordance with Subsection 10.3.2 of this Chapter and the site licensing requirements.
- Site Administrative: Responsible for site administrative functions, including the maintenance of records in accordance with Subsection 10.3.2 of this Chapter and the site licensing requirements, as well as site business records and contracts. Also responsible for ensuring appropriate hiring standards are followed in the selection of staff members.

The Site Manager, Radiation Protection Manager and Specialists are qualified as described in Table 10.1.1.

Table 10.1.1: Staffing Qualifications and Operation Organization	
Site Manager	The Site Manager, at the time of appointment to the position, shall have a minimum of five years of nuclear power plant or comparable experience, with relevant experience in the management of nuclear facility operations. The ISFSI Manager will be trained and certified in accordance with the HI-STORE CISF Specialist Training Program [10.1.1], and shall meet or exceed the minimum qualifications of ANSI N18.1-1971 [10.1.2] for a comparable position. In addition to the above specified requirements, the Site Manager will also be required to be qualified as an Independent Safety Reviewer (ISR) as described below.
Radiation Protection Manager	The Radiation Protection Manager, at the time of appointment, shall have a minimum of ten years in radiation protection within the nuclear industry. A maximum of four years of this 10 years of experience may be fulfilled by related technical or academic training. The RP Manager shall have a Bachelor or higher degree in radiation protection or a related field. The Radiation Protection Manager will be trained and certified in accordance with the HI-STORE CISF Specialist Training Program [10.1.1], and shall meet or exceed the minimum qualifications of ANSI N18.1-1971 [10.1.2] for a comparable position. In addition to the above specified requirements, the Radiation Protection Manager will also be required to be qualified as an Independent Safety Reviewer (ISR) as described below.
Specialists/Radiation Protection Technicians	The ISFSI Specialists, at the time of appointment to the position, shall have a High School diploma or successfully completed the General Education Development (GED) test. Operation of equipment and controls that are identified as important to safety shall be limited to personnel who are trained and certified in accordance with the Certified ISFSI Specialist Training Program[10.1.1] or personnel who are under the direct visual supervision of a person who is trained and certified in accordance with the Certified ISFSI Specialist Training Program. Specialists will be trained and certified in accordance with the Holtec Certified ISFSI Specialist Training Program and the Holtec HI-STORE Site Security Plan training and qualification requirements, and shall meet or exceed the minimum qualifications of ANSI N18.1-1971 for a comparable position. At the time of completion of training and appointment to the position, the Certified ISFSI Specialist shall have a minimum of two years of nuclear

	facility experience. Radiation Protection Technicians will be trained and certified in accordance with the Holtec Radiation Protection Technician Training Program and the Holtec HI-STORE Site Security Plan training and qualification requirements.
Independent Safety Reviewers	The Independent Safety Reviewer (ISR) shall be an individual not having direct involvement in the performance of the activities under review, but who may be from the same functionally cognizant organization as the individuals performing the original work. The ISR shall have five years of professional level experience and either A Bachelor's Degree in Engineering or the Physical Sciences or equivalent in accordance with ANSI/ANS-3.1-1981. The Holtec Corporate Executive shall designate the qualified ISRs in writing.

10.2 PREOPERATIONAL TESTING AND STARTUP OPERATIONS

Prior to operation of the HI-STORE CIS facility, a preoperational test, a startup test, and other tests and inspections will be performed to verify that the storage system satisfied the design criteria described in this SAR. Tests and inspections will also be completed prior to initial loading of the ISFSI to ensure that the storage system handling equipment satisfied the design criteria stated in Chapter 4. The results of such tests and inspections will be maintained in accordance with regulatory recordkeeping requirements and will be available at the ISFSI site.

Several of the tests and inspections of equipment involved with loading the storage system will be performed (e.g., load testing the CTB crane). These tests and inspections are not pre-operational or startup tests of the storage system, but are discussed below due to their importance to the safe loading and operation of the storage system.

10.2.1 Administrative Procedures for Conducting the Test Program

The development, approval, and performance of pre-operational and startup test procedures will will meet the requirements of the Holtec Quality Assurance Manual [12.0.1]. The procedures that govern testing will specify how the test results will be evaluated, documented, and approved. Test results must be shown to be within the acceptance criteria specified in test procedures.

The procedure that governs testing will specify the process for identifying needed system modifications that are recognized during testing. Also, the procedure will require evaluation of whether retesting is required after a needed modification has been implemented.

10.2.2 Preoperational Testing Plan

The test program is divided into two parts: preoperational testing and startup testing. Other tests and inspections which are not pre-operational or startup tests, are also briefly discussed in this section because of their importance to the proper operation and integrity of the storage system and handling equipment. The preoperational, startup, and other tests are described in this section and a summary is provided in Table 10.2.1.

The VVM storage system uses passive cooling, and therefore has no "operating" systems, other than the optional air outlet temperature monitoring system, to test prior to the loading of spent nuclear fuel (i.e., pre-operational testing). However, the other tests and inspections described below are performed to ensure the storage system will function in accordance with the design.

Startup testing is performed for each VVM after loading with a spent nuclear fuel canister. Startup testing confirms that the actual dose rates are less than the maximum expected dose rates determined in Chapter 11 of this SAR, such that estimated personnel exposures are bounded by the safety analyses.

In addition to the tests and inspections described in this section, all safety significant equipment will be inspected prior to use to ensure that these components are fabricated in accordance with the design drawings. Materials used specifically for shielding will be tested for shielding effectiveness. Steel properties will be verified by review of appropriate test reports. Structural and shielding adequacy of concrete will be determined by testing during construction.

10.2.2.1 Pre-Operational Testing of Equipment

The operations associated with the physical transfer of an MPC from receipt to installation in the VVM will be completed and verified using a full size, full weight dummy MPC. In addition to evaluating component function, pre-operational tests will also evaluate adequacy of procedural controls, communication, personnel safety and all other processes and controls that affect operations. Relevant operations include the following:

1. Receipt of the loaded HI-STAR 190 transport cask
2. Removal of the loaded HI-STAR 190 from the shipping railcar;
3. Canister integrity testing, including cavity gas sampling for Krypton-85, cavity evacuation, flushing and potential backfill, and MPC leakage testing while in the HI-STAR 190.
4. Preparation of the loaded HI-STAR 190 for unloading, including upending and placement in the CTF;
5. Removal of the HI-STAR 190 closure lid;
6. Installation of the CTF alignment plate;
7. Installation of rigging and lifting apparatus on the MPC;
8. Installation and alignment of the HI-TRAC transfer cask;
9. Loading of the dummy MPC into the HI-TRAC, and associated tasks for preparation for transfer to the VVM;
10. Transfer of the dummy MPC into the VVM;
11. Installation of the VVM closure lid and other associated components.

10.2.2.2 Startup Testing

A startup testing will consist of the measurement of external radiation dose rates for each VVM after it is loaded with spent nuclear fuel to confirm that the actual dose rates are less than the maximum expected dose rates defined in Chapter 11 of this SAR. This will confirm that the estimates of personnel exposures are bounded by the safety analysis.

10.2.2.3 Other Testing

Load tests: The following components are loaded test prior to pre-operational testing as part of fabrication acceptance requirements:

1. CTB crane
2. VCT lift brackets and structure
3. HI-STAR 190 lifting trunnions
4. Lift yoke for HI-STAR 190

5. Tilt frame
6. Transport cask horizontal lift beam
7. HI-TRAC lifting trunnions
8. HI-TRAC lower shield gates
9. Lift yoke for HI-TRAC
10. MPC lift attachment
11. MPC lifting device extension
12. HI-TRAC CS lift links

Functional testing of HI-TRAC: The efficient and dependable operation of the HI-TRAC cask is paramount to achieving ALARA operations while transferring the MPC from its transport cask to its VVM storage location. Before pre-operational testing, post-fabrication operational testing of the HI-TRAC shield gates will be performed to ensure the gates repeatedly function as designed, both prior to and after repeated application of a load representative of the worst-case MPC weight that will be transported by the HI-TRAC.

Sampling equipment validation: Equipment used for sampling gas from the HI-STAR 190 transport cask annulus will be calibrated by qualified personnel using a NIST-traceable validation source in accordance with NRC Regulatory Guide 1.21 [10.2.1]. Equipment will be functionally tested to both ensure repeatable operation and evaluate, and improve, the efficiency of the sampling operations.

Leak test equipment calibration: Equipment used for leak testing will be calibrated per the requirements of ANSI N14.5-2014 [10.3.3] before and after leak test measurements.

RTD monitoring system tests: Acceptance testing of the optional RTD monitoring system will be performed prior to pre-operational tests to ensure proper performance of the system. Prior to the installation of an MPC into each VVM, operational tests of each RTD monitoring component relevant to its VVM will be checked against an appropriate standard temperature source.

10.2.3 Evaluation of Tests

The tests will be deemed successful if the acceptance criteria provided in the test procedures are achieved safely and without damage to any of the components or associated equipment.

10.2.4 Corrective Actions

Modifications to equipment or components will be performed, should they become necessary, to ensure that the acceptance criteria are achieved. The modified equipment or components will be retested to confirm that the modification is sufficient. If required, pre-operational test procedure changes will be incorporated into the appropriate operating procedures.

Table 10.2.1

Pre-Operational, Startup, and Other Tests

Component	Type	Test Purpose / Objective(s)
Railcar transfer into CTB	Pre-Op	Operational clearances are confirmed and sequence/efficiency of operational steps is evaluated.
CTB crane test	Other	Receipt inspection and testing per requirements of ASME NOG-01[3.0.1]
Load test of HI-TRAC horizontal lift beam	Other	Load test in accordance with requirements of ANSI N14.6 [1.2.4]. Verify fitup and clearance of all associated lift equipment.
Transfer of HI-STAR 190 from railcar to tilting frame	Pre-Op	Check clearances and interferences of components. Evaluate sequence/efficiency of operational steps. Confirm alignment of tilting frame
Removal of HI-STAR 190 impact limiters	Pre-Op	Evaluate efficiency of rigging operations. Check clearances and interferences
HI-STAR 190 cask cavity sampling	Pre-Op	Evaluate functionality of equipment. Optimize sampling process. Verify calibration of equipment.
HI-STAR 190 cask cavity evacuation and backfill	Pre-Op	Optimize procedure. Evaluate time and steps required for backfill.
MPC leak test in HI-STAR 190 cavity	Pre-Op	Evaluate functionality of equipment. Optimize sampling process. Verify calibration of equipment.
CTF preparations	Pre-Op	Check fitup of alignment fixture on CTF
Load test of HI-STAR 190 lift yoke	Other	Load test in accordance with requirements of ANSI 14.6 [1.2.4]. Verify fitup and clearance of all associated lift equipment.
Transfer of HI-STAR 190 to CTF	Pre-Op	Check clearances and operational steps. Evaluate efficiency of rigging operations
HI-STAR 190 closure lid removal in CTF	Pre-Op	Evaluate ergonomics of rigging/removal.

Table 10.2.1

Pre-Operational, Startup, and Other Tests

Component	Type	Test Purpose / Objective(s)
Load test of MPC lift attachment	Other	Load test to demonstrate ability to safely lift a fully loaded MPC in accordance with requirements of ANSI 14.6 [1.2.4]. Verify fitup and clearance of all associated lift equipment.
Installation of MPC lift attachment	Pre-Op	Check fit up with MPC lid and CTF.
Acceptance test of HI-TRAC shield gates	Other	Demonstrate proper operation of gates after supporting the weight equivalent to 150% of design load.
Installation of CTF Adapter Plate	Pre-Op	Check fit up with transport cask and CTF.
Installation of HI-TRAC on CTF	Pre-Op	Check fit up with transport cask and CTF adapter plate.
Transfer Cask lifting trunnions	Other	300% load test to demonstrate ability to safely lift a loaded Transfer Cask.
Load test of HI-TRAC CS Lift Yoke	Other	Check fit up with Transfer Cask and crane. 150% load test to demonstrate ability to safely lift a loaded Transfer Cask.
Transfer of MPC into HI-TRAC	Pre-Op	Check for interferences. Evaluate operation and seating of MPC on HI-TRAC shield gates.
Transfer of HI-TRAC (with MPC) to ISFSI site	Pre-Op	Evaluate ability to maneuver haul path, review operational steps for efficiency,
Mating of HI-TRAC with HI-STORM UMAX VVM	Pre-Op	Check fit up and alignment. Evaluated procedure for installation of tie-down studs.
Transfer of MPC into HI-STORM UMAX VVM	Pre-Op	Check for interferences. Evaluate operation of VCT and HI-TRAC.
VVM air outlet temperature monitoring system components	Pre-op	Demonstrate proper operation of the temperature monitoring system components prior to placing a loaded MPC into the VVM
Installation of CEC closure lid	Other	Check fit up and lifting/handling operations.

10.3 NORMAL OPERATION

This section describes the administrative controls and conduct of operations associated with activities considered important to safety. Also described in this section is the management system for maintaining records related to the operation of the ISFSI.

10.3.1 Procedures

Activities affecting quality are accomplished in accordance with approved and documented instructions, procedures, or drawings. Written procedures will be used for site operations, maintenance, and testing activities that are quality-related as defined in the Holtec Quality Assurance Manual [12.0.1]. Procedures will be used to implement the Fire Protection Program and training and certification of personnel. The review and approval process for procedures, and changes thereto, will be procedurally controlled. The Site Manager or his designee will approve procedures and changes prior to implementation. Temporary changes to procedures are allowed if the intent of the existing procedure is not altered and the change is approved by the Site Manager or his/her designee.

Site procedures will require that any changes to facilities, equipment or procedures will be reviewed for safety impact to ensure that the proposed change does not require prior NRC approval pursuant to 10CFR72.48.

10.3.2 Records

Administrative procedures will be established and maintained to ensure quality assurance records are identifiable and retrievable. In addition to quality assurance records, the following records will also be maintained in accordance with 10CFR72.174:

1. Operating records, including maintenance and modifications.
2. Records of off-normal occurrences.
3. Events associated with radioactive releases.
4. Environmental survey records.
5. Personnel Training and Qualification Records.
6. Records of ISFSI design changes made pursuant to 10CFR72.48.
7. Records showing the receipt, inventory (including location), disposal, acquisition, and transfer of spent fuel and related nuclear material as required by 10CFR72.72(a).
8. Records of material control and inventory procedures to account for material in storage as required by 10CFR72.72.

Records of site procedure changes, and tests and experiments, conducted pursuant to 10CFR72.48 will be maintained in accordance with 10CFR72.48. Storage of the above records will be in accordance with the requirements of the Holtec Quality Assurance Manual [12.0.1].

Security records, including security training and qualification records, will be maintained in accordance with the HI-STORE Site Security Plan [3.1.1].

10.3.3 Conduct of Operations

The information presented in this section will be used to develop detailed operating procedures for the receipt of MPC transport casks and the safe transfer of the MPCs to their storage location at the HI-STORE site. In preparing the procedures, the user must consult the conditions of the Technical Specifications, equipment-specific operating instructions, and the HI-STORE site's working procedures as well as the information in this chapter to ensure that the short-term operations shall be carried out with utmost safety and ALARA.

The following generic criteria shall be used to determine whether the HI-STORE site operating procedures developed pursuant to the guidance in this chapter are acceptable for use:

- All heavy load handling instructions are in keeping with the guidance in industry standards and Holtec-provided instructions.
- The procedures are in conformance with this SAR and its Technical Specifications.
- The procedures are in conformance with the HI-STORM UMAX FSAR [1.0.6] and HI-STORM FW System FSAR [1.3.7] where applicable.
- The operational steps are ALARA.
- The procedures contain provisions for documenting successful execution of all safety significant steps for archival reference.
- Procedures contain provisions for classroom and hands-on training and for a Holtec-approved personnel qualification process to ensure that all operations personnel are adequately trained.
- The procedures are sufficiently detailed and articulated to enable craft labor to execute them in literal compliance with their content.

Independent safety reviews will be performed and documented by qualified Independent Safety Reviewers (ISR) prior the performance of any operations. The independent safety reviews shall confirm that changes to the facility, changes to operating procedures, and the performance of tests and experiments not described in the Safety Analysis Report are safe and do not require prior NRC approval pursuant to 10CFR72.48.

10.3.3.1 Receipt and Inspection of Transportation Cask and Canister

The following operational steps are used to receive and inspect the transportation cask in the HI-STORE CTB. The steps also include

1. The HI-STAR 190 packaging is visually receipt inspected to verify that there are no outward visual indications of impaired physical conditions except for superficial marks and dents. Any issues are identified to site management. Any road dirt is washed off and any foreign material is removed.
2. The HI-STAR 190 transportation package is moved into the CTB building security trap, where it is inspected by HI-STORE site security personnel to ensure no unauthorized devices enter the CTB building.

3. The HI-STAR 190 transportation package is moved into the CTB.
4. The personnel barrier, if used, is removed and the security seal installed on the top impact limiter is inspected to verify there was no tampering and that it matches the corresponding shipping documents.
5. The HI-STAR 190 tie-downs are removed. The radial shims are removed from the top and bottom of the cask.
6. Radiological surveys are performed in accordance with 49CFR173.443 [10.3.1] and 10CFR20.1906 [7.4.1]. Any issues are identified to site management. If necessary, the overpack is decontaminated as directed by site radiation protection. Appropriate notifications are made as detailed in the surveillance requirements.
7. The HI-STAR 190 is rigged and transferred to the tilt frame using the CTB building crane.

ALARA Warning:
Dose rates around the bottom end of the HI-STAR 190 cask may be higher that other locations around the cask. After the impact limiter is removed, the cask should be upended promptly. Personnel should remain clear of the bottom of the unshielded cask and exercise other appropriate ALARA controls.

8. The HI-STAR 190 impact limiters are rigged and removed using the CTB crane and a second visual inspection to verify that there are no outward visual indications of impaired physical condition is performed.
9. The neutron shield relief devices are inspected to confirm that they are installed, intact, and not covered by tape or any other covering.
10. As a safety precaution, the HI-STAR 190 closure lid access port cover is removed and sampling equipment is attached to test for the presence of Krypton-85. The sampling equipment consists of a cover flange that allows remote opening of the closure lid port plug to ensure there is no release of radioactive material. The cover flange and gas sample canister is evacuated prior to opening the port plug to ensure the sample accurately reflects the cask cavity contents. The cask cavity gas sample is handled in accordance with Radiation Protection directions by qualified personnel. Testing is performed per pre-approved procedure, using appropriately calibrated equipment that has been qualified for testing at expected concentration limits, to confirm that the sample meets the acceptance criteria of Table 10.3.3. In the unlikely event that the Krypton-85 concentration exceeds the acceptance criteria, the canister transfer operations are terminated and site management is informed for disposition. If necessary, the HI-STAR 190 cask access port cover and impact limiters shall be re-installed, the cask shall be rigged and transferred back to the railcar, restored to its shipping configuration (tie-downs, radial shims and personnel barrier installed) and moved to a designated staging area prior to off-site transport.

Operational Limit:
Prior to performing evacuation, flushing, and leak testing of the MPC within the HI-STAR 190 cask, an evaluation based on the specific transportation cask conditions, canister conditions (including heat load), and leak test conditions shall be performed to establish a canister-specific time limit for all operations performed without helium in the cask annulus. A previously performed bounding evaluation may also be utilized. Process steps shall be stopped before reaching the thermal time limit, and the helium backfill shall be re-established per the requirements of Table 10.3.4 before continuing.

11. The sampling equipment is isolated, and the HI-STAR 190 annulus space is evacuated and flushed with nitrogen using the sampling equipment connector. This process may be repeated several times, as determined by process experience and required by the approved test procedure, to ensure residual helium is flushed from the annulus space. Refer to Table 10.3.4 for process pressure limits.

12. The mass spectrometer leak test apparatus is attached to the sampling equipment connector and a leak test of the MPC is performed. Leakage rate testing is performed per procedures written and approved in accordance with the requirements of ANSI N14.5-2014 [10.3.3]. All testing is performed by personnel qualified in accordance with the Holtec QA program and certified in accordance with Recommended Practice No. SNT-TC-1A [10.3.2]. The written and approved test procedures shall clearly define the test equipment arrangement. Leakage rate testing procedures shall be approved by personnel certified by the ASNT as a Level III examiner for leakage testing. The applicable recommended guidelines of Recommended Practice No. SNT-TC-1A [10.3.2] shall be considered as minimum requirements. Canister leakage test specifications are listed in Table 10.3.2. If a canister leak is detected, the canister transfer operations are terminated and site management is informed for disposition.

13. The CTF is inspected and prepared for receipt of the HI-STAR 190 transportation cask.

14. The HI-STAR 190 is upended, removed from the tilting frame and transferred to the CTF using a lift yoke attached to the cask trunnions and the CTB crane.

10.3.3.2 Transfer of Canister from Transportation Cask to HI-TRAC

1. Using the CTB crane, the HI-TRAC alignment plate is installed on the CTF over the HI-TRAC cask.
2. The HI-STAR 190 closure lid bolts are removed and the closure lid is removed using the CTB crane.

ALARA Warning:
Personnel should remain clear of the open end of the unshielded cask and exercise other appropriate ALARA controls. Dose rates around open end of the HI-STAR 190 cask may be higher that other locations around the cask. Temporary shielding may be installed to reduce worker dose ALARA.

3. A cask seal surface protector is installed on the closure lid sealing surface to protect it from damage.
4. The MPC lifting attachment is connected to the threaded holes on the MPC closure lid. The lifting attachment bolts are tightened hand-tight.
5. Using the CTB crane, the HI-TRAC is placed on the HI-TRAC alignment plate with the shield gates open. The CTF studs are secured to the HI-TRAC and the nuts are tightened wrench- tight.
6. The MPC lifting extension is attached to the CTB crane, lowered through the HI-TRAC body, and engaged with the MPC lift attachment.
7. Using the CTB crane, the MPC is lifted into the HI-TRAC.
8. The HI-TRAC shield gates are closed, and the MPC is lowered to rest on the gates.
9. The MPC lifting extension is disconnected and removed using the CTB crane.
10. The HI-TRAC lift yoke is connected to CTB crane and the HI-TRAC lift trunnions.
11. The CTF stud nuts are removed.
12. The HI-TRAC is lifted using the CTB crane and placed in a location of the CTB floor that is accessible to the VCT.

10.3.3.4 Preparation of VVM for Receipt of MPC

1. Prior to receipt of the MPC, install or confirm installation of the appropriate divider shell in the appropriate VVM for the planned MPC. Installation and verification shall be procedurally controlled and reviewed to ensure correct VVM component designs are specified so that licensing requirements are met.
2. If not already removed, remove the closure lid using a crane or other equivalent lifting device.

3. Install the HI-TRAC restraint studs in the VVM threaded anchors.

> **Operations Note:**
>
> In addition to securing the HI-TRAC to the VVM, the restraint studs also provide alignment while positioning the HI-TRAC on the VVM.

10.3.3.5 Placement of Canisters in the CEC

1. Position the VCT over the loaded HI-TRAC.
2. Attach the HI-TRAC CS lift links to the HI-TRAC and lift the HI-TRAC several inches off the ground, as needed for transport to the ISFSI.

> **Operations Note:**
>
> If required for transport of the loaded HI-TRAC to the designated VVM, the outlet air vent extensions for previously loaded or unloaded VVMs may be temporarily removed (if installed) to minimize the required lift height for the HI-TRAC. For previously loaded VVMs, the outlet air vent extensions shall be expeditiously re-installed to restore the VVMs to its normal condition of storage.

3. Using the VCT, transport the loaded HI-TRAC to the ISFSI and place the loaded HI-TRAC on the VVM, using the HI-TRAC restraint studs (previously installed) to ensure proper alignment.
4. Disconnect the HI-TRAC CS lift links from the HI-TRAC and rig the MPC lifting attachment to the VCT using the MPC lifting extension.
5. Raise the MPC slightly to remove the weight of the MPC from the HI-TRAC Shield Gate.

> **ALARA Warning:**
>
> Temporary shielding may be used to reduce personnel dose during MPC transfer operations. If used, temporary shielding must not restrict air flow into CEC inlet vent openings. If ALARA considerations dictate that temporary shielding not be used, personnel must remain clear of the immediate area around the HI-TRAC Shield Gates during MPC downloading.

6. Open the HI-TRAC Shield Gate. At the user's discretion, install temporary shielding to cover the potential streaming paths around the HI-TRAC Shield Gates.
7. Lower the MPC into the VVM.
8. Verify that the MPC is fully seated in the VVM.

Caution:

Operations steps that occur with the MPC in the VVM with the HI-TRAC Shield Gate closed must be performed in an expeditious manner to avoid excessive heating of the MPC and fuel. The Mating Device must be removed or the drawer opened to establish air cooling within the time limits described in Section 4.5. In the event of equipment malfunction that results in the blockage of air flow, corrective actions must occur within the time limits of the 100% blocked duct accident condition.

9. Disconnect the MPC lifting attachment from the MPC and remove using the lifting extension and the VCT.
10. Remove any temporary shielding and close the HI-TRAC Shield Gates.

ALARA Warning:

Personnel should remain clear (to the maximum extent practicable) of the VVM annulus when HI-TRAC is being removed to comply with ALARA requirements.

11. Remove the HI-TRAC transfer cask from the top of the VVM.
12. Install plugs in the empty MPC bolt holes.

Guidance:

The VVM closure lid shall be preferably kept less than 2 feet above the top surface of the VVM while over the MPC. This lift limit action is purely a defense-in-depth measure because the Closure Lid cannot fall and impact the MPC because of geometric constraints.

13. Install the VVM closure lid. Check that the rigging (in its specific configuration) is rated to lift the load (rated to lift two times the load per NUREG 0612).
14. Remove the VVM closure lid rigging equipment and re-install the outlet vent cover (if previously removed).
15. Install the VVM temperature monitoring elements (if used).
16. Ensure records showing the receipt, inventory (including location), disposal, acquisition, and transfer of the canister, as required by 10CFR72.72(a), are complete.

10.3.3.6 Removal of Canisters from the CEC

If necessary, canisters are recovered from the HI-STORM UMAX VVM and returned to the transport cask in accordance with the steps described in this Section, except that the order is basically reversed.

10.3.4 Maintenance Program for the HI-STORM UMAX VVM Systems

An ongoing maintenance program shall be defined and incorporated into the HI-STORM UMAX system Operations and Maintenance Manual for the HI-STORE CIS facility. This document shall delineate the detailed inspections, testing, and parts replacement necessary to ensure continued structural, thermal performance, and radiological safety in accordance with 10CFR72 regulations, the conditions in the Technical Specifications, and the design requirements and criteria contained in this SAR.

The HI-STORM UMAX system is totally passive by design and requires minimal preventive maintenance to ensure that it will render its intended design functions satisfactorily. Periodic surveillance (via temperature monitoring or visual or camera-aided inspection of air passages) is required to ensure that the air passage in the VVM is not blocked. Preventive or remedial painting of the exposed steel surfaces as part of the user's preventive maintenance program is recommended to mitigate corrosion.

In-service inspection shall be performed by visual inspection of accessible areas of the HI-STORM UMAX VVM. Additional in-service inspection activities will be performed to visually inspect for interior and below-grade degradation. The frequency and scope of these visual in-service inspections are described in Table 10.3.1. Acceptance criteria for visual inspections shall be based on confirmation that the components continue to meet the licensing basis design requirements.

Among the QA commitments are performance of maintenance by trained personnel by written procedures and written documentation of the maintenance work performed and of the results obtained. Table 10.3.1 provides a listing of the minimum maintenance activities on the HI-STORM UMAX VVM.

In summary, the HI-STORM UMAX System is totally passive by design: There are no active components or monitoring systems required to assure the performance of its safety functions. As a result, only minimal maintenance will be required over its lifetime, and this maintenance would primarily result from the effects of weather. Typical of such maintenance would be the reapplication of corrosion inhibiting materials on accessible external surfaces. Visual inspection of the vent screens is required to ensure the air flow passages are free from obstruction

Maintenance activities shall be performed under Holtec's NRC-approved quality assurance program. Maintenance activities shall be administratively controlled and the results documented.

10.3.4.1 Structural Capacity Verification

Prior to each MPC loading, a visual examination in accordance with a written procedure shall be required of the Closure Lid lift lugs and the HI-TRAC trunnions, bottom lid bolts, and bolt holes. The examination shall inspect for indications of overstress such as cracks, deformation, wear marks, corrosion, etc. Repairs in accordance with written and approved procedures shall be required if an unacceptable condition is identified.

10.3.4.2 Shielding Capacity

The gamma and neutron shielding materials in HI-TRAC CS are not subject to measurable degradation over time or as a result of usage. The radiation shielding capacity of the HI-STORM UMAX System is expected to remain undiminished over time. Therefore, unless the VVM is subjected to an extreme environmental event that imparts stresses or temperatures beyond-the-design-basis limits for the system (i.e., prolonged fire or impact from a beyond-the-design basis large energetic projectile) with the plausible potential to degrade the shielding effectiveness of the VVM, no shielding effectiveness tests beyond that required by the HI-STORE's Radiation Protection Program are required over the life of the AFR facility.

Radiation monitoring of the ISFSI in accordance with 10CFR72.104(c) will provide ongoing evidence and confirmation of shielding integrity and performance. If increased radiation doses are indicated by the facility monitoring program, additional surveys of the ISFSI shall be performed to determine the cause of the increased dose rates.

10.3.4.3 Thermal Capacity

In order to assure that the HI-STORM UMAX System continues to provide effective thermal performance during storage operations, surveillance of the air vents (or alternatively, by temperature monitoring) shall be performed in accordance with written procedures.

10.3.5 Maintenance Program for the Canister

The canister is an all-welded stainless steel pressure vessel that does not require an in-service maintenance unless a disruptive occurrence such as deposition of flood-borne foreign materials on the canister's surface occurs. Because submergence from flood has been rules out as a credible occurrence at the HI-STORE ISFSI, no routine in-service maintenance activity on the stored canister is expected. The Aging Management Program described in Chapter 18, however, will require monitoring and inspection activities, and possibly remedial actions, if so determined.

10.3.6 Maintenance Programs for ITS Lifting and Handling Equipment, Including VCT

Maintenance, inspection and testing of lifting equipment designed to ANSI 14.6 [1.2.4] shall per the requirements of ANSI 14.6. Equipment designed the requirements of ASME Section III, Subsection NF [4.5.1] shall be functionally tested prior to initial use and visually inspected for any degradation or damage prior to each cask transfer.

10.3.7 Maintenance Programs for ITS Crane Systems

Maintenance, inspection and testing of crane systems designed to ASME NOG-1 [3.0.1] shall be per the requirements of ASME B30.2 [4.5.11] and manufacturer's recommendations.

10.3.8 Maintenance Program for HI-STAR 190 Cask

The maintenance program for the HI-STAR 190 Cask shall be as specified in the HI-STAR 190 SAR [1.3.6].

Table 10.3.1

Maintenance and Inspection Activities for the HI-STORM UMAX VVM Systems

	Activity	Frequency	Purpose
1.	Visual Inspection of CEC Cavity	Prior to MPC installation	To ensure that VVM internal components are properly aligned, the surface preservatives on all exposed surfaces are undamaged (including Divider Shell), the insulation on the Divider Shell is undamaged and the cavity is free of visible foreign material.
2.	Closure Lid Examination	Prior to MPC installation	Ensure that the preservatives on the external surfaces are in good condition and the lid is free of dents and rust stains.
3.	VVM Inlet/Outlet Vent Screen Inspection	Prior to installation of the flanged screen assembly and monthly when in use	Ensure that the screen is present and undamaged.
4.	ISFSI pad	Annually	Ensure that the ISFSI Pad (raised areas near the VVM) is free of visible cracks or repaired as appropriate, the interface between the ISFSI Pad and the CEC Flange is grouted (or caulked) if necessary, the ISFSI drain system is functional, the ground water collection and removal system (if used) is in working order. Ensure that the subgrade settlement is minimal and unsightly surface cracks in the ISFSI pad have not developed. Implement counter measures to prevent the opening of surface cracks and excessive pad settlement, if observed.
5.	Shielding Effectiveness Test	As required by the Radiation Protection Program described in Chapter 11	Ensure ALARA conditions are maintained per Technical Specifications

Table 10.3.1 (continued)

Maintenance Activities for the HI-STORM UMAX VVM Systems

	Activity	Frequency	Purpose
6.	ISFSI Settlement	Every five years	Confirm that the VVM settlement is within the range of its design basis.
7.	VVM Air Temperature Monitoring System	Continuous monitoring with alarms	Ensure design basis cooling of canister is maintained.
8.	VVM In-Service Inspection	Annually, for all loaded VVMs	Ensure that the vent screen assembly fasteners or weldments remain coated with preservative, the screen is present and undamaged, all visible external surfaces are free from significant corrosion and identification markings remain legible.
9.	VVM plenum inspection for accumulation of foreign materials	Annually or following a severe weather event that may introduce significant foreign materials material.	Visually verify inlet/outlet plenums are free of significant foreign material and air passages are not degraded.
10.	Additional VVM In-Service Inspection for Long-Term Interior and Below-grade Degradation	Every five years. The oldest VVM or VVM considered to be most vulnerable to corrosion degradation shall be selected for inspection.	Visual inspection of accessible exterior and interior surfaces of the VVM to determine the general condition of the system and assess long-term degradation. Condition of surface coatings, divider shell insulation and internal passages shall be evaluated and corrected as needed. Inspection and removal of accumulated foreign material, if any, shall be performed if required. CEC interior surfaces shall be inspected for corrosion and visible wall thinning. VVM may be inspected using remote devices such as a borescope.

11.	Visual Inspection of HI-TRAC CS	Prior to each handling campaign	Verify surface coatings of interior and exterior surfaces of the cask (including internal hole surfaces, etc.) and all shield gate components are intact. Verify shield gate operation mechanism appears undamaged and functional. Inspect tie-down stud threads for damage or wear. Lifting trunnions shall be inspected for indications of overstress such as cracking, deformation or wear marks.
12.	Visual Inspection of CTF	Prior to each handling campaign	Verify flow passages are free of significant foreign material. Verify surface coatings of accessible surfaces of CTF are intact
13.	Testing and Inspection of HI-TRAC CS Upper Trunnions	Per requirements of ANSI 14.6 [1.2.4].	Verify continuing compliance with ANSI 14.6 [1.2.4]. Identify cracks and/or permanent deformation indicating a need for trunnion replacement.
14.	Testing and Inspection of Special Lifting Devices	Per requirements of ANSI 14.6 [1.2.4].	Verify continuing compliance with ANSI 14.6 [1.2.4]
15.	CTB Crane Maintenance	Annually	Maintenance per requirements of ASME B30.2 [4.5.11] and manufacturer's recommendations
16.	CTF Floor Slab Inspection	Annually	Visual inspection of all accessible surfaces for cracking, loss of material, permeability and integrity.
17.	Transport Cask Tilt Frame Inspection	Annually	Visual inspection of all accessible surfaces for corrosion and integrity, including evaluation of dents, scratches, gouges or other damage.

Table 10.3.2

Canister Leakage Test Performance Specifications

Reference Helium Leakage Rate (L_R) Acceptance Criterion	1.85×10^{-7} ref-cm³/s helium (Leaktight as defined by ANSI N14.5-2014[10.3.3], using helium as tracer gas)
Leakage Rate Test Sensitivity	9.2×10^{-8} ref-cm³/s helium (½ of the leakage rate acceptance criterion per ANSI N14.5-2014 [10.3.3], using helium as tracer gas)
Type of Leakage Rate Test	A.5.4, per ANSI N14.5 [10.3.3], App. A
Instrument used	Helium mass spectrometer

Table 10.3.3 Acceptance Criteria for Testing of Shipping Cask Gas Sample	
Radionuclide	**Concentration Limit (Note 1)**
Krypton-85	10^{-4} μCi/cc (Note 2)

Note 1: Concentration measurement is performed using equipment specifically designed to detect gamma emission from Krypton-85 in the gas sample. Equipment shall be suitably designed and calibrated to correlate the rate of Krypton-85 radioisotope disintegration to volumetric concentration.

Note 2: Acceptance criteria based on occupational derived air concentration limits for Krypton-85 of Appendix B to 10 CFR Part 20 [7.4.1].

Table 10.3.4 Transport Cask Flushing/Backfill Requirements		
Process	**Gas**	**Limit**
Cask Backfill	99.9% Helium (recommended)	41 kPa (6 psig) to 103 kPa (15 psig)
Cask Flushing (Note 1)	99.7% Nitrogen (or greater)	≤ 103 kPa (15psig)

Note 1: Requirements applicable only for transport cask in horizontal orientation, on tilt frame.

10.4 PERSONNEL SELECTION, TRAINING, AND CERTIFICATION

10.4.1 Personnel Organization

The personnel organization is shown in the organization charts in Figures 10.4.1 and 10.4.2.

10.4.2 Selection and Training of Operating Personnel

The main objective of the training program is to provide personnel with the specialized training necessary to operate and maintain the site in a safe manner.

