UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION REPORT

Docket No. 72-1040
HI-STORM UMAX Canister Storage System
Holtec International, Inc.
Certificate of Compliance No. 1040

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1 SUMMARY

By letter dated June 29, 2012, as supplemented July 16, November 20, 2012, and January 30, April 2, April 19, June 21, August 28, December 6, December 31, 2013, and January 13, and 28, 2014, Holtec International (Holtec) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) for the HI-STORM UMAX Canister Storage System, Certificate of Compliance (CoC) No. 1040. The proposed application intends to provide an underground storage option compatible with the Holtec HI-STORM Flood/Wind (FW) Multipurpose Canister (MPC) System, CoC No. 1032.

This safety evaluation report (SER) documents the review and evaluation of the proposed application. The SER uses the same section-level format provided in NUREG-1536, Revision 1, "Standard Review Plan for Dry Cask Storage Systems," with some differences implemented for clarity and consistency. The NRC staff (staff) followed the guidance of NUREG-1536, Revision 1, Interim Staff Guidance (ISG) -11, "Cladding Considerations for the Transportation and Storage of Spent Fuel" and ISG-21, "Use of Computational Modeling Software" in performing its regulatory evaluation. Unless specifically identified, staff findings and conclusions have been made using these guidance documents as the bases of determination.

The staff's assessment is to determine that CoC No. 1040, meets the applicable requirements of 10 CFR Part 72 for independent storage of spent fuel and of 10 CFR Part 20 for radiation protection.

1.1 General Information Evaluation

The objective of the review of the general information evaluation of the HI-STORM UMAX Canister Storage System is to ensure that Holtec has provided a description that is adequate to familiarize reviewers and other interested parties with the pertinent features of the system.

1.2 HI-STORM UMAX CANISTER STORAGE SYSTEM GENERAL DESCRIPTION AND OPERATIONAL FEATURES

In Section 1.2 of the FSAR, the applicant provides the general description and operational features of the this system. According to the applicant, the HI-STORM (acronym for Holtec International Storage Module) UMAX Canister Storage System is a spent nuclear fuel storage

system designed to be in full compliance with the requirements of 10 CFR Part 72. The model designation "UMAX" denotes underground – maximum capacity. The proposed application intends to provide an underground storage option compatible with the Holtec HI-STORM Flood/Wind (FW) System as described in the HI-STORM FW Final Safety Analysis Report (FSAR). The underground structure system is described in the HI-STORM UMAX Canister Storage System FSAR. Unless designated otherwise in this SER the term “FSAR” denotes the HI-STORM UMAX Canister Storage System FSAR.

The HI-STORM UMAX Canister Storage System stores a hermetically sealed canister containing spent nuclear fuel (SNF) in an in-ground vertical ventilated module (VVM). The HI-STORM UMAX Canister Storage System is designed to provide long-term underground storage of loaded multi-purpose canisters (MPC) previously certified for storage in CoC No. 1032. The HI-STORM UMAX VVM is the underground equivalent of the HI-STORM FW storage module. Although the storage cavity dimensions and the air ventilation system in the HI-STORM UMAX VVM have been selected to enable it to also store all MPCs certified for storage in the HI-STORM 100 storage module, the proposed CoC No. 1040 does not seek to support the certification of all MPCs certified for storage in the HI-STORM 100 storage module at this time. The applicant explains that safety analyses and evaluations of the HI-STORM 100 MPCs under storage in HI-STORM UMAX are nevertheless included in HI-STORM UMAX FSAR, as appropriate, to provide a comparative reference for the licensing-basis analyses of the HI-STORM FW canisters (MPC-37 & MPC-89).

The applicant states that the HI-STORM UMAX Canister Storage System can store either PWR or BWR fuel assemblies, in the MPC-37 or MPC-89, respectively. The number associated with the MPC is the maximum number of fuel assemblies the MPC can contain in the fuel basket. The external diameters of the MPC-37 and MPC-89 are identical to allow the use of a single storage module design, however the height of the MPC, as well as the storage module and transfer cask, are variable based on the SNF to be loaded.

