

**From:** Manuel Camargo  
**Sent:** Thursday, June 11, 2020 3:10 PM  
**To:** Donna Gilmore  
**Cc:** David Victor (UCSD)  
**Subject:** Follow-up to SONGS Community Engagement Panel Meeting

*Transmitted on behalf of Mike Corradini*

Dear Ms. Gilmore,

I would like to address your comments at the May 28 CEP meeting regarding explosions from zirconium hydrides, hydrogen gas and your concerns about water intrusion and criticality. I consulted with Professors Arthur Motta and Joseph Shepard, as well as Randall Granaas (SCE ISFSI and Fuels Engineer) in preparing this response.

### Can zirconium hydride in a powder or gas form ignite when exposed to air causing explosions?

When ground up in a very fine powder Zirconium is pyrophoric (like other metals). This is however, only when it is in a very fine powder of a few microns and the surface area to-mass ratio is quite high. A tube of Zirconium, which has a much lower surface area to-mass ratio, is perfectly stable.

After reactor exposure, a very highly hydrided rod could have a hydrogen content of 600 wppm (weight parts per million). These will be in the form of hydrides at room temperature (representing a few percent of the clad volume fraction) distributed within the clad thickness mixed in within the Zr bulk matrix; and this is also indefinitely stable.

Additional empirical data:

1. There is no industry or NRC guidance that prohibits exposing fuel cladding to air in order to prevent ignition (zirconium fire scenarios notwithstanding). This alone is strong evidence that such a phenomenon has never been identified and does not exist.
2. Air has been used to remove bulk water from dry storage casks with no adverse effects.
3. National labs handle high burnup zirconium fuel rods in non-inert hot cells—the fuel rod does not ignite.
4. EPRI possesses zirconium cladding samples (Zircaloy-2) with very high hydride concentrations:
  - a. Bulk = 600 ppm, surface up to 2000-3000 ppm.
  - b. These samples are all stored in air, handled in air, and as would be expected, there has never been an issue of any kind handling these samples.

### When uranium is exposed to water can it generate hydrogen gas which is flammable, if the flashpoint of uranium is 255 to 320 c in air?

SONGS uranium fuel is not metallic; it is in the form of ceramic oxide, which is very stable, with a high melting point (~2800 C).

## What about documentation from Holtec and from the NRC regarding water intrusion and criticality?

Here, I have asked Randall to help address your question, as noted here:

*Holtec's response to the NRC (attached) does not state the canisters will go critical. Rather, it states criticality can only occur if fresh (unborated) water enters the multi-purpose canister (MPC).*

*The NRC requires a vendor, such as Holtec, to assume a canister is loaded completely with fresh (i.e., new, unirradiated) fuel when performing the criticality analysis. This is in lieu of using burnup credit in the criticality analysis. Of course, the probability of a utility loading fresh fuel into a dry storage canister is extremely low. SONGS has never loaded a dry storage canister when fresh fuel was present in the spent fuel pool, and there is no longer fresh fuel onsite.*

*For transportation, the NRC requires the criticality analysis to include flooding with unborated water (there are "moderator exclusion" exceptions). All SONGS dry storage canisters are configured and analyzed for transportation. Thus, from a criticality perspective, water entering a SONGS canister in storage is a moot point.*

Best regards,

Mike



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January 30, 2013

John Goshen, P.E., Project Manager – Licensing Branch  
Division of Spent Fuel Storage and Transportation  
Office of Nuclear Material Safety and Safeguards  
ATTN: USNRC Document Control Desk  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555-0001

Docket No. 72-1040  
Certificate of Compliance (CoC) No. 1040

Subject: Response to First Request for Additional Information (RAI) for HI-STORM  
UMAX Canister Storage System (TAC No. L24664)

References: [1] Letter from J. Goshen (NRC) to Terry Sensue (Holtec), dated December 12,  
2012.

Dear Mr. Goshen:

The referenced NRC letter documented the result of the NRC staff's acceptance review of Holtec International HI-STORM UMAX Canister Storage System application. The staff concluded that the application was acceptable to begin the detailed technical review and also transmitted one RAI.

Enclosure 1 to this letter contains the response to the RAI. Enclosure 2 contains the proposed change to the CoC, Condition 2.

If you have any questions, please contact me at 856-797-0900, ext. 3876.

Sincerely,

Terry Sensue  
Licensing Manager  
Holtec International

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Page 1 of 2

NM 5526



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Michele Sampson, USNRC  
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Holtec Group 1 (via email)  
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List of Enclosures:

- Enclosure 1: Response to Request for Additional Information RAI # 6-1
- Enclosure 2: Proposed change to CoC No. 1040

**Enclosure 1:  
Response to Request for Additional Information  
RAI # 6-1**

**RAI # 6-1**

Provide an evaluation to justify Holtec's conclusions in the FSAR, Section 2.0.5 that "The MPCs provide criticality control for all design basis normal, off-normal and postulated accident conditions."

