Responses to Request for Additional Information – Supplemented August 2, 2021
Certificate of Compliance No. 1032
Docket No. 72-1032
HI-STORM FW Storage System
Amendment No. 6

Structural Evaluation

RAI-3-1 (dated 11/6/2020)

Provide the following information:

a) an evaluation of a drop accident in all credible bounding orientations (e.g., a side drop or corner drop orientation) for assessing the handling accident conditions for the HI-STORM FW cask and the HI-TRAC VW transfer cask, and a justification of why the analyzed orientations are bounding; or

b) a justification for how other drop orientations are bounded by the existing end drop analysis.

As discussed in NUREG-2215, "Standard Review Plan for Spent Fuel Dry Storage Systems and Facilities," the review of a safety analysis report (SAR) should ensure that an applicant evaluated all credible potential orientations of the cask during cask transfer and handling drops. It is not clear to the staff how the vertical end drop analyzed in Holtec Report HI-2200647, "Analysis of the Postulated Drop and Missile Impact Events for the Loaded HI-STORM FW, Version E, Cask and the Loaded HI-TRAC VW System," considers all credible potential orientations of the cask for a handling accident.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.236 (b), (c), and (l).

Holtec Response (dated 12/21/2020)

1. When performing the lifting operations, the loaded HI-STORM FW overpack is lifted and handled in the vertical orientation at all times. And the maximum lift height of the HI-STORM is limited to 11 inches above the ground. Since the lifted height of the HI-STORM above the ground is very small relative to the cask overall dimensions (i.e., the cask height and the base diameter), it mitigates the HI-STORM from significant angular rotation with respect to the horizontal ground (or target) in the event of a lifting equipment failure. For a small drop height of 11 in., in case of an end slapdown condition, the maximum cask base angle w.r.t the ground is computed as 4.5°. This angle is very small and will not have any safety related consequence when compared to the vertical drop by 11 in. Moreover, these drops are not credible given that the cask lifting/handling device and the cask interface parts are qualified to meet the increased allowable limits per NUREG-0612.

2. Based on the evaluations from Holtec Report HI-2200647, HI-STORM FW FSAR, and the HI-STORM 100 FSAR, it is understood that the fuel rod loading is more critical under axial buckling than the lateral loading. Understandably, the buckling of the fuel rod assembly will be more pronounced in a pure vertical end drop orientation as compared to any other drop orientation. The initial trajectory and the long axis of the fuel assembly aligned in the vertical orientation is conservative since the kinetic energy

of dropped fuel will be focused on the minimized fuel impact area. This assumption is also reasonable because it is consistent with the configuration of the fuel assembly while it is being moved

3. The HI-STORM FW angular drops, although not credible, if postulated may result in local deformation of the target (i.e., the concrete pad) and the HI-STORM outer shell and baseplate localized in the vicinity of direct impact. Moreover, the HI-STORM cask angular drop through appreciably small height (as noted in # 1 above) will be bounded by the non-mechanistic tip-over analysis of the HI-STORM cask documented in Holtec Report HI-2200647. Due to the small drop height (< 11 in.) in conjunction with localized (limited) area participation in impact, the cask deceleration "g" load on the cask and its internals from the angular drops is expected to be significantly lower than those realized from pure vertical drop and non-mechanistic tipover event. The safety results for the MPC confinement boundary and the critical HI-STORM cask components will therefore be bounded by the HI-STORM cask vertical drop and the non-mechanistic tipover event.

Therefore, the HI-STORM cask drop is postulated in the most limiting vertical orientation as documented in Holtec Report HI-2200647.

NRC Request for Clarification (Conversation Record dated 3/8/2021)

During a phone call on March 8, 2021, the staff asked that the discussion justifying the vertical orientation as the most limiting orientation under the postulated cask drop, as provided in Holtec's initial response to Structural RAI 3-1, be added to the HI-STORM FW FSAR.

Holtec Response to Request for Clarification (dated 8/2/2021)

The level of information provided in Holtec's initial RAI response dated 12/21/20 is more appropriately included in the calculation package supporting the FSAR, as opposed to the actual FSAR text. As such, Holtec Report HI-2200647 has been revised accordingly.

RAI-3-2 (dated 11/6/2020)

Provide an evaluation of the fuel basket, including deflections, to determine if the fuel basket maintains the spent nuclear fuel in a subcritical arrangement under handling accident conditions (considering all credible bounding orientations), and include such evaluation in the design criteria for the handling accident condition.