According to the applicant, the HI-STORM UMAX Canister Storage System is autonomous in-as-much as it provides SNF and radioactive material confinement, radiation shielding, criticality control and passive heat removal independent of any other facility, structures, or components at the site. The surveillance and maintenance operations of the HI-STORM UMAX Canister Storage System are minimized since the system is completely passive and is composed of proven materials. The HI-STORM UMAX Canister Storage System can be used either singly or as an array at an independent spent fuel storage installation (ISFSI). The site for an ISFSI can be located either at a nuclear reactor facility or an away-from-reactor location.

1.3 Staff Evaluation Findings

F1.1 The general description and discussion of the HI-STORM UMAX Canister Storage System is acceptably presented in Section 1.2 of the FSAR. Special attention to design and operating characteristics, unusual or novel design features, and principal considerations important to safety (ITS) have been acceptably provided.

F1.2 Drawings for SSCs ITS are presented in Section 1.5 of the FSARs in sufficient detail for the staff to provide sound regulatory findings. A listing of those drawings (including dates and revision numbers) that were relied upon as a basis for approval appears in Section 1.5 of the FSARs.

F1.3 Specifications for the SNF to be stored in the HI-STORM UMAX Canister Storage System are acceptably provided in the FSAR Section 2.1.

F1.4 The quality assurance program and implementing procedures are acceptably described in Section 1.3 of the FSAR.

F1.5 The HI-STORM UMAX Canister Storage System is not being certified under 10 CFR Part 71 for use in transportation.

The staff concludes that the information presented in Chapter 1, "General Information" of the SAR satisfies the requirements for the general description under 10 CFR Part 72. This finding is reached on the basis of a review that considered NUREG 1536, Rev. 1.

2 PRINCIPAL DESIGN CRITERIA EVALUATION

The objective of evaluating the principal design criteria related to SSCs that are ITS is to ensure that they comply with the relevant general criteria established in 10 CFR Part 72. The staff specifically reviewed principal design criteria to determine with reasonable assurance that all design criteria are addressed in the FSAR. The following areas of review were specifically reviewed by the staff:

- Structures, Systems, and Components Important to Safety
- Design Basis for Structures, Systems, and Components Important to Safety
- Spent Nuclear Fuel (SNF) Specifications
- External Conditions
- Design Criteria for Safety Protection Systems
- Structural
- Thermal
- Shielding/Confinement/Radiation Protection
- Criticality
- Material Selection
- Operating Procedures
- Acceptance Tests and Maintenance
- Decommissioning

2.1 Structures, Systems and Components Important to Safety

HI-STORM UMAX Canister Storage System SSCs that are ITS are acceptably identified in Chapter 2 of the HI-STORM UMAX Canister Storage System and the HI-STORM FW System FSARs. SER section 3.2.1 provides a description of the major components described in the FSARS and the correlation between the FSARS. The safety classifications are based on the guidance in U.S. Nuclear Regulatory Commission, "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety," NUREG/CR-6407, INEL-95/0551, February 1996, and per NUREG 1536, Rev. 1, and are therefore acceptable.

2.2 Design Basis for Structures, Systems and Components Important to Safety

The HI-STORM UMAX Canister Storage System design criteria summary acceptably includes the allowed range of spent fuel configurations and characteristics, the enveloping conditions of use, and the bounding site characteristics.

2.2.1 Spent Fuel Specifications

According to the FSAR, the HI-STORM UMAX Canister Storage System is designed to store up to either 37 PWR fuel assemblies or up to 89 BWR fuel assemblies. Detailed specifications for the approved fuel assemblies are provided in the HI-STORM FW FSAR Section 2.1. These include the maximum enrichment, maximum decay heat, maximum fuel assembly average burnup, minimum cooling time, maximum initial enrichment, and detailed physical fuel assembly parameters. The limiting fuel specifications are based on the fuel parameters considered in the structural, thermal, shielding, criticality and confinement analyses.

2.2.2 External Conditions

The HI-STORM UMAX Canister Storage System FSAR Section 2.2 identifies the bounding site environmental conditions and natural phenomena for which the HI-STORM UMAX Canister Storage System is analyzed.

2.3 Design Criteria for Safety Protection Systems

The principal design criteria for the HI-STORM UMAX Canister Storage System are acceptably identified in the HI-STORM UMAX Canister Storage System and HI-STORM FW System FSARs, Chapter 2.

2.4 Staff Evaluation Findings

F2.1 The FSAR and docketed materials adequately identify and characterize the SNF to be stored in the DSS in conformance with the requirements given in 10 CFR 72.236.