Individuals requiring unescorted access to the site will receive training in the following areas: Radiation Protection, Security, Radiological Emergency Plan, Quality Assurance, Fire Protection, Chemical Safety, OSHA compliance, and the Policy statement on worker responsibility for safe operation of the ISFSI. Individuals requiring continued unescorted access will receive refresher training on these topics annually.

Individuals performing quality-related activities in support of the site will receive training on the QA Program, QA policies, and if applicable, site procedures and organization as necessary to ensure that suitable proficiency is maintained.

Operation of equipment and controls that are identified as important to safety for the ISFSI shall be limited to personnel who are trained and certified in accordance with the HI-STORE Specialist Training Program [10.1.1] or personnel who are under the direct visual supervision of a person who is trained and certified in accordance with the HI-STORE Specialist Training Program [10.1.1].

On-site workers will receive radiation protection training commensurate with their responsibilities in accordance with 10 CFR 19, "Notices, Instructions and Reports to Workers: Inspection and Investigations." [11.1.1]

Records will be maintained on the status of trained personnel, training of new employees, and refresher training of present personnel.

10.4.3 Selection and Training of Security Guards

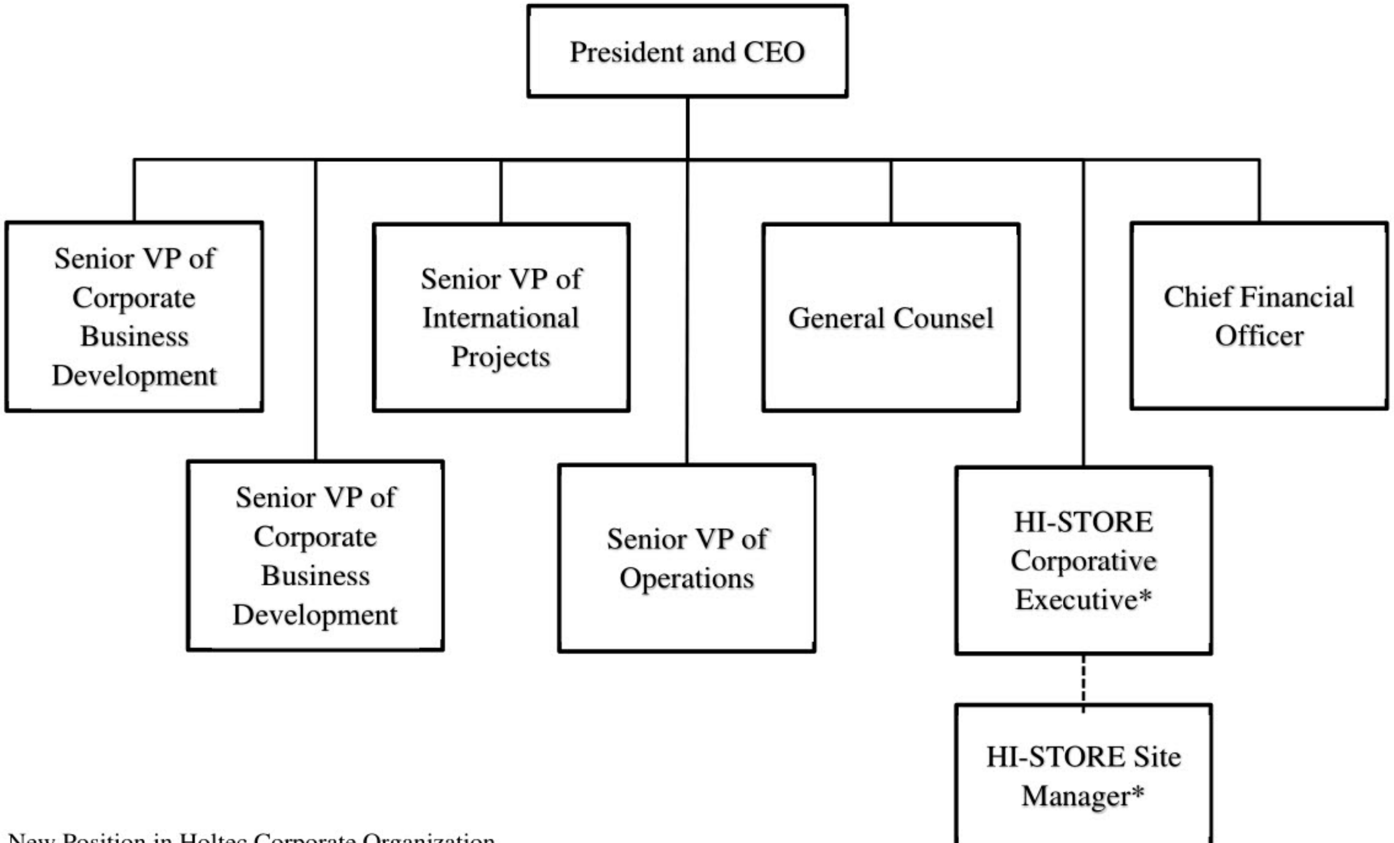
Security training will be provided in accordance with the training and qualification requirements outlined in the HI-STORE Site Security Plan [3.1.1].

10.4.4 Selection and Training of Radiation Protection Technicians

Radiation Protection Technicians will be trained and certified in accordance with the HI-STORE Radiation Protection Technician Training Program. The main objective of the training program is to provide personnel with the specialized training necessary to implement the procedures associated with the Radiation Protection Program. Radiation Protection Technicians will receive training in the use and calibration of radiation survey equipment, RWP generation and implementation, ALARA principles, verifying proper packaging of radioactive material, and proper response in the event of an emergency in accordance with the Radiological Emergency Plan.

In addition, Radiation Protection Technicians will receive training in the following areas: Security, Quality Assurance, Fire Protection, Chemical Safety, OSHA compliance, and the Policy statement on worker responsibility for safe operation of the ISFSI. Individuals requiring continued unescorted access will receive refresher training on these topics annually.

Records will be maintained on the status of trained personnel, training of new employees, and refresher training of present personnel.



* New Position in Holtec Corporate Organization

Figure 10.4.1: Holtec Corporate Organization

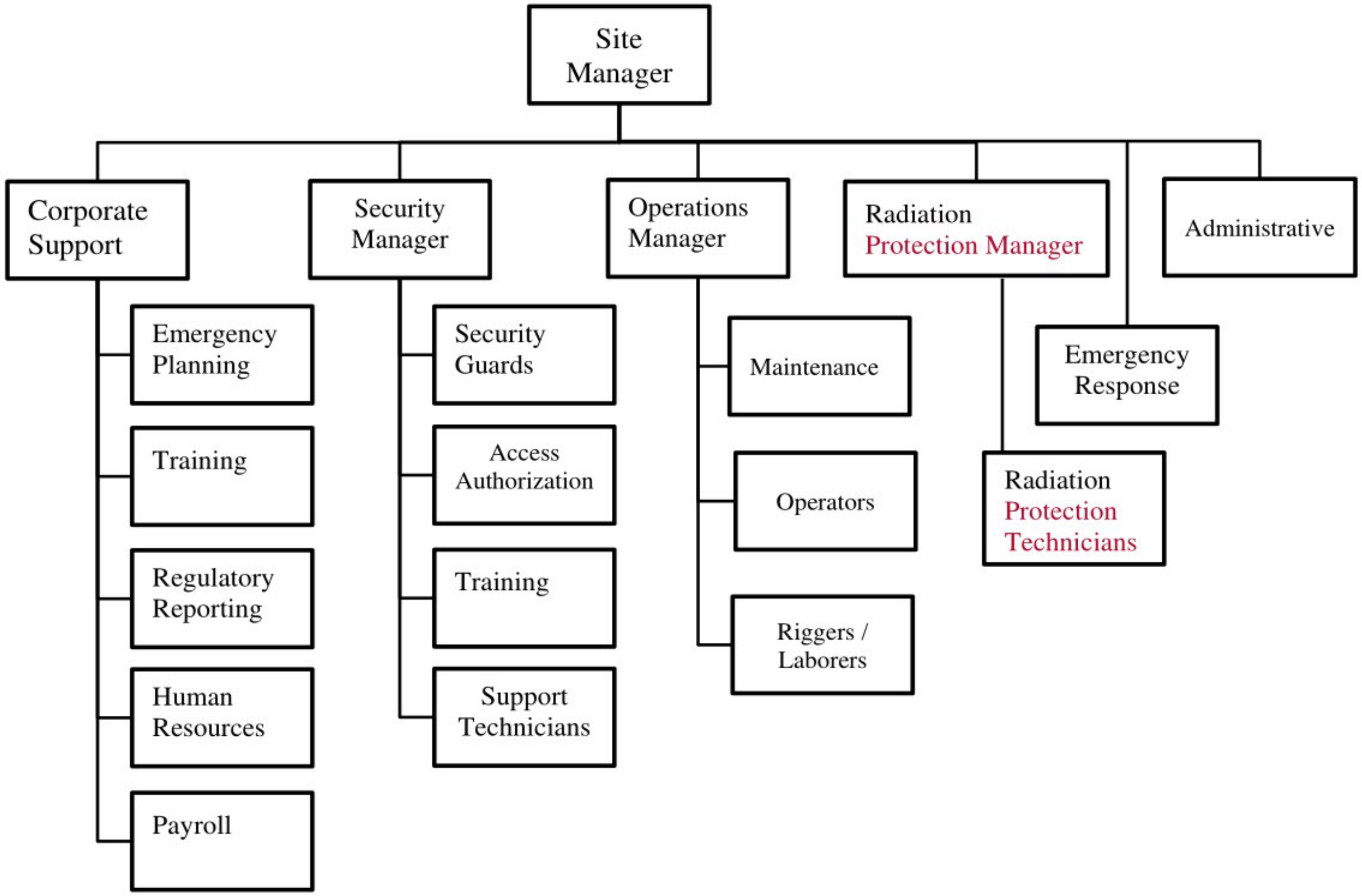


Figure 10.4.2: HI-STORE Site Organization

10.5 EMERGENCY PLANNING

The Holtec CISF Emergency Response Plan [10.5.1] evaluates and describes the necessary and sufficient emergency response capabilities for managing all reasonably anticipated emergency conditions associated with the operation of the HI-STORE facility. The plan meets all requirements of 10CFR72.32(a).

10.6 PHYSICAL SECURITY AND SAFEGUARDS CONTINGENCY PLANS

The HI-STORE Site Security Plan [3.1.1] contains a detailed plan for security measures for physical protection of the site. In addition, this plan contains contingencies for responding to threats and potential radiological sabotage. This plan complies with the requirements of 10CFR72, Subpart H, "Physical Protection."

10.7 RADIATION PROTECTION PLAN

Chapter 11 contains a detailed plan for radiation protection measures for the site. This plan complies with the requirements of 10CFR72, Subpart H, “Physical Protection.” A Radiation Protection Program is implemented at the CIS Facility in accordance with requirements of 10CFR72.126, 10CFR20.1101, and 10CFR19.12 [1.0.5], [7.4.1], and [11.1.1].

The CIS Facility is committed to a strong ALARA program. The ALARA program follows the guidelines of Regulatory Guides 8.8 [11.1.2] and 8.10 [11.1.3] and the requirements of 10 CFR 20 [7.4.1].

10.8 SUMMARY

The conduct of operations described in this chapter fulfills the requirements of NUREG-1567 [1.0.3], Section 10, by providing the following information:

1. A plan for conduct of operations at the HI-STORE CIS site in compliance with 10CFR72.24(h).
2. Detailed description of the HI-STORM UMAX storage system operations which, based on successful previous experience, is concluded to be largely demonstrated and in compliance with 10CFR72.24(i).
3. Detailed description of the program covering preoperational testing and initial operations, in compliance with 10CFR72.24(p).
4. The provision of acceptable technical qualifications, including training and experience, for personnel who will be engaged in the proposed activities, in compliance with 10CFR72.28(a).
5. A description of a personnel training program to comply with 10CFR72,Subpart I.
6. A description of the operating organization, delegations of responsibility and authority, and the minimum skills and experience qualifications relevant to the various levels of responsibility and authority, in compliance with 10CFR72.28(c).
7. A commitment to maintain an adequate complement of trained and certified installation personnel before receipt of spent fuel or high-level radioactive waste for storage, in compliance with 10CFR72.28(d).
8. Assurance of qualification by reason of training and experience to conduct the operations covered by the regulations in 10 CFR 72, in compliance with 10CFR72.40(a)(4).
9. Assurance with regard to the management, organization, and planning for preoperational testing and initial operations that the activities authorized by the license can be conducted without endangering the health and safety of the public, in compliance with 10CFR72.40(a)(13).

CHAPTER 11: RADIATION PROTECTION EVALUATION*

11.0 INTRODUCTION

11.0.1 Ensuring Occupational Radiation Exposures are As Low As is Reasonably Achievable

The objective for the Centralized Interim Storage (CIS) Facility Radiation Protection Program is to keep radiation exposures to facility workers and the general public as low as is reasonably achievable (ALARA). Subsection 11.1.1 describes the policy and procedures that ensure that ALARA occupational exposures are achieved. Subsection 11.1.2 describes the ALARA design considerations and Subsection 11.1.3, the ALARA operational considerations.

The HI-STORE CIS Facility utilizes the HI-STORM UMAX storage system (Docket #72-1040) [1.0.6], and only canisters approved for that system and listed in Table 1.0.3 are permitted for storage in the facility. Therefore, the principal radiation protection evaluation is directly taken from the HI-STORM UMAX FSAR, and is incorporated by reference. Table 11.0.1 lists all sections from the HI-STORM UMAX FSAR that are incorporated by reference, together with a technical justification. However, some additional radiation protection evaluation that is different from that in the HI-STORM UMAX FSAR is required specifically for the HI-STORE CIS Facility, due to site-specific considerations. These additional radiation protection evaluations are clearly identified in the following sections.

* All references are in placed within square brackets in this report and are compiled in Chapter 19 (References)

Table 11.0.1: Material Incorporated by Reference in this Chapter (Sheet 1 of 2)

Information Incorporated by Reference	Source of the Information	NRC Approval of Material Incorporated by Reference	Location in this SAR where Material is Incorporated	Technical Justification of Applicability to HI-STORM UMAX
Ensuring that Occupational Radiation Exposures are As-Low-As-Reasonably-Achievable (ALARA)	Section 11.1 of Reference [1.0.6]	SER HI-STORM UMAX Amendments 0, 1, and 2, References [7.0.1, 7.0.2, and 7.0.3]	Section 11.1	From the radiation protection perspective, the HI-STORM UMAX system at the HI-STORE CIS Facility is the same as the one described in the HI-STORM UMAX FSAR and originally approved in the referenced SER. The generic radiation protection policy considerations, radiation exposure criteria, operational considerations, and auxiliary/temporary shielding measures established in this SAR are also applicable for the site-specific HI-STORE CIS Facility license.
Radiation Protection Features in the HI-STORM UMAX System Design	Section 11.2 of Reference [1.0.6]	SER HI-STORM UMAX Amendments 0, 1, and 2, References [7.0.1, 7.0.2, and 7.0.3]	Section 11.2	The HI-STORM UMAX radiation protection design features are the same as described in the HI-STORM UMAX FSAR and therefore the conclusions established therein that the radiation protection features ensure that the occupational dose as well as off-site dose from the ISFSI will be ALARA, remain unchanged in this SAR.
Estimated On-Site Cumulative Dose Assessment - Excavation Activities and accident site boundary dose limits.	Subsection 11.3.2 of Reference [1.0.6]	SER HI-STORM UMAX Amendments 0, 1, and 2, References [7.0.1, 7.0.2, and 7.0.3]	Subsection 11.3.1	In the event it is desired to expand the HI-STORE CIS Facility's HI-STORM UMAX VVM ISFSI, radiation protection of the excavation activities is achieved on a site-specific level using the same prescription as in the generic case (i.e. prescribing a minimum distance between the excavation area and the loaded VVMs, as well as radiological monitoring of the excavation area. The shielding design basis accident dose presented in the HI-STORM UMAX FSAR for the HI-STORM UMAX system demonstrates compliance with 10CFR72.106 [1.0.5] for the HI-STORE CIS Facility.

Table 11.0.1: Material Incorporated by Reference in this Chapter (Sheet 2 of 2)

Information Incorporated by Reference	Source of the Information	NRC Approval of Material Incorporated by Reference	Location in this SAR where Material is Incorporated	Technical Justification of Applicability to HI-STORM UMAX
Estimated Exposures for Surveillance and Maintenance	Subsection 11.3.4 of Reference [1.0.6]	SER HI-STORM UMAX Amendment 0, 1, and 2, Reference [7.0.1, 7.0.2, and 7.0.3]	Subsection 11.3.1	Security surveillance and maintenance activities for the HI-STORM UMAX ISFSI are addressed in the HI-STORM UMAX FSAR. The HI-STORM UMAX ISFSI at the HI-STORE CIS Facility utilizes electronic temperature monitoring of the HI-STORM UMAX modules, which significantly lowers personnel dose accumulated from security and surveillance measures.

11.1 AS LOW AS REASONABLY ACHIEVABLE CONSIDERATIONS

11.1.1 ALARA Policies and Programs

A Radiation Protection Program is implemented at the CIS Facility in accordance with requirements of 10CFR72.126, 10CFR20.1101, and 10CFR19.12 [1.0.5], [7.4.1], and [11.1.1]. The program draws upon the experience and expertise of programs and personnel of Holtec International and utilities that plan to transport radioactive waste to the CIS Facility.

Section 11.1 of the HI-STORM UMAX FSAR [1.0.6] is incorporated by reference into this SAR, and describes radiation protection policy considerations, radiation exposure criteria, operational considerations, and auxiliary/temporary shielding measures applicable to the HI-STORE CIS Facility, as described in Table 11.0.1 of this SAR.

The primary goal of the Radiation Protection Program is to minimize exposure to radiation such that the individual and collective exposure to personnel in all phases of operation and maintenance are kept ALARA. This is accomplished by integrating ALARA concepts into design, construction, and operation of the facility.

Trained personnel develop and conduct the Radiation Protection Program and will assure that procedures are followed to meet CIS Facility and regulatory requirements. Training programs in the basics of radiation protection and exposure control is provided to all facility personnel whose duties require working in radiation areas.

Basic objectives of the ALARA program are:

1 Protection of personnel, including surveillance and control over internal and external radiation exposure to maintain individual exposures within permissible limits and ALARA, and to keep the annual integrated (collective) dose to facility personnel ALARA.

2 Protection of the public, including surveillance and control over all conditions and operations that may affect the health and safety of the public.

The radiation protection staff is responsible for and has the appropriate authority to maintain occupational exposures as far below the specified limits as reasonably achievable. Ongoing reviews are performed to determine how exposures might be reduced. The program ensures that CIS Facility personnel receive sufficient training and that radiation protection personnel have sufficient authority to enforce safe facility operation. Periodic training and exercises are conducted for management, radiation workers, and other site employees in radiation protection principles and procedures, protective measures, and emergency responses. Revisions to operating and maintenance procedures and modifications to CIS Facility equipment and facilities are made when the proposed revisions will substantially reduce exposures at a reasonable cost. The program also ensures that adequate equipment and supplies for radiation protection work are provided.

The CIS Facility is committed to a strong ALARA program. The ALARA program follows the guidelines of Regulatory Guides 8.8 [11.1.2] and 8.10 [11.1.3] and the requirements of 10 CFR 20 [7.4.1]. Management is committed to compliance with regulatory requirements regarding control of personnel exposures and establishes and maintain a comprehensive program at the CIS

Facility to keep individual and collective doses ALARA. Management will assure that each staff member integrates appropriate radiation protection controls into work activities. CIS Facility personnel are trained and updated on ALARA practices and dose reduction techniques to assure that each individual understands and follows procedures to maintain his/her radiation dose ALARA. Design, operation, and maintenance activities are reviewed to ensure ALARA criteria are met.

The ALARA program ensures that:

1 An effective ALARA program is administered at the CIS Facility that appropriately integrates management philosophy and NRC regulatory requirements and guidance.

2 CIS Facility design features, operating procedures, and maintenance practices are in accordance with ALARA program guidelines. Formal periodic reviews of the Radiation Protection Program will assure that objectives of the ALARA program are attained.

3 Pertinent information concerning radiation exposure of personnel is reflected in design and operation.

4 Appropriate experience gained during the operation of nuclear power stations relative to radiation control is factored into procedures, and revisions of procedures, to assure that the procedures continually meet the objectives of the ALARA program.

5 Necessary assistance is provided to ensure that operations, maintenance, and decommissioning activities are planned and accomplished in accordance with ALARA objectives.

6 Trends in CIS Facility personnel and job exposures are reviewed to permit corrective actions to be taken with respect to adverse trends.

7 When it is not practicable to apply process controls or other engineering controls, dose reduction techniques such as access control, limitation of exposure times, and other controls in accordance with 10CFR20.1702 [7.4.1] may be used.

CIS Facility personnel are responsible for ensuring that activities are planned and accomplished in accordance with the objectives of the ALARA program. Staff will ensure that procedures and their revisions are implemented in accordance with the objectives of the ALARA program, and that radiation protection staff is consulted as necessary for assistance in meeting ALARA program objectives. Individual radiation doses, and collective doses associated with tasks controlled by radiation work permits, are tracked to identify trends and support development of alternative procedures that result in lower doses.

11.1.2 Design Considerations

ALARA considerations have been incorporated into the CIS Facility design, in accordance with 10CFR72.126(a) [1.0.5], based upon the layout of the CIS Facility area and the type of spent fuel storage system selected. The following summarizes the design considerations:

- The HI-STORM UMAX ISFSI is located at least 400 meters (1312 feet) to the controlled area boundary. This provides an acceptable distance from radiation sources to offsite personnel to ensure dose rates at the controlled area boundary are minimized and maintained within specified limits.

- The HI-STORM UMAX ISFSI has been sized to allow adequate spacing between Vertically Ventilated Modules (VVMs) to permit workers to function efficiently during loading/unloading operations at the ISFSI and during performance of maintenance (e.g. clearing blockage from the inlet ducts and surveillances. Adequate work space helps to minimize time spent by workers in the vicinity of storage casks, limiting worker dose.
- The storage system design is based on a metal canister that is sealed by welding for spent fuel confinement, preventing release of radionuclides from inside the canister. Radioactive effluents are thus precluded by design. This meets the intent of 10CFR72.24(e)(l) and 10CFR72.126(d) [1.0.5], which requires that the ISFSI design provide means to limit the release of radioactive materials in effluents during normal operations to levels that are ALARA. There are no radioactive effluents released from the CIS Facility during normal operations. This passive system design also requires minimum maintenance and surveillance requirements by personnel.
- The data acquisition of the VVM temperature monitoring system enables remote readout of temperatures representative of cask thermal performance, avoiding time spent by CIS staff to perform daily walkdowns, or take measurements, or read instrumentation in the vicinity of the HI-STORM UMAX ISFSI.
- Holtec International, the vendor of the spent fuel storage system, has incorporated a number of design features to provide ALARA conditions during transportation, handling, and storage as described in its HI-STORM UMAX Final Safety Analysis Report [1.0.6].
- Where practical, power operated wrenches are used to reduce the times associated with tasks involving bolt insertion and removal during transport cask receipt and canister transfer operations. This minimizes times spent in radiation fields. Temporary shielding is used where it is determined to be effective in reducing total dose for a task (considering doses to personnel involved in its installation and removal).

Regulatory Position 2 of Regulatory Guide 8.8 [11.1.2] is incorporated into design considerations, as described below:

- Regulatory Position 2a on access control is met by use of a fence with a locked gate that surrounds the HI-STORM UMAX ISFSI and prevents unauthorized access.
- Regulatory Position 2b on radiation shielding is met by the heavy shielding of the shipping, storage, and transfer casks, which minimizes personnel exposures during transport cask reception, canister transfer, canister storage, and offsite shipment operations. The designs of the storage cask air inlet and outlet ducts prevent direct radiation streaming. The Canister Transfer Building is positioned a substantial distance (as shown in Figure 2.1.4) from the HI-STORM UMAX ISFSI to minimize dose from the ISFSI to personnel during operations taking place in the Canister Transfer Building. The designs of the shipping, storage, transfer casks and auxiliary equipment assure adequate shielding for personnel inside the Cask Transfer Building.
- The Security and Administrative Buildings is also positioned a substantial distance (as shown in Figure 2.1.4) from the HI-STORM UMAX ISFSI to minimize dose from the ISFSI to personnel residing in this building.

- Regulatory Position 2c on process instrumentation is met since the cask temperature monitoring system utilizes a data acquisition system to record cask temperature instrumentation readings, avoiding time spent by CIS Facility staff to make daily cask vent blockage surveillances and to read instrumentation in the vicinity of the storage casks.
- Regulatory Position 2d on control of airborne contaminants is not applicable because gaseous releases are precluded by the sealed canister design. No significant surface contamination is expected on the outer surfaces of the canister since process controls are maintained during fuel loading into the canister at the originating nuclear power plants. Additionally, the nuclear power plant shipping the cask is required to demonstrate compliance with 49CFR173.443 [10.3.1], which places strict controls on non-fixed contamination.
- Regulatory Position 2e on crud control is not applicable to the CIS Facility because there are no systems at the CIS Facility that could produce crud.
- Regulatory Position 2f on decontamination is met because the internal surfaces of shipping, transfer, and storage casks have hard surfaces that lend themselves to decontamination by wiping. Interior surfaces of the Canister Transfer Building are painted with a special paint that is easily decontaminated.
- Regulatory Position 2g on radiation monitoring is met with the use of area radiation monitors in the Canister Transfer Building for monitoring general area dose rates from the casks and canisters during canister transfer operations, and with thermoluminescent dosimeters (TLDs) along the perimeters of the RA and OCA to provide information on radiation doses. Continuous air monitors, if deemed necessary, are located in the exhaust of the Canister Transfer Building (Subsection 11.2.5) and/or available as portable air samplers.
- Regulatory Position 2h on resin treatment systems is not applicable to the CIS Facility because there are not any radioactive systems containing resins.
- Applicable portions of Regulatory Position 2i concerning other miscellaneous ALARA items is met because CIS Facility features provide a favorable working environment and promote efficiency (Paragraph 2i(13)) [11.1.2]. These include:
    - Adequate lighting in the Canister Transfer Building, and HI-STORM UMAX ISFSI; adequate ventilation in the Canister Transfer Building;
    - Adequate working space in the Canister Transfer Building and at the HI-STORM UMAX ISFSI; and accessibility – with platforms or scaffolding and ladders that facilitate ready access to the tops of the transport casks and storage casks and to the transfer cask doors where operators need to perform tasks during canister transfer operations.
    - Regulatory Position 2i(15) is met because the emergency lighting system is adequate to permit prompt egress from any high radiation areas that could possibly exist in the vicinity of the canister/casks during canister transfer operations.

11.1.3 Operational Considerations

Specific CIS Facility operational considerations to achieve ALARA conditions are as follows:

- Fuel loading operations take place at the originating nuclear power plants, away from the CIS Facility. There are no assembly handling operations at the CIS Facility.
- No significant surface contamination is expected on the canisters as the result of controls applied during the fuel loading operations at the originating nuclear power plants. Workers therefore are not exposed to significant surface contamination or airborne contamination during canister transfer operations.
- Canister transfer between the transport cask and the HI-STORM UMAX VVM will take place within a shielded transfer cask.
- Prior to canister transfer operations, "dry runs" are performed to train personnel on canister transfer procedures, discuss methods to minimize exposures, and refine procedures to achieve minimum probable exposures.
- The CIS Facility procedures and work practices reflect ALARA lessons learned from other ISFSIs that use VVMs, as applicable.
- Operations research is performed to determine types of tools, portable shielding, and equipment that helps to minimize exposures to workers involved in canister transfer operations.
- The gantry crane located in the Canister Transfer Building is single-failure proof and is designed to withstand the design basis ground motion, as described in Chapter 5. The gantry crane, whose range of travel covers the length and width of the Canister Transfer Building, handles the transport casks and moves the transport casks from a horizontal orientation on the inbound rail car to a vertical orientation where it can be placed in the Canister Transfer Facility (indoor pit).
- The Vertical Cask Transporter (VCT) is used to move the HI-TRAC CS (transfer cask) from the Canister Transfer Building to the HI-STORM UMAX ISFSI. The VCT requires minimum personnel and allows for quick and accurate placement of a storage cask.
- The storage systems do not require any systems that process liquids or gases or contain, collect, store, or transport radioactive liquids. Therefore, there are no such systems to be maintained or operated.

Regulatory Position 4 of Regulatory Guide 8.8 is met with the use of area radiation monitors in the Canister Transfer Building and TLDs around the Restricted Area fence and the Controlled Area boundary. In addition, radiation protection personnel use portable monitors during transport cask receipt, inspection, and canister transfer operations, and the operating staff will have personal dosimetry (Subsection 11.4.2). The access control point is at the Security Building, as described in Subsection 11.4.2.

Protective equipment, that may include anti-contamination clothing and respirators, is available in the Security Building and controlled by radiation protection personnel. Airborne monitoring is performed using portable monitors as needed.

Regulatory Guide 8.10 [11.1.3] is incorporated into the CIS Facility operational considerations as described below:

1 Facility personnel are made aware of management's commitment to keep occupational exposures ALARA.

2 Ongoing reviews are performed to determine how exposures might be lowered.

3 There is a well-supervised radiation protection capability with specific, defined responsibilities.

4 Facility workers receive sufficient training.

5 Sufficient authority to enforce safe facility operation is provided to radiation protection personnel.

6 Modification to operating and maintenance procedures and to equipment and facilities are made where they substantially reduce exposures at a reasonable cost.

7 The radiation protection staff understands the origins of radiation exposures in the facility and seeks ways to reduce exposures.

8 Adequate equipment and supplies for radiation protection work are provided.

11.2 RADIATION PROTECTION DESIGN FEATURES

The HI-STORM UMAX radiation protection design features are incorporated by reference from Section 11.2 of [1.0.6], as described in Table 11.0.1 of this SAR.

11.2.1 Installation Design Features

A description of the CIS Facility layout and design is provided in Section 2.1. The CIS Facility layout and design are in accordance with the facility and equipment design features identified in Position 2 of Regulatory Guide 8.8 [11.1.2], as described in Subsection 11.1.2.

The CIS Facility has the following design features that ensure that exposures are ALARA:

- The site is located far from population centers [1.0.4].
- The nearest resident is 1.5 miles (2.41 km) north of the site, as shown in Table 1.0.1.
- The only sources of radiation at the CIS Facility are the sealed canisters containing spent fuel assemblies. These canisters are always shielded by shipping, storage, or by transfer casks during canister transfer operations.
- Measures are taken at the originating nuclear power plants to prevent loose surface contamination levels on the exterior of the canisters. Controls assure that canisters are not transported to the CIS Facility unless contamination levels are within specified limits.
- The canisters are sealed by welding, eliminating the potential for release of radioactive gases or particles.
- The canisters are never opened, nor will spent fuel assemblies be unloaded at the CIS Facility.
- The fuel assemblies are stored dry inside the canisters, so that no radioactive liquid is available for release.
- The shipping, transfer, and HI-STORM UMAX VVMs are heavily shielded to minimize external dose rates.
- The CIS Facility site layout provides substantial distance between the HI-STORM UMAX ISFSI and the Controlled Area boundary, as shown in Table 1.0.1, minimizing radiation exposures to individuals outside the controlled area boundary and assuring offsite dose rates are below the 10CFR72.104 [1.0.5] criteria.
- The location of the Canister Transfer Building inside the Restricted Area (RA) minimizes the route between the Canister Transfer Building and the HI-STORM UMAX ISFSI, provides for minimal other traffic on the route, and maintains substantial distance from the Controlled Area boundary.
- There are no radioactive liquid wastes associated with the CIS Facility.

The CIS Facility building ventilation systems are not designed for any special radiological considerations since there is no credible scenario for which a significant radioactive release would occur. Shielding of the canister is provided by the HI-STORM UMAX systems and by the shipping and transfer casks during canister receipt, transfer, and offsite shipping operations.

The general area inside the RA fence is a Restricted Area, as defined by 10CFR20 [7.4.1], and is controlled in accordance with applicable requirements of 10CFR20, with personnel dosimetry required. Certain areas within the Restricted Area are designated as Radiation Areas, and specific locations within the RA have the potential to be High Radiation Areas, and are posted and controlled in accordance with applicable requirements of 10CFR20 [7.4.1]. The cask load/unload bay, crane bay, cask transporter bay, and canister transfer cells inside the Canister Transfer Building are designated as Radiation Areas whenever loaded canisters are present in these areas, since the potential exists for dose rates to exceed 5 mrem/hr in these areas. Upon removal of the impact limiters from the transport casks in the Canister Transfer Building, the potential exists for dose rates in the vicinity of the top and or bottom of the casks to exceed 100 mrem/hr in localized areas, and these localized areas will be posted as High Radiation Areas, with necessary controls applied. Due to distances from the transport casks when their impact limiters are removed, dose rates outside the Canister Transfer Building are well below 100 mrem/hr.

11.2.2 Access Control

The CIS Facility is designed to provide access control in accordance with 10CFR72. Access control to the RA is provided for both personnel radiological protection and facility physical protection. The physical protection program is covered in the Security Plan, which is classified and submitted as part of the License Application under separate cover.

The access control boundary for the restricted area are established along the security fence lines (see Figure 2.1.4). The RA is that space which is controlled for purposes of protecting individuals from exposure to radiation or radioactive materials and for providing facility physical security. Operational controls ensure the total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem in accordance with 10CFR20.1301(a)(1) [7.4.1]. The boundary for the RA is the security fence where the dose rate is less than 2 mrem/hr, in accordance with 10CFR20.1301(a)(2) [7.4.1]. The controlled area is the area inside the site boundary. The dose rate beyond the controlled area is less than 25 mrem/year, in accordance with 10CFR72.104 [1.0.5].

Access to the RA is controlled through a single access point in the Security Building (See Figure 2.1.4). Personal dosimetry is issued and controlled in this building to individuals entering the Restricted Area (RA). Provisions exist in this building for donning and removing personal protective equipment, such as anti-contamination clothing and/or respirators if deemed necessary, in the event of contamination in the Canister Transfer Building as a result of off-normal or accident conditions. Provisions for personnel decontamination are also contained in the Security Building. The Restricted Area also includes the cask storage area and Canister Transfer Building. In accordance with the CIS Facility Radiation Protection Program (Section 11.4), radiation protection personnel monitor radiation levels in the RA and establish access requirements as needed.

11.2.3 Radiation Shielding

The HI-STORM UMAX VVMs are designed to maintain radiation exposures ALARA. No low-level radioactive waste (LLW) materials are expected to be generated on site, and there are no special design provisions for low-level radioactive waste materials are not required.

In the unlikely event that low level waste is generated on site such as for smears, disposable clothing, tape, blotter paper, rags, and related health physics material, this material will be processed and temporarily stored on-site while awaiting removal to a licensed LLW disposal facility. The material will be packaged and stored in sealed LLW containers. The LLW containers provide necessary shielding, and dose rates on the outside surfaces of the drums are expected to be negligible. In the unlikely event that LLW materials are stored on-site with significant activity levels, temporarily located shielding may be used to maintain dose rates in the area ALARA, as determined by radiation protection personnel.

11.2.3.1 Shielding Configurations

Chapter 5 of the HI-STORM UMAX FSAR [1.0.6] identifies the shielding materials and geometries of the HI-STORM UMAX system and describes the codes used to model shielding and assess cask dose rates. Further descriptions of site specific shielding configurations are provided in Chapter 7 of this SAR.

11.2.4 Confinement and Ventilation

10CFR72.122(h)(3) [1.0.5] requires that ventilation systems and off-gas systems be provided where necessary to ensure the confinement of airborne radioactive particulate materials during normal or off-normal conditions. However, there are no special ventilation systems installed at the CIS Facility buildings. There are no credible scenarios that would require installation of ventilation systems to protect against off-gas or particulate filtration.

11.2.5 Area Radiation and Airborne Radioactivity Monitoring Instrumentation

10CFR72.122(h)(4) [1.0.5] requires the capability for continuous monitoring of the storage system to enable the licensee to determine when corrective action needs to be taken to maintain safe storage conditions. This is not applicable to the CIS Facility because the canisters are sealed by welding and with the canisters in HI-STORM UMAX systems, there are no credible events that could result in releases of radioactive material from within the canisters or unacceptable increases in direct radiation levels, as described in Chapter 9. Area radiation and airborne radioactivity monitors are therefore not needed at the storage pads. However, TLDs are used to record dose rates in the Restricted Area and along the Controlled Area boundary. TLDs provide a passive means for continuous monitoring of radiation levels and provide a basis for assessing the potential impact on the environment.