The referenced FSAR for the HI-STORM FW indicates that once established, the integrity of the MPC Confinement Boundary is maintained during all credible off-normal and accident conditions, and thus, the MPC cannot be flooded. However, there is no evaluation presented, especially during the initial 40-year storage period, that would demonstrate the double contingency principle for criticality safety for a below ground system such as UMAX as stated in 10 CFR 72.124. Although the HI-STORM UMAX system is similar in design to the HI-STORM FW, since the UMAX is an underground configuration there are other potential failure paths that must be addressed. 10 CFR 72.124(a) states "Spent fuel handling, packaging, transfer, and storage systems must be designed to be maintained subcritical and to ensure that, before a nuclear criticality accident is possible, at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. Two unlikely events need to be identified and the system has to be designed in order to be subcritical given one unlikely event occurs (e.g., fresh water intrusion into canister).

In your response to the RSIs you stated that, "Therefore, since all single unlikely events (off-normal or accidents) are covered by the analysis, it follows that two unlikely events would be necessary before a criticality accident is possible." This appears to be an incorrect interpretation of double contingency. The system must be designed to address all unlikely events, such as the failure of the MPC, and demonstrate that at least two unlikely, independent, and concurrent or sequential changes have to occur before a criticality would be possible.

This information is needed to evaluate compliance with 10 CFR 72.124(a) and 72.236(c).

### **HOLTEC Response:**

The two unlikely, independent events that must occur and then exist simultaneously in order for an inadvertent criticality to occur in the HI-STORM UMAX are flooding of the Cavity Enclosure Container (CEC) and a significant breach of the Multi-Purpose Canister (MPC) confinement boundary. These two events are selected because a criticality can only occur if fresh (unborated) water enters the MPC. [Note that this concern does not exist for the MPC-89, as it is loaded under fresh water conditions and therefore is designed to be subcritical while flooded with fresh water.] The rest of this discussion is only applicable to the MPC-37 for PWR fuel, since the criticality evaluation for MPC-37 credits the soluble boron in the spent fuel pool for criticality control during loading operations. Therefore flooding of the MPC with unborated water during storage conditions must be prevented.

Under normal conditions, the inside of the MPC is dry, the MPC confinement is considered to have no leakage path, and the inside of the CEC around the MPC is also dry. In order for the MPC to fill with water both of these conditions would have to change. The CEC would have to be filled with water, and the MPC would have to have a leakage path to let water in (and also a vent path to helium out). The following is a discussion on the unlikely events that could result in changes to the normal conditions.

### **Flooding of the CEC with water:**

This RAI seeks information on the “other potential failure paths” that are unique to an underground system. In addition to the unique underground sources of water that must be considered, an underground system must be designed so as not to collect above ground sources of water such as rain or snow.

Flooding of the CEC is unlikely from underground sources of water for the following reasons.

- Each MPC is stored in a thick cylindrical steel weldment that has no penetrations or openings. This steel shell is appropriately coated with surface preservatives or by other means to protect it from corrosion from long-term use. Thus, groundwater has no path for intrusion into the interior space of the CEC. [FSAR Section 1.1]
- Corrosion mitigation measures commensurate with site-specific conditions are implemented on the below grade external surfaces of the CEC. [FSAR Subsection 1.2.2 and additional information on these measures can be found in FSAR Section 8.7.]
- The enclosure wall is an optional structure which used to mitigate groundwater intrusion at sites with a high water table. The enclosure wall is a 2-foot thick concrete wall that completely surrounds the subsurface portion of the ISFSI from the support foundation pad to the ISFSI pad on the surface. Therefore, in those locations where groundwater is present, there are two barriers that prevent groundwater intrusion into the CEC. The first

- is the outer concrete barrier consisting of the enclosure wall, support foundation, and ISFSI pad. The second barrier is the CEC itself. [FSAR Subsection 1.2.2, Item F.]

Flooding of the CEC from precipitation is unlikely for the following reasons.