F2.2 The FSAR and the docketed materials relating to the design bases and criteria meet the general requirements as given in 10 CFR 72.122(a), (b), (c), (f), (h)(1), (h)(4), (i), and (l).

F2.3 The FSAR and docketed materials relating to the design bases and criteria for structures categorized as important to safety meet the requirements given in 10 CFR 72.122(a), (b)(1), (b)(2) and (b)(3), (c), (f), (h)(1), (h)(4), and (i); and 10 CFR 72.236.

F2.4 The FSAR and docketed materials meet the regulatory requirements for design bases and criteria for thermal consideration as given in 10 CFR 72.122 (a), (b)(1), (b)(2) and (b)(3), (c), (f), (h)(1), (h)(4), and (i).

F2.5 The FSAR and docketed materials relating to the design bases and criteria for shielding, confinement, radiation protection, and ALARA considerations meet the regulatory requirements as given in 10 CFR 72.104(a) and (b); 10 CFR 72.106(b); 10 CFR 72.122(a), (b), (c), (f), (h)(1), (h)(4), and (i); 10 CFR 72.126(a).

F2.6 The FSAR and docketed materials relating to the design bases and criteria for criticality safety meet the regulatory requirements as given in 10 CFR 72.124(a) and (b).

F2.7 The FSAR and docketed materials relating to the design bases and criteria for retrievability meet the regulatory requirements as given in 10 CFR 72.122(a), (b)(1), (b)(2), and (b)(3), (c), (f), (h)(1), (h)(4), and (l).

F2.8 The FSAR and docketed materials relating to the design bases and criteria for other SSCs not important to safety but subject to NRC approval meet the general regulatory requirements as given in the following subparts of 10 CFR Part 72: Subpart E, "Siting Evaluation Factors" 72.104 and 72.106; Subpart F, "General Design Criteria" 72.122, 72.124, and 72.126; and Subpart L, "Approval of Spent Fuel Storage Casks."

The staff finds that the principal design criteria for the HI-STORM UMAX Canister Storage System are acceptable with regard to demonstrating compliance with the regulatory requirements of 10 CFR Part 72. This finding is based on a review that considered the regulation itself, NUREG 1536, Rev. 1, applicable codes and standards, and accepted engineering practices. More detailed evaluations of design criteria and assessments of compliance with those criteria are presented in SER Sections 3, 4,5,6,7, and 8.

3 STRUCTURAL EVALUATION

3.1 Overview

In this portion of the dry storage system (DSS) review, the NRC evaluates aspects of the DSS design and analysis related to structural performance under normal and off-normal operations, accident conditions, and natural phenomena events. In conducting this evaluation, the NRC staff seeks a high degree of assurance that the cask system will maintain confinement, subcriticality, radiation shielding, and retrievability or recovery of the fuel, as applicable, under all credible loads for normal and off-normal conditions accidents, and natural phenomenon events.

The objective of the structural review is to assess the safety analysis of the structural design features, the structural design criteria, and the structural analysis and evaluation criteria used to confirm the structural performance of the HI-STORM UMAX Canister Storage System under normal operations, off-normal operations, accident conditions and natural phenomena events for those ITS SSCs.

The review was conducted utilizing applicable regulations in 10 CFR 72.124 (a), 72.234 (a) and (b), 72.236 (b), (c), (d), (g), (h), and (l) that identify the specific requirements for spent fuel storage cask approval and fabrication.

3.2 Structural Design

3.2.1 Overview

As described in FSAR section 1.2, the HI-STORM UMAX Canister Storage System has three major components: MPC-37 and MPC-89, the HI-TRAC VW transfer cask, and the HI-STORM UMAX VVM. The MPCs and the HI-TRAC components used in the HI-STORM UMAX Canister Storage System are identical to those reviewed and approved in the HI-STORM FW System, CoC No. 72-1032. No other approvals were sought for MPC variants for this licensing action.

The structural sub-components of the HI-STORM UMAX VVM include the following items: the steel and concrete closure lid, the steel cavity enclosure container (CEC) shell, the independent spent fuel storage installation (ISFSI) pad, the support foundation pad (SFP), the subgrade, the under-grade, and an optional enclosure wall.

All components classified as ITS are designated on the licensing drawings in FSAR section 1.5.