TLDs are located at the Restricted Area fence and at the Controlled Area Boundary in accordance with 10CFR20.1302 [7.4.1]. Additionally, TLDs are located at strategic locations inside the Canister Transfer Building, Security Building, and Administration Building where personnel are normally working. These TLDs serve as a backup for monitoring personnel radiation exposure and maintaining this exposure ALARA. For redundancy, each TLD location mentioned above house a set of two TLDs. The TLDs are retrieved and processed quarterly. The TLDs primarily detect gamma radiation and have a lower limit of sensitivity of (0.02 mrem). The storage system design is based on a metal canister that is sealed by welding for spent fuel confinement, preventing release of radionuclides from inside the canister. Radioactive effluents are thus precluded by design.

Local radiation monitors with audible alarms are installed in the Canister Transfer Building. These provide warning to personnel involved in the canister transfer operation of abnormal radiation levels that could possibly occur during transfer operations. Because of measures taken at the originating nuclear power plants to minimize loose surface contamination levels on the exterior of the canisters during fuel loading operations, as discussed in Subsection 11.1.3, it is unlikely that canister transfer operations would generate significant levels of airborne contaminants. Local continuous air monitors include alarms to warn operating personnel in the unlikely event of an airborne release, remote alarm in the Security Building alarm station to ensure coverage at all times, and charting capability to provide data necessary to quantify any release. The radiological alarm systems are designed with provisions for calibration and operability testing. There are no liquid or gaseous effluent releases from the CIS Facility. This satisfies the requirements of 10CFR72.24(e)(l) and 10CFR72.126(b)(c) [1.0.5].

11.3 DOSE ASSESSMENT

11.3.1 Onsite Dose

The shipping, transfer, and storage casks are designed to limit dose rates to ALARA levels for operators, inspectors, maintenance, and radiation protection personnel when the canisters are being transferred from the shipping to the transfer casks, when the transfer cask is being moved to the ISFSI, and while the canisters are transferred from the transfer cask to the HI-STORM UMAX VVMs.

HI-TRAC CS dose rates at the surface, 0.5 meter, 1 meter, and 2 meter distances are presented in Table 7.4.1. HI-STORM UMAX Version C dose rates at the surface and at 1 meter are presented in Table 7.4.2.

Table 11.3.1 shows the estimated occupational exposures to CIS Facility personnel during receipt of the transport cask and transfer of the canister from the transport cask to the HI-STORM UMAX using the HI-TRAC CS transfer cask. The operational sequence for these operations is also described in Chapter 3.

Dose rate values include both gamma and neutron flux components, and are based on design basis PWR fuel as shown in Table 7.1.1. Fuel with these characteristics is considered to conservatively represent fuel assemblies that are contained in canisters handled at the CIS Facility, and dose estimates based on fuel with these characteristics are considered to be realistic and reflect expected personnel exposures.

Occupational doses to individuals are administratively controlled to ensure that they are maintained below 10 CFR 20.1201 limits. Temporarily positioned shielding is used during transfer operations to reduce dose rates from streaming paths or relatively high radiation areas where its use results in a net reduction in worker exposures. Conservatively, the effects of temporarily positioned shielding are not considered in the Table 11.3.1 dose estimates for canister transfer operations. It is expected the actual crew dose per loading would be significantly less than what is presented in Table 11.3.1, and operational experience gained with each loading also has been shown to lower crew dose on subsequent loadings.

The shielding design basis accident dose analysis for the HI-STORM UMAX system presented in Subsection 11.3.2 of Reference [1.0.6] is incorporated by reference as described in Table 11.0.1. Additionally, in the event it is desired to expand the HI-STORE CIS Facility's HI-STORM UMAX VVM ISFSI, radiation protection of excavation activities is incorporated by reference from Section 11.3.2 of Reference [1.0.6] as described in Table 11.0.1.

Occupational exposures are also estimated to security personnel and CIS Facility personnel that conduct inspections, surveillances, and maintain the storage systems. Subsection 11.3.4 of the HI-STORM UMAX FSAR [1.0.6], which addresses estimated exposures for security surveillance and maintenance, is incorporated by reference into this SAR as described in Table 11.0.1.

11.3.2 Offsite Dose

The offsite dose evaluation is provided in Section 7.4, with results in Table 7.4.3 and Table 7.4.4.

Table 11.3.1: Estimated Personnel Exposures for Loading Operations of One Canister at the HI-STORE CIS Facility

(Sheet 1 of 2)

OPERATION	OPERATION FIGURE 3.1.1	NUMBER OF PERSONNEL	DURATION (MINS)	OCCUPANCY FACTOR (%)	DOSE RATE (mrem/hr)	CREW DOSE (mrem)
RECEIVE HI-STAR 190	a	2	120	20	50	40.0
PERFORM HI-STAR 190 INSPECTION	a	2	30	50	50	25.0
REMOVE PERSONNEL BARRIER	a	2	20	50	10	3.3
REMOVE TIE-DOWN	a	2	20	70	10	4.7
ATTACH HORIZONTAL LIFT BEAM	b	2	25	30	50	12.5
MOVE HI-STAR 190 TO TILT FRAME	c	2	25	70	10	5.8
REMOVE IMPACT LIMITERS	d	2	30	90	10	9.0
PERFORM ANNULUS SAMPLE	e	2	60	20	200	80.0
REMOVE LID BOLTS	f	2	80	90	10	24.0
ATTACH LIFT YOKE TO HI-STAR 190	g	1	20	30	10	1.0
TILT HI-STAR 190 TO VERTICAL	g	2	10	80	10	2.7
PLACE HI-STAR 190 IN CTF	h	2	20	80	10	5.3
REMOVE HI-STAR 190 CLOSURE LID	i	2	20	70	50	23.3
INSTALL SEAL SURFACE PROTECTOR	i	2	10	80	256	68.3
INSTALL MPC LIFTING ATTACHMENT	i	2	20	90	256	153.6
PLACE ALIGNMENT PLATE ON HI-STAR 190	i	2	25	80	51	34.1
PLACE HI-TRAC ON CTF	j	2	20	90	17	10.1
GRAPPLE MPC LIFTING ATTACHMENT	k	1	15	100	17	4.2
RAISE MPC INTO HI-TRAC	l	2	5	100	17	2.8
CLOSE HI-TRAC SHIELD GATES	m	2	5	100	35	5.8

Table 11.3.1: Estimated Personnel Exposures for Loading Operations of One Canister at the HI-STORE CIS Facility

(Sheet 2 of 2)

OPERATION	OPERATION FIGURE 3.1.1	NUMBER OF PERSONNEL	DURATION (MINS)	OCCUPANCY FACTOR (%)	DOSE RATE (mrem/hr)	CREW DOSE (mrem)
MOVE HI-TRAC TO VCT PICK UP AREA	n	2	30	90	17	15.1
CONNECT VCT TO HI-TRAC	o	3	20	100	17	16.8
REMOVE CEC LID	p	3	120	50	2.1	6.2
INSTALL DIVIDER SHELL	p	3	120	50	2.1	6.2
TRANSPORT HI-TRAC TO CEC	q	2	120	100	17	69.3
PLACE HI-TRAC ON CEC	r	3	20	100	17	17.3
CONNECT MPC LIFTING EXTENSION TO MPC LIFTING ATTACHMENT	r	1	15	100	17	4.3
OPEN HI-TRAC SHIELD GATES	s	2	5	100	35	5.8
LOWER MPC INTO CEC	t	1	10	100	17	2.9
DISCONNECT MPC LIFTING EXTENSION	u	1	5	100	17	1.4
REMOVE HI-TRAC FROM CEC	v	3	60	90	17	46.7
REMOVE MPC LIFTING ATTACHMENT	w	2	15	40	512	102.4
INSTALL CEC LID	x	2	60	100	2.79	5.6
TOTAL						815.8

11.4 RADIATION PROTECTION PROGRAM

11.4.1 Organizational Structure

The CIS Facility Radiation Protection Manager reports to the Site Manager (Figure 10.4.2) and is responsible for administering the radiation protection program and for the radiation safety of the facility. Minimum qualification requirements are set forth in Chapter 10.

Responsibilities of the CIS Facility Radiation Protection Manager include the following:

- Administer the Radiation Protection program policies and procedures
- Review and approve radiation protection procedures
- Coordinate radiation protection group activities with operations and maintenance personnel
- Ensure adequate staffing, facilities, and equipment are available to perform the functions assigned to radiation protection personnel
- Establish goals for the Radiation Protection program
- Initiate and implement exposure control program that factors dosimetry results into operational planning
- Issue or rescind "stop work" orders as appropriate
- Ensure that locations, operations, and/or conditions that have potential for causing significant exposures to radiation are identified and controlled
- Review and approve training programs related to work in radiological areas or involving radioactive material
- Administer shipments (if necessary) of solid radioactive waste offsite for disposal
- Review root causes and corrective actions for incidents and deficiencies associated with Radiation Protection
- Ensure an effective ALARA program is maintained, in accordance with the guidance provided in Regulatory Guides 8.8 [11.1.2] and 8.10 [11.1.3]
- Supervise the collection, analysis and evaluation of data obtained from radiological surveys and monitoring activities in accordance with 10CFR20.1501 [7.4.1]
- Participate in the event of an emergency, as required

Radiation protection technicians report to the Radiation Protection Manager. Responsibilities of the radiation protection technicians include the following:

- Conduct radiation, contamination, and airborne surveys and prepare complete and accurate records
- Prepare Radiation Work Permits to control access to and activities in radiologically controlled areas

- Identify and post radiation, contamination, hot particle, airborne and radioactive material areas in accordance with 10 CFR 20 [7.4.1] requirements
- Monitor CIS Facility operations to assure good radiological work practices
- Implement ALARA program requirements
- Maintain and calibrate portable monitoring instruments
- Issue "stop work" orders whenever activities have the potential to jeopardize the health and safety of workers, visitors, or the general public
- Verify proper packaging of any radioactive material
- Participate in the event of an emergency, as required

11.4.2 Equipment, Instrumentation, and Facilities

A sufficient inventory and variety of operable and calibrated portable and fixed radiological instrumentation is maintained to allow for effective measurement and control of radiation exposure and radioactive material and to provide back-up capability for inoperable equipment. Equipment is ensured to be appropriate to enable the assessment of sources of gamma, neutron, beta, and alpha radiation, including the capability to measure dose rates and radioactivity concentrations expected. Radiation protection procedures govern instrument calibration, instrument inventory and control, and instrument operation.

Portable survey and personnel monitoring instrumentation, if deemed necessary during normal, off-normal, or accident conditions, will include, but not be limited to, the following:

- Low-level contamination meters
- Beta/gamma portable survey meters
- Alarming beta/gamma personnel friskers
- Portable air samplers

Area radiation monitors are utilized in the Canister Transfer Building since the operations performed in this building (transport cask receipt, inspection, and canister transfer operations) pose the greatest risk to the operating staff for radiation exposure. These monitors have audible alarms to warn operating personnel of abnormal radiation levels. Area radiation monitors are not utilized outside the Canister Transfer Building since these areas have relatively low area radiation levels and there are no operations performed in these areas which could result in rapid change in radiation level and pose a risk for over-exposure of personnel.

The Restricted Area is surrounded by a chain link security fence and an outer chain link nuisance fence with an isolation zone and intrusion detection system between the two fences. Access to the Restricted Area is controlled through a single access point in the Security Building (see Figure 2.1.4). Personal dosimetry is issued and controlled in this building to individuals entering the Restricted Area. External radiation dose monitoring is accomplished through the use of thermoluminescent dosimeters (TLDs) and self-reading dosimeters (SRDs) or digital alarming dosimeters (DADs). During transfer operations inside the Canister Transfer Building alarming dosimeters shall be used to warn of excessively high direct radiation to maintain exposures

ALARA, thereby providing assurance that occupational exposures do not exceed the limits of 10 CFR Part 20. The official record of external dose to beta and gamma radiations is normally obtained from the TLDs with SRDs or DADs used as a means for tracking dose between TLD processing periods as a backup to TLDs. Self-reading dosimeters are administered in accordance with the guidance in Regulatory Guide 8.4 [11.4.1].

Provisions exist in the Security Building for donning and removing personal protective equipment, such as anti-contamination clothing, which could be necessary in the event of contamination in the Canister Transfer Building due to off-normal or accident conditions. A respiratory protection program, if deemed necessary, will be established in accordance with 10 CFR 20 and consistent with the guidance of NUREG-0041 [11.4.2].

Provisions for personnel decontamination are contained in the Security Building. Contamination of equipment or personnel is not expected to occur under normal conditions of operation. In accordance with the CIS Facility policy of preventing generation of liquid radioactive waste, any necessary decontamination of equipment and personnel will be conducted using methods that produce only solid radioactive waste. Decontamination methods would typically include wiping the contaminated item with rags or paper wipes.

Drain sumps are provided in the cask load/unload bay of the Canister Transfer Building which catch and collect water that drips from transport casks (e.g. from melting snow) onto the floor. Water collected in the cask load/unload bay drain sumps is sampled and analyzed to verify it is not contaminated prior to its release. In the event contaminated water is detected, it will be collected in a suitable container, solidified by the addition of an agent such as cement or "Aquaset" so that it qualifies as solid waste, staged on-site while awaiting shipment offsite, and transported to a LLW disposal facility, in accordance with Radiation Protection procedures.

No process or effluent monitors are necessary because of the design of the CIS Facility storage system, in which spent fuel assemblies are stored in welded canisters. During routine storage operations at the CIS Facility, the only radiological instrumentation in use in the storage area are the TLDs, as described in Subsection 11.2.5. Routine radiological surveys use instruments that are controlled by the Radiation Protection Program and governed by existing procedures. Calibration procedures for radiological instrumentation are established and applied to instruments used at the CIS Facility.

11.4.3 Policies and Procedures

Radiation protection requirements for all radiological work at the CIS Facility are governed by radiation protection procedures. Radiation protection practices for cask loading and unloading operations, canister transfer, canister storage, and monitoring are also based on these procedures, as well as on anticipated conditions when the task is to be performed. These procedures, if deemed necessary, include, but are not limited to, the following:

- Procedure for performing badging functions for access authorization to the Restricted Area.
- Procedure for issuing personnel dosimetry, and monitoring, recording, and tracking individual exposures.
- Procedure for performing radiological safety training and refresher training.

- Procedure for performing ALARA reviews of plant procedures and monitoring of operations.
- Procedure for determining radiation doses on a periodic basis at the Restricted Area and Controlled Area boundaries using TLDs.
- Procedure for issuing, revising, and terminating radiation work permits and standing radiation work permits.
- Procedure for roping off, barricading, and posting radiation control zones.
- Procedure for decontaminating personnel, equipment, and areas.
- Procedure for performing radiation surveys in accordance with 10CFR20.1501.
- Procedure for smear swab sampling, counting, and calculation.
- Procedure for calibrating detection, monitoring, and dosimetry instruments.
- Procedure for quantifying airborne radioactivity.
- Procedure for maintaining records of the radiation protection program, including audits and other reviews of program content and implementation; radiation surveys; instrument calibrations; individual monitoring results; and records required for decommissioning.

Implementation of the Radiation Protection Program procedures ensures that occupational doses are below the limits required by 10 CFR 20.1201 [7.4.1]. Area radiation monitors in the Canister Transfer Building have audible alarms and warn operating personnel of abnormal radiation levels. While area radiation monitors are not installed in the Restricted Area, measures are in place to ensure personnel in the Restricted Area do not exceed dose limits. Process and engineering controls at the HI-STORE CIS Facility ensures that contamination is non-existent or minimized, that controls are in place to ensure air concentrations of radioactive material is non-existent or insignificantly low, and that there is no or minimal generation of radioactive waste on-site in accordance with 10CFR20.1406 and 10CFR20.1701 [7.4.1].

As discussed in Subsection 11.2.2, access to the Restricted Area is controlled through a single access point in the Security Building where personal dosimetry is issued to individuals entering the Restricted Area. Periodic radiation surveys are conducted of areas inside the Restricted Area and maps are generated showing the radiation levels in all areas. Radiation work permits (RWPs) are completed by qualified radiation protection personnel prior to any entry and serve to identify normal and unusual radiation readings. Workers are required to read, understand and sign that they are aware of the conditions or unknowns. Personnel are trained to use the appropriate radiation detection instruments or are required to have a qualified radiation protection technician with them at all times while in the areas. Training includes responses to unusual readings and off-scale conditions. The Radiation Protection program will provide for the immediate reading of any individual's TLD if an unusual reading or off-scale condition occurs.

11.5 REGULATORY COMPLIANCE

The HI-STORM UMAX System at the HI-STORE CIS Facility provides radiation shielding and confinement features that are sufficient to meet the requirements of 10CFR72.104 and 10CFR72.106 [1.0.5].

Occupational radiation exposures satisfy the limits of 10CFR20 [7.4.1] and meet the objective of maintaining exposures ALARA.

The design of the HI-STORM UMAX System is in compliance with 10CFR72 [1.0.5] and applicable design and acceptance criteria have been satisfied. The radiation protection system design provides reasonable assurance that the HI-STORM UMAX System at the HI-STORE CIS Facility allows safe storage of spent fuel.

CHAPTER 12: QUALITY ASSURANCE PROGRAM*

12.0 INTRODUCTION

12.0.1 Overview

This chapter provides a summary of the quality assurance program implemented by Holtec International for activities related to the design, qualification analyses, material procurement, fabrication, assembly, testing and use of structures, systems, and components of the Company's dry storage/transport systems including the HI-STORM UMAX System and other equipment at the HI-STORE CIS facility. This chapter is included in this SAR to fulfill the requirements in 10CFR72.140(c)(2) as elaborated in NUREG-1567[1.0.3].

Important-to-safety activities related to construction and deployment of the HI-STORM UMAX System and other equipment at the HI-STORE CIS Facility are controlled under the NRC-approved Holtec Quality Assurance Program. The Holtec QA program manual [12.0.1]† is approved by the NRC under Docket 71-0784. The Holtec QA program satisfies the requirements of 10CFR72, Subpart G and 10CFR71, Subpart H. In accordance with 10CFR72.140(d), this approved 10CFR71 QA program will be applied to spent fuel storage cask activities at HI-STORE under 10CFR72. The additional recordkeeping requirements of 10CFR72.174 are addressed in the Holtec QA program manual and must also be complied with.

The Holtec QA program is implemented through a hierarchy of procedures and documentation, listed below.

1. Holtec Quality Assurance Program Manual [12.0.1]
2. Holtec Quality Assurance Procedures
3. Miscellaneous Documents including, but not limited to:
    a. Holtec Standard Procedures
    b. Holtec Project Procedures
    c. Project Specifications
    d. Drawing packages
    e. Project Bill-of-Materials
    f. Inspection and testing procedures
    g. Welding procedure Specifications
    h. Calculation packages
    i. Technical Reports (generic and project specific)
    j. Position Papers and Technical Memos

* All references are in placed within square brackets in this report and are compiled in Chapter 19 of this report
† Holtec QA manual [12.0.1] is incorporated by reference in its entirety in this chapter. Format and content of QA manual is in accordance with NUREG 1567 [1.0.3] and Regulatory Guide 3.50 [1.0.2].

k. Corporate Documents that include Corporate Governance, Safety and other manuals

l. A series of databases including the Lessons Learned database

Quality activities performed by others on behalf of Holtec are governed by the supplier's quality assurance program or Holtec's QA program extended to the supplier. The type and extent of Holtec QA control and oversight is specified in the procurement documents for the specific item or service being procured. The fundamental goal of the supplier oversight portion of Holtec's QA program is to provide the assurance that activities performed in support of the supply of safety-significant items and services are performed correctly and in compliance with the procurement documents.

12.0.2 Graded Approach to Quality Assurance

Holtec International uses a graded approach to quality assurance on all safety-related or important-to-safety projects. This graded approach is controlled by Holtec Quality Assurance (QA) program documents as described in Subsection 12.0.1.

NUREG/CR-6407 [1.2.2] provides descriptions of quality categories A, B and C. Using the guidance in NUREG/CR-6407, Holtec International assigns a quality category to each individual, important-to-safety component of the HI-STORM UMAX System and HI-TRAC transfer cask. The ITS categories assigned to the HI-STORM UMAX cask components and for other equipment deployed at the HI-STORE CIS Facility, and equipment needed to deploy the HI-STORM UMAX System at HI-STORE CIS are provided in Chapter 4 using the guidelines of NUREG/CR-6407 [1.2.2].

Activities affecting quality will be defined by Holtec's Purchase Specifications and/or written instructions/procedures for use of the HI-STORM UMAX System under the license provisions of 10CFR72, Subpart C at the HI-STORE CIS independent spent fuel storage installation (ISFSI). These activities include any or all of the following: design, procurement, fabrication, handling, shipping, storing, cleaning, assembly, inspection, testing, operation, maintenance, repair, monitoring and aging management of HI-STORM UMAX and other HI-STORE CIS Facility equipment structures, systems, and components (SSCs) that are important-to-safety.

The quality assurance program described in the Holtec QA Program Manual fully complies with the requirements of 10CFR72 Subpart G and the intent of NUREG-1567 [1.0.3]. However, NUREG-1567 does not explicitly address incorporation of a QA program manual by reference. Therefore, invoking the NRC-approved QA program in this SAR constitutes a literal deviation from NUREG-1567. This deviation is acceptable since important-to-safety activities are implemented in accordance with the latest revision of the Holtec QA program manual and implementing procedures. Further, incorporating the QA Program Manual by reference in this SAR avoids duplication of information between the implementing documents and the SAR and any discrepancies that may arise from simultaneous maintenance to the two program descriptions governing the same activities. The Holtec Quality Assurance Manual has been included as one of the documents incorporated by reference in this SAR (Table 1.0.3).

12.1 REGULATORY COMPLIANCE

The chapter complies with the quality assurance requirements of 10CFR72. As indicated in Table 1.0.3, Holtec's NRC-approved QA program, is adopted herein for 10CFR72 activities performed at the HI-STORE CIS Facility. The QA program applies to the dockets listed in Table 1.3.1 of this SAR. The QA program covers activities affecting important to safety components identified in this report for the HI-STORE CIS Facility.

The format and content of the Quality Assurance Program Manual [12.0.1] is in accordance with NUREG-1567 [1.0.3] and Regulatory Guide 3.50 [1.0.2].

CHAPTER 13: DECOMMISSIONING EVALUATION*

13.0 INTRODUCTION

This chapter contains the information for the design and operational features of the HI-STORE CIS Facility that will allow for eventual decontamination and decommissioning of the site. Also, described in this chapter is the financial assurance mechanisms that will fund the decommissioning effort.

* All references are in placed within square brackets in this report and are compiled in Chapter 19 of this report.

Table 13.0.1: Material Incorporated By Reference				
Information Incorporated by Reference	**Source of the Information**	**NRC Approval of Material Incorporated by Reference**	**Location in this SAR where Material is Incorporated**	**Technical Justification of Applicability to HI-STORM UMAX**
HI-STORM UMAX Decommissioning Considerations	HI-STORM UMAX FSAR Chapter 2.11 [1.0.6]	SER HI-STORM UMAX Amendments 0, 1, and 2 [7.0.1, 7.0.2, 7.0.3]	Section 13.1	The ISFSI structure is the same as the one described in the HI-STORM UMAX FSAR and the same Decommissioning Considerations would apply at the HI-STORE CIS Facility.

13.1 DESIGN FEATURES

Section 2.11 of the HI-STORM UMAX FSAR [1.0.6] is incorporated by reference into this SAR, and describes all the design features of the ISFSI which are considered for the decommissioning of the Site. The CTF and other auxiliary SSCs, as described in Chapter 4, support decommissioning processes similar to those used for the HI-STORM UMAX VVM structures.

13.2 OPERATIONAL FEATURES

The layout and design of the HI-STORE CIS Facility will facilitate rapid, safe, and economical decommissioning of the Site. As described in Chapter 2 of the HI-STORM UMAX FSAR [1.0.6], the VVM components are designed to allow the retrieval of the MPC under all conditions of storage. The MPC, which holds the SNF assemblies, is engineered to be suitable as a waste package for permanent internment in a deep Mined Geological Disposal System (MGDS). Towards that end, the loaded MPC has been designed with the objective to transport it in a transportation cask, which is an *a priori* assumption for receipt of the canisters at the Site.

The HI-STORE CIS Facility will be operated as a “clean” facility. All components of the facility including the transport casks and storage canisters are designed to minimize the potential for any contamination. Canisters are already welded shut and sealed to prevent leaks at the generator facility. All procedures controlling handling and storage operations of the canisters will emphasize minimizing any potential contamination at the Site. Dose rate surveys will be performed throughout the operations for site receiving and loading of canisters as discussed in Chapter 3 of this SAR. The dose requirements for these surveys are discussed in Chapter 7 of this SAR.

Pursuant to 10 CFR 72.30(f), records of importance to the decommissioning of the HI-STORE CIS Facility will be maintained until the site is released for unrestricted use. Records will include:

- Records of spills or other unusual occurrences involving the spread of contamination in and around the facility, equipment, or site.
- Records on contamination that may have spread to inaccessible areas.
- As-built drawings and modifications of structures and equipment used in the storage of radioactive materials.
- A list containing all areas designated as a restricted area.
- The decommissioning funding plan, cost estimate, and records of the funding method used for assuring funds are available for decommissioning.

13.3 DECOMMISSIONING PLAN

13.3.1 General Provisions

A Preliminary Decommissioning Plan for the HI-STORE CIS Facility is provided in Holtec Report HI-2177558 [13.3.1]. A summary of this preliminary plan and is presented below.

The objective of decommissioning activities at the HI-STORE CIS Facility is to verify that any potential radioactive contamination is below established release limits, and in the unlikely event of contamination, to identify and remove radioactive contamination that is above the NRC release limits, so that the site may be released for unrestricted use and the NRC license terminated.

Residual radioactive contamination is not anticipated at the HI-STORE CIS Facility for several reasons:

- Canisters are surveyed and decontaminated at the generator facility, prior to shipment, to ensure the outer surfaces are clean. This is repeated at the HI-STORE CIS Facility to ensure dose rate and contamination requirements are met.
- Canisters are welded shut and sealed to prevent leaks.
- Canisters will not be opened during transportation to the Site or during transfer, handling, or storage operations at any time.
- Radiological activation of the VVM and concrete pad materials is expected to be insignificant with radiation levels below the applicable NRC criteria for unrestricted release.

An insignificant amount of radioactive wastes are expected to be generated at the HI-STORE CIS Facility from normal operations of the Site. Conventional decontamination techniques will be used to minimize the volume of waste generated. Any waste generated will be sent to a licensed facility for disposal. Gaseous and liquid wastes are not generated at the HI-STORE CIS Facility. Small volumes of solid radioactive waste may be produced from routine operations involving contamination surveys and decontamination activities involving incoming and outgoing transportation casks and equipment. Potential solid waste streams are collected and temporarily stored at the Site until offsite shipping, processing, and disposal methods are available.

A Final Decommissioning Plan detailing activities and procedures for decommissioning will be provided once all of the canisters are removed from the facility. The Final Decommissioning Plan will address final status survey of the site and termination of the license. The final plan will evaluate NRC criteria for decommissioning to ensure all requirements are satisfied. Decommissioning activities will be planned using ALARA principles and in a manner that protects the public and environment during the process.

13.3.2 Cost Estimate

Pursuant to 10 CFR 72.30, a decommissioning cost estimate was prepared and is presented in Holtec Report HI-2177565 [13.3.2]. This report discusses the decommissioning cost estimate and financial funding assurance per 10 CFR 72.30(b)(2). The decommissioning cost estimate follows the guidance of NUREG-1757 [13.3.3, 13.3.4] for activities that will allow the NRC license to be terminated and the remaining facility and site may be released for unrestricted use.

The cost estimating method used for developing the overall decommissioning cost estimate is based on resource costing. The resource costing is based on the resources and duration to estimate the costs associated with radiological surveys and decontamination activities. The estimated labor costs are based on an R.S. Means 2017 [13.3.5] that will allow an independent third party to assume the responsibility and carry out the decommissioning project. Non-labor costs include equipment and security.

The decommissioning cost estimate is based on the following key assumptions:

- All costs associated with removing the canisters from the site is not included.
- Four crews will be used to perform the radiological survey within a one year time frame.
- No subsurface material is assumed to require remediation regarding radionuclides.
- No canisters will be opened at the CIS Facility
- Nuclear activation of the VVMs and concrete pads are anticipated to be below the release limits, however for the purposes of the cost estimate, it is assumed that removal and remediation of the VVMs will be necessary
- There is no subsurface soil containing residual radioactivity that will require remediation.
- The decommissioning tasks are assumed to be completed in a two year time frame.
- All costs used in the estimates were current on January 2017.

The decommissioning cost estimate will be updated a minimum of every three years, adjusting the estimated cost for current prices of services, inflation (as necessary), and approach. The key assumptions will be also be revisited and adjusted as warranted.

13.3.3 Financial Assurance Mechanism

The method of financial assurance as specified in 10 CFR 72.30(e)(3) will be met by Holtec International. Expected decommissioning costs for Phase 1 of the HI-STORE CIS Facility are presented in Holtec Report HI-2177565 [13.3.2]. A decommissioning fund will be established by setting aside a fixed dollar amount per MTU stored at the HI-STORE facility. These funds, plus earnings on such funds calculated at a fixed rate of return over the life of the facility, will cover the estimated cost to complete decommissioning.

13.4 REGULATORY COMPLIANCE

Pursuant to the guidance provided in NUREG-1567 [1.0.3], the foregoing material in this Chapter provides:

i. A complete description of the Design Features of the Site which facilitate decommissioning as mandated by 10CFR72.24, 72.30, and 72.130;

ii. A complete description of the Operational Features of the Site which facilitate decommissioning as mandated by 10CFR72.24, 72.30, and 72.130;

iii. A complete description of the Decommissioning Plan for the Site including the Decommissioning Cost Estimate and Decommissioning Funding Plan as mandated by 10CFR72.24, 72.30, and 72.130;

Therefore, it can be concluded that this SAR provides adequate information to assure that decommissioning issues for the ISFSI facility have been adequately characterized, so that the site will ultimately be available for unrestricted use for any private or public purpose. Additionally, it can be concluded that this SAR provides adequate information to estimate the costs of decommissioning activities as well as sufficient financial assurance mechanisms to provide reasonable assurance that adequate funds will be available to decommission the facility so that the site will ultimately be available for unrestricted use for any private or public purpose.

CHAPTER 14: WASTE CONFINEMENT AND MANAGEMENT EVALUATION*

14.0 INTRODUCTION

Radioactive wastes are not generated as a result of handling and storage operations for spent fuel or high-level waste (HLW) at the HI-STORE CIS site. The canisters bearing SNF and other approved contents for storage in HI-STORM UMAX systems at the HI-STORE CIS serves as the confinement system during storage and related operations, as noted in Chapter 9 of this report. There is no breaching or opening of the confinement canister during storage operations. The integrity of the confinement system has been proven via analysis to be maintained during normal, off-normal and hypothetical accident conditions as discussed in Chapters 9 and 15 of this report.

* All references are in placed within square brackets in this report and are compiled in Chapter 19 of this report.

14.1 WASTE SOURCES

Radioactive wastes typically generated during operations at an ISFSI fall into the categories (a and b) below. However, as discussed in Sections 14.3, 14.4 and 14.5, the HI-STORE CIS does not generate radioactive wastes in any form during operations. Therefore, implicitly, the HI-STORE CIS complies with the radioactive wastes and radiological impact criteria in 10CFR20 and 10CFR72, as they pertain to the waste generated onsite.

a) Effluents (gaseous and liquid), and

b) Wastes (solid or solidified)

In addition to the radioactive waste types above, NUREG-1567 [1.0.3] also recommends evaluation of exposure of radioactive wastes to non-radioactive wastes such as combustion products and chemical wastes.

Combustion Products

An explosion within the protected area of the ISFSI is unlikely, since explosive materials are generally prohibited within the site boundary. However, an explosion as a result of combustible fluid contained in the VCT is possible (Subsection 6.5.2). Due to the quantity of combustible fluid and the structurally robust construction materials of the HI-TRAC transfer cask, HI-STORM UMAX VVM and the canister, the effects of a fire is minimal, and the confinement boundary of the canister is not compromised (Subsection 6.5.2). The canister is in the HI-TRAC during transfer by the VCT to the HI-STORM UMAX VVM, which provides protection to the canister during an explosion. The effect of an explosion on the canister is further reduced after loading into a HI-STORM UMAX. Canisters in a HI-STORM UMAX system are protected from an explosion by the robust lid of the HI-STORM UMAX, the ISFSI pad, the subgrade and HI-STORM UMAX VVM. Thus explosions due to combustion products will not compromise canisterized wastes being transferred to the VVM or in the VVM, and therefore have no radiological impact. There is also no credible mechanism through which radioactive wastes will come into contact with the fuel prior to or after loading into the VCT, which could potentially result in unplanned releases as exhausts effluents from the VCT's engine during operations.

Chemical Wastes

There are no chemical wastes generated at the HI-STORE CIS Facility.

14.2 OFF-GAS TREATMENT AND VENTILATION

The HI-STORE CIS is not a waste treatment facility. Canisters loaded and welded shut at the waste site of origin remain closed during transfer operations and storage at the HI-STORE CIS. The canister confinement boundary is not procedurally opened during operations upon arrival at the HI-STORE CIS. Furthermore, upon arrival at the HI-STORE CIS and prior to opening the transport cask containment boundary, the transport cask and the loaded canister are leak tested to ANSI N14.5 (Subsection 10.3.3) "leaktight" criteria to ensure the confinement boundary of the canister was not compromised during transport to the HI-STORE CIS. If a breach of the loaded canister is detected during the leakage test, the loaded transport cask is transported off-site to a facility authorized to perform contents unloading operations or transported back to the site of origin of the radioactive wastes without opening its transport cask containment boundary.

Therefore, since a) breach of the confinement canisters is deemed non-credible under analyzed conditions, b) opening of the confinement boundary of canisters is procedurally prohibited at the HI-STORE CIS, and c) the HI-STORE CIS is not a waste treatment facility, the generation or presence of gaseous effluents, either due to contamination cleanup or other activities is non-credible, and negates the need for off-gas treatment and ventilation systems.

14.3 LIQUID WASTE TREATMENT AND RETENTION

The HI-STORE CIS is designed for passive storage of HI-STORM UMAX Systems that require no further handling once canisters are loaded into the VVM. Liquid wastes, radioactive or non-radioactive, are not generated at the HI-STORE CIS during handling and or storage operations. Therefore treatment and retention systems for liquid wastes are not required.

Fuel and HLW loaded canisters are inspected prior to transport to the HI-STORE CIS. Upon arrival at the HI-STORE CIS, the transport cask or overpack is inspected for damage and is also leak tested along with the loaded canister. In the unlikely scenario that leakage is detected or damage is observed to a degree that may compromise the long term integrity of the canister, the transport cask with the loaded canister is returned to the waste site of origin or other authorized facility for decontamination, which may involve a washdown, followed by canister unloading. Washdowns or decontamination activities of the transport cask and canisters, if required, will not occur at the HI-STORE CIS. This prevents generation of liquid radioactive or non-radioactive wastes at the CIS. Furthermore, the CIS has no labs or other facilities that may produce liquid wastes, that may become susceptible to contamination, radiologically or otherwise.

Furthermore, the ISFSI pads are designed to ensure drainage of rain water or other spilled liquids away from the HI-STORM UMAX VVMs. Radioactive contamination of drained liquids from the ISFSI pad is unlikely since all radioactive wastes onsite are in canisters. The canister design, as approved by the NRC, precludes a breach of its steel weldment construction under all analyzed conditions (Chapters 9 and 15) during storage in the HI-STORM UMAX systems. Therefore leakage of radioactive material from the canisters is non-credible.

14.4 SOLID WASTES

As explained in Subsection 14.3, the liquid waste (radioactive or non-radioactive) is not generated as a result of facility normal operations and off-normal events as defined in Chapters 9 and 15 of this report. As such, solidified wastes – generated from liquid waste stream(s) – are not generated at the HI-STORE CIS, and there isn't a need for a packaging system or storage facility for solidified wastes.

Solid radioactive wastes, are not generated at the HI-STORE CIS as a result of facility operations. SNF and HLW stored at the CIS arrives in a canister that is transferred to the HI-STORM UMAX VVM following inspection that ensures the integrity of the canister weldment is uncompromised. At no time during storage and transfer operations at the CIS is the canister opened and waste handled or treated. If breach of the canister is detected during leak testing of the transport cask and loaded canister, the package is transported back to the site of origin or other site authorized to handle the radioactive contents of the package for unloading and other remediation activities. Therefore no solid radioactive wastes are generated as a result of CIS facility operations, and no packaging and storage system is needed.

14.5 RADIOLOGICAL IMPACT OF NORMAL OPERATIONS

There are no radioactive wastes generated during normal operations of the HI-STORE CIS Facility. The radiological impact of the HI-STORE CIS Facility is provided in Chapter 11 of this report, and is in compliance with 10CFR20 [7.4.1] and 10CFR72 [1.0.5] effluents and dose criteria.