The structural evaluation of the handling accident condition detailed in Holtec Report HI-2200647 provides a structural analysis of the plastic strains of the fuel basket. However, the evaluation in Holtec Report HI-2200647 does not consider all the design criteria defined for the spent fuel basket defined in Chapter 2 of the SAR (e.g., the maximum deflection defined in the structural design criteria for the fuel basket listed in Table 2.2.11 of the SAR). Additionally, the acceptance criteria for the handling accident condition described in Section 2.2.3(a) of the SAR does not include any criteria for the fuel basket or subcritical arrangement of the spent nuclear fuel.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.236(b) and (c).

Holtec Response (12/21/2020)

1. This fuel basket panel is primarily challenged when the cask is oriented horizontally, and the fuel basket panels are subject to significant inertial loading from the fuel during the lateral drop events such as the non-mechanistic tipover event. The fuel basket panel deformation criterion is discussed in Chapter 2 Section 2.2.8 as 0.5% of the basket panel width. Stated differently, the acceptance criteria is defined as the ratio of maximum total basket panel lateral deflection over its width which must be less than 0.005 as specified in Table 2.2.11.

2. The criticality analysis, in Chapter 6 Subsection 6.3.1 of the FSAR, conservatively assumes that 2 adjacent cell walls in each cell are deflected to the maximum extent possible over their entire length and width (i.e., that the cell ID is increased or reduced by 0.5% of the cell width). Similarly, it is assumed for all flux traps that their thickness is reduced by 0.5 mm, or 0.045” for the MPC-37 cells and 0.030” for the MPC-89 cells. For completeness, a reference to Chapter 6 Section 6.3.1 will be added for the panel deflection acceptance criteria noted in Chapter 2.

3. The fuel basket inside the overpack is evaluated in HI-2200647 for the vertical drop orientation. In the vertical drop orientation, it shall be noted that the fuel baskets are subject to inertial (or dynamic) loading from self-weight independent from the stored fuel assemblies. In other words, the fuel baskets are not subject to significant loading from the fuel assemblies during the HI-STORM cask pure vertical end drop. Since there is no lateral loading on the fuel baskets, and the inertial load from the self-weight being insignificant as compared to the weight of the stored fuel assemblies, the basket panel is not subject to lateral deflection under the cask free vertical end drop. Moreover, the HI-STORM vertical end drop analysis documented in HI-2200647 concluded that the fuel basket experiences negligible plastic strain (< 0.0041) which is localized in the bottom elements of the fuel basket (well below the fuel active region). Figure 3.4.54 and Figure 3.4.61 in the FSAR are updated to show the regions of maximum plastic strain. The Figures 7 and 16 in the calculation package HI-2200647 are also updated.

4. Conversely, during the cask non-mechanistic tipover drop event the fuel baskets are subject to increased lateral loading from the fuel assemblies. The HI-STORM FW FSAR establishes the lateral plastic deformation limit for the basket panels in the active fuel region in Table 2.2.11 of the FSAR. And it is demonstrated from the HI-STORM cask tipover analysis, documented in HI-2200647, that the fuel basket plastic deformation is limited in couple of peripheral cells near the top of the basket and beyond the active fuel region. Furthermore, the fuel baskets are considered to be structurally safe since the baskets maintain appropriate spacing between fuel assemblies after the HI-STORM cask tipover event thereby substantiating no criticality consequence subsequent to the HI-STORM cask tipover event.

NRC Request for Clarification (Conversation Record dated 3/8/2021)

During a phone call on March 8, 2021, the staff asked that the discussion regarding basket panel deformation provided in Holtec's initial response to Structural RAI 3-2 be added to the HI-STORM FW FSAR.

Holtec Response to Request for Clarification (dated 8/2/2021)

The level of information provided in Holtec's initial RAI response dated 12/21/20 is more appropriately included in the calculation package supporting the FSAR, as opposed to the actual FSAR text. As such, Holtec Report HI-2200647 has been revised accordingly.

RAI-3-3 (dated 11/6/2020)

Provide the following information:

a) mechanical property data based on physical testing for the materials evaluated using a strain-based approach for the drop accident conditions presented in Holtec Report HI-2200647;

b) failure strains and material flow curves based on this physical testing that consider strain-rate effects, uniform elongation, and triaxiality effects for use in the finite element analysis and structural evaluation of the drop accident conditions presented in Holtec Report HI-2200647; and

c) an updated finite element analysis and structural evaluation of the drop accident conditions presented in Holtec Report HI-2200647 using failure strains and material flow curves based on mechanical property data obtained from physical testing.