3.2.1.1 VVM Components and ISFSI Structure

The FSAR states that the HI-STORM UMAX VVM serves as a missile and radiation barrier, provides flow paths for natural convection, and provides kinematic stability to the system. The VVM is not a pressure vessel since it is open to the environment. Each subcomponent is summarized below based upon information in the FSAR:

CEC – A thick walled open top shell welded to a bottom base plate that defines the storage cavity for the MPCs. The CEC rests on the SFP and is surrounded laterally by a self-hardening engineered subgrade.

Closure Lid - A steel structure filled with plain concrete that is designed to protect the VVM from the impact of the design basis missiles as well as provide an inlet and outlet for air flow.

ISFSI Pad - A reinforced concrete slab that surrounds the upper portion of the CEC and extends to the underside of the CEC Flange. The ISFSI pad provides robust support for a loaded transporter and to enable rainwater to flow away from the storage array.

SFP - A reinforced concrete provides below grade support to the CEC for loadings due to seismic events and long term settlement.

Subgrade and Under-grade - The soil between the SFP and the ISFSI pad and lateral to the CECs which is replaced with a self-hardening engineered subgrade (SES) is the subgrade. The undisturbed soil in the space below the SFP is referred to as the under-grade.

Enclosure Wall (optional) - The Enclosure Wall was designed to provide a barrier to the engineered fill beneath the ISFSI pad such that each VVM array would be distinct from surrounding soil or other VVM arrays. Another function of the Enclosure Wall is to provide a means of preventing water intrusion beneath the ISFSI pad.

3.2.1.2 Multi-Purpose Canisters

As described in the FSAR, the HI-STORM UMAX system utilizes two MPCs as confinement vessels: the MPC-37 for pressurized water reactor (PWR) fuel and the MPC-89 for boiling water reactor (BWR) fuel. These MPCs have been previously reviewed and approved for storage (CoC No. 1032) and all relevant evaluations are presented in the HI-STORM FW FSAR. Only relevant information necessary to evaluate the interaction between the HI-STORM UMAX VVM and the MPCs was presented in the HI-STORM UMAX Canister Storage System application.

3.2.1.3

3.2.1.4 Transfer cask (HI-TRAC VW)

According to the FSAR, the HI-STORM UMAX Canister Storage System utilizes the HI-TRAC VW transfer cask to provide a missile and radiation barrier during transport of the MPCs from the fuel pool to the HI-STORM UMAX VVM. The HI-TRAC VW has been previously reviewed and approved for storage activities (CoC No. 1032) and all relevant evaluations are presented in the HI-STORM FW FSAR. Only relevant information necessary to evaluate the interaction between the HI-STORM UMAX VVM and the HI-TRAC was presented in the HI-STORM UMAX Canister Storage System application.

3.2.2 Design Criteria and Applicable Loads

Table 2.3.1 of the FSAR summarizes all loads, design criteria, applicable regulations, reference codes and standards for the VVM.

Table 2.3.2 of the FSAR summarizes design data for HI-STORM UMAX Canister Storage System.

3.2.2.1 Applicable Loadings

Loadings applicable to the HI-STORM UMAX Canister Storage System are defined in FSAR Sections 2.4 and 2.5.

3.2.2.2 Design Basis Loads and Load Combinations

Table 2.4.1 of the FSAR contains design basis loads and acceptance criteria applicable to VVM components.

Table 2.4.3 of the FSAR contains load combinations applicable to ISFSI structures.

3.2.2.3 Allowable Stresses

The ITS components of the HI-STORM UMAX system are identified on the design drawings in FSAR Section 1.5. Allowable stresses and stress intensities for American Society of Mechanical Engineers (ASME) B&PV Code (Code) are identified in Tables 3.1.11 and 3.1.12 of the FSAR. Tables 3.1.2 to 3.1.8 of the FSAR contain tabulated values for all VVM and MPC components. Specifically, FSAR Table 3.1.4 contains Level A allowable stresses, FSAR Table 3.1.5 contains Level B allowable stresses, and FSAR Table 3.1.6 contains Level D allowable stresses.

3.2.3 Stress Analysis Models and Computer Codes

The applicant's finite element analysis was performed with LS-DYNA, which is a commercial explicit dynamics code for dynamic events, and ANSYS which was used for static stress analysis. Some stress analysis was also performed with closed form classical methods.

3.2.3.1 HI-STORM UMAX VVM