14.6 REGULATORY COMPLIANCE

In accordance with NUREG-1567 [1.0.3], this chapter should comply with 10CFR20 Appendix B Table 2, 10CFR72.24(l) and (f), 10CFR72.40(a)(13), 10 CFR72.104, 72.122(h), 10 CFR 72.126(c) and (d), and 10CFR72.128(a)(5) and (b).

10CFR20 Appendix B, Table 2 gaseous or liquid effluents radionuclide concentration limits shall not be exceeded at the HI-STORE CIS Facility.

10CFR72.24(f) requires this report to include features of the ISFSI design and operating modes that reduce to the extent practicable radioactive waste volumes generated at the installation.

10CFR72.24(l) requires description of instruments that maintain control over radioactive materials in gaseous and liquid effluents produced during normal operations and expected operational occurrences.

10CFR72.40(a)(13) requires that this report provide reasonable assurance that (i) the activities authorized by the license can be conducted without endangering the health and safety of the public, and (ii) the activities be conducted in compliance with applicable regulations of this chapter.

10CFR72.104 doses shall not be exceeded.

10CFR72.122(h)(3) requires that ventilation systems and off-gas systems must be provided where necessary to ensure the confinement of airborne radioactive particulate materials during normal or off-normal conditions.

10CFR72.126(c) requires as appropriate for handling and storage systems that effluent monitoring system be provided, and direct radiation monitoring system be provided in and around areas containing radioactive materials.

10CFR72.126(d) requires the ISFSI be designed to provide means to limit as low as reasonably achievable the release of radioactive materials in effluents during normal operations; and control the release of radioactive materials under accident conditions. Show via analysis that releases to the environment will be within the exposure limits given in 10 CFR 72.104 for normal conditions and 10 CFR 72.106 for design basis accident conditions.

10CFR72.128(a)(5) requires spent fuel and other radioactive wastes handling and storage systems must be designed to minimize the quantity of radioactive wastes generated.

10CFR 72.128(b) radioactive waste treatment facilities must be provided. Provisions must be made for the packing of site-generated low-levels wastes in a form suitable for storage onsite awaiting transfer to disposal sites.

This chapter ensures that the HI-STORE CIS Facilities complies with the applicable waste confinement and management regulatory requirements of 10 CFR 20 and 72. The HI-STORE CIS Facility is designed to receive welded canisters containing SNF and related hardware. No radioactive wastes (gaseous or liquid effluents) will be generated at the ISFSI site, and the canisters will arrive welded and remain welded throughout the storage duration at the HI-STORE CIS ISFSI. The canisters are classified as "leaktight" in accordance with ANSI N14.5 (Subsection 10.3.3), and release to the environment or impact on public health and safety is considered non credible or negligible. Therefore no effluents monitoring system are provided. Radiation monitoring equipment are provided at the HI-STORE CIS Facility as discussed in the Radiation Protection chapter (11).

As noted in Section 2.2 of this report, four nuclear facilities exist or are planned to be built within 50 miles of the proposed site for the HI-STORE CIS Facility. The closest nuclear facility is located 16 miles southwest of the proposed site for the HI-STORE CIS Facility. As such, there is no concern of the cumulative impact from operation of the HI-STORE CIS Facility and nearby facilities on the public. The environmental impacts of other nuclear facilities are in impact statements in Section 2.2 of this report.

CHAPTER 15: ACCIDENT ANALYSIS[1]

15.0 INTRODUCTION

This chapter is focused on the safety evaluation of all off-normal and accident events germane to the HI-STORE CIS facility. For each postulated event, the event cause, means of detection, consequences, and corrective actions, as applicable, are discussed and evaluated. For other miscellaneous events (i.e., those not categorized as either design basis off-normal or accident condition events), a similar outline for safety analysis is followed. As applicable, the evaluation of consequences includes the impact on the structural, thermal, shielding, criticality, confinement, and radiation protection performance of the system due to each postulated event.

As the HI-STORE facility deploys the NRC licensed HI-STORM UMAX System for long term storage of spent fuel the applicable off-normal and accident events addressed in the HI-STORM UMAX FSAR [1.0.6] are incorporated herein by reference. A roadmap of applicable HI-STORM UMAX material is tabulated in Table 15.0.1.

The structural, thermal, shielding, criticality, and confinement features and performance of the HI-STORM UMAX system under the short-term operations and various conditions of storage are discussed in Chapters 5, 6, 7, 8 and 9. The evaluations provided in this chapter are based on the safety analyses reported therein. The accidents considered in this chapter follow guidance in NUREG-1567 [1.0.3] and NUREG-1536 [15.3.1].

[1] All references are in placed within square brackets in this report and are compiled in Chapter 19 (last chapter).

Table 15.0.1: Material Incorporated by Reference in this Chapter				
Information Incorporated by Reference	**Source of the Information**	**NRC Approval of Material Incorporated by Reference**	**Location in this SAR where Material is Incorporated**	**Technical Justification of Applicability to HI-STORM UMAX**
Off-Normal Events	Section 12.1, Reference [1.0.6]	SER HI-STORM UMAX Amendments 0,1,2 References [7.0.1, 7.0.2, 7.0.3]	Section 15.2	See Note 1
Accident Events	Sections 12.2 and 12.3, Reference [1.0.6]	SER HI-STORM UMAX Amendments 0,1,2 References [7.0.1, 7.0.2, 7.0.3]	Section 15.3	See Note 1
Note 1: As the HI-STORM UMAX Version C System is essentially the same as the version approved for use in the HI-STORM UMAX Docket[2] and the severity of events are no greater than off-normal and accident events evaluated in the HI-STORM UMAX FSAR [1.0.6] it follows that the consequences evaluated in it are bounding.				

[2] Minor changes introduced in Version C have no adverse effect on the analyses performed for the generic license version.

15.1 ACCEPTANCE CRITERIA

15.1.1 Off-Normal Events

Criticality

In accordance with 10CFR72.124(a) regulations spent fuel sub-criticality must be maintained with k_{eff} equal to or less than 0.95.

Confinement

In accordance with 10CFR72.128(a)(3) regulations systems important to safety must be evaluated to reasonably ensure radioactive material remains confined under off-normal and accident events.

Retrievability

In accordance with 10CFR72.122(l) storage systems must allow safe retrieval of the stored spent fuel without endangering public health and safety or undue exposure to workers.

Instrumentation

In accordance with 10 CFR72.122(i) and 72.128(a)(1) the SAR must identify all instruments and control systems required to remain operational under accident conditions.

15.1.2 Accident Events

In addition to Subsection 15.1.1 criteria, dose rates to individuals located at or beyond controlled area boundary must meet 10CFR72.106(b) limits under design basis accidents.

15.2 OFF-NORMAL EVENTS

In this section, design events pertaining to off-normal operation under expected operational occurrences are considered and evaluated.

The following off-normal events are applicable to the HI-STORE CIS facility:

- Off-Normal Pressure
- Off-Normal Environmental Temperature
- Leakage of One MPC Seal
- Partial Blockage of Air Inlet and Outlet Ducts
- Hypothetical Non-Quiescent Wind[3]
- Cask Drop Less Than Design Allowable Height
- Off-Normal Events Associated with Pool Facilities

15.2.1 Off-Normal Pressure

The sole pressure boundary in the HI-STORM UMAX storage System is the MPC enclosure vessel. The off-normal pressure condition is specified in Section 6.4 and evaluated in Section 6.5. The off-normal pressure for the MPC internal cavity is a function of the initial helium fill pressure and the steady state temperature reached within the MPC cavity under normal ambient temperature. The MPC internal pressure under the off-normal condition is evaluated with 10% of the fuel rods ruptured and with 100% of ruptured rods fill gas and 30% of ruptured rods fission gases released to the cavity.

15.2.1.1 Postulated Cause of Off-Normal Pressure

Fuel rods rupture is a non-mechanistic event postulated as a defense-in-depth measure and evaluated.

15.2.1.2 Detection of Off-Normal Pressure

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

15.2.1.3 Analysis of Effects and Consequences of Off-Normal Pressure

The MPC off-normal internal pressure is analyzed in Section 6.4. The analysis shows that the MPC pressure remains below Off-Normal limit.

i. Structural

Structural integrity of the MPC enclosure vessel is not affected as the pressure computed under this event remains below the MPC Off-Normal pressure limit as qualified by the

[3] Hypothetical non-quiescent wind intends to evaluate HI-STORM UMAX under a sustained persistent wind of a constant magnitude and direction to maximize disruption of the thermal performance.

structural design of the MPC in Section 3.1 of the HI-STORM UMAX FSAR [1.0.6] and incorporated herein by reference.

ii. Thermal

The MPC internal pressure under off-normal conditions is evaluated in Section 6.5. The computed pressure remains below Off-Normal pressure limit.

iii. Shielding

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

iv. Criticality

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

v. Confinement

There is no effect on the confinement function of the MPC as a result of this off-normal event. As discussed in the structural evaluation above, all pressure boundary stresses remain within allowable ASME Code values, assuring Confinement Boundary integrity.

vi. Radiation Protection

As shielding and confinement functions are not affected as evaluated above, there is no adverse effect on occupational or public exposures as a result of this off-normal event.

15.2.1.4 Corrective Action for Off-Normal Pressure

The HI-STORM UMAX system is designed to withstand the off-normal pressure without any effects on its ability to maintain safe storage conditions. Therefore, there is no corrective action requirement for off-normal pressure.

15.2.1.5 Radiological Impact of Off-Normal Pressure

The event of off-normal pressure has no radiological impact because the confinement barrier and shielding integrity are not affected.

15.2.1.6 Conclusion

Based on this evaluation, it is concluded that the off-normal pressure does not affect the safe operation of the HI-STORM UMAX system.

15.2.2 Off-Normal Environmental Temperature

As evaluated in Subsection 6.5.1 this event is bounded by HI-STORM UMAX FSAR [1.0.6]. Event evaluation incorporated by reference. See Table 15.0.1 and HI-STORM UMAX FSAR Subsection 12.1.2 [1.0.6].

15.2.3 Leakage of one MPC seal

The MPC confinement boundary is defined by MPC shell, baseplate, lid, vent and drain port covers, closure ring and associated welds. Leakage of an MPC seal weld evaluated in HI-STORM UMAX FSAR Subsection 12.1.3 [1.0.6] is incorporated by reference.

15.2.4 Partial Blockage of the Air Inlet and Outlet Ducts

As evaluated in Subsection 6.5.1 this event is bounded by HI-STORM UMAX FSAR [1.0.6]. Event evaluation incorporated by reference. See Table 15.0.1 and HI-STORM UMAX FSAR Subsection 12.1.4 [1.0.6].

15.2.5 Hypothetical Non-Quiescent Wind

As evaluated in Subsection 6.4.3 this event is bounded by HI-STORM UMAX FSAR [1.0.6]. Event evaluation incorporated by reference. See Table 15.0.1 and HI-STORM UMAX FSAR Subsection 12.1.5 [1.0.6].

15.2.6 Cask Drop Less Than Design Allowable Height

<u>HI-STORM UMAX VVM</u>

Not applicable as HI-STORM UMAX VVM is a permanently installed underground structure.

<u>HI-TRAC CS</u>

HI-TRAC CS drop not credible as heavy load handling requires redundant drop protection. See Chapter 4, Subsections 4.5.1, 4.5.2 and 4.5.3.

<u>HI-STAR 190</u>

HI-STAR 190 drop not credible as heavy load handling requires redundant drop protection. See Chapter 4, Subsections 4.5.1, 4.5.2 and 4.5.3.

15.2.7 Off-Normal Events Associated with Pool Facilities

Not applicable to HI-STORE CIS facility as pool facilities not required to support operations.

15.2.8 Safety Evaluation

Off-Normal event analyses support the conclusion that HI-STORM UMAX robustly withstands impact of off-normal events and complies with Section 15.1 Acceptance Criteria and Chapter 4 Design Limits.

15.3 ACCIDENTS

Accidents, in accordance with ANSI/ANS-57.9 [2.7.2], are either infrequent events that could reasonably be expected to occur during the lifetime of the cask or events postulated because their consequences may affect public health and safety. Accidents germane to the safety evaluation of HI-STORM UMAX system are considered and evaluated herein.

The following accident events are applicable to the HI-STORE CIS facility:

- Fire Accident
- Partial Blockage of MPC Basket Vent Holes
- Tornado Missiles
- Flood
- Earthquake
- 100% Fuel Rods Rupture
- Confinement Boundary Leakage
- Explosion
- Lightning
- 100% Blockage of Air Inlet and Outlet Ducts
- Burial Under Debris
- Extreme Environmental Temperature
- Cask Tipover
- Cask Drop
- Loss of Shielding
- Adiabatic Heatup
- Accidents at Nearby Sites
- Accidents Associated with Pool Facilities
- Building Structural Failure onto SSCs
- 100% Rod Rupture Accident Coincident with Accident Events

15.3.1 Fire Accident

The potential of a fire accident is extremely remote by ensuring that there are no significant combustible materials in the area. The only credible concern is related to a transport vehicle fuel tank fire engulfing a loaded HI-STORM UMAX VVM or a HI-TRAC CS transfer cask. Fire accident involving the HI-STORM UMAX VVM, HI-TRAC CS or HI-STAR 190 fire is evaluated in the following.

15.3.1.1 Fire Analysis

(a) HI-STORM UMAX VVM Fire

The analysis for the fire accident including the methodology is articulated in Subsection 6.5.2. The transport vehicle fuel tank fire is analyzed to evaluate the storage overpack heating by the incident thermal radiation and forced convection heat fluxes and fuel cladding and MPC temperatures.

i. Structural

As evaluated in Subsection 6.5.2 there are no structural consequences of the fire accident condition as the short-term temperature limit on great majority of the concrete is not exceeded and component temperatures remain within Chapter 4 temperature limits. The MPC structural boundary remains within normal condition internal pressure and temperature limits.

ii. Thermal

Based on a conservative analysis articulated in Subsection 6.5.2 and computed response under the hypothetical event, it is concluded that the fire event does not affect the temperature of the MPC or contained fuel. Furthermore, the ability of the HI-STORM UMAX System to maintain cooling of the spent nuclear fuel within temperature limits during and after fire is not compromised.

iii. Shielding

With respect to limited damage to the outer layers of concrete subject to direct fire flux, NUREG-1536 (4.0,V,5.b) states: “the loss of a small amount of shielding material is not expected to cause a storage system to exceed the regulatory requirements in 10 CFR 72.106 and, therefore, need not be estimated or evaluated in the FSAR.”

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 as the structural integrity of the confinement boundary is unaffected.

vi. Radiation Protection

As there is minimal reduction, if any, in shielding and no effect on the confinement capabilities as discussed above, there is no effect on occupational or public exposures as a result of this accident event.

As supported by evaluation above, it is concluded that the design basis fire does not affect the safe operation of the HI-STORM UMAX System.

(b) HI-TRAC CS Fire

The HI-TRAC CS must withstand elevated temperatures under the Design Basis Fire event defined Chapter 6. The acceptance criteria for the fire accident are specified in Design Criteria Chapter 4.

i. Structural

The effect of the fire accident on the HI-TRAC CS is an increase in fuel cladding and system component temperatures and MPC internal pressure and thus an increase in MPC pressure boundary stresses. The resultant temperatures and pressures are below the accident design limits as evaluated below. The MPC pressures resulting from the fire accident event are be bounded by the applicable pressure boundary limits; therefore, there is no effect on structural function.

ii. Thermal

As evaluated in Section 6.5, the effect of the fire does not result in any system component or the contained fuel to exceed temperature limits set in this SAR. The Design Basis Fire has a minor impact on MPC pressure. The temperatures and pressures resulting from the fire accident event are to be bounded by the applicable system temperature and pressure limits; therefore, there is no deleterious effect on the system's thermal function. With respect to limited damage to the outer layers of concrete subject to direct fire flux, NUREG-1536 (4.0,V,5.b) states: "the loss of a small amount of shielding material is not expected to cause a storage system to exceed the regulatory requirements in 10 CFR 72.106 and, therefore, need not be estimated or evaluated in the FSAR."

iii. Shielding

Under the fire accident condition, the outside of the cask would heat up significantly, and while the outer steel shell would assure the overall integrity of the cask, and hence prevent any significant loss of shielding function, the outer area of the shielding concrete may experience some degradation. To model this in an analysis, shielding calculations are performed in which the density of the HI-TRAC CS concrete is substantially degraded as shown in Table 7.3.1. Results of the analyses are presented in Table 7.4.4, demonstrating compliance with 10CFR72.106.

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 as the structural integrity of the confinement boundary is unaffected.

vi. Radiation Protection

There is no effect on the confinement capabilities as evaluated above, and the site boundary shielding accident dose limits in 10CFR72.106 are not exceeded thereby ensuring occupational and public safety.

(c) HI-STAR 190 Fire

As evaluated in Subsection 6.5.2 HI-STAR 190 fire accident under HI-STORE CIS deployment is bounded by the HI-STAR 190 SAR transport fire accident [1.3.6]. The accident Section 3.4 is incorporated by reference.

15.3.1.2 Fire Accident Corrective Actions

Upon detection of a fire appropriate fire protection actions are initiated in accordance with facility Emergency Response Plan [10.5.1] to extinguish the fire. Following the termination of the fire, a visual and radiological inspection of the equipment shall be performed.

If damage to HI-STORM UMAX VVM, HI-TRAC CS or HI-STAR 190 warrant, and/or radiological conditions require (based on dose rate measurements), the MPC shall be transferred to HI-TRAC CS in accordance with procedures set down in Chapter 3. The HI-STORM UMAX VVM, HI-TRAC CS or HI-STAR 190 may be returned to service after appropriate restoration (reapplication of coatings, etc.) and if there is no significant increase in the measured dose rates (i.e., the shielding effectiveness of overpack is confirmed) and if visual inspection is satisfactory.

15.3.1.3 Conclusion

Based on the above evaluation, it is concluded that the Design Basis Fire accident does not affect the safe operation of the HI-STORM UMAX, HI-TRAC CS and HI-STAR 190 casks.

15.3.2 Partial Blockage of MPC Basket Vent Holes

Event evaluation incorporated by reference. See Table 15.0.1 and UMAX FSAR Subsection 12.2.2.

15.3.3 Tornado Missiles

HI-STORM UMAX VVM

Site specific tornado hazards are identified in Chapter 2, Section 2.3. These hazards are bounded by HI-STORM UMAX FSAR [1.0.6] as justified in Chapter 4, Table 4.3.1. Accordingly, HI-STORM UMAX FSAR tornado accident Subsection 12.2.3 [1.0.6] is incorporated by reference.

HI-TRAC CS

See discussion below.

HI-STAR 190

HI-STAR 190 damage from tornado missile impacts are bounded by the more onerous 1-meter puncture drop accident evaluated in the HI-STAR 190 SAR [1.3.6].

15.3.3.1 Cause

Tornado and high winds are principally caused by the uneven heating of the earth's atmosphere, coupled with gravitational forces and the rotation of the earth. The HI-TRAC CS involves deployment in an open area environment and thus will be subject to extreme environmental conditions throughout the storage period.

15.3.3.2 Tornado Analysis

A tornado event is characterized by high wind velocities and tornado-generated missiles. The reference missiles considered in this SAR are of three sizes: small, medium, and large. A small projectile, upon collision with a cask, would tend to penetrate it. A large projectile, such as an automobile, on the other hand, would tend to cause deformation.

The tornado analysis for a HI-TRAC CS transfer cask is evaluated in Chapter 5. The evaluation is summarized below.

i. Structural

There is no effect on the structural function of HI-TRAC CS as a result of this accident event.

ii. Thermal

There is no effect on the function of HI-TRAC CS heat transfer features as a result of this accident event. Tornado borne missile may cause localized damage. Global heat dissipation characteristics are unaffected.

iii. Shielding

Tornado borne missile may cause localized damage. Dose consequences of the localized damage are bounded by accident analysis in Shielding Chapter 7

iv. Criticality

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

v. Confinement

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

15.3.3.3 Radiation Protection and Consequences

There is no adverse effect on confinement functions. Controlled area boundary accident dose limits in 10CFR72.106 are not exceeded.

15.3.3.4 Tornado Accident Corrective Action

Following a tornado accident visual and radiological inspection shall be performed in accordance with site Emergency Response Plan and appropriate restoration measures undertaken if localized damage results in a significant increase in measured dose.

15.3.3.5 Conclusion

Based on the above evaluation, it is concluded that the Design Basis tornado accident will not affect the safe operation of the HI-STORM UMAX, HI-TRAC CS and HI-STAR 190 casks.

15.3.4 Flood

Site specific flood hazards are identified in Chapter 2, Section 2.4.3. These hazards are bounded by HI-STORM UMAX FSAR [1.0.6] as justified in Chapter 4, Table 4.3.1. Moderator exclusion under flood accident is evaluated in Chapter 8. HI-STORM UMAX FSAR flood accident Subsection 12.2.4 [1.0.6] is incorporated by reference.

15.3.5 Earthquake

HI-STORM UMAX

Site specific earthquake hazards are identified in Chapter 4, Subsection 4.3.2. These hazards are bounded by HI-STORM UMAX FSAR [1.0.6] as justified in Chapter 4, Table 4.3.1. HI-STORM UMAX FSAR earthquake accident Subsection 12.2.5 [1.0.6] is incorporated by reference.

HI-TRAC CS

See discussion below.

HI-STAR 190

HI-STAR 190 g-loads under earthquake events are reasonably bounded by the 10CFR Part 71 10-meter drop accident evaluated in the HI-STAR 190 SAR [1.3.6]. In addition, the seismic stability of freestanding HI-STAR 190 under site specific earthquake is evaluated in Chapter 5.

15.3.5.1 Cause of Event

Earthquake is a terrestrial instability event cause by relative movements in the mantle of the earth. The only concern is under a stack up of HI-TRAC CS in the CTB during canister transfer operations. This event is analyzed under site earthquake loading in Chapter 5 and evaluated below.

15.3.5.2 Analysis of the Effect of Site-Specific Earthquake

i. Structural

The stack-up scenario of the HI-TRAC CS has been fully evaluated in Chapter 5. Due to the robust configuration of the HI-TRAC CS and its earthquake resistant bolting design, it has been demonstrated that there are no structural concerns with the HI-TRAC CS under an earthquake event.

ii. Thermal

There is no effect on the function of HI-TRAC CS heat transfer features as a result of this accident event because no constriction of the air flow passages within the system is computed to occur and vertical configuration is not compromised as evaluated in the structural analysis above. Thus, the cooling effectiveness of the HI-TRAC CS remains undiminished in under an earthquake event.

iii. Shielding

There is no adverse effect on the function of shielding features of the system as a result of this accident event.

iv. Criticality

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

v. Confinement

There is no effect on the confinement function of the MPC as a result of this accident event. Structural evaluation shows stresses remain within design criteria, assuring confinement boundary integrity.

vi. Radiation Protection and Consequences

As there is no effect on shielding or confinement functions as evaluated above, there is no radiological consequence (from effluents and direct radiation) as a result of this accident event. A minor increase to occupational exposures for the performance of corrective actions is expected.

15.3.5.3 Earthquake Accident Corrective Action

Following a seismic event HI-TRAC CS must be inspected for localized damage. Visual inspection shall be performed as follows:

- Visual inspection to confirm the extent of damage (if any) to the MPC shell is negligible.
- Visual inspection to verity the extent of damage (if any) to HI-TRAC CS components important-to-safety is negligible.
- Visual inspection to confirm air flow passages are clear of obstructions.

Corrective actions shall be implemented based on the results of the inspection.

15.3.5.4 Conclusion

Based on the above evaluation, it is concluded that the Design Basis Earthquake will not affect the safe operation of HI-TRAC CS. Corrective actions may be necessary to restore the system to the pre-seismic condition.

15.3.6 100% Fuel Rods Rupture

The rupture of every fuel rod inside the Canister is postulated as a *non-mechanistic event* in NUREG -1536 [15.3.1]. In other words, simultaneous failure of all fuel rods in a Canister is a counter-factual event whose actuation mechanism cannot be articulated but it is nevertheless postulated to ascertain the robustness of the Confinement boundary. (A similar non-credible event requiring safety assessment in NUREG-1536 is the "non-mechanistic tip-over" of above-ground storage casks). Because the rods are assumed to have failed *a' priori,* the 100% rod rupture event does not require satisfaction of a specific fuel cladding temperature limit. Rather, the acceptance criterion focuses on demonstrating the integrity of the Confinement Boundary. This accident is analyzed in Subsection 6.4.3 and integrity of the Canister's pressure boundary evaluated to ensure the internal pressure in the Canister remains below the Chapter 4 accident design pressure.

From a thermal perspective 100% percent rod rupture event is not adverse to heat transfer because internal convection heat transfer in the Canister is significantly boosted by the release of the plenum gases in the rods (due to their rupture), thus spatial temperature field in the Canister is moderated (reduced in magnitude).

15.3.7 Confinement Boundary Leakage

Event evaluation incorporated by reference. See Table 15.0.1 and HI-STORM UMAX FSAR Subsection 12.2.7 [1.0.6].

15.3.8 Explosion

Accident event is bounded by HI-STORM UMAX FSAR [1.0.6]. See site specific explosion evaluation in Chapter 4, Table 4.3.1 and Chapter 6, Subsection 6.5.2. HI-STORM UMAX FSAR explosion accident Subsection 12.2.8 [1.0.6] is incorporated by reference.

15.3.9 Lightning

Event evaluation incorporated by reference. See Table 15.0.1 and HI-STORM UMAX FSAR Subsection 12.2.9 [1.0.6].

15.3.10 100% Blockage of Air Inlets

Event evaluation incorporated by reference. See Table 15.0.1 and HI-STORM UMAX FSAR Subsection 12.2.10 [1.0.6].

15.3.11 Burial Under Debris

<u>HI-STORM UMAX</u>

As evaluated in Chapter 6, Subsection 6.5.2 burial accident is not credible.

<u>HI-TRAC CS</u>

See Subsection 15.3.19.

15.3.12 Extreme Environmental Temperature

This event is bounded by the HI-STORM UMAX FSAR [1.0.6] as the site extreme ambient temperature and cask heat loads are bounded by HI-STORM UMAX (See Table 6.3.1). Accordingly the event evaluation is incorporated by reference. See Table 15.0.1 and HI-STORM UMAX FSAR Subsection 12.2.12 [1.0.6].

15.3.13 Tip-over

Because the HI-STORM UMAX VVM is situated underground, a tip-over event is not a credible accident for this design. See Table 4.3.1.

HI-TRAC CS cask and HI-STAR 190 cask tip-over is not credible as demonstrated in Chapter 5.

15.3.14 Cask Drop

<u>HI-STORM UMAX VVM</u>

Not applicable as HI-STORM UMAX VVM is a permanently installed underground structure.

<u>HI-TRAC CS</u>

HI-TRAC CS drop not credible as heavy load handling requires redundant drop protection. See Chapter 4, Subsections 4.5.1, 4.5.2 and 4.5.3.

HI-STAR 190

HI-STAR 190 drop not credible as heavy load handling requires redundant drop protection. See Chapter 4, Subsections 4.5.1, 4.5.2 and 4.5.3.

15.3.15 Loss of Shielding

Loss of shielding rendered not-credible under an array of challenging off-normal and accident events wherein shielding function is concluded to result in *no-impact*.

15.3.16 Adiabatic Heat-up

Accident not credible as this requires a counter-factual postulate choking all means of heat dissipation including conduction, convection and radiation.

15.3.17 Accidents at Nearby Sites

To ensure HI-STORE CIS facility is not under undue risk from off-site facilities the surrounding area must be assessed for potential hazards such as military installations, gas and oil processing or storage facilities, oil or gas pipelines, chemicals, fireworks or explosives factories.

A survey of surrounding areas evaluated in Sections 2.1 and 2.2 yields one fire hazard that warrants attention. The fire hazard is evaluated in Section 6.5 concluding no adverse effect on the HI-STORM UMAX storage casks or on-site transfer operations involving the HI-TRAC CS and HI-STAR 190.

15.3.18 Accidents Associated with Pool Facilities

Not applicable to HI-STORE CIS as pool facilities not required to support operations.

15.3.19 Building Structural Failure onto SSCs

15.3.19.1 Cause of Building Collapse

This accident is defined as a postulated structural collapse of CTB building roof and burial under it of canister bearing HI-TRAC CS and HI-STAR 190 casks. The event is analyzed in Section 5.4 and Section 6.5, for structural and thermal considerations, respectively.

15.3.19.2 Building Collapse Analysis

Burial of casks under debris adversely affects ventilation cooling because debris will block the inflow of air. A thermal analysis is undertaken in Section 6.5 to compute steady state maximum cask temperatures and co-incident MPC pressures. The results are evaluated below.

i. Structural

The effect of burial under collapsed debris on the MPC is an increase in component and fuel cladding temperatures and internal pressure and thus an increase in pressure boundary stresses. The resultant temperatures and pressures obtained in Subsection 6.5.2 remain below accident limits. In addition, the HI-TRAC CS and HI-STAR 190 casks are structurally analyzed to evaluate the damage due to a potential building collapse in Section 5.4.

ii. Thermal

The fuel cladding and MPC integrity is evaluated in Section 6.5. The evaluation supports the conclusion that fuel cladding and confinement function of the MPC is not compromised.

iii. Shielding

<u>HI-TRAC CS</u>

The thermal results support the conclusion there is no material loss in the shielding capacity of the HI-TRAC CS cask.

<u>HI-STAR 190</u>

Limited reduction in shielding effectiveness is possible as Holtite neutron shield temperature limits are nominally exceeded. These effects are reasonably bounded by Holtite loss under the 10CFR Part 71 fire accident evaluated in HI-STAR 190 SAR [1.3.6].

iv. Criticality

Criticality control function is not affected under this event.

v. Confinement

Confinement function is not affected under this event.

vi. Radiation Protection and Consequences

As shielding and confinement functions as evaluated above are not affected, there is no radiological consequence. A negligible-to-minor increase to occupational exposures for the performance of corrective actions is expected.

15.3.19.3 Corrective Action

Analysis of building collapse accident shows that fuel, components and MPC pressures remain below accident limits. Under building collapse accident, operator shall remove the debris from around loaded casks in accordance with facility Emergency Response Plan [10.5.1]. Upon debris removal flow passages shall be visually inspected to verify air flow path is free of obstructions. The site's emergency action plan shall include provisions for the implementation of this corrective action.

15.3.19.4 Conclusion

Based on the above evaluation, it is concluded that the burial-under-debris accident event does not affect the safe operation of canister bearing casks in the CTB.

15.3.20 100% Rod Rupture Accident Coincident with Accident Events

The rupture of every fuel rod inside the Canister is postulated as a *non-mechanistic event* in NUREG -1536 [15.3.1]. In other words, simultaneous failure of all fuel rods in a Canister is a counter-factual event whose actuation mechanism cannot be articulated but it is nevertheless postulated to ascertain the robustness of the Confinement boundary. (A similar non-credible event requiring safety assessment in NUREG-1536 is the "non-mechanistic tip-over" of above-ground storage casks). Because the rods are assumed to have failed *a' priori,* the 100% rod rupture event does not require satisfaction of a specific fuel cladding temperature limit. Rather, the acceptance criterion focuses on demonstrating the integrity of the Confinement Boundary. The integrity of the Canister's pressure boundary is satisfied if the internal pressure in the Canister remains below the Chapter 4 accident design pressure.

From a thermal perspective 100% percent rod rupture event is not adverse to heat transfer because internal convection heat transfer in the Canister is significantly boosted by the release of the plenum gases in the rods (due to their rupture), thus spatial temperature field in the Canister is moderated (reduced in magnitude).

Because the 100% rod rupture is a hypothetical postulate, the standard safety analysis practice as licensed in the Part 72 dockets (viz 72-1008, 72-1014, 72-1032, 72-1040) is to treat it as a stand-alone event, not to be combined with any accident such as fire near the HI-STORM UMAX ISFSI. The above position is supported by quote from the NRC Safety Evaluation Report as shown in the text highlighted below for emphasis:

HI-STORM 100 SER[4]:

"The HI-STORM 100 Cask System postulated accidents are described in Chapter 11 of the proposed FSAR and include:

1. HI-TRAC Transfer Cask Handling Accident
2. HI-STORM 100 Overpack Handling Accidents
3. Tip Over
4. Fire Accident
5. Partial Blockage of MPC Basket Vent Holes
6. Tornado
7. Flood
8. Earthquake
9. **100% Fuel Rod Rupture**
10. Confinement Boundary Leakage
11. Lightning
12. Explosion
13. 100% Blockage of Air Inlets
14. Burial Under Debris
15. Extreme Environmental Temperature
16. SCS Failure"

[4] "Final Safety Evaluation Report Docket No. 72-1014 Holtec International HI-STORM 100 Cask System Certificate of Compliance No. 1014 Amendment No. 5", pp. 11-2 & 11-3.

15.4 OTHER NON-SPECIFIED ACCIDENTS

This section addresses miscellaneous events, which are placed in the category of "other events" since they cannot be categorized as off-normal or accident events. The following "other events" are discussed in this chapter:

- Hazards during Construction Proximate to existing VVMs

This situation will arise if the facility owner decides to expand storage capacity by adding VVMs adjacent to operating VVMs. Evaluation of this event is incorporated by reference to HI-STORM UMAX FSAR Subsection 12.3.1 [1.0.6]. See Table 15.0.1. The results of the evaluations demonstrate that loaded HI-STORM UMAX VVMs can withstand the effects of "other events" without affecting safety function.

15.5 I&C SYSTEMS

The HI-STORM UMAX System does not rely on instruments or control systems for safety limits compliance under accident conditions.

15.6 REGULATORY COMPLIANCE

The accident compliance pursuant to the provisions of NUREG-1567 for deployment of canisters certified in the HI-STORM UMAX docket (#72-1040) has been demonstrated in this chapter.

As required by 10CFR72.124(a) the spent fuel sub-criticality is maintained under all design basis off-normal and accident events.

As required by 10CFR72.128(a)(3) confinement barrier integrity is maintained under all design basis off-normal and accident events.

As required by 10CFR72.122(l) spent fuel retrievability defined as the capability of returning stored radioactive material to a safe condition without endangering public health and safety is not compromised under all design basis off-normal and accident conditions.

As required by 10CFR72.106(b) regulations dose rates to individuals located at or beyond controlled area boundaries do not exceed specified accident limits under all design basis accidents.

In accordance with 10CFR72.122(i) and 72.128(a)(1) regulations instruments and control systems required to be operational under accident conditions are identified herein.

CHAPTER 16: TECHNICAL SPECIFICATIONS*

16.0 INTRODUCTION†

This chapter defines the operating controls and limits (i.e., Technical Specifications) including their supporting bases for deployment and storage of approved MPCs in a HI-STORM UMAX VVM at the HI-STORE CIS Facility ISFSI. The technical specifications define the conditions that are deemed necessary and sufficient for safe ISFSI use, and are in Appendix A to the HI-STORE CIS Facility license (No. SNM-1051) [16.0.2]. The technical specifications are required by 10CFR72.44(c) to include functional/operating limits, monitoring instruments, limiting control settings, limiting conditions, surveillance requirements, design features, and administrative controls. Technical specifications for a Part 72 storage facility, specifically the HI-STORE CIS Facility, shall be necessary to maintain subcriticality, confinement, shielding, heat removal, and structural integrity under normal, off-normal, and accident conditions. The technical specifications for the HI-STORE CIS Facility, contained herein, are supported by analyses. However, since the HI-STORE CIS Facility is designed for dry storage of MPCs loaded and shipped from a licensed 10CFR72 or 10CFR50 facility, and MPCs are not opened at the HI-STORE CIS Facility, technical specifications LCOs and their bases outside the scope of this SAR, but related to fuel loading and unloading of the MPC, including drying operations and criticality control and surface contamination surveys, shall be complied with prior to transport and storage at the HI-STORE CIS Facility in a HI-STORM UMAX System.

Table 16.0.1 contains material incorporated by reference from the HI-STORM UMAX FSAR and CoC that are applicable to the HI-STORE CIS Facility.

* All references are in placed within square brackets in this report and are compiled in Chapter 19 of this report.
† This chapter is based on the format and content of NUREG 1567 [1.0.3] and Regulatory Guide 3.50, Rev. 2 [1.0.2].

Table 16.0.1 : Material Incorporated by Reference in this chapter				
Information Incorporated by Reference	**Source of the Information**	**NRC Approval of Material Incorporated by Reference**	**Location in this SAR where Material is Incorporated**	**Technical Justification of Applicability to HI-STORM UMAX**
MPCs 37 and 89 Confinement Analysis	Section 7.0 of Reference [1.0.6]	HI-STORM UMAX SER Amendments 0, 1 and 2 of Reference [7.0.1, 7.0.2, 7.0.3]	Section 16.6 of this chapter	The canister was originally qualified for the HI-STORM FW and incorporated by reference into the HI-STORM UMAX FSAR and subsequently this HI-STORE SAR by reference. See Table 1.0.3 of this SAR.
MPC Design Codes and Standards (including alternatives)	HI-STORM UMAX CoC, Appendix B (Section 3.3), Amendment 0,1 and 2, Reference [16.0.1]	HI-STORM UMAX SER Amendments 0, 1 and 2, Reference [7.0.1, 7.0.2, 7.0.3]	Section 16.4 of this chapter	MPC deign codes and standards (including alternatives) approved by NRC in the generic CoC (No. 1040) for the HI-STORM UMAX System are unchanged in this application and therefore are applicable during deployment of the HI-STORM UMAX System at the HI-STORE CIS facility.