- The ISFSI Pad acts as a barrier against gravity-induced seepage of rain or floodwater around the Vertical Ventilated Module (VVM) body. [FSAR Subsection 1.2.2, Item C.]
- The HI-STORM UMAX VVM is designed to direct storm water and snow/ice melt-off away from the CEC Flange and the Closure Lid where the air passages are located. The engineered rain caps installed on the inlet and outlet serve to keep rain and snow away from the VVM cavity. Moreover, any minor amount of moisture that may intrude into the MPC [storage]\* cavity due to wind-driven rain will evaporate in a short period of time due to the continuous movement of heated air in the MPC storage cavity. [FSAR Section 10.3. Item iv]
- The portion of the ISFSI pad adjacent to the VVM is slightly sloped and thicker than the rest of the ISFSI pad to ensure that rain water will be directed away from the VVM. [FSAR Subsection 1.2.2.]
- As explained in the chapter on operations, the transfer of the MPCs into or out of the storage cavity will occur in an identical manner to HI-STORM 100U using a certified transfer cask as approved in CoC #1014, amendment 7. Screens are installed on the air inlet and outlet openings. The flue in the inlet and outlet plenum is equipped with a rain guard. The flue shell is lightweight and fastened to the outlet duct to allow easy installation and removal. [FSAR Subsection 1.2.3.]
- Should water enter the CEC during loading operations, removal of water from the bottom of the storage cavity can be carried out by the simple expedient use of a flexible hose inserted through the air inlet or outlet passageways. [FSAR Subsection 1.2.3.]
- The design life of the HI-STORM UMAX System is 60 years. This is accomplished by using materials of construction with a long proven history in the nuclear industry, specifying materials known to withstand their operating environments with little to no degradation (see Chapter 8), and protecting material from corrosion by using appropriate mitigation measures. A maintenance program, as specified in Chapter 10, is also implemented to ensure that the service life will exceed the design life. [FSAR Subsection 1.2.3.4.]

\* The word “storage” was missing from the original FSAR. Holtec will update the FSAR to fix this oversight.



- To verify the effectiveness of the storm water drainage design, a one-time test will be performed after construction of the first VVM to ensure that the design is effective in directing storm water away from the VVM to the ISFSI's drainage system. The VVM will be subjected to a water spray that simulates exposure to rainfall of at least 2 inches per hour for at least one hour. At the conclusion of the water spray, the depth of the water (if any) in the bottom of the module cavity will be measured. Any amount of water accumulation beyond wetting of the Bottom Plate indicates an inadequacy in rain diversion features of the VVM and will be appropriately corrected. [FSAR Section 10.3 Item iv, this requirement will be added into the CoC as an acceptance test. Refer to Enclosure 2.]
- In-service inspection for long-term interior and below-grade degradation will be performed on a site-specific basis in accordance with Holtec specified long-term maintenance guidelines and the licensee's preventive maintenance program. [FSAR Section 10.4.]
- Additional in-service inspection activities may include more thorough inspections for foreign material accumulation, corrosion (CEC wall thinning) and insulation degradation as warranted by site-specific conditions. In-service inspections for evaluating foreign material accumulation, corrosion (CEC wall thinning) and/or insulation degradation are not required if it is determined that the applicable degradation actuating mechanisms do not exist. A VVM with a loaded MPC may be inspected using remote devices such as a boroscope. The oldest VVM or VVM considered to be most vulnerable to corrosion degradation will be selected for inspection. [FSAR Section 10.4.]
- An inspection of the VVM inlet plenum for the accumulation of FME is required every five years or following a severe weather event that may introduce significant FME material. In the unlikely event that a minor amount of water has accumulated, it would be identified by this inspection. [See Table 10.4.1 in FSAR Section 10.4.]

Given the design features, tests, and inspections that ensure the CEC's will not flood, Holtec has concluded that flooding of a CEC cavity is very unlikely.

#### **Water leakage into an MPC:**

The second question is if a leakage path for water into an MPC could develop. The MPC enclosure vessel is made from high quality material - stainless steel, connected using full penetration welds that are fully tested according to the ASME code requirements, and the shell and its welds are further qualified using a helium leak test. All of these welds are done under NRC approved Quality Assurance programs. [Note that no Holtec MPC has ever failed this helium leak test, which further highlights the robustness of the design and manufacturing

process.] The introduction of a water leakage path during the initial manufacturing process is therefore highly unlikely. In addition:

- The closure of the MPC is performed with a large multipass weld, performed in a way that leakage of any gases from the MPC is understood to be non-credible. Additionally, there is a redundantly welded second cover plate over that weld. The introduction of a water leakage path during the closure operation is therefore extremely unlikely.
- Based on the material, initial conditions (manufacturing, closing), and the physical protection of the MPC, any problems with the long term integrity of the MPC containment function is not considered credible. Recently, and with the prospect of much longer storage periods – beyond the initial license term, concerns have arisen that certain environmental conditions could result in stress corrosion cracking problems of stainless steel canisters as early as the first certificate renewal period. This is an emerging issue which is undergoing industry and NRC evaluation as stated below. The concern is that small cracks could result in loss of the helium overpressure and release of radionuclides from the MPC. No MPC has been shown to exhibit SCC, and even if SCC were shown to exist on an MPC at some time in the future, the small cracks associated with SCC are much smaller than those that would be necessary to present a water inleakage path into the MPC. Industry is currently conducting further research, and testing programs, to determine if such concerns are valid. If so, appropriate monitoring programs and mitigating actions will be implemented. If necessary, such programs would be included in the ageing management program. While the NRC has captured these concerns in Information Notice 2012-20, Holtec is unaware of any information that invalidates previous evaluations of canister integrity. Because of the quality controls, fabrication process, testing, inspections, and operating experience, Holtec finds that the gross breaching of an MPC boundary sufficient to allow water inleakage is highly unlikely.
- A water inleakage path could also be created by some significant mechanical impact on the system that would penetrate the overpack and the MPC. The design accident conditions cover all credible such impacts and show that they have no effect on the containment boundary. In addition, any such accident would be self-evident and appropriate corrective action would be promptly taken.

Overall it is therefore concluded that it is highly unlikely that there would be a water inleakage path into the MPC. Further, all those events that could create an inleakage path are independent of the events that could result in flooding of the cavity. It would therefore require two unlikely and independent events until an accidental criticality would be possible.

**Enclosure 2:  
Proposed Change to CoC No. 1040  
(Condition 2)**

**CERTIFICATE OF COMPLIANCE  
FOR SPENT FUEL STORAGE CASKS  
Supplemental Sheet**

Certificate No. 1040  
Amendment No. TBD  
Page 2 of 4

DESCRIPTION (continued)

There are two types of MPCs permitted for storage in HI-STORM UMAX VVM: the MPC-37 and MPC-89. The number suffix indicates the maximum number of fuel assemblies permitted to be loaded in the MPC. Both MPC models have the same external diameter.

The HI-TRAC VW transfer cask provides shielding and structural protection of the MPC during loading, unloading, and movement of the MPC from the cask loading area to the VVM. The transfer cask is a multi-walled (carbon steel/lead/carbon steel) cylindrical vessel with a neutron shield jacket attached to the exterior and a retractable bottom lid used during transfer operations.

The HI-STORM UMAX VVM utilizes a storage design identified as an air-cooled vault or caisson. The HI-STORM UMAX VVM relies on vertical ventilation instead of conduction through the fill material around the VVM, as it is essentially a below-grade storage cavity. Air inlets and an air outlet allow air to circulate naturally through the cavity to cool the MPC inside. The subterranean steel structure is seal welded to prevent ingress of any groundwater in the MPC storage cavity from the surrounding subgrade, and it is mounted on a stiff foundation. The surrounding subgrade and a top surface pad provide significant radiation shielding. A loaded MPC is stored within the HI-STORM UMAX VVM in a vertical orientation.

CONDITIONS

1. OPERATING PROCEDURES

Written operating procedures shall be prepared for handling, loading, movement, surveillance, and maintenance. The user's site-specific written operating procedures shall be consistent with the technical basis described in Chapter 9 of the FSAR.

2. ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

Written acceptance tests and a maintenance program shall be prepared consistent with the technical basis described in Chapter 10 of the FSAR. At completion of welding the MPC shell to baseplate, an MPC confinement weld helium leak test shall be performed using a helium mass spectrometer. The confinement boundary welds leakage rate test shall be performed in accordance with ANSI N14.5 to "leaktight" criterion. If a leakage rate exceeding the acceptance criteria is detected, then the area of leakage shall be determined and the area repaired per ASME Code Section III, Subsection NB, Article NB-4450 requirements. Re-testing shall be performed until the leakage rate acceptance criterion is met.

To verify the effectiveness of the storm water drainage design, a one-time test will be performed after construction of the first VVM at the first site to deploy UMAX to ensure that the design is effective in directing storm water away from the VVM to the ISFSI's drainage system. The VVM will be subjected to a water spray that simulates exposure to rainfall of at least 2 inches per hour for at least one hour. At the conclusion of the water spray, the depth of the water (if any) in the bottom of the module cavity will be measured. Any amount of water accumulation beyond wetting of the Bottom Plate indicates an inadequacy in rain diversion features of the VVM and will be appropriately corrected.

3. QUALITY ASSURANCE

Activities in the areas of design, purchase, fabrication, assembly, inspection, testing, operation, maintenance, repair, modification of structures, systems and components, and decommissioning that are important-to-safety shall be conducted in accordance with a Commission-approved quality assurance program which satisfies the applicable requirements of 10 CFR Part 72, Subpart G, and which is established, maintained, and executed with regard to the storage system