Holtec Report HI-2200647 includes a description of the structural evaluation of HI-STORM FW components from the drop accident conditions. This evaluation used a strain-based methodology with strain-based acceptance criteria to determine the structural integrity of important to safety (ITS) components subjected to an 11-inch drop. The applicant calculated true-stress-true-strain data in Appendix B to Holtec Report HI-2200647 and used this data in the analysis of the drop accident for the following materials:

- Metamic,
- Alloy X,
- SA350-LF2,
- SA193-B7,
- SA53,
- SA516-70,
- 304 type stainless steel,
- SA350-LF3,
- SB-637,
- SA-336 f 11,
- SA-240 304 type stainless steel, and
- SA106 grade C.

The methodology used in Appendix B to Holtec Report HI-2200647 to compute material flow curves for the finite element structural analysis and strain-based evaluations follows the Holtec Position Paper DS-307, “Construction of True-Stress-True-Strain Curves for LS-DYNA Simulations.” The staff notes that the use of the methodology outlined in this position paper has previously been found inadequate to provide material data for strain-based evaluations, in particular for an evaluation of the ATB 1T transportation package. Specifically, constants used to develop material flow curves have been determined analytically (e.g., constants “K” and “n”) without the support of material testing. As discussed in the summary of the November 13, 2018, meeting with Holtec International (ADAMS Accession No. ML18331A184), the staff’s position is that these constants should be based on mean test values obtained from material testing. In addition, the applicant needs to supply material flow curves that consider strain-rate effects, uniform elongation, and triaxiality effects if the material is challenged beyond the uniform elongation limit.

The staff notes that strain-based acceptance criteria are specified in the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Non-mandatory Appendices EE and FF. The criteria specified by the applicant is not based on an industry code or standard, but rather a reference that was used in the development of Non-mandatory Appendices EE and FF. In addition, Non-mandatory Appendices EE and FF provide some of the physical data that the applicant needs to provide for 304 type stainless steel.

As the mechanical property data is essential to the validity of the structural analysis of the drop accident condition, the staff requests that the material models used in the LS-DYNA simulations described in Holtec Report HI-2200647 be based on sufficient physical testing and any results be updated.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.236(l).

Holtec Response (dated 12/21/2020)

Since the LS-DYNA computer program considers the reduction in the area of the finite elements in the computation of stress during the execution of the analysis, a true stress strain curve is expected to be input for the material properties.

The following simple power law relation is often used to represent the flow curve of all metals in the region of uniform plastic deformation.

$$\boldsymbol{\sigma = K\varepsilon_t{}^n} \qquad (1)$$

where n is the strain-hardening exponent and K is the strength coefficient. A log-log plot of the true stress and true strain up to the maximum load (i.e., immediately before necking) will result in a straight line for the flow curve represented by Equation (1). Note that n = 0 and n = 1 represent the two extreme cases, i.e., perfectly plastic and elastic, respectively. It shall be noted that the stress state in the specimen changes from uniaxial tensile stress to complicated triaxial stresses as the necking develops.

To characterize the true-stress after necking, Equation (1) and a linear stress-strain relationship are used as lower bound and upper bound, respectively in [Ref-1] to predict the actual true-stress-true-strain curve after necking using the finite element method in conjunction with test data. For simplicity, we conservatively extend the use of Equation (1) to the entire flow curve and determine n and K based on material properties obtained from regular tensile tests.