16.1 FUNCTIONAL/OPERATING LIMITS, MONITORING INSTRUMENTS, AND LIMITING CONTROL SETTINGS

This section provides a discussion of the operating controls and limits, monitoring instruments, and limiting control settings for the HI-STORM UMAX system to assure long-term performance consistent with the conditions analyzed in this SAR.

Functional and operating limits, monitoring instruments, and limiting control settings include limits placed on fuel, waste handling, and storage conditions to protect the integrity of the fuel and MPC, to maintain radiation workers exposure to radiation at the storage facility ALARA, and to guard against the uncontrolled release of radioactive materials.

As discussed in Section 16.0, loading and unloading of MPC contents occurs at a 10CFR72 license facility or a Part 50 license facility, in accordance with QA'd program procedures, prior to shipment to the HI-STORE CIS Facility. Therefore fuel loadings are verified and records maintained. Waste handling (fuel loading and MPC handling) at the site of origin is performed by individuals appropriately trained and qualified. Upon arrival at the HI-STORE CIS Facility, MPC handling shall be performed by personnel trained under the HI-STORE CIS Facility QA program. The controls and limits apply to operating parameters and conditions which are observable, detectable, and/or measurable. The HI-STORM UMAX system is completely passive during storage and requires no monitoring instruments. A temperature monitoring system or visual inspection of the vent screens to verify operability of the VVM heat removal system may be employed in accordance with Technical Specification Limiting Condition for Operation (LCO) 3.1.1 (Appendix 16.A) .

16.2 LIMITING CONDITIONS

Limiting Conditions for Operation (LCO) specify the minimum capability or level of performance that is required to assure that the HI-STORM UMAX system at the HI-STORE CIS can fulfill its safety functions. Limiting Conditions are supported by analyses in this SAR (Chapters 5 – 9) and provided in Appendix A of the proposed license (No. SNM-1051 Rev. 0), and their bases are contained herein Appendix 16.A to this chapter.

16.3 SURVEILLANCE REQUIREMENTS

The analyses in this SAR show that the HI-STORE CIS Facility fulfills its safety functions, provided that the Technical Specifications in Appendix A of the proposed license (No. SNM-1051 Rev. 0) are met. Surveillance requirements during storage operations at the HI-STORE CIS Facility are provided in the Technical Specifications. Surveillance is required to ensure LCOs are not violated.

16.4 DESIGN FEATURES

This subsection describes design features at the HI-STORE CIS Facility that are Important to Safety. These features require design controls and fabrication controls. The design features, detailed in this SAR and in Section 4.0 of Appendix A to the Proposed HI-STORE CIS Facility license (No. SNM-1051), are established in specifications and drawings which are controlled through the quality assurance program. Fabrication controls and inspections are in place to ensure that the HI-STORE CIS Facility and important to safety systems are fabricated or constructed in accordance with the licensing drawings in Section 1.5.

The HI-STORE and HI-STORM UMAX system and its components, as appropriate, have been analyzed for specified normal, off-normal, and accident conditions, including extreme environmental conditions. Analysis has shown that no credible condition or event prevents the important to safety systems at from performing their function. As a result, there is no threat to public health and safety from any postulated accident condition or analyzed event. When all equipment are tested and placed into service in accordance with procedures developed for the ISFSI, no failure of the system to perform its safety function is expected to occur.

Design codes and standards for the MPC, including alternatives, are incorporated by reference in Section 3.3 of the NRC issued HI-STORM UMAX CoC No. 1040 Amendments 0, 1 and 2. Criticality control features of the MPC are referenced from Section 3.2 of the HI-STORM UMAX CoC No. 1040 Amendments 0, 1 and 2. Design codes and standards, and criticality control features are incorporated by reference into this chapter in accordance with Table 16.0.1.

The cask lifting equipment to be used at the HI-STORE CIS Facility, which includes specially designed lifting devices, the Cask Transfer Building Crane, and the Vertical Cask Transporter, have design features to render cask drops non-credible. These design features are described in Section 4.5 of this SAR, and captured in Section 4.0 of Appendix A to the Proposed HI-STORE CIS Facility Technical Specifications (No. SNM-1051).

Criteria and analyses (as applicable) for design features, including important to safety components of drawings in Section 1.5 and ancillaries in Subsection 1.2.7, are provided in Chapters 4 – 9 of this SAR.

16.5 ADMINISTRATIVE CONTROLS

Administrative control is established through the development of organizational and management procedures, recordkeeping, review and audit systems, and reporting necessary to ensure that the HI-STORE CIS Facility is managed in a safe and reliable manner. Administrative action, in accordance with written procedures, shall be taken in the event of non-compliance.

Administrative controls for the HI-STORE CIS Facility in Appendix A to proposed HI-STORE license No. SNM-1051 Rev. 0 is in alignment with Conduct of Operations in Chapter 10 of this Safety Analysis Report.

16.6 REGULATORY COMPLIANCE

This chapter ensures regulatory compliance with 10CFR72.24, 72.26 and 72.44(a)(c) and (d).

10CFR72.24(g) requires identification and justification for the selection of those subjects that will be probable license conditions and technical specifications

10CFR72.26 requires that each application under this part include proposed technical specifications.

10CFR72.44(a) requires that each license includes license conditions

10CFR72.44(c) requires that each license includes technical specifications that must include requirements in the following categories:

1. Functional and operating limits and monitoring instruments and limiting control settings.
2. Limiting conditions.
3. Surveillance requirements.
4. Design features
5. Administrative Controls

10CFR72.44(d) states that each license must include an annual report that specifies the quantity of each of the principal radionuclides released to the environment.

This chapter discusses the technical specifications and LCO bases as applicable for the HI-STORE CIS Facility or incorporated by reference. The Technical Specifications are license conditions. Therefore, compliance with 10CFR72.44(c) is by extension compliance with 10CFR72.24(g) and 10CFR72.26. Technical specifications noted in 10CFR72.44(a) and (c) are discussed in this chapter. 10CFR72.44(d) requirement for an annual report that specifies the quantity of each of the principal radionuclides released to the environment is not discussed in the chapter and not required for the HI-STORE CIS Facility. Analysis (Table 16.0.1) of the MPCs confirms it remains intact and welds are not breached under normal, off-normal and accident conditions. Since the MPC meets the ANSI N14.5 leaktight criteria (Subsection 10.3.3), release of effluents from MPCs are on an order of magnitude to be considered negligible and with no impact on public health and safety.

HI-STORE CIS Facility SAR

APPENDIX 16.A

TECHNICAL SPECIFICATION (LCOs) BASES

FOR THE HOLTEC HI-STORE CIS Facility

BASES TABLE OF CONTENTS

B 3.0 LIMITING CONDITION FOR OPERATION (LCO) APPLICABILITY

BASES	
LCOs	LCO 3.0.1, 3.0.2, 3.0.4, and 3.0.5 establish the general requirements applicable to all Specifications and apply at all times, unless otherwise stated.
LCO 3.0.1	LCO 3.0.1 establishes the Applicability statement within each individual Specification as the requirement for when the LCO is required to be met (i.e., when the facility is in the specified conditions of the Applicability statement of each Specification).
LCO 3.0.2	LCO 3.0.2 establishes that upon discovery of a failure to meet an LCO, the associated ACTIONS shall be met. The Completion Time of each Required Action for an ACTIONS Condition is applicable from the point in time that an ACTIONS Condition is entered. The Required Actions establish those remedial measures that must be taken within specified Completion Times when the requirements of an LCO are not met. This Specification establishes that: a. Completion of the Required Actions within the specified Completion Times constitutes compliance with a Specification; and b. Completion of the Required Actions is not required when an LCO is met within the specified Completion Time, unless otherwise specified. There are two basic types of Required Actions. The first type of Required Action specifies a time limit in which the LCO must be met. This time limit is the Completion Time to restore a system or component or to restore variables to within specified limits. Whether stated as a Required Action or not, correction of the entered Condition is an action that may always be considered upon entering ACTIONS. The second type of Required Action specifies the remedial measures that permit continued operation that is not further restricted by the Completion Time. In this case, compliance with the Required Actions provides an acceptable level of safety for continued operation.

(continued)

BASES	
LCO 3.0.2 (continued)	Completing the Required Actions is not required when an LCO is met or is no longer applicable, unless otherwise stated in the individual Specifications. The Completion Times of the Required Actions are also applicable when a system or component is removed from service intentionally. The reasons for intentionally relying on the ACTIONS include, but are not limited to, performance of Surveillances, preventive maintenance, corrective maintenance, or investigation of operational problems. Entering ACTIONS for these reasons must be done in a manner that does not compromise safety. Intentional entry into ACTIONS should not be made for operational convenience.
LCO 3.0.3	This specification is not applicable to a dry storage cask system because it describes conditions under which a power reactor must be shut down when an LCO is not met and an associated ACTION is not met or provided. The placeholder is retained for consistency with the power reactor technical specifications.
LCO 3.0.4	LCO 3.0.4 establishes limitations on changes in specified conditions in the Applicability when an LCO is not met. It precludes placing the HI-STORM UMAX System in a specified condition stated in that Applicability (e.g., Applicability desired to be entered) when the following exist: a. Facility conditions are such that the requirements of the LCO would not be met in the Applicability desired to be entered; and b. Continued noncompliance with the LCO requirements, if the Applicability were entered, would result in being required to exit the Applicability desired to be entered to comply with the Required Actions. Compliance with Required Actions that permit continuing with dry fuel storage activities for an unlimited period of time in a specified condition provides an acceptable level of safety for continued operation. This is without regard to the status of the dry storage system. Therefore, in such cases, entry into a specified condition in the Applicability may be made in accordance with the provisions of the Required Actions. The provisions of this Specification should not be interpreted as endorsing the failure to exercise the good practice of restoring systems or components before entering an associated specified condition in the Applicability.

(continued)

BASES	
LCO 3.0.4 (continued)	The provisions of LCO 3.0.4 shall not prevent changes in specified conditions in the Applicability that are required to comply with ACTIONS. In addition, the provisions of LCO 3.0.4 shall not prevent changes in specified conditions in the Applicability that are related to the unloading of an SFSC. Exceptions to LCO 3.0.4 are stated in the individual Specifications. Exceptions may apply to all the ACTIONS or to a specific Required Action of a Specification.
LCO 3.0.5	LCO 3.0.5 establishes the allowance for restoring equipment to service under administrative controls when it has been removed from service or determined to not meet the LCO to comply with the ACTIONS. The sole purpose of this Specification is to provide an exception to LCO 3.0.2 (e.g., to not comply with the applicable Required Action(s)) to allow the performance of testing to demonstrate: The equipment being returned to service meets the LCO; or Other equipment meets the applicable LCOs. The administrative controls ensure the time the equipment is returned to service in conflict with the requirements of the ACTIONS is limited to the time absolutely necessary to perform the allowed testing. This Specification does not provide time to perform any other preventive or corrective maintenance.

B 3.0 SURVEILLANCE REQUIREMENT (SR) APPLICABILITY

BASES

SRs	SR 3.0.1 through SR 3.0.4 establish the general requirements applicable to all Specifications and apply at all times, unless otherwise stated.
SR 3.0.1	SR 3.0.1 establishes the requirement that SRs must be met during the specified conditions in the Applicability for which the requirements of the LCO apply, unless otherwise specified in the individual SRs. This Specification is to ensure that Surveillances are performed to verify that systems and components meet the LCO and variables are within specified limits. Failure to meet a Surveillance within the specified Frequency, in accordance with SR 3.0.2, constitutes a failure to meet an LCO.

Systems and components are assumed to meet the LCO when the associated SRs have been met. Nothing in this Specification, however, is to be construed as implying that systems or components meet the associated LCO when:

a. The systems or components are known to not meet the LCO, although still meeting the SRs; or

b. The requirements of the Surveillance(s) are known to be not met between required Surveillance performances.

Surveillances do not have to be performed when the HI-STORM UMAX System is in a specified condition for which the requirements of the associated LCO are not applicable, unless otherwise specified.

Surveillances, including Surveillances invoked by Required Actions, do not have to be performed on equipment that has been determined to not meet the LCO because the ACTIONS define the remedial measures that apply. Surveillances have to be met and performed in accordance with SR 3.0.2, prior to returning equipment to service. Upon completion of maintenance, appropriate post-maintenance testing is required. This includes ensuring applicable Surveillances are not failed and their most recent performance is in accordance with SR 3.0.2. Post maintenance testing may not be possible in the current specified conditions in the Applicability due to the necessary dry storage cask system parameters not having been established. In these situations, the equipment may be considered to meet the LCO provided testing has been satisfactorily completed to the extent possible and the equipment is not otherwise believed to be incapable of performing its function. This will allow dry fuel storage activities to proceed to a specified condition where other necessary post maintenance tests can be completed.

(continued)

BASES

SR 3.0.2

SR 3.0.2 establishes the requirements for meeting the specified Frequency for Surveillances and any Required Action with a Completion Time that requires the periodic performance of the Required Action on a "once per..." interval.

SR 3.0.2 permits a 25% extension of the interval specified in the Frequency. This extension facilitates Surveillance scheduling and considers facility conditions that may not be suitable for conducting the Surveillance (e.g., transient conditions or other ongoing Surveillance or maintenance activities).

The 25% extension does not significantly degrade the reliability that results from performing the Surveillance at its specified Frequency. This is based on the recognition that the most probable result of any particular Surveillance being performed is the verification of conformance with the SRs. The exceptions to SR 3.0.2 are those Surveillances for which the 25% extension of the interval specified in the Frequency does not apply. These exceptions are stated in the individual Specifications as a Note in the Frequency stating, "SR 3.0.2 is not applicable."

As stated in SR 3.0.2, the 25% extension also does not apply to the initial portion of a periodic Completion Time that requires performance on a "once per..." basis. The 25% extension applies to each performance after the initial performance. The initial performance of the Required Action, whether it is a particular Surveillance or some other remedial action, is considered a single action with a single Completion Time. One reason for not allowing the 25% extension to this Completion Time is that such an action usually verifies that no loss of function has occurred by checking the status of redundant or diverse components or accomplishes the function of the affected equipment in an alternative manner.

The provisions of SR 3.0.2 are not intended to be used repeatedly merely as an operational convenience to extend Surveillance intervals or periodic Completion Time intervals beyond those specified.

(continued)

BASES

SR 3.0.3

SR 3.0.3 establishes the flexibility to defer declaring affected equipment as not meeting the LCO or an affected variable outside the specified limits when a Surveillance has not been completed within the specified Frequency. A delay period of up to 24 hours or up to the limit of the specified Frequency, whichever is less, applies from the point in time that it is discovered that the Surveillance has not been performed in accordance with SR 3.0.2, and not at the time that the specified Frequency was not met.

This delay period provides adequate time to complete Surveillances that have been missed. This delay period permits the completion of a Surveillance before complying with Required Actions or other remedial measures that might preclude completion of the Surveillance.

The basis for this delay period includes consideration of HI-STORM UMAX System conditions, adequate planning, availability of personnel, the time required to perform the Surveillance, the safety significance of the delay in completing the required Surveillance, and the recognition that the most probable result of any particular Surveillance being performed is the verification of conformance with the requirements. When a Surveillance with a Frequency based not on time intervals, but upon specified facility conditions, is discovered not to have been performed when specified, SR 3.0.3 allows the full delay period of 24 hours to perform the Surveillance.

SR 3.0.3 also provides a time limit for completion of Surveillances that become applicable as a consequence of changes in the specified conditions in the Applicability imposed by the Required Actions.

Failure to comply with specified Frequencies for SRs is expected to be an infrequent occurrence. Use of the delay period established by SR 3.0.3 is a flexibility which is not intended to be used as an operational convenience to extend Surveillance intervals.

(continued)

BASES

SR 3.0.3 (continued)

If a Surveillance is not completed within the allowed delay period, then the equipment is considered to not meet the LCO or the variable is considered outside the specified limits and the Completion Times of the Required Actions for the applicable LCO Conditions begin immediately upon expiration of the delay period. If a Surveillance is failed within the delay period, then the equipment does not meet the LCO, or the variable is outside the specified limits and the Completion Times of the Required Actions for the applicable LCO Conditions begin immediately upon the failure of the Surveillance.

Completion of the Surveillance within the delay period allowed by this Specification, or within the Completion Time of the ACTIONS, restores compliance with SR 3.0.1.

SR 3.0.4

SR 3.0.4 establishes the requirement that all applicable SRs must be met before entry into a specified condition in the Applicability.

This Specification ensures that system and component requirements and variable limits are met before entry into specified conditions in the Applicability for which these systems and components ensure safe conduct of dry fuel storage activities.

The provisions of this Specification should not be interpreted as endorsing the failure to exercise the good practice of restoring systems or components before entering an associated specified condition in the Applicability.

However, in certain circumstances, failing to meet an SR will not result in SR 3.0.4 restricting a change in specified condition. When a system, subsystem, division, component, device, or variable is outside its specified limits, the associated SR(s) are not required to be performed per SR 3.0.1, which states that Surveillances do not have to be performed on equipment that has been determined to not meet the LCO. When equipment does not meet the LCO, SR 3.0.4 does not apply to the associated SR(s) since the requirement for the SR(s) to be performed is removed. Therefore, failing to perform the Surveillance(s) within the specified Frequency does not result in an SR 3.0.4 restriction to changing specified conditions of the Applicability. However, since the LCO is not met in this instance, LCO 3.0.4 will govern any restrictions that may (or may not) apply to specified condition changes.

(continued)

BASES	
SR 3.0.4 (continued)	The provisions of SR 3.0.4 shall not prevent changes in specified conditions in the Applicability that are required to comply with ACTIONS. In addition, the provisions of LCO 3.0.4 shall not prevent changes in specified conditions in the Applicability that are related to the unloading of an SFSC. The precise requirements for performance of SRs are specified such that exceptions to SR 3.0.4 are not necessary. The specific time frames and conditions necessary for meeting the SRs are specified in the Frequency, in the Surveillance, or both. This allows performance of Surveillances when the prerequisite condition(s) specified in a Surveillance procedure require entry into the specified condition in the Applicability of the associated LCO prior to the performance or completion of a Surveillance. A Surveillance that could not be performed until after entering the LCO Applicability would have its Frequency specified such that it is not "due" until the specific conditions needed are met. Alternately, the Surveillance may be stated in the form of a Note as not required (to be met or performed) until a particular event, condition, or time has been reached. Further discussion of the specific formats of SRs' annotation is found in Section 1.4, Frequency.

B 3.1 SFSC Integrity

B 3.1.1 SFSC Heat Removal System

BASES

BACKGROUND	The SFSC 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. Air is drawn into the inlet ducts and travels down the space between the Cavity Enclosure Container (CEC) and the Divider Shell, through the cut-outs at the bottom of the Divider Shell, up the space between the Divider Shell and the MPC, and out through the outlet duct. The MPC transfers its heat from its surface to the air via natural convection. The buoyancy created by the heating of the air creates a chimney effect.
APPLICABLE SAFETY ANALYSIS	The thermal analyses of the SFSC take credit for the decay heat from the spent fuel assemblies being ultimately transferred to the ambient environment surrounding the VVM. Transfer of heat away from the fuel assemblies ensures that the fuel cladding and other SFSC component temperatures do not exceed applicable limits. Under normal storage conditions, the inlet and outlet duct screens are unobstructed and full air flow occurs. Analyses have been performed for half and complete obstruction of the inlet duct screens. Blockage of half of the inlet ducts reduces air flow through the VVM and decreases heat transfer from the MPC. Under this off-normal condition, no SFSC components exceed the short term temperature limits. The complete blockage of all inlet air ducts stops normal air cooling of the MPC. The MPC will continue to radiate heat to the relatively cooler subgrade. With the loss of normal air cooling, the SFSC component temperatures will increase toward their respective short-term temperature limits. None of the components reach their temperature limits over the duration of the analyzed event.

(continued)

BASES	
LCO	The SFSC Heat Removal System must be verified to be operable to preserve the assumptions of the thermal analyses. Operability is defined as 50% or more of the inlet vent duct areas are unblocked and available for flow. 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 SFSC component temperatures within design limits. The intent of this LCO is to address those occurrences of air duct screen blockage that can be reasonably anticipated to occur from time to time at the ISFSI (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 4.2.4 of Appendix A to the license (SNM-1051).
APPLICABILITY	The LCO is applicable during STORAGE OPERATIONS. Once a VVM containing an MPC loaded with spent fuel has been placed in storage, the 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, for this LCO, separate Condition entry is allowed for each SFSC. This is acceptable since the Required Actions for each Condition provide appropriate compensatory measures for each SFSC not meeting the LCO. Subsequent SFSCs that don't meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

(continued)

BASES

ACTIONS (continued)

A.1

Although the heat removal system remains operable, the blockage should be cleared expeditiously.

B.1

If the heat removal system has been determined to be inoperable, it must be restored to operable status within eight hours. Eight hours is a reasonable period of time to take action to remove the obstructions in the air flow path.

C.1

If the heat removal system cannot be restored to operable status within eight hours, the VVM and the fuel may experience elevated temperatures. Therefore, dose rates are required to be measured to verify the effectiveness of the radiation shielding provided by the concrete. This Action must be performed immediately and repeated every twelve hours thereafter to provide timely and continued evaluation of the effectiveness of the concrete shielding. As necessary, the system user shall provide additional radiation protection measures such as temporary shielding. The Completion Time is reasonable considering the expected slow rate of deterioration, if any, of the concrete under elevated temperatures.

C.2.1

In addition to Required Action C.1, efforts must continue to restore cooling to the SFSC. Efforts must continue to restore the heat removal system to operable status by removing the air flow obstruction(s) unless optional Required Action C.2.2 is being implemented.

This Required Action must be complete in 24 hours. The Completion Time is consistent with the thermal analyses of this event, which show that all component temperatures remain below their short-term temperature limits up to 32 hours after event initiation.

(continued)

BASES

ACTIONS	C.2.1 (continued)
(continued)	The Completion Time reflects the 8 hours to complete Required Action B.1 and the appropriate balance of time consistent with the applicable analysis results. The event is assumed to begin at the time the SFSC heat removal system is declared inoperable. This is reasonable considering the low probability of all inlet ducts becoming simultaneously blocked.
	C.2.2
	In lieu of implementing Required Action C.2.1, transfer of the MPC into a TRANSFER CASK will place the MPC in an analyzed condition and ensure adequate fuel cooling until actions to correct the heat removal system inoperability can be completed. Transfer of the MPC into a TRANSFER CASK removes the SFSC from the LCO Applicability since STORAGE OPERATIONS does not include times when the MPC resides in the TRANSFER CASK.
	An engineering evaluation must be performed to determine if any deterioration which prevents the VVM from performing its design function. If the evaluation is successful and the air inlet duct screens have been cleared, the VVM heat removal system may be considered operable and the MPC transferred back into the VVM. Compliance with LCO 3.1.1 is then restored. If the evaluation is unsuccessful, the user must transfer the MPC into a different, fully qualified VVM to resume STORAGE OPERATIONS and restore compliance with LCO 3.1.1
	In lieu of performing the engineering evaluation, the user may opt to proceed directly to transferring the MPC into a different, fully qualified VVM.
	The Completion Time of 24 hours reflects the Completion Time from Required Action C.2.1 to ensure component temperatures remain below their short-term temperature limits for the respective decay heat loads.

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.1.2

The long-term integrity of the stored fuel is dependent on the ability of the SFSC to reject heat from the MPC to the environment. There are two options for implementing SR 3.1.1, either of which is acceptable for demonstrating that the heat removal system is OPERABLE.

Visual observation that all air inlet duct screens are unobstructed ensures that the SFSC is operable. If greater than 50% of the air inlet duct screens are blocked the heat removal system is inoperable and this LCO is not met. While 50% or less blockage of the total air inlet duct screen area does not constitute inoperability of the heat removal system, corrective actions should be taken promptly to remove the obstruction and restore full flow.

Visual observation of air outlet duct screen blockage does not constitute inoperability of the heat removal system; however, corrective action should be taken to promptly remove the obstruction.

As an alternative, for VVMs with air temperature monitoring instrumentation installed in the air outlets, the temperature difference between the outlet air and the ambient air may be monitored to verify operability of the heat removal system. Blocked air inlet duct screens will reduce air flow and increase the outlet duct air temperature. Based on the analyses, if the temperature difference between the ambient air and the outlet duct air meets the criteria in the LCO, adequate air flow is occurring to provide assurance of long term fuel cladding integrity. The reference ambient temperature used to perform this Surveillance shall be measured at the ISFSI facility.

The Frequency of 24 hours is reasonable based on the time necessary for SFSC 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. SAR Chapter 6
2. ANSI/ANS 57.9-1992

CHAPTER 17: MATERIAL EVALUATION

17.0 INTRODUCTION

This chapter presents an assessment of the materials selected for use in the HI-STORM UMAX system [1.0.6] components that are envisaged to be deployed at the HI-STORE CIS facility. The assessment of the materials selected for use in the MPCs is provided in the previously licensed HI-STORM FW system FSAR [1.3.7]. The fuel loading, dewatering, drying and welding of the canister occur at the nuclear plant site, the material selection decisions for the canister are comprehensively covered in [1.3.7]. The canisters will arrive at the HI-STORE site in *ready-to-store* condition; no material selection decision vis-à-vis the canisters will be made at the HI-STORE site. Because the environmental conditions and design criteria for the MPCs for use at HI-STORE are completely bounded by those in the HI-STORM FW (and HI-STORM UMAX) dockets, reference is made to the material selection considerations for the MPCs (canisters) in their native docket (HI-STORM FW FSAR). The information on the suitability of the MPC for the local environmental conditions at HI-STORE CIS, however, underpins the Aging Management program presented in Chapter 18.

The HI-STORM UMAX components must withstand the environmental conditions experienced during normal operation, off-normal conditions, and accident conditions for the entire service life of the interim storage facility (please see Table 17.0.1).

Chapter 1 provides a general description of the HI-STORM UMAX System including information on materials of construction. The ITS categories of the principal materials of construction in the HI-STORM UMAX VVM and ISFSI system are identified in the drawing package provided in Section 1.5.

Nevertheless, for completeness, it is necessary that the material considerations applicable to HI-STORM UMAX be independently evaluated for compliance with the ISG-15 [17.0.1] which contains the latest NRC position in this matter. The principal purpose of ISG-15 is to evaluate the dry cask storage system to ensure adequate material performance of components deemed to be important-to-safety at an independent spent fuel storage installation (ISFSI) under normal, off-normal, and accident conditions.

ISG-15 sets down the following general acceptance criteria for material evaluation:

- The safety analysis report should describe all materials used for dry spent fuel storage components important-to-safety, and should consider the suitability of those materials for their intended functions in sufficient detail to evaluate their effectiveness in relation to all safety functions.
- The dry spent fuel storage system should employ materials that are compatible with wet and dry spent fuel loading and unloading operations and facilities. These materials should not degrade to the extent that a safety concern is created.

* All references are in placed within square brackets in this report and are compiled in Chapter 19 of this report.

The information compiled in this chapter seeks to address the above acceptance criteria in full measure for the HI-STORM UMAX VVM and ISFSI. To perform the material suitability evaluation, it is necessary to characterize the following for each component: (i) the applicable environment, (ii) potential degradation modes and (iii) potential hazards to continued effectiveness of the selected material.

The material evaluation presented in this chapter is intended to be complete, even though *a' priori* conclusion of the adequacy of the materials can be made on the basis of the following facts:

i. The materials used in HI-STORM UMAX VVM are identical to those used in the widely deployed HI-STORM 100 System (Docket No. 72-1014) [1.3.3] including its underground VVM denoted as HI-STORM 100U and the HI-STORM FW system (Docket No. 72-1032) [1.3.7].

ii. As can be ascertained from Table 2.7.1, the thermal environment in the HI-STORM UMAX system at the HI-STORE site is bounded by the design basis for its generic certification in the HI-STORM UMAX docket [1.0.6].

In this chapter, the significant mechanical, thermal, radiological, and metallurgical properties of materials identified for use in the components of the HI-STORM UMAX System and ISFSI are presented. The material evaluation effort is directed towards the interim storage at HI-STORE CIS for its intended service life and its consequences to the system's continued safety. Table 17.0.1 provides the expected licensing, design and service life data for the HI-STORE CIS facility.

Because the materials designated to be used at the HI-STORE CIS facility have a long pedigree of usage in other HI-STORM dockets, their mechanical and thermos-physical properties are well documented in the prior FSARs approved by the NRC. The identification of such sections/appendices/tables that are adopted by reference herein is summarized in Table 17.0.2.

Table 17.0.1; Target License, Design and Service Life of the HI-STORE CIS Facility		
Item	**Definition**	**Value in Years**
License Life	The period for which the NRC is expected to grant the initial license	40
Design Life	A conservative estimate of the useable life of the system in full compliance with the regulations and ALARA expectations	80
Service Life	The expected life of the facility for which it will continued to meet all safety requirements if the aging management program described in this SAR is implemented without limitation	120

Table 17.0.2: Material Incorporated By Reference				
Information Incorporated by Reference	**Source of the Information**	**NRC Approval of Material Incorporated by Reference**	**Location in this SAR where Material is Incorporated**	**Technical Justification of Applicability to HI-STORE**
Mechanical Properties of materials	Section 3.3 of [1.0.6]	SER HI-STORM UMAX Amendments 0, 1, and 2 References [7.0.1, 7.0.2,7.0.3]	Subsection 17.4.1	The materials used in the canisters and components at the HI-STORE CIS Facility are identical to those used in the HI-STORM UMAX Generic License FSAR.
Summary of Thermal Properties of materials	Section 4.2 of [1.0.6]	SER HI-STORM UMAX Amendments 0, 1, and 2 References [7.0.1, 7.0.2,7.0.3]	Subsection 17.4.2	The materials used in the canisters and components at the HI-STORE CIS Facility are identical to those used in the HI-STORM UMAX Generic License FSAR.
Alloy X Description	Appendix 1.A of [1.3.7]	SER HI-STORM FW Amendments 0, 1, and 2 References [8.0.1, 8.0.2,8.0.3]	Sub-section 17.4.3	The materials used in the canisters and components at the HI-STORE CIS Facility are identical to those used in the HI-STORM UMAX Generic License FSAR.
MPC Material Selection Information	Section 8.2 of [1.3.7]	SER HI-STORM FW Amendments 0, 1, and 2 References [8.0.1, 8.0.2, 8.0.3]	Section 17.2	The MPCs are identical to those loaded under the HI-STORM UMAX and FW generic licenses, and therefore the same material selection criteria apply.
Metamic-HT	Paragraph 1.2.1.4 of [1.3.7]	SER HI-STORM FW Amendments 0, 1, and 2 References [8.0.1, 8.0.2, 8.0.3]	Section 17.9	The materials used in the canisters and components at the HI-STORE CIS Facility are identical to those used in the HI-STORM UMAX Generic License FSAR.

Table 17.0.2: Material Incorporated By Reference				
Information Incorporated by Reference	**Source of the Information**	**NRC Approval of Material Incorporated by Reference**	**Location in this SAR where Material is Incorporated**	**Technical Justification of Applicability to HI-STORE**
Fuel Integrity Evaluation	Section 8.13 of [1.3.7]	SER HI-STORM FW Amendments 0, 1, and 2 References [8.0.1, 8.0.2, 8.0.3]	Section 17.12	The fuel remains in seal welded canisters, with lower temperatures and pressures than originally licensed, therefore the fuel integrity evaluation is still applicable.
Examination and Testing	Section 8.13 of [1.0.6],	SER HI-STORM UMAX Amendments 0, 1, and 2 References [7.0.1, 7.0.2, 7.0.3]	Section 17.12	The canisters to be stored at the HI-STORE facility must fully meet the fabrication examination and testing requirements that are in the HI-STORM UMAX FSAR.
Acceptable Coatings	Section 8.7.2 and Appendix 8.A of [1.3.7]	SER HI-STORM FW Amendments 0, 1, and 2 References [8.0.1, 8.0.2, 8.0.3]	Section 17.7	Surface preservative requirements are identical to those defined for HI-STORM FW system; coatings defined for the HI-STORM FW system are therefore applicable.

17.1 MATERIAL DEGRADATION MODES

Tables 17.1.1, 17.1.2 and 17.1.3 provide a summary of the environmental states, potential degradation modes, and hazards applicable to the HI-STORM UMAX modules and other ITS SSCs that are specific to HI-STORE CIS facility. The facility specific SSCs employ similar materials as to those employed in HI-STORM UMAX modules. These components include HI-TRAC CS, CTB Crane, Lift Yokes (Transfer Cask and Transport Cask), MPC Lift Attachments, Special Lifting devices, Transport Cask Lift Beams and Tilt Frames. Table 17.1.4 provides the listing of material types that are important to safety and are subject to the ambient environmental of the HI-STORE Facility.

To provide a proper context for the subsequent evaluations, the potential degradation mechanisms applicable to the ventilated systems are summarized in Table 17.1.5. The degradation mechanisms listed in Table 17.1.5 are considered in the suitability evaluation presented in this chapter.

Table 17.1.1: Considerations Germane to Performance of Materials used in the MPCs in Long Term Storage in HI-STORM UMAX	
Consideration	**Environment**
Environment	MPC's internal environment is hot (≤ 752°F), inertized and dry. Temperature of the MPC internals cycles vary gradually due to changes in the environmental temperature.
Potential degradation modes	Corrosion of the external surfaces of the MPC (stress, corrosion, cracking, pitting, etc.).
Potential hazards to effective performance	Blockage of ventilation ducts under an extreme environmental phenomenon leading to a rapid heat-up of the MPC internals.

Table 17.1.2: Considerations Germane to the HI-STORM UMAX VVM Material Performance	
Consideration	**Performance Data**
Environment	Cool ambient air is progressively (but marginally) heated as it flows up the annulus between the Divider Shell and the MPC heating the inside surface of the cask and cooling the outside surface of the MPC. The heated air has reduced relative humidity the warmer it gets. As a result, the bottom external surface of the Closure Lid is heated and the top external surfaces are in contact with ambient air, rain, and snow, as applicable. The exterior surfaces of the CEC are in contact with either engineered fill or concrete (concrete encasement or "free-flow "concrete).
Potential degradation modes	Peeling or perforation of surface preservatives on steel surfaces and corrosion of exposed steel surfaces.
Potential hazards to effective performance	Blockage of ducts by debris leading to overheating of the concrete in the ISFSI pad, scorching of the cask by proximate fire, lightning.

Table 17.1.3: Considerations Germane to the Other SSCs Material Performance	
Consideration	**Performance Data**
Environment	The components and their external surfaces are in contact with ambient air, rain, and snow, as applicable.
Potential degradation modes	Peeling or perforation of surface preservatives on steel surfaces and corrosion of exposed steel surfaces.
Potential hazards to effective performance	None, as all components and surfaces are accessible for repair and/or replaceable as required.

Table 17.1.4:*Material Types in the HI-STORE CIS Facility Components Exposed to the Long-Term Ambient Environment		
	Material Type	**Components and Their Surfaces Exposed to Ambient Environment**
1.	Low carbon steel	• All surfaces of the closure lid • Internal surfaces of the CEC (expose to air) • External surfaces of the CEC (exposed to CLSM) or subgrade • Internal and External surfaces of the Divider shell • All external surfaces of HI-TRAC CS, CTB Crane, Lift Yokes, Lift Beams & Attachments, Tilt Frames and Special Lifting Devices.
2.	Shielding concrete	• The outside surface of the ISFSI pad • The embedded densified concrete in HI-TRAC CS
3.	Alloy X Austenitic Stainless Steel (Defined in Appendix 1A of the HI-STORM 100 FSAR [1.3.3] and used in all HI-STORM dockets.	• External surfaces of the stored MPC • MPC Guides and MPC support surfaces inside the CEC. • Surfaces of the closure lid • Internal surfaces of the CEC • External surfaces of the CEC Internal External surfaces of the Divider shell (optional per Section 1.5)
4.	Elastomeric Gasket	• Closure Lid Seal • Divider Shell Seal

* Specific material grades used at the HI-STORE ISFSI will comply with the requirements set forth in Subsection 8.2.3 of [1.3.7] which provides the conditions to establish material equivalence.

Table 17.1.5: Failure and Degradation Mechanisms*				
	Mechanism	**Area of Performance Affected**	**Vulnerable Parts**	**Location of Discussion**
1.	General Corrosion	Structural Integrity	All carbon steel parts	Section 18.3
2.	Stress Corrosion Cracking	Structural Integrity	Austenitic Stainless Steel	Section 18.3
3.	Galling	Equipment handling and deployment	Threaded Fasteners	Section 17.6
4.	Fatigue	Structural Integrity	Fuel Cladding & Bolting	Section 18.3
5.	Brittle Fracture	Structural Integrity	Thick Steel Parts	Section 17.4.3
6.	Boron Depletion	Criticality Control	Neutron Absorber	Section 18.3
7.	Creep	Structural Integrity	All steel parts	Section 17.4.4
8.	Galvanic Corrosion	Structural integrity	All carbon steel parts	Section 17.11

* This table lists all potential (generic) mechanisms, whether they are credible for the HI-STORM UMAX System or not. The viability of each failure mechanism is discussed later in this chapter and/or chapter 18.

17.2 MATERIAL SELECTION

The acceptance criteria for the materials subject to long-term storage conditions in HI-STORM UMAX are extracted from ISG-15 [17.0.1] as follows:

a. The material properties of a dry spent fuel storage component should meet its service requirements in the proposed cask system for the duration of the licensing period.

b. The materials that comprise the dry spent fuel storage should maintain their physical and mechanical properties during all conditions of operations. The spent fuel should be readily retrievable without posing operational safety problems.

c. Over the range of temperatures expected prior to and during the storage period, any ductile-to-brittle transition of the dry spent fuel storage materials, used for structural and nonstructural components, should be evaluated for its effects on safety.

d. Dry spent fuel storage gamma shielding materials should not experience slumping or loss of shielding effectiveness to an extent that compromises safety. The shield should perform its intended function throughout the licensed service period.

e. Dry spent fuel storage materials used for neutron absorption should be designed to perform their safety function.

f. Dry spent fuel storage protective coatings should remain intact and adherent during all loading and unloading operations within wet or dry spent fuel facilities, and during long-term storage.

The qualification of the materials used in the MPC types is documented in Section 8.2 of the HI-STORM FW FSAR [1.3.7] incorporated herein by reference. The material selection opportunities for the HI-STORM UMAX system, therefore, are limited to the HI-TRAC CS and the VVM module assembly components and the reinforced concrete structures that support or surround them.

However, to obviate the need for any new material qualification effort, the materials permitted for the HI-STORM UMAX system are limited to those certified in other HI-STORM 100 and HI-STORM FW dockets. The material qualification information presented in this chapter is accordingly adapted from Docket Number 72-1032 [1.3.7].

17.2.1 Structural Materials

17.2.1.1 Cask Components and Their Constituent Materials

The major structural material that is used in the HI-STORM UMAX VVM is steel. The concrete in the VVM Closure Lid does not play a major structural role but is present in large quantity for the main purpose of shielding. The major structural materials in the ISFSI structures are the concrete and rebars in the Support Foundation Pad, the ISFSI Pad and the Self-hardening Engineered Subgrade in the inter-CEC space.

17.2.1.2 Synopsis of Structural Materials

i. Carbon Steel, Low-Alloy Steel

Materials for the HI-STORM UMAX VVM are selected to preclude brittle fracture. Details of discussions are provided in Section 17.4 herein.

ii. Reinforced Concrete

All reinforced concrete load bearing structures (concrete and rebar) in the HI-STORM UMAX ISFSI will conform to stress criteria of ACI-318(2005) [5.3.1]. Section 3.3 in the HI-STORM UMAX FSAR [1.0.6] provides properties for reinforced concrete to be used for the HI-STORM UMAX interfacing ISFSI structures. The service life of the ISFSI structures is specified to be the same as that of the HI-STORM UMAX VVM.

iii. Self-hardening Engineered Subgrade

The SES material (i.e., lean concrete or CLSM) used in the HI-STORM UMAX ISFSI will conform to the stress criteria of ACI-318(2005) or ACI-229(1999). Tables 2.3.2 and 3.3.4 in the HI-STORM UMAX FSAR [1.0.6] provide the critical properties for the SES material used for HI-STORM UMAX ISFSI safety analyses. In the interest of a reliably robust design and long service life, additional performance properties of CLSM are listed in table below. The service life for the SES is the same as that of the VVM and ISFSI reinforced concrete.

iv. Austenitic Stainless Steel

Austenitic stainless steel may be used for certain components of the HI-STORM UMAX VVM. Chapter 5 provides the structural evaluation for the HI-STORM UMAX VVM using the governing structural materials. Since stainless steel materials do not undergo a ductile-to-brittle transition in the minimum permissible service temperature range of the HI-STORM UMAX System, brittle fracture is not a concern for stainless steel components. It is recognized that austenitic stainless steels are qualified for use with other HI-STORM UMAX System components (namely Alloy X for the MPC) by the HI-STORM FW FSAR.

Chapter 5 discusses the structural evaluations of the HI-STORM UMAX System components and ISFSI structures. It is demonstrated that the structural steel components of the HI-STORM UMAX VVM and the SFP concrete meet the allowable stress limits for normal, off-normal, and accident loading conditions as applicable. The analyses documented in Chapter 5 also demonstrate that the SES remains stable under the Design Basis Earthquake condition and provides sufficient protection to the stored MPC even if any side of the self- hardening sub-grade (SES) is fully exposed during excavation for ISFSI expansion.

17.2.2 Non-Structural Materials

i. Plain Concrete

Plain concrete is specified for the VVM Closure Lid for its shielding properties and also as an encasement around the exterior of the VVM CEC shell, if required, for its corrosion mitigation properties. The requirements on the shielding concrete are specified in Table 4.3.3.

The shielding performance of the plain concrete is maintained by ensuring that the minimum concrete density is met during construction and the allowable concrete temperature limits are not exceeded. The durability and thermal analyses for normal and off-normal conditions are carried out in this SAR to ensure that the plain concrete does not exceed the allowable long term temperature limit provided in Chapter 4. The strength analysis is carried out in Chapter 5 of this SAR.

ii. Insulation

The Divider Shell is lined with insulation on its outer surface to prevent excessive heating of the ISFSI pad. The insulation selected shall be suitable for high temperature and high humidity operation and shall be foil faced, jacketed, or otherwise made water-resistant to ensure the required thermal resistance is maintained in accordance with Chapter 6. The high zinc content present in the coating of the Divider Shell provides protection for the jacketing or foil from the potential of galvanic corrosion. To ensure adequate radiation resistance, the insulation blanket does not contain any organic binders. The damage threshold for ceramics is known to be approximately 1×10^{10} Rads. Chloride corrosion is not a concern since chloride leachables are limited and sufficiently low. Stress corrosion cracking of the foil or jacketing, whether made from stainless steel or other material, is not an applicable corrosion mechanism due to minimal stresses derived from self-weight. The foil or jacketing and attachment hardware shall either have sufficient corrosion resistance (e.g., stainless steel, aluminum, or galvanized steel) or shall be protected with a suitable surface preservative. The insulation is adequately secured to prevent blockage of the ventilation passages in case of failure of a single attachment (strap, clamp, bolt or other attachment hardware). Table 17.2.2 provides the acceptance criteria for the selection of insulation material for the VVM assembly and ranks them in order of importance.

Table 17.2.1: Additional CLSM Performance Properties*		
Performance Property	**Test Property**	**Nominal Value**
Corrosive Resistance	pH Resistivity Permeability	7.5 – 11.5 > 279000 ohm-cm < 10^{-5} cm/sec
Flowability	Flow	6" – 8" (ASTM D 6103)
Excavatability	Unconfined Compressive Strength	Not excavatable since compressive strength is greater than 300 psi
Permeability	Water Permeability	< 10^{-5} cm/sec
Strength	Penetration Resistance	> 650
Acidity/Alkalinity	pH	7.5 – 11.5
Note: * These properties are not used in HI-STORM UMAX safety analyses; nominal values obtained from References [17.2.1], [17.2.2], and [17.2.3] are tabulated for information only.		

Table 17.2.2: Acceptance Criteria for the Selection of the Insulation Material[Note 1]	
Rank	**Criteria**
1	Adequate thermal resistance
2	Adequate high temperature resistance
3	Adequate humidity resistance
4	Adequate radiation resistance
5	Adequate resistance to the ambient environment
6	Sufficiently low chloride leachables
7	Adequate integrity and resistance to degradation and corrosion during long-term storage

Note 1: Kaowool® ceramic fiber insulation [17.2.1] is selected as one that satisfies the acceptance criteria to the maximum degree. The Kaowool® insulation material provides excellent resistance to chemical attack and is not degraded by oil or water. It has been used in all HI-STORM UMAX ISFSIs thus far. Equivalent materials that meet the above criteria are also commercially available.

17.3 APPLICABLE CODES AND STANDARDS

The design, material selection, manufacturing, inspection and testing of the SSCs for the HI-STORM UMAX system are undergirded by national codes and consensus standards to ensure the longest possible service life. The principal codes and standards applied to the HI-STORM UMAX System components are the ASME Code Section II [17.3.1], the ACI code [5.3.1], the ASTM Standards, and the ANSI standards.

The Codes and standards for the ISFSI pad are discussed in Chapter 5.

Allowable stresses and stress intensities for various materials for the HI-STORM UMAX structures are extracted from ASME Section III Subsection NF for various service conditions. "NF" is also invoked to establish fracture toughness test requirements for low service temperature conditions. Mechanical properties of materials are extracted from applicable ASME sections [17.3.1], [17.3.2] and are tabulated for various materials used in HI-STORM UMAX System. Concrete properties are from ACI 318-2005 [5.3.1] code.

In order to meet the requirements of the codes and standards the materials must conform to the minimum acceptable physical strengths and chemical compositions and the fabrication procedures must satisfy the prescribed requirements of the applicable codes.

Additional codes and standards applicable to welding are discussed in Section 17.5 and those for the bolts and fasteners are discussed in Section 17.6.

Review of the above shows that the identified codes and standards are appropriate for the material control of major components. Additional material control is identified in material specifications. Material selections are appropriate for environmental conditions to be encountered during loading, unloading, transfer, and storage operations. The materials and fabrication of major components are suitable based on the applicable codes of record.

17.4 MATERIAL PROPERTIES

This section provides discussions on material properties that mainly include mechanical and thermal properties. The material properties used in the design and analysis of the HI-STORM UMAX System are obtained from established industry sources such as the ASME Boiler and Pressure Vessel Code [17.3.1], ASTM publications, handbooks, textbooks, other NRC-reviewed SARs, and government publications, as appropriate.

17.4.1 Mechanical Properties

Section 3.3 of the HI-STORM UMAX FSAR [1.0.6], incorporated herein by reference, provides mechanical properties of all ITS materials used in the HI-STORM UMAX System at HI-STORE. Section 5.4 in Chapter 5 of HI-STORE SAR provides a detailed description of structural aspects, design criteria and material properties of the other SSCs that are classified as ITS components. The structural materials include Alloy X, carbon steel, low-alloy and nickel-alloy steel, bolting materials, and weld materials. The properties include yield stress, mean coefficient of thermal expansion, ultimate stress, and Young's modulus of these materials and their variations with temperature. Certain mechanical properties are also provided for nonstructural materials such as concrete used for shielding.

The discussion on mechanical properties of materials in Chapter 3 of [1.0.6] provides reasonable assurance that the class and grade of the structural materials are acceptable under the applicable construction code of record. Selected parameters such as the temperature dependent values of stress allowables, modulus of elasticity, Poisson's ratio, density, thermal conductivity, and thermal expansion have been appropriately defined in conjunction with other disciplines. The material properties of all code materials are guaranteed by procuring materials from Holtec-approved vendors through the so-called "material dedication" process*, if necessary.

17.4.2 Thermal Properties

Section 4.2 of [1.0.6], incorporated herein by reference, presents thermal properties of materials used in the MPC such as Alloy X, Metamic-HT, aluminum shims and helium gas; materials present in HI-STORM UMAX such as carbon steel, stainless steel and concrete; and materials present in HI-TRAC transfer cask that include carbon steel and plain concrete. The properties include density, thermal conductivity, heat capacity, and surface emissivity/absorptivity. Variations of these properties with temperature are also provided in tabular forms.

The thermal properties of fuel (UO_2) and fuel cladding are also reported in Section 4.2 of [1.0.6]. Thermal properties are obtained from standard handbooks or established text books.

17.4.3 Protection Against Brittle Fracture of Ferritic Steel Parts

The risk of brittle fracture in the HI-STORM UMAX components and other ITS SSCs at the HI-STORE CIS facility is eliminated by utilizing materials that maintain high fracture toughness under "cold" conditions (-40 degrees F).

* Dedication is a term of art in nuclear quality assurance.

The MPC canister is constructed from a menu of stainless steels termed Alloy X (Appendix 1A of HI-STORM 100 FSAR, incorporated herein by reference]. These stainless steel materials do not undergo a ductile-to-brittle transition in the minimum service temperature range of the HI-STORM UMAX system. Therefore, brittle fracture is not a concern for the MPC components. Such an assertion cannot be made *a' priori* for the HI-STORM UMAX VVM and HI-TRAC CS transfer cask that contain ferritic steel parts. In general, the impact testing requirement for the VVM and the transfer cask is a function of two parameters: the Lowest Service Temperature (LST)* and the normal stress level. The significance of these two parameters, as they relate to impact testing of the VVM is discussed below.

In normal storage mode, the LST of the VVM structural members may reach the minimum ambient temperature in the limiting condition wherein the spent nuclear fuel (SNF) in the contained MPCs emits no (or negligible) heat. The minimum service temperature of the storage VVM and HI-TRAC CS steel components is conservatively set at a temperature that is 10 degrees F below the 24-hour average for any day at the HI-STORE site recorded for the site in the previous year. This temperature restriction also applies to other SSCs and the heavy load handling operations at the ISFSI. All load bearing parts are deemed to have the necessary level of protection against brittle fracture if the NDT (nil ductility transition) temperature of the part meets ASME Section III Subsection NF requirements.

It is well known that the NDT temperature of steel is a strong function of its composition, manufacturing process (viz., fine grain vs. coarse grain practice), thickness, and heat treatment. For example, it is well known that increasing the carbon content in carbon steels from 0.1% to 0.8% leads to the change in NDT from -50°F to approximately 120°F. Likewise, lowering of the normalizing temperature in the ferritic steels from 1200°C to 900°C may lower the NDT from 10°C to -50°C. It therefore follows that the fracture toughness of steels can be varied significantly within the confines of the ASME Code material specification set forth in Section II of the Code. For example, SA516 Gr. 70 can have a maximum carbon content of up to 0.3% in plates up to four inches thick. Section II further permits normalizing or quenching followed by tempering to enhance fracture toughness. Manufacturing processes that have a profound effect on fracture toughness, but little effect on tensile or yield strength of the material, are also not specified with the degree of specificity in the ASME Code to guarantee a well-defined fracture toughness. In fact, the Code relies on actual coupon testing of the part to ensure the desired level of protection against brittle fracture. For Section III, Subsection NF Class 3 parts, the desired level of protection is considered to exist if the lowest service temperature is equal to or greater than the NDT temperature (per NF 2311(b)(10)).

17.4.4 Protection Against Creep

Creep, a visco-elastic and visco-plastic effect in metals, manifests itself as a monotonically increasing deformation if the metal part is subjected to stress under elevated temperature. Since certain parts of the HI-STORM UMAX system, notably the fuel basket, operate at relatively high temperatures, creep resistance of the fuel basket is an important property. Creep resistance of the MPC internals is discussed in the HI-STORM FW FSAR [1.3.7]. Creep is not a concern in the

* LST (Lowest Service Temperature) is defined as the daily average for the host ISFSI site

Enclosure Vessel, the HI-STORM UMAX, the HI-TRAC steel weldment or the other ITS SSCs at the HI-STORE CIS facility because of the operating metal temperatures, stress levels and material properties. Steels used in ASME Code pressure vessels have a high threshold temperature at which creep becomes a factor in the equipment design. The ASME Code Section II material properties provide the acceptable upper temperature limit for metals and alloys acceptable for pressure vessel service.

In the selection of steels for the HI-STORM UMAX system, a critical criterion is to ensure that the sustained (normal) metal temperature of the part made of the particular steel type shall be less than the Code permissible temperature for pressure vessel service. This criterion guarantees that excessive creep deformation will not occur in the steels used in the HI-STORM UMAX system.

17.5 WELDING MATERIAL AND WELDING SPECIFICATION

No welding operations are expected to occur on the system components at the HI-STORE CIS site. Nevertheless, the requirements on welding are set down in this section to ensure that the SSCs manufactured at a remote fabrication plant (such as Holtec's plants in Camden, NJ, Orrville, OH or Pittsburgh, PA) comply with the essential provisions specified below.

Welds in the HI-STORM UMAX system and the other ITS SSCs are divided into two broad categories:

i. Structural welds

ii. Non-structural welds

Structural welds are those that are essential to withstand mechanical and inertial loads exerted on the component under normal storage and handling.

Non-structural welds are those that are subject to minor stress levels and are not critical to the safety function of the part. Non-structural welds are typically located in the redundant parts of the structure. The guidance in the ASME Code Section NF-1215 for secondary members may be used to determine whether the stress level in a weld qualifies it to be categorized as non-structural.

Both structural and non-structural welds must satisfy the material considerations listed in Tables 8.1.1 and 8.1.2 of [1.0.6] for the MPC and the HI-STORM UMAX VVM, respectively. In addition, the welds must not be susceptible to any of the applicable failure modes listed in Table 17.1.5.

The welding material and welding specification considerations for the MPC and HI-TRAC are discussed in Section 8.5 of the HI-STORM FW FSAR [1.3.7].

To ensure that all structural welds in the HI-STORM UMAX system and the other ITS SSCs shall render their intended function, the following requirements are observed:

i. The welding procedure specifications comply with ASME Section IX for every Code material used in the system.

ii. The quality assurance requirements applied to the welding process correspond to the highest ITS classification of the parts being joined.

iii. The non-destructive examination of every weld is carried out using quality procedures that comply with ASME Section V.

The welding operations are performed in accordance with the requirements of codes and standards depending on the design and functional requirements of the components.

The selection of the weld wire, welding process, range of essential and non-essential variables*, and the configuration of the weld geometry has been carried out to ensure that each weld will have:

i. Greater mechanical strength than the parent metal.
ii. Acceptable ductility, toughness, and fracture resistance.
iii. Corrosion resistance properties comparable to the parent metal.
iv. No risk of crack propagation under the applicable stress levels.

The welding procedures implemented in the manufacturing of all HI-STORM UMAX SSCs are intended to fulfill the above performance expectations.

The weld filler material shall comply with requirements set forth in the applicable Welding Procedure Specifications qualified to ASME Section IX at the manufacturer's facility. Only those Welding Procedures that have been qualified to the Code are permitted in the manufacturing of HI-STORE CIS facility components.

The weld procedure qualification record specifies the requirements for fracture control (e.g., post weld heat treatment). The HI-STORM UMAX module assembly does not require any post weld heat treatment due to the material combinations and provisions in the applicable codes and standards.

Non-structural welds shall meet the following requirements:

1. The welding procedure shall comply with Section IX of the ASME Code or AWS D1.1.
2. The welder shall be qualified, at minimum, to the commercial code such as ASME Section VIII, Div.1, or AWS D1.1.
3. The weld shall be visually examined by the weld operator or a Q.C. inspector qualified to Level 1 (or above) per ASNT designation.

* Please refer to Section IX of the ASME Code for the definition and delineation of essential and non-essential variables.

17.6 BOLTS AND FASTENERS

The HI-STORM UMAX VVM assembly does not employ any ITS bolts or fasteners. However, during the MPC transfer into the HI-STORM UMAX, the HI-TRAC is attached to the VVM assembly to prevent tip-over during a seismic event. The MPC Lift Attachment is a one-piece lifting device that is bolted directly to threaded anchor locations on the top surface of the MPC closure lid which allows the raising or lowering of MPC during canister transfer operations using either the CTB or the VCT. Likewise, the HI-TRAC CS cask is bolted to the CTF (located in the Cask Transfer Building) during the canister transfer operation. These bolts used to secure the HI-TRAC against tip-over, the bolts and anchor location material are classified as ITS and are procured in accordance with the Holtec QA program. Bolt and anchor location material must meet either an ASME or ASTM specification.

The only bolts employed in the HI-STORM UMAX VVM system are those used to secure the vent flue to the inlet and outlet plenums. All bolts and fasteners are made of alloy materials which are not expected to experience any significant corrosion and/or SCC in the operating environment.

All threaded surfaces are treated with a preservative to prevent corrosion. The O&M program for the storage system calls for all bolts to be monitored for corrosion damage and replaced, as necessary.

The coefficient of thermal expansion (CTE) describes how the size of an object changes with a change in temperature. Bolts and fasteners used in HI-STORE CIS systems, used only for short term operations, will have a CTE that is similar to the CTE of the materials being bolted together. In case of dissimilar material bolting, the temperature gradient is not high enough to alter the size of the bolts, and it is not credible that the bolts will lose their intended functions.

17.7 COATINGS AND CORROSION MITIGATION

In order to provide reasonable assurance that the VVM will meet its intended Design Life (Table 17.0.1) and perform its intended safety function(s), chemical and galvanic reactions and other potentially degrading mechanisms must be accounted for in its design and construction.

It should be noted that, although the CEC is a buried steel structure it is substantially sequestered from the native soil through two engineered features:

a. A thick reinforced concrete Enclosure Wall surrounds the VVM array and, along with the Support Foundation pad, provides a physical separation (water intrusion protection) to the CECs.

b. The subgrade in contact with the CECs is either a "free flow" concrete or an engineered fill selected to provide a non-aggressive environment around the CECs.

The above engineered features provide an environmentally benign condition for the CECs. The above said, although the CEC is not a part of the MPC confinement boundary, it should not corrode to the extent where localized in-leakage of water occurs or where gross general corrosion prevents the component from performing its primary safety function. In the following, considerations in the VVM's design and construction consistent with the applicable guidance provided in ISG-15 [17.0.1] are summarized.

All VVM components are protected from galvanic corrosion by appropriate designs. Except for the CEC exterior surfaces (exterior CEC surface coating requirements discussed separately), all carbon steel surfaces of the VVM are lined and coated with the same or equivalent surface preservative that is used in the aboveground HI-STORM FW and HI-STORM 100 overpacks. Acceptable coatings are fully characterized in the HI-STORM FW FSAR [1.3.7] in Paragraph 8.7.2 and Appendix 8.A, which are incorporated herein by reference [see Table 17.0.2]. The same is true for all the other ITS SSCs and care is taken to avoid the formation of corrosion products by deposition of appropriate coatings, as necessary. The pre-approved surface preservative is a proven zinc-rich inorganic/metallic (may also be an organic zinc rich coating) material that protects galvanically and has self-healing characteristics for added protection. The coating also meets the emissivity requirements of Table 4.2.4 of [1.0.6], which is incorporated by reference into Section 6.4.1 of this FSAR, for the interior surface of the CEC divider shell. All exposed surfaces interior to the VVM are accessible for the reapplication of surface preservative, if necessary.

The native soil excavated at the ISFSI site shall not be used as subgrade at the HI-STORE CIS ISFSI. Instead, CLSM will be used to provide corrosion protection and enhanced shielding.

17.7.1 Exterior Coating

The CEC exterior shall be coated with a radiation resistant surface preservative designed for below-grade and/or immersion service. Inorganic and/or metallic coatings are sufficiently radiation-resistant for this application; therefore, radiation testing is not required. Organic coatings such as epoxy, however, must have proven radiation resistance or must be tested without failure to at least 10^7 Rad. Radiation testing shall be performed in accordance with ASTM D 4082 [17.7.4] or equivalent.

The coating should be conservatively treated as a Service Level II coating as described in Reg. Guide 1.54 [17.7.1]. As such, the coating shall be subjected to appropriate quality assurance in accordance with the applicable guidance provided by ASTM D 3843-00 [17.7.2]. The coating should preferably be shop-applied in accordance with manufacturer's instructions and, if appropriate, applicable guidance from ANSI C 210-03 [17.7.3]. The following table provides the acceptance criteria for the selection of coatings for the exterior surfaces of the CEC and ranks them in order of importance.

Acceptance Criteria for the Selection of Coatings

Rank	Criteria
1	suitable for immersion and/or below grade service
2a	compatible with the ICCPS (if used) • adequate dielectric strength • adequate resistance to cathodic disbondment
2b	compatible with concrete encasement (if used) • adequate resistance to high alkalinity
3	adequate radiation resistance
4	adequate adhesion to steel
5	adequate bendability/ductility/cracking resistance/abrasion resistance
6	adequate strength to resist handling abuse and substrate stress

17.8 GAMMA AND NEUTRON SHIELDING MATERIALS

Gamma and neutron shield materials in the HI-STORM UMAX VVM system are discussed in Section 1.2. The primary shielding materials used in the HI-STORM UMAX VVM system, as listed in Table 17.1.3, are plain concrete, reinforced concrete, and steel.

The plain concrete provides the main shielding function in the HI-STORM UMAX lids to minimize sky shine.

17.8.1 Plain Concrete

Unlike the above ground HI-STORM models, the use of plain concrete for shielding purposes in the underground VVMs is limited to the VVM Closure Lid. The critical characteristics of concrete used in the Closure Lid are its density and compressive strength. Table 2.3.2 in the HI-STORM UMAX FSAR provides reference properties of plain concrete used in the Closure Lid.

The density of plain concrete within the HI-STORM UMAX VVM is subject to a minor decrease due to long-term exposure to elevated temperatures. The reduction in density occurs primarily due to liberation of unbonded water by evaporation.

17.9 NEUTRON ABSORBING MATERIALS

The neutron absorber material is permanently installed inside the Canisters for reactivity control. Metamic-HT is the neutron absorber material utilized the MPC-37 and MPC-89 -Canisters initially certified in the HI-STORM FW docket (#72-1032). The properties of Metamic-HT are fully characterized in the HI-STORM FW FSAR [1.3.7] in Paragraph 1.2.1.4 which is incorporated herein by reference [see Table 17.0.2].

Because Metamic-HT is enclosed in a helium environment and is subject to no interaction with the environment, its service life is not subject to attrition in storage.

17.10 SEALS

The HI-STORM UMAX VVM assembly does not utilize any gaskets that seal against a large pressure differential.

The only external gasket used in the system is the soft gasket at the Closure lid-CEC Flange interface that helps prevent the ingress of moisture and insects (through the small crack that may exist due to weld distortion in the fabrication of interfacing fabricated steel weldment surfaces) into the module cavity space.

The Divider shell is sealed against the Closure lid using a pliable, non-organic seal material that is suitable for long-term ambient air application up to 300 degree F.

BISCO® BF-1000 Extra Soft Cellular Silicone gasket material [17.10.1] is selected as one that satisfies the acceptance criteria to the maximum degree. The seal/gasket material provides excellent compressibility, softness, and durability to adapt to various environments, making it an ideal choice for sealing Closure Lid. It has been used in all HI-STORM UMAX ISFSIs thus far. Equivalent materials that meet the above criteria are also commercially available.

17.11 CHEMICAL AND GALVANIC REACTIONS

The materials used in the HI-STORM UMAX System and all other ITS SSCs are examined to establish that these materials do not participate in any chemical or galvanic reactions when exposed to the various environments during all normal operating conditions and off-normal and accident events. Chemical and galvanic reactions related to the MPC are discussed in Section 8.12 of the HI-STORM FW FSAR.

The following acceptance criteria for chemical and galvanic reactions are extracted from ISG-15 [17.0.1] for use in HI-STORM UMAX VVM components.

a. The DCSS should prevent the spread of radioactive material and maintain safety control functions using, as appropriate, noncombustible and heat resistant materials.

b. A review of the DCSS, its components, and operating environments (wet or dry) should confirm that no operation (e.g., short-term loading/unloading or long-term storage) will produce adverse chemical and/or galvanic reactions, which could impact the safe use of the storage cask.

c. Components of the DCSS should not react with one another, or with the cover gas or spent fuel, in a manner that may adversely affect safety. Additionally, corrosion of components inside the containment vessel should be effectively prevented.

d. Potential problems from general corrosion, pitting, stress corrosion cracking, or other types of corrosion, should be evaluated for the environmental conditions and dynamic loading effects that are specific to the component.

The materials and their ITS pedigree are listed in the drawing package provided in Section 1.5 of Chapter 1. The compatibility of the selected materials with the operating environment and to each other for potential galvanic reactions is discussed in this section.

- External atmosphere – During long-term storage the casks are exposed to outside atmosphere, air with temperature variations, solar radiation, rain, snow, ice, etc.

As discussed herein, the ITS components of the HI-STORM UMAX System and other SSCs have been engineered to ensure that the environmental conditions expected to exist at nuclear power plant installations do not prevent the cask components from rendering their respective intended functions.

The principal operational considerations that bear on the adequacy of the VVM for the service life are addressed as follows:

Exposure to Environmental Effects

All exposed surfaces of the HI-STORM UMAX VVM components are made from stainless steels or ferritic steels that are readily painted. The same is true for all the other ITS SSCs and care is taken to avoid the formation of galvanic cells by deposition of appropriate coatings, as necessary, in case dissimilar materials are joined together. Concrete, which serves strictly as a shielding material in the VVM Closure Lid, is encased in steel. Therefore, the potential of environmental vagaries such as spalling of concrete are ruled out for HI-STORM UMAX VVM.

Under normal storage conditions, the bulk temperature of the HI-STORM UMAX storage overpack will change very gradually with time because of its large thermal inertia. Therefore, material degradation from rapid thermal ramping conditions is not credible for the HI-STORM UMAX VVM. Similarly, corrosion of structural steel embedded in the concrete structures due to salinity in the environment at coastal sites is not a concern for HI-STORM UMAX VVM because it does not rely on rebars (indeed, it contains no rebars). The configuration of the storage VVM assures resistance to freeze-thaw degradation. In addition, the storage system is specifically designed for a full range of enveloping design basis natural phenomena that could occur over the service life of the storage system as catalogued in Section 2.2 and evaluated in Chapter 15.

The ISFSI pad, which is exposed to the elements, shall be subject to a surveillance program to monitor its potential degradation, as discussed in Chapter 10.

Material Degradation

The relatively low neutron flux to which the VVM is subjected cannot produce measurable degradation of the cask's material properties and impair its intended safety function. Exposed carbon steel components are coated to prevent corrosion. The ambient environment of the ISFSI storage pad mitigates damage due to exposure to corrosive and aggressive chemicals that may be produced at other industrial plants in the surrounding area.

Maintenance and Inspection Provisions

The requirements for periodic inspection and maintenance of all the ITS SSCs at HI-STORE CIS facility throughout their service life is defined in Chapter 10. These requirements include provisions for routine inspection of the exterior surfaces of equipment and periodic visual verification that the ventilation flow paths are free and clear of debris in the VVM. In addition, the HI-STORM UMAX system is designed for easy retrieval of the MPC from the VVM should it become necessary to perform more detailed inspections and repairs on the storage system.

The above findings are consistent with those of the NRC's Continued Storage of Spent Nuclear Fuel Decision [17.11.1], which concluded that dry storage systems designed, fabricated, inspected, and operated in accordance with such requirements are adequate for the design and service life expectations set down in Table 17.0.1.

17.12 FUEL CLADDING INTEGRITY

The discussion related to the fuel cladding integrity during short term operations is incorporated by reference from Section 8.13 of the HI-STORM FW FSAR and is not repeated here.

17.13 EXAMINATION AND TESTING

Examination and testing are integral parts of manufacturing of the HI-STORM UMAX System and other ITS components that will be used at the HI-STORE CIS facility. The requirements for HI-STORM UMAX system are incorporated by reference from HI-STORM UMAX FSAR [1.0.6], Section 8.13.

Post-fabrication inspections are discussed in Chapter 10 of this SAR as part of the HI-STORM UMAX VVM System maintenance program. Inspections are conducted prior to fuel loading or prior to each fuel handling campaign. Other periodic inspections are conducted during storage.

The HI-STORM UMAX VVM is a passive device with no moving parts. The vent screens are inspected on scheduled intervals for damage, holes, etc. All the other ITS SSCs are inspected per scheduled intervals (Table 18.6.1) for general corrosion and/or mechanical damage.

The external surface of the VVM and the other ITS SSCs at the site, including identification markings, is visually examined on a periodic basis in accordance with the ISFSI's surveillance plan. The temperature monitoring system, if used, is inspected per the licensee's QA program and manufacturer's recommendations.

17.14 REGULATORY COMPLIANCE

The preceding sections describe the materials used in important-to-safety SSCs and the suitability of those materials for their intended functions in the HI-STORM UMAX System at the HI-STORE CIS facility.

The requirements of 10CFR72.122(a) are met: The material properties of SSCs important to safety conform to quality standards commensurate with their safety functions.

The requirements of 10CFR72.104(a), 106(b), 124, and 128(a)(2) are met: Materials used for shielding are adequately designed and specified to perform their intended function.

The requirements of 10CFR72.122(h)(1) are met: The design of the DCSS and the selection of materials adequately protect the spent fuel cladding against degradation that might otherwise lead to gross rupture of the cladding by ensuring that the cladding temperature remains below the ISG-11 Rev 3 limits.

The requirements of 10CFR72.122(l) are met: The material properties of SSCs important-to-safety will be maintained during normal, off-normal, and accident conditions of operation as well as short-term operations so the spent fuel can be readily retrieved without posing operational safety problems.

The requirements of 10CFR72.122(f) are met: The material properties of SSCs important-to-safety will be maintained during all conditions of operation so the spent fuel can be safely stored for the specified service life and maintenance can be conducted as required.

The requirements of 10CFR72.1226(b) are met: The HI-STORM UMAX System employs materials that are not vulnerable to degradation over time or react with one another during long-term storage.

CHAPTER 18: AGING MANAGEMENT PROGRAM*

18.0 INTRODUCTION

This chapter contains the essentials of the Aging Management Programs (AMP) for the HI-STORE CIS ISFSI which is intended to possess a long Service life (Table 17.0.1). An effective AMP is considered an imperative for an ISFSI that may ultimately house thousands of canisters containing spent nuclear fuel. For such a facility, a well-construed program to thwart gradual weakening of the safety margins associated with aging of the facility with potentially adverse consequences to important-to-safety structures, systems and components (SSCs) is a necessity. AMPs monitor and control the degradation of storage system's SSCs, so that the aging effects will not result in loss of their safety-significant function during their service life in interim storage. An effective AMP prevents, mitigates, or detects the aging effects and provides for the prediction of the extent of the effects of aging and timely corrective actions before there is a loss of intended function.

It is recognized that the HI-STORE ISFSI will store canisters most of which have been previously stored at an ISFSI at an operating or shuttered nuclear plant site. An AMP has not been required as a part of the initial licensing cycle of an ISFSI which has historically been 20 years. An acceptable AMP is required, however, at the end of the initial licensed life as a regulatory predicate for life extension of the storage license. At HI-STORE CIS, Holtec International plans to implement a state-of-the-art AMP that incorporates certain innovative approaches pioneered by the Company which are founded on the fundamentals of material degradation mechanisms. The architecture of the Program is informed by the published regulatory and industry literature as synopsized below.

NUREG-1927 [18.0.1] sets down an AMP containing 10 elements to manage the effects of aging. This document emphasizes the operating experience of all operating units to be documented and reviewed. Periodic future reviews of operating experience are required to confirm the effectiveness of AMP, or identify a need to enhance/modify the AMP. Managing aging mechanisms and effects in a "learning" manner articulated in [18.0.1] means ISFSI owners would monitor both the known SSC degradation mechanisms and the symptoms that would be indicators of a potential unknown SSC degradation mechanism.

The AMP set down in this chapter consists of four major components, namely

- Monitoring for emerging signs of potential degradation
- Periodic inspection and testing to uncover onset of the SSC's degradation
- Implementation of preventive measures (barriers) to arrest degradation
- Recovery and remedial measures if all barriers were to fail

Each of the above constituents of the AMP is summarized in the following sections.

* All references are in placed within square brackets in this report and are compiled in Chapter 19 (last chapter)

Nuclear Energy Institute (NEI) publication #14-03, Revision 1 [18.0.2] elaborates on [18.0.1] providing an explicit set of expectations from a well implemented AMP. The NEI espoused program calls for the AMP to have the following attributes:

- safety-focused
- operations-based
- implemented within existing corrective action and operating experience programs
- qualitatively risk-informed based on relevant failure modes and effects
- forward-looking
- proactive
- responsive to condition-based monitoring.

NEI 14-03 [18.0.2] provides a framework for AMP through the use of tollgates, defined as periodic points within the period of extended operation when licensees would be required to evaluate aggregate feedback and perform and document a safety assessment that confirms the safe storage of spent fuel. Tollgates are an additional set of in-service assessments beyond the normal continual assessment of operating experience, research, monitoring, and inspections on component performance that is part of normal ISFSI operations for licensees during the initial license period as well as the renewal period.

The concept of operations-based aging management is to manage aging mechanisms and timeframes (duration to loss of intended function) that are either not known or not well understood. Known aging mechanisms will be managed using existing corrective action and operating experience programs with the objective of preventing loss of intended safety functions due to aging effects. Because some postulated aging mechanisms and/or timeframes for in-scope SSCs are not well-characterized by operating data, aging management should be implemented in a manner that feeds information back in a timely fashion to the licensees. This feedback will be used to perform corrective actions on components to preclude the loss of safety function over the renewed operating period.

Operations-based aging management programs should include the following attributes for the known and unknown degradation mechanisms and time frames:

- recognition and evaluation (key technical issues)
- storage system inspections
- monitoring and operational inspections
- analysis and assessment
- tollgate assessment
- feedback and corrective actions (mitigation/repair and/or analysis).

The AMP outlined in this chapter incorporates the above elements of [18.0.1 and 18.0.2] and is termed a "progressively enhanced plan" (PEP) that is shaped and guided by fundamental technical principles and ongoing operating experience.

All the important-to-safety (ITS) SSCs scoped for aging management were granted a 20 year initial license under the HI-STORM UMAX license. HI-STORE SAR will be requesting a 40 year license. To ensure an uninterrupted performance of these ITS SSCs and their intended functions through the 40 year license period, all such ITS SSCs will be inspected and monitored per their respective AMP, and a concern-free service life of those SSCs will be established. Additional AMPs are also included for those SSCs that are not part of the HI-STORM UMAX generic license. Typical aging mechanisms and quantitative and/or qualitative analyses are discussed in Section 18.3 below.

18.1 SCOPING EVALUATION AND SEVERITY INDEX

The HI-STORE CIS ISFSI consists of (i) the MPC, (ii) the VVM, and (iii) other support SSCs. These components were evaluated using the two scoping criteria in NUREG-1927 [18.0.1]. In summary, these criteria are (1) an SSC that is Important to Safety (ITS) or (2) an SSC that supports SSC safety functions.

Because the canister provides the confinement protection and reactivity control, its AMP is the most critical activity and is accordingly the central focus of the program. The VVM which includes the top pad (ISFSI pad) is the other critical component. As a steel and concrete structure that is limited to providing dose attenuation, the aging management demands on the VVM are different in nature from those on the MPC and are also somewhat less severe. Furthermore, the top lid (Closure Lid) of the VVMs is a removable item which can be replaced with a new lid, if needed, making the aging management demands on it less consequential. (The VVM body is integral to the ISFSI and cannot be replaced). The HI-TRAC CS transfer cask is used only during loading operations; it does not store any used Fuel. The AMP for the Transfer cask is accordingly informed by its functional requirement. An assessment of the VVM, MPCs, HI-TRAC CS Transfer Cask, ISFSI pad, and other SSCs is documented in [1.2.1] which identifies the necessary inspection and monitoring activities to provide reasonable assurance that the SSCs will perform their intended functions for the duration of their License life. A summary of the SSCs that warrant an AMP along with the severity of the consequence of each SSC's degradation is provided in Table 18.1.1 (partially adapted from [1.2.1]). The Severity index is essentially a graded approach to defining AMP requirements: A Severity Index of 3 is the highest, 2 means moderate severity, 1 is minor impact on SSC, and 0 means the SSC is not subject to an AMP.

Table 18.1.1: Summary of SSCs Requiring Aging Management & Their Severity Index

SSC	Scoping Results		In-Scope SSC	Severity of the consequence of degradation (3 most severe, 2 moderately severe, 1 Minor; 0 not severe and not-included)
	Criterion 1[1]	Criterion 2[2]		
MPC	Yes	N/A	Yes	3
HI-TRAC CS Transfer Cask	Yes	N/A	Yes	1
VVM	Yes	N/A	Yes	2
Fuel Assembly	Yes	N/A	Yes	3
ISFSI Pad	Yes	No	Yes	2
SFP	Yes	No	Yes	1
CTB Crane	Yes	No	Yes	1
CTB Slab	Yes	No	Yes	1
CTF	Yes	No	Yes	1
HI-TRAC CS Lifting Device (Lift Yoke)	Yes	No	Yes	1
MPC Lift Attachment	Yes	No	Yes	1
MPC Lifting Device Extension	Yes	No	Yes	1
VCT	Yes	No	Yes	1
Special Lifting Devices	Yes	No	Yes	1
Transport Cask Horizontal Lift Beam	Yes	No	Yes	1
Transport Cask Tilt Frame	Yes	No	Yes	1
Transport Cask Lift Yoke	Yes	No	Yes	1
CLSM	No	No	No	0
CTB	No	No	No	0
CTF Adapter Plate	No	No	No	0

ISFSI Security Equipment	No	No	No	0

Notes:
(1) SSC is Important to Safety (ITS)
(2) SSC is Not Important to Safety (NITS), but its failure could prevent an ITS function from being fulfilled

18.2 MAINTENANCE PROGRAM FOR THE HI-STORM UMAX VVM & HI-TRAC CS

The maintenance program is an essential element of a comprehensive AMP. The essentials of the maintenance program for the HI-STORE ISFSI SSCs are summarized in Chapter 10. The relationship of aging management to the maintenance program is discussed in Section 18.13.

18.3 MECHANISMS FOR AGING OF SSCS

In this section, the fundamental mechanisms that underlie aging of a dry storage SSC are summarized to serve as the guide in evolving an effective aging management program. The principal effects that can cause aging of an SSC are:

i. Cyclic fatigue from thermal and pressure transients
ii. Creep
iii. Erosion
iv. General Corrosion
v. Boron depletion (of neutron absorbing or shielding materials)
vi. Crack propagation
vii. Repetitive mechanical loading (of trunnions and threaded anchor locations)
viii. Stress corrosion cracking (SCC)

Each mechanism is discussed below in the context of its potential role in aging of the HI-STORE SSCs.

i. Cyclic Fatigue:

Cyclic fatigue is caused by thermal or pressure transients in a SSC. The necessary condition for fatigue expenditure in metals is a rapid pulsation of large amplitude stress which is only possible in the dry storage SSCs if the environmental conditions were to change drastically (hundreds of °F change) in a matter of seconds and such changes were to occur repeatedly (thousands of cycles). Because such cyclic conditions are not realistic for any terrestrial environment, cyclic fatigue of dry storage components and structures is not a credible mechanism for their degradation.

Quantitative analysis of long term fatigue on HI-TRAC CS, Transport Cask lift beams and other lifting ancillaries (lift yokes, etc.) is discussed in Chapter 5 of this SAR.

It summarizes a cyclic loading fatigue evaluation of the HI-TRAC CS Transfer Cask, Transport Cask lift beams and other lifting ancillaries which concludes that stresses are well below the endurance limit of the trunnion material. Thus, trunnion fatigue is not an issue during the aging management period. It is conservatively assumed that the HI-TRAC CS, Transport Cask lift beams and other lifting ancillaries are utilized for all lifts of the ISFSI MPCs. However, the allowable number of lifting cycles far exceeds the number of lifts that will be needed. Therefore, no additional aging management plan is needed to address fatigue failure of the HI-TRAC CS, Transport Cask lift beams and other lifting ancillaries.

The Transport Cask Tilt Frame is not a lifting device since it is a stationary device that provides support to the cask from below. Also, during upending or down ending operations, the cask always remains connected to the single failure proof CTB Crane via a special lifting device. Structural analysis of tilt frame is summarized in Chapter 5 of this SAR.

ii. Creep:

Creep is a time-dependent effect that produces ever-increasing deformation under a sustained load. Creep is a factor in components that operate at a high temperature and are subject to an elevated state of stress. Creep effects are negligible in most metals at moderate temperature (below 600°F) and stress levels (less than half of the material's Yield Strength). Creep, therefore, is a concern only for the fuel assembly rods inside the canisters. Because the fuel rods are thin walled pressurized tubes and operate at elevated temperatures, the incidence of damage from creep cannot be ruled out. In this respect, the high thermal capacity of the HI-STORM UMAX system provides an effective protection against creep. A quantitative estimate of the benefit accrued by HI-STORM UMAX to the canisters brought in at a substantially lower heat load (Section 4.1) can be obtained by using the creep rate equation for fuel cladding from [18.3.1]:

(b)(4)

The creep rate corresponding to the maximum heat load in HI-STORM UMAX to that if the fuel rod were at the ISG-11 Rev 3 limit temperature can be obtained by assuming the cladding hoop stress is directly proportional to the absolute temperature of the cladding material. Using the cladding temperature result from Table 18.3.1, the ratio is determined and presented in Table 18.3.1. As can be seen from this result, the high thermal capacity of the HI-STORM VVMs has the effect of reducing the creep rate by several orders of magnitude.

Of course, as the canister ages, its heat load decreases, causing a corresponding decrease in the creep rate, reaching vanishing small values after a few years. Therefore, the threat of creep damage to the fuel recedes to a negligible range as the canisters will age in interim storage at HI-STORE.

Appendix D of NUREG-1927 [18.0.1] provides supplemental guidance for the use of a demonstration program as a surveillance tool for confirmation of integrity of High Burnup Fuel (HBF) during the period of extended operation. The technical discussion and guidance provided by the demonstration program will be used for learning purposes and the results obtained from the program will be analyzed. All appropriate actions shall be taken at the HI-STORE facility, as needed, based on the demonstration program results.

iii. Erosion:

Erosion is a mechanical action wherein the impinging particles carried by a fluid medium on a surface causes the target surface to release fine surface matter. Erosion requires a high fluid velocity to cause noticeable material loss. Contemporary design practice in tubular heat exchanger thermal design holds that the incident velocity must be high enough so that E defined by $\rho v^2 > 500$, where ρ is density of the fluid carrier in lb/cubic feet, and v is the flow velocity orthogonal to the target surface in feet/sec.

The evident area on the canister's surface potentially vulnerable to erosion would be the surface facing the inlet ducts through which ventilation air enters. The value of in-duct air velocity from the FLUENT analysis is used for comparison purposes. The key computed data is summarized in the unnumbered table below which shows that the minimum required threshold value is orders of magnitude larger than the actual value.

Empirical correlation for the rate of erosion states that the rate varies as 4.5 power of velocity. Using this correlation gives the computed factor of safety against the onset of erosion on the canister's surface.

(b)(4)

Therefore, erosion is ruled out as an actuating mechanism to cause damage to the stored canister at the HI-STORE facility.

iv. General Corrosion & Spalling of the ISFSI concrete surface:

General corrosion of painted carbon steel surfaces in the HI-STORE CIS is expected and dealt with in the maintenance program described in the foregoing. Because the ambient air is relatively dry, the incidence of peeling of the coating is expected to be much more subdued.

Likewise spalling of the ISFSI concrete surface around the VVM due to freeze/thaw cycles following water infiltration is prevented by keeping the surface coating in good condition through preventive maintenance.

v. Boron depletion:

The theoretical risk of boron depletion applies to the neutron absorber panels in the canister's Fuel Basket wherein the B-10 isotope in the material serves to capture thermalized neutrons produced by the radioactive decay of the used fuel. Calculations performed on a typical canister show that the fraction of boron atoms consumed during the service life of the MPC (Table 17.0.1) will be a small fraction of boron available in the Fuel Basket.

A quantitative analysis on Boron depletion has been discussed in Section 3.4.8 of HI-STORM FW FSAR [1.3.7]. The analysis demonstrates that the Boron depletion in Metamic-HT material is negligible over a 60 year duration. Thus, sufficient levels of Boron are present in the fuel basket neutron absorbing material to maintain criticality safety functions over the license life of the MPC.

Therefore, aging management of the canister to insure adequate boron-10 isotope in the Fuel Basket is not necessary; the canister does not run a credible risk of boron depletion below the needed level to maintain subcriticality.

vi. Crack propagation:

Every material has flaws at microscopic level. Those components whose load bearing materials are volumetrically examined are less apt to have hidden flaws but the existence of imperfections that can propagate over time can't be entirely ruled out. In order to ensure that any pre-existing flaw will not propagate and lead to sudden failure, the following design measures will be implemented in the design and manufacturing of the SSCs for HI-STORE:

- In high strength materials, such as those used in lift rigs, the maximum primary stress in the material during lifting and handling operations is required to be less than 1/6th of the material Yield Strength which is generally considered to be the limit at which a pre-existing crack may propagate.
- In high ductility materials, such as austenitic stainless steel (used in the canister), the maximum stress is required to meet the limit in Reg Guide 3.61. Furthermore, the primary stress in the canister under normal storage condition is required to meet the limit for ASME Section III Class 1 components.

Observing the above restrictions eliminates the threat of crack propagation in critical equipment at the HI-STORM ISFSI and hence the need for any prophylactic measures to avoid their occurrence.

vii. Repetitive Mechanical Loading:

The design measure employed by Holtec requires the maximum primary stress in a trunnion or threaded anchor location under the maximum lifted load to be below the "endurance strength" of the material. Observing the endurance limit criterion eliminates the threat of cyclic fatigue failure *a' priori.* Quantitative analysis of long term fatigue on lifting ancillaries is discussed in Chapter 5 in the SAR.

viii. Stress Corrosion Cracking (SCC):

Unique to austenitic and duplex stainless steels, SCC causes cracking at the intergranular or transgranular level in the material. It is a serious threat to the canister's confinement boundary which is exposed to the ambient environment at the ISFSI. The incidence of SCC requires three essential conditions to be present concurrently:

a. Significant tensile stress at the surface exposed to the environment, and

b. Halides in the environment, and

c. Relative humidity in excess of 20%

At the HI-STORE site, the halide content in the air is negligible as mentioned in Chapter 2, therefore an essential requirement for SCC is not satisfied and the incidence of SSC becomes a remote possibility. Nevertheless, the risk of SCC cannot be entirely ruled out and the AMP must provide for a way to anticipate it. Accordingly, the monitoring method for the canister proposed in this SAR assumes that the threat of SCC is real and possible.

Table 18.3.1: Calculation of Creep Rate Attenuation Under HI-STORM UMAX Storage Baselined to ISG-11 Revision 3 Limit

Property	Value
Bounding Cladding Stress (σ_{max})	144.7 MPa @ T_{ref} = 387°C [1]
Baseline Cladding Temperature (T_{cb})	400°C
Max. Cladding Temperature under HI-STORM UMAX Storage (T_{cs})	330°C [2]
Cladding Stress (σ_b) @ T_{cb} (σ_{max} * (T_{cb} + 273)/ (T_{ref} + 273))	147.6 MPa
Cladding Stress (σ_s) @ T_{cs} (σ_{max} * (T_{cs} + 273)/ (T_{ref} + 273))	132.2 MPa
Creep Rate Ratio (φ @ T_{cs} / φ @ T_{cb})	0.04

[1] Data adopted from Appendix 4.A for bounding PWR fuel rods [18.3.1]
[2] Data adopted from Chapter 6, Section 6.4 of the HI-STORE SAR.

18.4 UNIQUE ASPECTS OF THE HI-STORE CIS WITH NEXUS TO ITS AMP

The following aspects of the HI-STORE ISFSI are relevant to developing a sound AMP for the site:

i. Because the storage system is subterranean, the extent of the exposed metal surface of the VVM is quite small compared to the above-ground storage systems.

ii. The relatively thin wall of the exposed surface of the canister (the canister's shell which is made of austenitic stainless steel) is disposed vertically which, as expected, discourages the deposition of aggressive species from accumulating on the shell surface. (An EPRI/Holtec measurement program at Diablo Canyon and Salem/Hope Creek ISFSIs showed that the deposition on the shell surface is significantly less than that on the horizontal surface [18.4.1]). It is well known that the deposition of solutes on the surface of stainless steel directly correlates with the risk of generation of nucleation sites where stress corrosion cracking (SCC) may initiate. Reduced deposition rate on the thin wall of the canister is a positive feature for an extended service life.

iii. As described in Chapter 2, the ambient environment at the HI-STORE site has minuscule amount of salts and other airborne particulates known to be injurious to stainless steel. The minuscule concentration of halides in the air starves the canister's surface of an essential ingredient for initiating SCC.

iv. There is no location for contaminant hide-out (such as crevice or gouge) on the surface of the vertically arrayed canister (in contrast to the condition where the canister is horizontally stored), where halide-bearing particles may concentrate enabling SCC to take hold.

v. The settling of moisture on the canister's shell during cool hours followed by warm hours causing the moisture to evaporate leaving behind the particulate residue is the principal means for salts to accumulate on the canister's surface. In the high desert of south-eastern New Mexico, the relative humidity in the air is low, making the delivery of salts to the canister's surface less effective.

In light of the above, it is reasonable to expect that the canisters stored at HI-STORE CIS will have a substantially longer service life than that projected in Table 17.0.1. Nevertheless, a progressively enhanced plan for Aging Management has been adopted in this SAR as explained in this Chapter.

18.5 CANISTER AGING MANAGEMENT PROGRAM

The welded canisters need inspections and enhanced monitoring programs in order to detect potential chloride-induced stress corrosion cracking (CISCC) initiation and propagation prior to through wall growth. To identify SCC in canisters at HI-STORE CIS prior to a loss of function, a set of criteria and associated canister ranking values will be developed per EPRI Report [18.5.1]. This ranking may be used to assess welded MPCs at the site with regard to selecting more susceptible canisters for inspections .

[18.5.1] also mentions additional factors that should be considered for prioritizing canisters among a population of canisters with the same rank. The canister ranking criteria are designed to rank individual canisters at HI-STORE site based on the anticipated level of chloride accumulation, the contribution of the material alloy to CISCC susceptibility, and the surface regions where deliquescence could occur. The chloride accumulation/deposition criterion provides a rank factor based on the previous site and the time elapsed since the canister was emplaced in the overpack. The material criterion provides a ranking factor based on resistance to SCC. The decay heat criterion provides a ranking factor relating current canister residual decay heat to the prevalence of deliquescent conditions on the canister surface using surface temperatures from available thermal models. The results of the canister ranking will be used in the canister inspection selection criteria and in the development of the learning based AMP/operating experience.

18.5.1 Visual Examination

The canister AMP involves monitoring the exterior surface of a MPC, including visual inspection of the MPC surface for signs of degradation. The canisters with the highest susceptibility for SCC should be selected for inspection. The selection criteria include oldest and coldest canisters with a potential for accumulation and deliquescence of deposited salts that may promote localized corrosion and/or SCC. The selection criteria for inspection of the installed canisters at the site will be re-evaluated as and when additional canisters are installed. The visual inspection frequency has been outlined per Table 18.6.1. All the accessible weld areas of the canister(s) will be covered for SCC inspection/monitoring and the canisters selected for inspection will be visually inspected for conditions listed below.

The monitored conditions include, but are not limited to:

- Localized corrosion pits, stress corrosion cracking, etching, or deposits
- Discrete colored corrosion products, especially those adjacent to welds and weld heat affected zones
- Linear appearance of corrosion products parallel to or traversing welds or weld heat affected zones
- Red-orange colored corrosion products combined with deposit accumulations in any location
- Red-orange colored corrosion tubercles of any size

18.5.2 Accelerated Coupon Testing

(b)(4)

18.5.3 Eddy Current Testing:

(b)(4)

(b)(4)

[redacted]

Table 18.5.1: Initial Coupon Testing Protocol

Test Item	Count	Remarks
Test Coupons/canister	Four Coupons	One in each quadrant located near the inlets
Canister Sample Size	Five lead canisters	Selected based on lowest canister heat load
Coupon Testing Frequency	Once Every Five Years	Frequency aligned with visual inspections (See Table 18.6.1).
Note 1: Coupon testing must not be solely relied as a basis for acceptable performance. Note 2: Coupon evaluation must be coordinated with eddy current and visual inspection results to provide a comprehensive and informed basis for future inspections.		

(b)(4)

Figure 18.5.1: Coupon Schematic and Dimensions

(b)(4)

Figure 18.5.2: Representative Eddy Current Inspection Ring

18.6 HI-TRAC CS TRANSFER CASK AGING MANAGEMENT PROGRAM

The HI-TRAC CS Transfer Cask Aging Management Program utilizes inspections to ensure that the transfer cask maintains its intended function throughout its Service Life by performing a visual inspection for degradation of the external surfaces of the Transfer Cask and trunnions. This inspection is performed prior to use of the Transfer Cask per Table 18.6.1.

The visual inspection will include the following:

- All painted surfaces for corrosion and paint integrity
- All surfaces for dents, scratches, gouges, or other damage
- Lifting trunnions for deformation, cracks, damage, corrosion, and galling

Table 18.6.1: Periodic Inspection Frequency of HI-STORE CIS ISFSI Components

Components	Periodic Inspection Frequency
MPC	Every 5 years
HI-TRAC CS Transfer Cask	Pre-Use and Once every year while in use
VVM	Every 5 years
ISFSI Pad and SFP	Once every year
CTB Crane	Pre-Use and Once every year while in use
CTB Slab	Once every year
Lifting Devices (HI-TRAC CS Lift Yoke, VCT, MPC Lift Attachment, MPC Lifting Device Extension, Transport Cask Lift Yoke, Horizontal Lift Beam)	Pre-Use and Once every year while in use
Transport Cask Tilt Frame	Pre-Use and Once every year while in use
CTF	Every 5 years

18.7 VVM AGING MANAGEMENT PROGRAM

The Vertical Ventilated Module (VVM) AMP utilizes condition monitoring to manage aging effects of the Cavity Enclosure Container (CEC), Divider Shell, and the Closure Lid as set down in the maintenance program in the foregoing. The initial frequency of inspection is set down in Table 18.6.1 which is subject to change depending on the 'tollgate" protocol explained in Section 18.13.

The visual inspection of the steel components and structures will include the following:

- All internal surfaces for corrosion and integrity
- All other surfaces for dents scratches, gouges, or other damage.

18.8 REINFORCED CONCRETE AGING MANAGEMENT PROGRAM

The ISFSI pad, SFP and Cask Transfer Building (CTB) slab are examples of reinforced concrete structures at the HI-STORE CIS facility. The AMP includes periodic visual inspections by personnel qualified to monitor reinforced concrete for applicable aging effects, and evaluate identified aging effects against acceptance criteria derived from the design bases. The initial frequency of inspection is set down in Table 18.6.1.

The program also includes periodic sampling and testing of groundwater, and the need to assess the impact of any changes in its chemistry on the concrete structures underground. Additional activities may include periodic inspections to ensure the air convection vents are not blocked.

The inspection of the reinforced concrete structures will include the following:

- All accessible surfaces for cracking, loss of material, permeability and integrity
- Groundwater chemistry monitoring to identify conditions conducive to underground aging mechanisms such as corrosion of steel and degradation due to chemical attack.

18.9 HBF AGING MANAGEMENT PROGRAM

This is a program that monitors and assesses data and other information regarding HBF performance, to confirm that the design-bases HBF configuration is maintained during the period of extended operation. The HBF AMP relies on a surrogate demonstration program to provide data on HBF performance. Guidance to support HBF AMP is given in Appendix D of NUREG-1927.

The aging management review is not expected to identify any aging effects that could lead to fuel reconfiguration, as long as the HBF is stored in a dry inert environment, temperature limits are maintained, and thermal cycling is limited. Short term testing and scientific analyses examining the performance of HBF have provided a foundation for the technical basis that storage of HBF in the period of extended operation may be performed safely and in compliance with regulations. However, there has been relatively little operating experience, to date, with dry storage of HBF.

Therefore, the purpose of HBF AMP is to monitor and assess data and other information regarding HBF performance to confirm there is no degradation of HBF that would result in an unanalyzed configuration during the period of extended operation.

The parameters (maximum assembly-average burnup, cladding type, peak cladding temperatures) of the demonstration program are applicable to the design-bases HBF at HI-STORE.

18.10 LIFTING DEVICE AGING MANAGEMENT PROGRAM

Ancillaries for the HI-STORE CIS are equipment, systems or devices that are needed to carry out Short Term Operations to place the canister into interim storage or to remove the loaded canister from storage. The lifting and handling ancillaries needed for operation of the HI-STORE CIS are classified as either "lifting devices" or "special lifting devices". The design requirements and stress compliance criteria applicable for such devices are located in Section 4.5 of this SAR.

The term *lifting device* as used in this SAR refers to components of a lifting and handling system that are not classified as *special lifting devices*. ANSI N14.6 is not applicable to these *lifting devices*. Examples of *lifting devices* used with Holtec's systems include the VCT used in the transport cask receiving area of the Cask Transfer Building (CTB).

The term *special lifting device* refers to components to which ANSI N14.6 [1.2.4] applies. As stated in ANSI N14.6 (both 1978 and 1993 versions), "This standard shall apply to *special lifting devices* that transmit the load from lifting attachments, which are structural parts of a container to the hook(s) of an overhead hoisting system." Examples of *special lifting devices* are MPC Lift Attachment, HI-TRAC CS Lifting Device (Lift Yoke), Transport Cask Lift Yoke and Transport Cask Horizontal Lift Beam.

The Lifting Device AMP utilizes condition monitoring to manage aging effects of the Cask Transfer Building (CTB) Crane, Vertical Cask Transporter (VCT), MPC Lift Attachment, MPC Lifting Device Extension, HI-TRAC CS Lift Yoke, HI-TRAC CS Lift Link, Transport Cask Lift Yoke and Horizontal Lift Beam as set down in the maintenance program in the foregoing. The initial frequency of inspection is set down in Table 18.6.1 which is subject to change depending on the "tollgate" protocol explained in Section 18.13.

The visual inspection of the steel components and structures will include the following:

- All external surfaces for corrosion, dents, scratches, gouges, or other signs of damage which may be adverse to the structural integrity of the component.

18.11 TILT FRAME AGING MANAGEMENT PROGRAM

The Tilt Frame AMP utilizes condition monitoring to manage aging effects of the Transport Cask Tilt Frame as set down in the maintenance program in the foregoing. Visual inspections are performed to ensure that the external surfaces of the Tilt Frame maintain its intended function throughout its service life without degradation. The initial frequency of inspection is set down in Table 18.6.1 which is subject to change depending on the 'tollgate" protocol explained in Section 18.13.

The visual inspection of the steel components and structures will include the following:

- All accessible surfaces for corrosion and integrity, dents scratches, gouges, or other damage.

18.12 CTF AGING MANAGEMENT PROGRAM

The Canister Transfer Facility (CTF) AMP utilizes condition monitoring to manage aging effects of the components of the CTF. The initial frequency of inspection is set down in Table 18.6.1 which is subject to change depending on the 'tollgate" protocol explained in Section 18.13.

The visual inspection of the steel components and structures will include the following:

- All internal surfaces for corrosion and integrity
- All other surfaces for dents scratches, gouges, or other damage.

18.13 LEARNING BASED AMP

The "tollgate" approach is based on NEI's report [18.0.2]. Tollgates are established to evaluate aging management feedback and perform a safety assessment that confirms the safe storage of spent nuclear fuel. The impact of the aggregate feedback will be assessed as it pertains to components at the ISFSI and actions taken as necessary, such as:

- Adjustment of aging-related degradation monitoring and inspection programs in AMPs described in the foregoing
- Modification of testing frequency based on operating experience
- Performance of mitigation activities

Each tollgate assessment should address the following elements:

- Utilize the performance criteria outlined below to evaluate the aging management program
- Correlate the performance criteria in the license application with one or more of the applicable ten program elements. It is not necessary to evaluate all ten elements; however, particular attention should be focused on the detection of aging effects (element 4), corrective action (element 7), and operating experience (element 10) as a minimum
- Perform a review of plant-specific and industry operating experience to confirm the effectiveness of aging management programs, utilizing the INPO database described below
- Use the following criteria to arrive at a conclusion regarding "effective"
    - Aging management program implementing activities are completed as scheduled
    - Industry and site-specific operating experience is routinely evaluated and program adjustments are made as necessary
    - Self-assessments are conducted and program adjustments are made as necessary.
    - No significant findings are identified from external assessments or internal audits.
- Ineffective programs or ineffective elements of programs would be addressed in the site's corrective action program
- Document the results of the effectiveness reviews, summarize in a tollgate assessment, and maintain as records available for audit and NRC inspection.

ISFSI's tollgates are shown in Table 18.13.1. Note that the implementation of these tollgates does not infer that ISFSI will wait until one of these designated times to evaluate information. ISFSI will continue to follow existing processes for addressing emergent issues, including the use of the corrective action program on site. These tollgates are specific times where an aggregate of information will be evaluated as a whole.

Table 18.13.1: Tollgate Assessments for HI-STORE ISFSI

Tollgate	Year	Assessment
1	See Note [1]	Perform an assessment of the AMP effectiveness considering the criteria in the license renewal application. It is not necessary to evaluate all ten elements; however, particular attention should be focused on the detection of aging effects (element 4), corrective action (element 7), and operating experience (element 10) as a minimum. This assessment should include information from the INPO AMID.
2	Tollgate 1 Year + 5	Evaluate additional information gained from the AMID and subsequent AMP inspections to update the assessment listed in Tollgate 1, to ensure continued AMP effectiveness.
3	Tollgate 2 Year + 5	Evaluate additional information gained from the AMID and subsequent AMP inspections to update the assessment listed in Tollgate 2, to ensure continued AMP effectiveness.
4	Tollgate 3 Year + 5	Evaluate additional information gained from the AMID and subsequent AMP inspections to update the assessment listed in Tollgate 3, to ensure continued AMP effectiveness.
5	Tollgate 4 Year + 5	Evaluate additional information gained from the AMID and subsequent AMP inspections to update the assessment listed in Tollgate 4, to ensure continued AMP effectiveness.
6	Tollgate 5 Year + 5	Evaluate additional information gained from the AMID and subsequent AMP inspections to update the assessment listed in Tollgate 5, to ensure continued AMP effectiveness.
7	Tollgate 6 Year + 5	Evaluate additional information gained from the AMID and subsequent AMP inspections to update the assessment listed in Tollgate 6, to ensure continued AMP effectiveness.
8	Tollgate 7 Year + 5	Evaluate additional information gained from the AMID and subsequent AMP inspections to update the assessment listed in Tollgate 7, to ensure continued AMP effectiveness.

<u>Notes</u>:
(1) The calendar year when the first MPC (37 or 89) completes 20 years of service life. If the first canister at HI-STORE already exceeds 20 years of service life, then the calendar year is the year of first canister placed in a VVM at HI-STORE.

18.14 TIMING OF AGING MANAGEMENT IMPLEMENTATION

18.14.1 Canisters

Based on the fact that canisters will be arriving at the HI-STORE CIS that may have been stored for extended period of time at other sites, it is important to identify when aging management will be performed. Regardless of when aging management begins, the canisters will still be required to undergo the acceptance testing described in Chapters 3 and 10.

Canister Age Less than 20 Years

If the canister arrives at HI-STORE at a date less than 20 years from the date of first being placed on a storage pad, aging management is not required. Once the canister reaches 20 years from first being placed on a storage pad, the aging management activities described in this chapter are implemented. The canister is added to all other canisters undergoing aging management and the selection criteria given in this chapter are utilized to determine which canisters need to be inspected.

Canister Age Greater than 20 Years

If the canister arrives at HI-STORE at a date greater than 20 years from the date of first being placed on a storage pad, the canister is added to the list of canisters undergoing aging management immediately. The selection criteria given in this chapter are utilized to determine which canisters need to be inspected.

18.14.2 All Other SSCs

For all other SSCs, which are constructed exclusively for the HI-STORE facility, the aging management activities described in this chapter are implemented once the SSC reaches 20 years from use for first loading. These may be separate dates for groups of HI-STORM UMAX VVMs, as the construction of HI-STORE is designed to be performed in stages.

Chapter 10 of HI-STORE SAR discusses the operations and maintenance procedures established for the equipment and lifting ancillaries used at HI-STORE CIS facility. The preoperational and startup testing programs, and other tests and inspections of ISFSI equipment are located in Section 10.2.2, and the normal operations and maintenance procedures are located in Section 10.3 of Chapter 10. Maintenance activities will be performed on brand new equipment and devices for 20 years prior to introduction of aging management, and it will be a combination of maintenance and aging management from thereon.

As mentioned earlier, maintenance activities at the ISFSI will be carried out on dates of different frequency. Overlapping of maintenance activity and aging management program may be expected at a future date. Hence, if aging management is scheduled within 1 year of a maintenance program, certain inspection activities may not need to be repeated, but the conditions of the SSC/device will have to meet the acceptance criteria per AMP.

18.15 AMELIORATING THE RISK OF CANISTER DEGRADATION OVER A LONG-TERM STORAGE DURATION

Industry data on SCC attack on austenitic stainless steels indicates that wet surfaces are more vulnerable to attack than dry surfaces. Maintaining the proximate air's relative humidity below 20%, as noted above, helps mitigate the risk of SCC. Noting that the canister's internal heat generation rate will decrease exponentially with the passage of time, its surface will get progressively cooler. After a long period in storage, the canister's surface may cool off sufficiently to allow moisture to reside on it. From the SCC perspective, this is not a welcome situation. To address this perverse effect of canister cool down, Holtec proposes to seek a license amendment at a later date that will permit the inlet and/or outlet ventilation passages to be progressively constricted so that the canister's surface remains warm and moisture free.

This approach is a part of the long-term AMP (many decades from now) that Holtec International expects to formalize and submit to the NRC for review.

18.16 RECOVERY PLAN

The AMP described in this chapter has been configured to provide an advance warning of the potential of loss of Confinement integrity in a loaded canister. The accelerated coupon testing and, if the coupon testing indicates onset of nucleation on the canister surface, then a comprehensive canister wall integrity determination using eddy current testing provide a reliable strategy to predict the risk of leakage well before such a problem would materialize.

Nevertheless, it is deemed prudent to have the ability to isolate an at-risk canister before leakage occurs. Towards this end, Holtec will insure that a HI-STAR 190 transport cask can be brought to the HI-STORE CIS site within 30 days after the site's Emergency Response organization identifies such a need.

Finally, it should be noted that there is adequate cross sectional and vertical space available in the VVM cavity to accommodate a highly conductive sequestration canister with a gasketed lid that can be used to isolate a leaking canister from the environment. Such a sequestration canister can be installed using the canister Transfer Facility using a set of steps that are ALARA. This sequestration canister will provide a defense-in-depth measure (in addition to the transport cask which provides a high integrity containment boundary) for dealing with an extenuating situation involving the likelihood of an impending canister leak at the HI-STORE CIS site.

CHAPTER 19: CONSOLIDATED REFERENCES

References cited throughout this SAR are compiled in this chapter. Each reference may be cited multiple times in multiple chapters. The context of the citation delineates the extent of reliance in this SAR on any particular reference. No reference, unless so stated, is invoked in its entirety. Each reference is identified by a decimal system (its native chapter. Section, and numeric sequence) and is enclosed in square brackets throughout this document. All Holtec origin documents are proprietary subject to 10CFR2.390 protection from dissemination except for Safety Analysis Reports which are available in redacted version in the Public Document Room. The unabridged version of any referenced Holtec document is shared with the USNRC upon request.

[1.0.1] Report to the Secretary of Energy, "Blue Ribbon Commission on America's Nuclear Future", January 2012. (https://energy.gov/sites/prod/files/2013/04/f0/brc_finalreport_jan2012.pdf)

[1.0.2] USNRC Regulatory Guide 3.50 "Standard Format and Content for a Specific License Application for an Independent Spent Fuel Storage Installation or Monitored Retrievable Storage Facility", Revision 2, September 2014.

[1.0.3] USNRC NUREG-1567, "Standard Review Plan for Spent Fuel Dry Storage Facilities", March 2000.

[1.0.4] "Environmental Report on The HI-STORE CIS Facility", Holtec Report 2167521, dated March 2017

[1.0.5] 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-level Radioactive Waste, and Reactor-Related Greater than Class C Waste", Title 10 of the Code of Federal Regulations- Energy, Office of the Federal Register, Washington, D.C.

[1.0.6] USNRC Docket 72-1040, "Final Safety Analysis Report on The HI-STORM UMAX Canister Storage System", Holtec Report No. HI-2115090, Revision 3. Submitted with Holtec Letter 5021032 (ML16193A336), dated June 30, 2016

[1.2.1] "Aging Assessment and Management Program for HI-STORE CIS", Holtec Report 2167378, Revision 3, dated January 2019

[1.2.2] NUREG/CR-6407, "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety", U.S. Nuclear Regulatory Commission, February 1996.

[1.2.3] ANSI/NSF Standard 61, "Drinking Water System Components – Health Effects", 2013.

[1.2.4] ANSI N14.6-1993, "American National Standard for Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4,500 Kg) or More", American National Standards Institute, Inc., Washington D.C., June 1993.

[1.2.5] Interim Staff Guidance (ISG) – 2, "Fuel Retrievability", Revision 1, February 22, 2010.

[1.2.6] Interim Staff Guidance (ISG) – 3, "Post Accident Recovery and Compliance with 10 CFR 72.122(l)"

[1.2.7] NUREG 0612, "Control of Heavy Loads at Nuclear Power Plants", U.S. Nuclear Regulatory Commission, Washington, D.C., July 1980.

[1.3.1] 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities", Title 10 of the Code of Federal Regulations, Office of the Federal Register, Washington, D.C.

[1.3.2] 10CFR Part 71, "Packaging and Transportation of Radioactive Material", Title 10 of the Code of Federal Regulations, Office of the Federal Register, Washington, D.C.

[1.3.3] USNRC Docket 72-1014, "Final Safety Analysis Report for the HI-STORM 100 Cask System", Holtec Report No. HI-2002444, Revision 14.

[1.3.4] USNRC Docket 72-1008, "Final Safety Analysis Report for the HI-STAR 100 Cask System", Holtec Report No. HI-2012610, Revision 3.

[1.3.5] USNRC Docket 71-9261, "Safety Analysis Report on the HI-STAR 100 Cask System", Holtec Report No. 951251, Revision 15.

[1.3.6] USNRC Docket 71-9373, "Safety Analysis Report on the HI-STAR 190 Package", Holtec Report No. 2146214, Revision 0.D.

[1.3.7] USNRC Docket 72-1032, "Final Safety Analysis Report on the HI-STORM FW System", Holtec Report No. HI-2114830, Revision 4.

[2.1.1] Eddy-Lea Energy Alliance. *Memorandum of Agreement with Holtec International*. April 2016.

[2.1.2] New Mexico Board of Finance. "Action Taken: Board of Finance Meeting." Governor's Cabinet Room – Fourth Floor, State Capitol Building – Santa Fe, New Mexico. July 19, 2016.

[2.1.3] Eddy-Lea Energy Alliance. *GNEP Siting Study*. 2007. (https://curie.ornl.gov/system/files/EDDY_LEA_Siting_Study_ML102440738.pdf)

[2.1.4] United States Department of Agriculture, Natural Resources Conservation Service (USDA/NRCS). 2016. Soil Survey Geographic (SSURGO) Database for Lea County, New Mexico. Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Available at: http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx , Accessed September 30, 2016.

[2.1.5] Dick-Peddie, W.A., W.H. Moir, and R. Spellberg. New Mexico Vegetation: Past, Present and Future. Albuquerque, NM: University of New Mexico Press.

[2.1.6] Federal Emergency Management Agency (FEMA). Flood Insurance Study, Lea County, New Mexico and Incorporated Areas. December 16, 2008.

[2.1.7] FEMA. FEMA Flood Map Service Center. Available at: http://msc.fema.gov/portal/search?AddressQuery=Lea%20County%2C%20new%20mexico#searchresultsanchor. Accessed October 2016.

[2.1.8] Holtec International. *Data Call for the CISF Environmental Report.* September 2016.

[2.1.9] U.S. Census Bureau (USCB). Table B01003, Total Population, American Community Survey 5-Year Estimates. Available at: http://factfinder.census.gov/bkmk/Table/1.0/en/ACS/11_5YR/B01003/0400000US35|0400000US48|0500000US35015|0500000US35025|0500000US48003|0500000US48165. Accessed on October 19, 2016.

[2.1.10] New Mexico Department of Workforce Solutions (NMDWS). New Mexico Annual Social and Economic Indicator, Statistical Abstract for Data Users, 2015. Available at: https://www.dws.state.nm.us/Portals/0/DM/LMI/ASEI_2015.pdf.

[2.1.11] Texas Demographic Center (Texas). Texas Population Projections. Available at: http://txsdc.utsa.edu/data/TPEPP/Projections/Index. Accessed on October 19, 2016.

[2.1.12] U.S. Census Bureau (USCB). Table GCT-PH1, Population, Housing Units, Area, and Density: 2010 – County, 2010 Census Summary File 1. Available at: http://factfinder.census.gov/bkmk/Table/1.0/en/DEC/10_SF1/GCTPH1.CY07/0500000US35015|0500000US35025|0500000US48003|0500000US48165.

[2.1.13] Environmental Justice Screen (EJSCREEN). EPA's Environmental Justice Screening and Mapping Tool (Version 2016). Location with 50-mile buffer. Available at: https://ejscreen.epa.gov/mapper/. Accessed on October 14, 2016.

[2.1.14] CEHMM. "Transient Employment." Email from Doug Lynn, Executive Director CEHMM, to Tetra Tech on July 27, 2017.

[2.1.15] International Isotopes Fluorine Products, Inc. (IIFP). Fluorine Extraction Process & Depleted Uranium De-conversion Plant (FEP/DUP) Environmental Report. December 27, 2009.

[2.1.16] AECOM. "Environmental Geology Assessment Report for Issues Related to the Proposed Ochoa Mine, Lea County, New Mexico." July 2012.

[2.1.17] CEHMM. "Oil and Gas Information." E-mail from Doug Lynn, Executive Director CEHMM, to Tetra Tech on July 31, 2017.

[2.1.18] Golder and Associates. Report to USDOI and USGS on Recommendations on Abandonment of the Will-Weaver Mine and Shafts. Prepared for the U.S. Geological Survey by Golder and Associates, November 1979.

[2.1.19] Intrepid Potash LLC. "Phone conversation with Mr. Robert Baldridge, Operations Manager for Intrepid Potash, and Jay Rose, Tetra Tech." July 25, 2017.

[2.1.20] New Mexico Bureau of Mines and Minerals Resources (NMBMMR). "Potash in New Mexico." February 1980.

[2.1.21] United Nations Environment Programme (UNEP). "Environmental Aspects of Phosphate and Potash Mining. 2001.

[2.1.22] U.S. Geological Survey (USGS). "Geological Survey Circular 876-- Subsidence from Underground Mining: Environmental Analysis and Planning Considerations." 1983.

[2.1.23] CEHMM. "Holtec HI-Store Facility Area GIS Conflict Analysis." October 7, 2016.

[2.1.24] GEI Consultants (GEI). "Geotechnical Data Report: HI-STORE CISF Phase 1 Site Characterization." February 2018.

[2.2.1] CEHMM. "Pipeline Information." E-mail from Doug Lynn, Executive Director CEHMM, to Tetra Tech on July 27, 2017.

[2.2.2] C-FER Technologies, Stephens, Mark. "A Model for Sizing High Consequence Areas Associated with Natural Gas Pipelines." October 2000.

[2.2.3] National Transportation Safety Board (NTSB). "Pipeline Accident Report PAR-03-01, dated August 19, 2000." Available at: NTSB.gov. Accessed July 2017.

[2.2.4] Pipeline and Hazardous Materials Safety Administration (PHMSA). "Pipeline Safety." Available at: https://www.phmsa.dot.gov/. Accessed July 2017.

[2.2.5] Not Used

[2.2.6] Not Used

[2.2.7] National Hazardous Materials Route Registry (NHMRR). U.S. Department of Transportation. Available at: www.fmcsa.dot./gov/regulations/hazardous-materials/national-hazardous-materials-route-registry-state. Accessed on July 18, 2017.

[2.2.8] United States Department of Transportation (USDOT) Bureau of Transportation Statistics. "State Transportation Statistics." Available at: www.bts.gov. Accessed on July 18, 2017.

[2.2.9] New Mexico Department of Transportation (NMDOT). "Road Segments by Posted Route/Point with (AADT) Info." Email from Jessica Crane, NMDOT, to Tetra Tech. November 30, 2016

[2.2.10] NMDOT. "New Mexico Freight Plan." Available at: dot.state.nm.us/content/dam/nmdot/planning/nm_2040_plan-freight_plan.pdf. August 2015.

[2.2.11] Department of Energy (DOE). *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement.* DOE/EIS-0026-S2. September. Available at: http://energy.gov/nepa/eis-0026-s2-waste-isolation-pilot-plant-disposal-phase-carlsbad-new-mexico.

[2.2.12] DOE. *Waste Isolation Pilot Plant Annual Site Environmental Report for 2014.* DOE/WIPP-15-8866. September 2015.

[2.2.13] NRC. *Environmental Impact Statement for the Proposed National Enrichment Facility in Lea County, New Mexico*. NUREG-1790. June 2005.

[2.2.14] NRC. *Environmental Impact Statement for the Proposed Fluorine Extraction Process and Depleted Uranium Deconversion Plant in Lea County, New Mexico.* NUREG-2113. August 2012.

[2.2.15] Waste Control Specialists. "WCS Consolidated Interim Spent Fuel Storage Facility Environmental Report." May 2016. (Compiled from ADAMS Numbers: ML16133A137, ML16133A161, ML16133A158, ML16133A139, ML16133A162, ML16133A153, ML16133A151, ML16133A146, ML16133A145, ML16133A144, ML16133A143, ML16133A142, ML16133A099)

[2.2.16] U.S. Department of Transportation Federal Aviation Administration, Albuquerque VFR Sectional Chart, 101st Edition, 4/26/2018

[2.2.17] U.S. Department of Transportation Federal Aviation Administration, Order JO 7400.11B "Airspace Designations and Reporting Points", 8/3/2017

[2.2.18] U.S. Department of Transportation Federal Aviation Administration, Order 8260.19H "Flight Procedures and Airspace", 7/20/2017

[2.2.19] U.S. Department of Defense National Geospatial-Intelligence Agency, AP/1B "Flight Information Publication: Area Planning: Military Training Routes: North and south America", 3/29/2018

[2.2.20] U.S. Department of Transportation Federal Aviation Administration, "Aeronautical Information Services: Aeronautical Chart User's Guide", 3/29/2018

[2.2.21] 14 CFR Part 1.1, "Aeronautics and Space Definitions and Abbreviations", Title 14 of the Code of Federal Regulations – Transportation, Federal Aviation Administration, Washington, D.C.

[2.2.22] U.S. Department of Transportation Federal Aviation Administration, FAA Form 5010-1 "FAA Airport Master Record for ATS" Available at: http://www.gcr1.com/5010web/airport.cfm?Site=ATS&AptSecNum=2 , Accessed on 5/18/2018.

[2.2.23] U.S. Department of Transportation Federal Aviation Administration, FAA Form 5010-1 "FAA Airport Master Record for CNM" Available at: http://www.gcr1.com/5010web/airport.cfm?Site=CNM&AptSecNum=2 , Accessed on 5/18/2018.

[2.2.24] U.S. Department of Transportation Federal Aviation Administration, FAA Form 5010-1 "FAA Airport Master Record for HOB" Available at: http://www.gcr1.com/5010web/airport.cfm?Site=HOB&AptSecNum=2 , Accessed on 5/18/2018.

[2.2.25] U.S. Department of Transportation Federal Aviation Administration, FAA Form 5010-1 "FAA Airport Master Record for E06" Available at: http://www.gcr1.com/5010web/airport.cfm?Site=E06&AptSecNum=2 , Accessed on 5/18/2018.

[2.2.26] U.S. Department of Transportation Federal Aviation Administration, FAA Form 5010-1 "FAA Airport Master Record for MAF" Available at: http://www.gcr1.com/5010web/airport.cfm?Site=MAF&AptSecNum=2 , Accessed on 5/18/2018.

[2.2.27] U.S. Department of Transportation Federal Aviation Administration, FAA Form 5010-1 "FAA Airport Master Record for ROW" Available at: http://www.gcr1.com/5010web/airport.cfm?Site=ROW&AptSecNum=2 , Accessed on 5/18/2018.

[2.2.28] U.S. Department of Transportation Federal Aviation Administration, Air Traffic Activity Data System (ATADS)

[2.2.29] U.S. Department of Transportation Federal Aviation Administration, Order 8260.3D "United States Standard for Terminal Instrument Procedures (TERPS)", 2/16/2018

[2.2.30] Jeppesen, Instrument Approach Chart 12-3, CNM Cavern City Air Terminal, RNAV (GPS) Runway 21

[2.2.31] Jeppesen, Instrument Approach Chart 11-1, HOB Lea County Regional Airport, ILS or LOC Runway 3, 12/29/2017

[2.2.32] Email Correspondence from Dyess AFB Airspace Manager Dwight Williams, "RE: [Non-DoD Source] Facility locations in Eddy and Lea Counties New Mexico." to Beth Bennington, Thursday, March 22, 2018

[2.2.33] NUREG 0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants", U.S. Nuclear Regulatory Commission, Washington, D.C., March 2010

[2.2.34] 14 CFR Part 91, "General Operating and Flight Rules", Title 14 of the Code of Federal Regulations – Transportation, Federal Aviation Administration, Washington, D.C.

[2.2.35] U.S. Department of Transportation Federal Aviation Administration, "ENR 5.2 Military Exercise and Training Areas", Aeronautical Information Publication, 24th edition, 3/29/2018

[2.2.36] AirNav, LLC, AirNav Airport Information Database, https://www.airnav.com/airport/

[2.2.37] Holtec International, "HI-STORE CIS Aircraft Crash Assessment", Holtec Report No. HI-2188201, Revision 0

[2.2.38] Memorandum for John F. Cordes, Director, Office of Commission Appellate Adjudication, dated November 14, 2001, Subject: Staff Requirements – Affirmation Session, 8:55 A.M., Wednesday, November 14, 2001, Reference M011114A.

[2.3.1] Western Regional Climate Center Hobbs, Lea County Airport data. Available at: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nm4028. Accessed on October 14, 2016.

[2.3.2] Holzworth, G.C. Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout The Contiguous United States. January 1972.

[2.3.3] Greer. American Meteorological Society. Glossary of Weather and Climate. 1996.

[2.3.4] National Oceanic and Atmospheric Administration (NOAA). Enhanced F Scale for Tornado Damage. Available at: http://www.spc.noaa.gov/faq/tornado/ef-scale.html. Accessed on October 14, 2016.

[2.3.5] Tornado history. Available at: http://www.tornadohistoryproject.com/tornado/New-Mexico/. October 14, 2016.

[2.4.1] Eddy-Lea Energy Alliance (ELEA). GNEP Siting Study. 2007.

[2.4.2] CEHMM. "Holtec Hi-Store Facility Area GIS Conflict Analysis." October 7, 2016.

[2.4.3] Federal Emergency Management Agency (FEMA). FEMA Flood Map Service Center. Available at: https://msc.fema.gov/portal.

[2.4.4] "Hydrologic Features." 32.583, -103.708. Google Earth. February 1, 2017. Accessed on: July 21, 2017.

[2.4.5] State of New Mexico Interstate Stream commission, Office of the State Engineer. Lea County Regional Water Plan 1999. Available at: http://www.ose.state.nm.us/Planning/RWP/region_16.php.

[2.4.6] State of New Mexico Interstate Stream commission, Office of the State Engineer. Lea County Regional Water Plan 2016. Available at: http://www.ose.state.nm.us/Planning/RWP/Regions/16_Lea%20County/2016/Reg%2016_Lea%20County_Regional%20Water%20Plan%202016_December%202016.pdf

[2.4.7] NatureServe. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Databases. Arlington, VA. U.S.A. 2009.

[2.4.8] NatureServe. Madrean Archipelago Rapid Ecoregional Assessment Pre-Assessment Report. Arlington, Virginia. 2013.

[2.4.9] U.S. Geological Survey (USGS), National Geospatial Program. 3D Elevation Program Digital Elevation Model Resolution 1/3 arc second (10 meters). https://nationalmap.gov

[2.4.10] New Mexico Resource Geographic Information System. Hydrologic Unit Boundary "New Mexico HUC-12 Boundaries", http://rgis.unm.edu/

[2.4.11] U.S. Department of Agriculture, National Resources Conservation Service. NRCS Web Survey. https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

[2.4.12] U.S. Fish and Wildlife Service. National Wetlands Inventory, Wetlands-Data. Available at: https://www.fws.gov/wetlands/data/Google-Earth.html.

[2.4.13] NOAA. NOAA Atlas 14 Point Precipitation Frequency Estimates: NM. Available at: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

[2.4.14] Bonnin, M., D. Martin, B. Lin, T. Parzybok, M. Yekta, and D. Riley, "Precipitation Frequency Atlas of the United States: NOAA Atlas 14, Volume 1: Semiarid Southwest (Arizona, Southeast California, Nevada, New Mexico, Utah)," Version 5.0, Silver Spring, MD: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, 2011.

[2.5.1] New Mexico Office of the State Engineer (NMOSE). Declared Underground Water Basins Map. Available at: http://www.ose.state.nm.us/GIS/maps.php. Accessed October 2016.

[2.5.2] Nicholson, Alexander Jr. and Alfred Clebsch, Jr. 1963. Ground-water Report 6, Geology and Ground-water Condition in Southern Lea County, New Mexico. State Bureau of Mines and Mineral Resources, New Mexico Institute of Mining and Technology. 1963.

[2.6.1] Powers, D. W., Lambert, S. J., Shaffer, S. E., Hill, L. R., and Weart, W. D., eds., 1978, Geological Characterization Report for the Waste Isolation Pilot Plant (WIPP) Site, Southeastern New Mexico. SAND78-1596, Vols. I and II. Sandia National Laboratories.

[2.6.2] Nuclear Regulatory Commission (NRC). Safety Evaluation Report for the National Enrichment Facility in Lea County, New Mexico, Louisiana Energy Services (NUREG-1827), Available at: http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1827/, Accessed October 28, 2016.

[2.6.3] United States Geological Survey (USGS). Earthquake Archive Search. Available at: http://earthquake.usgs.gov/earthquakes/search/. Accessed on September 29, 2016.

[2.6.4] USGS. Earthquake Probability Mapping, 2009 PSHA Model. United States Geological Survey. Available at: http://geohazards.usgs.gov/eqprob/2009/. Accessed on October 13, 2016.

[2.6.5] Sanford A., Balch, R., and Delap S., 1993, Report 68: A Review of the Seismicity and Seismic Risk at the WIPP Site, Geoscience Department and Geophysical Research Center, New Mexico Tech. Available at: https://www.ees.nmt.edu/images/ees/Geop/nmquakes/R68/R68.HTM Accessed October 24, 2016.

[2.6.6] Safety Evaluation Report for Approval of DOE/WIPP 07-3372, Waste Isolation Pilot Plant Documented Safety Analysis, Revision 5 and DOE/WIPP 07-3373, Waste Isolation Pilot Plant Technical Safety Requirements, Revision 5

[2.6.7] USGS. Quaternary Faults in Google Earth. Available at: http://earthquake.usgs.gov/hazards/qfaults/google.php . Accessed on September 29, 2016.

[2.6.8] USGS. Geologic Hazards Map. Available at: http://geohazards.usgs.gov/hazards/apps/cmaps/ . Accessed September on 30, 2016.

[2.6.9] Mineral Lease Relinquishment Agreement between Intrepid Potash and Holtec International, October 5, 2016.

[2.6.10] 10 CFR Part 100, "Reactor Site Criteria", Title 10 of the Code of Federal Regulations, Office of the Federal Register, Washington, D.C.

[2.6.11] USNRC Regulatory Code 1.198, "Procedures and Criteria for Assessing Seismic Liquefaction at Nuclear Power Sites", November 2003.

[2.6.12] Youd, T.L., et al. "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils." American Society of Civil Engineers, Journal of Geotechnical and Geoenvironmental Engineering, October 2001.

[2.7.1] Regulatory Guide 1.76, "Design Basis Tornado and Tornado Missiles for Nuclear Power Plants," United States Nuclear Regulatory Commission, March 2007.

[2.7.2] ANSI/ANS 57.9-1992, "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)", American Nuclear Society, LaGrange Park, IL, May 1992.

[3.0.1] ASME NOG-1, Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder), American Society of Mechanical Engineers, New York, 2015.

[3.1.1] Holtec International & Eddy Lea Energy Alliance (ELEA) Underground Consolidated Interim Storage Facility – Physical Security Plan, Holtec Report HI-2177559, Latest Revision.

[3.1.2] 49 CFR 171, "General Information, Regulations, and Definitions," Title 49 of the Code of Federal Regulations – Transportation, Office of the Federal Register, Washington, D.C.

[3.1.3] 49 CFR 172, "Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, Training Requirements, and Security Plans," Title 49 of the Code of Federal Regulations – Transportation, Office of the Federal Register, Washington, D.C.

[3.1.4] 49 CFR 174, "Carriage by Rail," Title 49 of the Code of Federal Regulations – Transportation, Office of the Federal Register, Washington, D.C.

[3.1.5] 49 CFR 177, "Carriage by Public Highway," Title 49 of the Code of Federal Regulations – Transportation, Office of the Federal Register, Washington, D.C.

[4.0.1] ISG-11, "Cladding Considerations for the Transport and Storage of Spent Fuel," USNRC, Washington, DC, Revision 3, November 17, 2003.

[4.2.1] Holtec Position Paper DS-381, "Guidelines for Specifying ITS Categories," Revision 0, dated October 8, 2012

[4.2.2] Holtec Standard Procedure HSP 345, Important-to-Safety Classification Procedure.

[4.3.1] ASLB Hearings, Private Fuel Storage, LLC, Docket # 72-22-ISFSI, ASLBP 97-732-02-ISFSI, February 2005.

[4.3.2] U.S. Nuclear Regulatory Commission, Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants," Revision 1, 1973.

[4.3.3] U.S. Nuclear Regulatory Commission, Regulatory Guide 1.92, "Combining Modal Responses and Spatial Components in Seismic Response Analysis," Revision 2, 2006.

[4.3.4] ASCE 4-16, "Seismic Analysis of Safety-Related Nuclear Structures," American Society of Civil Engineers, 2017.

[4.3.5] "HI-STORE Bearing Capacity and Settlement Calculations", Holtec Report HI-2188143, Revision 0.

[4.5.1] ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NF - Supports, 2010.

[4.5.2] Crane Manufacturer's Association of America (CMAA), Specification #70, 1988, Section 3.3.

[4.5.3] ASME Boiler and Pressure Vessel Code, Welding, Section IX, 2010.

[4.5.4] AWS D1.1:2006 Structural Welding Code – Steel, 2008.

[4.5.5] ISO 9001:2008, Quality Management Systems.

[4.5.6] American Society of Mechanical Engineers, American National Standard, Safety Standards, “Slings”, ASME B30.9, 1971

[4.5.7] National Fire Protection Association (NFPA), NFPA 70, “National Electric Code”.

[4.5.8] American Society of Mechanical Engineers, American National Standard, Safety Standards, “Jacks”, ASME B30.1-2009.

[4.5.9] American Institute for Steel Construction (AISC), Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design, 13th Edition.

[4.5.10] ASTM D92, “Standard Test Method for Flash and Fire Points”.

[4.5.11] American National Standard Institute, “Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)”, ANSI B30.2, 1976.

[4.5.12] National Fire Protection Association NFPA 10-2013 Standard for Portable Fire Extinguishers.

[4.6.1] ANSI/ASCE 7-05 (formerly ANSI A58.1), “Minimum Design Loads for Buildings and Other Structures,” American Society of Civil Engineers, 2006.

[4.6.2] ASCE 7-10, “Minimum Design Loads for Building and Other Structures,” American Society of Civil Engineers, 2013.

[4.6.3] ASME Boiler and Pressure Vessel Code, Section II, Part D, Properties, 2010.

[4.6.4] International Building Code (IBC), International Code Council, 2015.

[5.3.1] ACI-318 (2005), Building Code Requirements for Structural Concrete (ACI 318-05) and Commentary (ACI 318R-05), American Concrete Institute, 2005.

[5.3.2] Boresi, A. et al., Advanced Mechanics of Materials, John Wiley and Sons, Third Edition.

[5.4.1] U.S. Nuclear Regulatory Commission, “Standard Review Plan Chapter 3.7.1 – Seismic Design Parameters”, Revision 3, March 2007.

[5.4.2] LS-DYNA, Version 971, Livermore Software Technology, 2012.

[5.4.3] ASME BTH-1-2011, Design of Below-the-Hook Lifting Devices, January 2012.

[5.4.4] “Regulatory Guide 1.60 Time Histories Using EZ-FRISK”, Holtec Report HI-2146083, Revision 2.

[5.4.5] ASCE/SEI 43-05, Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities, American Society of Civil Engineers, 2005.

[5.4.6] "Structural Calculation Package for HI-STORE CIS Facility", Holtec Report HI-2177585, Revision 0.

[5.4.7] "Structural Calculation Package for the HI-STORM UMAX System", Holtec Report HI-2125228, Revision 9.

[5.5.1] ANSYS (Versions up to 17.1), SAS IP, Inc., 2016.

[6.4.1] FLUENT Computational Fluid Dynamics Software, Fluent, Inc., Centerra Resource Park, 10 Cavendish Court, Lebanon, NH 03766.

[6.4.2] "Topical Report on the HI-STAR/HI-STORM Thermal Model and its Benchmarking with Full-Size Cask Test Data," Holtec Report HI-992252, Revision 1, Holtec International, Marlton, NJ, 08053.

[6.4.3] "Standard for Verification and Validation in Computational Fluid Dynamics and Heat Transfer", ASME V&V 20-2009.

[6.4.4] "Procedure for Estimating and Reporting of Uncertainty due to Discretization in CFD Applications", I.B. Celik, U. Ghia, P.J. Roache and C.J. Freitas (Journal of Fluids Engineering Editorial Policy on the Control of Numerical Accuracy).

[6.4.5] Perry, Robert.H., Perry's Chemical Engineers' Handbook, Sixth Edition, Texas: McGraw-Hill, pg. 3-167, 1984.

[6.4.6] "Fuel, Weather and Considerations", United States Department of Agriculture, Forest Service Southern Region, February 1989; Technical Publication R8-TP 11.

[6.4.7] "HI-STORE CTF Thermal Evaluation", Holtec Report HI-2177597, Rev. 0.

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

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

[6.5.3] "Evaluation of Effects of Tracked VCT Fire on HI-STORM FW System", Holtec Report HI-2135677, Latest Revision.

[6.5.4] "Thermal Analysis of HI-TRAC CS Transfer Cask", Holtec Report HI-2177553, Revision 0.

[6A.1] Darr, J.H., and S.P. Vanka, "Separated flow in a driven trapezoidal cavity", Physics Fluids A, 3, 3, 385-392, (March 1991).

[6A.2] Young, D.F. and F.Y. Tsai, "Flow characteristics in models of arterial stenoses-I steady flow", Journal of Biomechanics, 6, 395-410, (1973).

[6A.3] Coutanceau, M. and J.R. Defaye, "Circular cylinder wake configurations - A flow visualization survey", Applied Mechanics Review, 44, 6, (June 1991).

[6A.4] Braza, M.P. Chassaing and H.H. Minh, "Numerical study and physical analysis of the pressure and velocity fields in the near wake of a circular cylinder", Journal of Fluid Mechanics, 165, 79-130, (1986).

[6A.5] Hayes, R.E., K. Nandkumar and H. Nasr-El-Din, "Steady laminar flow in a 90 degree planar branch", Computers and Fluids, 17, 4, 537-553, (1989).

[6A.6] Kuehn, T.H. and R.J. Goldstein, "An experimental study of natural convection heat transfer in concentric and eccentric horizontal cylinder annuli", Journal of Heat Transfer, 100, 635-640, (1978).

[6A.7] Yucel, A., S. Acharya and M.L. Williams, "Natural convection and radiation in a square enclosure", Numerical Heat Transfer, Part A, 15, 261-278, (1989).

[6A.8] Sorensen, J.N. and T.P. Loc, "Higher-order axisymmetric Navier-Stokes Code: Description and evolution of boundary conditions", International Journal for Numerical Methods in Fluids, 9, 1517-1537, (1989).

[6A.9] Michelsen, J.A., "Modelling of laminar incompressible rotating fluid flow", AFM 86-05, Ph.D. dissertation, Department of fluid mechanics, Technical University of Denmark, (1986).

[6A.10] Eidelman, S., P. Collela and R.P. Shreeve, "Application of the Godunov method and its second-order extension to cascade flow modelling", AIAA Journal, 22, 1609-1615, (1984).

[6A.11] Karki, K.C., "A calculational procedure for viscous flows at all speeds in complex geometries", Ph.D. Thesis, U. of Minnesota, (1986).

[6A.12] Vogel, J.C. and J.K. Eaton, "Combined heat transfer and fluid dynamic measurements downstream of a backward facing step", Journal of Heat Transfer, 107, 922-929, (1985).

[6A.13] Antonopoulos, K.A., "The prediction of turbulent inclined flow in rod bundles", Computers and Fluids, 14, 4, 361-378, (1986).

[6A.14] Humphrey, T.A.C., A.M.K. Taylor and J.H. Whitelaw, "Laminar flow in a square duct of strong curvature", Journal of Fluid Mechanics, 83, 509-527, (1977).

[6A.15] Rogers, S.E., D. Kwak and C. Kiris, "Steady and Unsteady Solutions of the Incompressible Navier-Stokes Equations", AIAA Journal, 29, 4, 603-610, (April 1991).

[6A.16] Yeo, R.N., P.E. Wood and A.N. Hrymak, "A numerical study of laminar 90-degree bend duct flow with different discretization schemes", Journal of Fluid Engineering, 113, 563-568, (December 1991).

[6A.17] Bradley, D., L.A. Kwa, A.K.C. Lau, M. Missaghi and S.B. Chin, "Laminar Flamelet modelling of recirculating premixed methane and propane-air combustion", Combustion and Flame, 71, 109-122, (1988).

[6A.18] Kakac, S., R.K. Shah and W. Aung, "Handbook of single-phase convective heat transfer", Wiley interscience, NY, (1987).

[6A.19] Stanitz, J.D., W.M. Osborn and Mizisin, "An experimental investigation of secondary flow in an accelerating rectangular elbow with 90 degree turning", NACA-TN-30150, (1953).

[6A.20] EPRI, "The TN-24P PWR Spent Fuel Storage Cask: Testing and Analyses, EPRI ND-5128, April 1987.

[6A.21] "Topical Report on the HI-STAR/HI-STORM Thermal Model and its Benchmarking with Full-Size Cask Test Data", Holtec Report HI-992252, Revision 1.

[7.0.1] Safety Evaluation Report for the HI-STORM UMAX System, Amendment 0, dated April 2, 2015, ML15093A510.

[7.0.2] Safety Evaluation Report for the HI-STORM UMAX System, Amendment 1, dated September 8, 2015, ML15252A423.

[7.0.3] Safety Evaluation Report for the HI-STORM UMAX System, Amendment 2, dated January 6, 2017, ML16341B129.

[7.4.1] 10 CFR Part 20 "Standards for Protection Against Radiation," Title 10, of the Code of Federal Regulations – Energy, Office of the Federal Register, Washington, D.C.

[7.4.2] HI-STORE CIS Facility Site Boundary Dose Rates Calculations for HI-STORM UMAX System" HI-2177599 Revision 1. Holtec International.

[8.0.1] Safety Evaluation Report for the HI-STORM FW System, Amendment 0, dated July 14, 2011, ML111950325.

[8.0.2] Safety Evaluation Report for the HI-STORM FW System, Amendment 1, dated December 17, 2014, ML14351A475.

[8.0.3] Safety Evaluation Report for the HI-STORM FW System, Amendment 2, dated October 25, 2016, ML16280A302.

[10.1.1] HI-STORE CISF Specialist Training Program.

[10.1.2] ANSI N18.1. "Selection and Training of Nuclear Power Plant Personnel", American National Standards Institute, Inc., Washington D.C., 1971.

[10.1.3] HI-STORE CISF Radiation Protection Technician Training Program.

[10.2.1] U.S. Nuclear Regulatory Commission, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste", Regulatory Guide 1.21, Revision 2, June 2009.

[10.3.1] 49 CFR 173, "Shippers – General Requirements for Shipments and Packagings," Title 49 of the Code of Federal Regulations – Transportation, Office of the Federal Register, Washington, D.C.

[10.3.2] American Society for Nondestructive Testing, "Personnel Qualification and Certification in Nondestructive Testing," Recommended Practice No. SNT-TC-1A, December 1992.

[10.3.3] ANSI N14.5, American National Standard for Radioactive Materials – Leakage Tests on Packages for Shipment, 2014.

[10.5.1] Holtec CISF Emergency Response Plan, Holtec Report HI-2177535, dated March 2017.

[11.1.1] *U.S. Code of Federal Regulations,* Title 10, "Energy" Part 19 "Notices, Instructions and Reports to Workers: Inspection and Investigations".

[11.1.2] U.S. Nuclear Regulatory Commission "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power at Nuclear Power Stations will be As Low As Reasonably Achievable", Regulatory Guide 8.8, June 1978.

[11.1.3] U.S. Nuclear Regulatory Commission, "Operating Philosophy for Maintaining Occupational and Public Radiation Exposures As Low As is Reasonably Achievable", Regulatory Guide 8.10, Revision 2, August 2016.

[11.4.1] U.S. Nuclear Regulatory Commission "Personnel Monitoring Device – Direct-Reading Pocket Dosimeters" Regulatory Guide 8.4, Revision 1. June 2011.

[11.4.2] NUREG/CR-0041, "Manual of Respiratory Protection Against Airborne Radioactive Material" U.S. Nuclear Regulatory Commission, Revision 1. January 2001.

[12.0.1] Holtec International Quality Assurance Program, Latest Approved Revision on Docket 71-0784.

[13.3.1] Holtec Report HI-2177558, "Holtec International & Eddy Lea Energy Alliance (ELEA) Underground Consolidated Interim Storage Facility - Decommissioning Plan," dated March 2017

[13.3.2] Holtec Report HI-2177565, "Holtec International & Eddy Lea Energy Alliance (ELEA) CIS Facility - Decommissioning Cost Estimate and Funding Plan".

[13.3.3] NUREG-1757 Volume 1, "Consolidated Decommissioning Guidance".

[13.3.4] NUREG-1757 Volume 3, "Consolidated Decommissioning Guidance, Financial Assurance, Recordkeeping and Timeliness".

[13.3.5] R.S. Means, Construction Cost Data, 2017.

[15.3.1] NUREG-1536, "Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility", Rev 1, U.S. Nuclear Regulatory Commission, Washington, DC.

[16.0.1] HI-STORM UMAX CoC, Amendments 0, 1, 2, Issued April 6, 2015, September 8, 2015 and January 9, 2017 respectively.

[16.0.2] Proposed HI-STORE CIS Facility License SNM-1051, Appendix A (Technical Specifications), Revision 0, March 31, 2017.

[17.0.1] ISG-15, "Materials Evaluation," USNRC, Washington D.C., dated January 10, 2001

[17.2.1] Morgan Thermal Ceramics Inc., Product Data Sheet for Blanket Products (Kaowool® Blanket).

[17.2.2] "Properties, Behavior and Construction Use of Controlled Low Strength Material (CLSM) (U)," Engineering Studies Research Report K-ESG-G-00004, Revision 1.0, September 2002, Geotechnical Engineering Group.

[17.2.3] "Guide Specification for Controlled Low Strength Materials (CLSM)", National Ready Mixed Concrete Association, Silver Spring, MD.

[17.3.1] ASME Boiler and Pressure Vessel Code, Section II, Part A – Ferrous Material Specifications," American Society of Mechanical Engineers, New York, NY, 2010 Edition.

[17.3.2] ASME Boiler and Pressure Vessel Code, Section III, Appendices, 2010 Edition.

[17.7.1] Reg. Guide 1.54, "Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants", Revision 2, US Nuclear Regulatory Commission, Washington, DC.

[17.7.2] ASTM D 3843-00, "Standard Practice for Quality Assurance for Protective Coatings Applied to Nuclear Facilities", ASTM International, West Conshohocken, PA.

[17.7.3] ANSI C 210-03, "Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipes".

[17.7.4] ASTM D4082-10, "Standard Test Method for Effects of Gamma Radiation on Coatings for use in Nuclear Power Plants", ASTM International, West Conshohocken, PA.

[17.10.1] Rogers Corporation, Product Data Sheet for BISCO® Silicones (BF-1000 – Extra Soft Cellular Silicone).

[17.11.1] SECY-14-0072, "Final Rule: Continued Storage of Spent Nuclear Fuel," dated July 14, 2014, as supported by NUREG-2157, "Generic Environmental Impact Statement for Continued Storage of Spent Nuclear Fuel".

[18.0.1] NUREG-1927, "Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel" Revision 1 – USNRC 2016 ADAMS # ML16179A148.

[18.0.2] NEI 14-03, "Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management for Dry Cask Storage" Revision 1 – NEI 2015 ADAMS # ML15272A329.

[18.3.1] USNRC Docket 72-1014, "Final Safety Analysis Report on the HI-STORM 100 Cask System", Holtec Report No. HI-2002444, Revision 1.

[18.4.1] "MPC Surface Inspection of Diablo Canyon Power Plant", Holtec Report No. HI-2146301, Revision 2.

[18.5.1] "Susceptibility Assessment Criteria for Chloride-Induced Stress Corrosion Cracking (CISCC) of Welded Stainless Steel Canisters for Dry Cask Storage Systems", EPRI Report No. 3002005371, 2015.

[18.5.2] ASTM G 30, "Standard Practice for Making and Using U-Bend Stress Corrosion Test Specimens", ASTM ,100 Barr Harbor Drive, W Conshohocken, PA 19428-2959, 1997.

[18.5.3] ASTM G 1, "Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens", ASTM 100 Barr Harbor Drive, W Conshohocken, PA 19428, 2011.

[18.5.4] ASME Section V, "Nondestructive Examination", Two Park Avenue, New York, NY 10016, 2015.