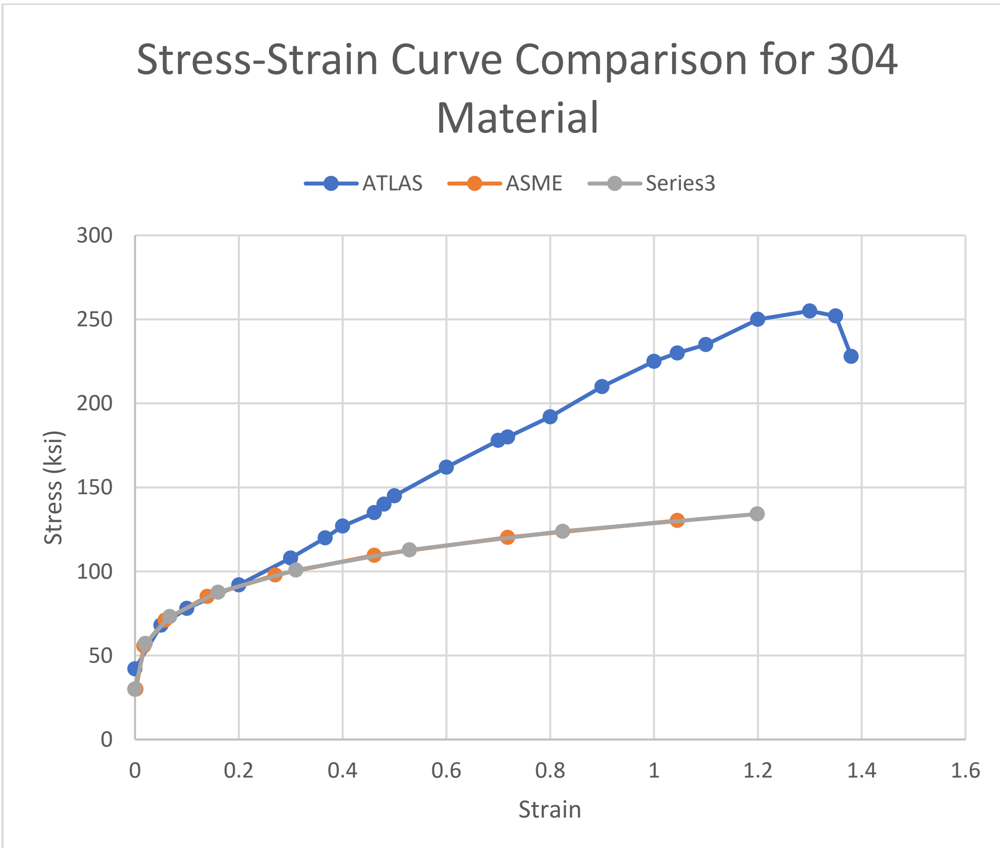
The constants used to develop material flow curves (e.g., constants "K" and "n") are not arbitrary "guessed" values. The values of K and n are computed using an iterative solution method implemented in Mathcad to find the converged solution, which requires an <u>initial</u> guess value. The final converged values of K and n are mathematically accurate and consistent with the underlying material properties (i.e., Sy, Su, elongation, % reduction of area). See the response to RAI 5-21 from HI-STORE application (Docket # 72-1051) for more detailed information (which was recently submitted on November 20, 2020).

Accordingly, the HI-STORM drop simulation performed in support of this amendment use the minimum ASME material properties to develop the true-stress-vs-true strain curves. The actual test properties (Certified Mill test Report) generally show the material strength properties to be higher by approximately 15%. This is substantiated in the following paragraph.

The following figure show the comparison between the material flow curves for a typical stainless-steel 304 material using 2 distinct approaches, as follows:

a. ASME minimum strength properties
b. Atlas-stress and strain curves [Ref-2]

It is clearly noted that the curve developed using the ASME minimum properties, which is the basis for the licensing analysis in support of this amendment, is lower than the curve obtained from the other two sources.



Using the minimum material strength properties from ASME Section II, therefore, yields conservative results for the HI-STORM cask and the MPC confinement when subject to impacts. This is attributed to the fact that the increased material strength and the percentage area reduction results in higher material flow curves (true-stress-vs-strain curves) as compared to the true-stress-vs-strain curves developed using the ASME minimum properties. Consequently, it increases the potential for more energy absorption by the cask components which directly participate in the impact thereby protecting the confinement boundary (i.e., the MPC and the stored fuel inside MPC). Distinctly stated, the plastic region the true stress developed using the ASME minimum properties is always lower than the true stress values using the actual testing [Ref-2]. Thus, at any given deformation level the total energy absorbed by the MPC will be underestimated. This results in a conservative response because it overestimates the total deformation (strain) for the components influenced by the impact loading.

[Ref-1] K.S. Zhang and Z.H. Li, "Numerical Analysis of the Stress-Strain Curve and Fracture Initiation for Ductile Metal," Engineering Fracture Mechanics, 49, 235-241, 1994.
[Ref-2] Atlas of Stress-Strain Curves," Second Edition, ASM International.

NRC Request for Clarification (Conversation Records dated 3/8/2021 & 3/24/2021)

During a phone call on March 8, 2021, the staff noted that Holtec's initial response to Structural RAI 3-6 is not entirely acceptable to the staff and cited NRC queries on other Holtec systems (e.g., the HI-STAR ATB 1T). The staff also noted that the RAI response did not include the material properties based on testing as requested in the original RAI or reasoning for why these testing-based material properties were not needed, and mentioned an interest in whether the strains being compared in the drop analysis were close to the region of non-uniform elongation.

During a second phone call on March 24, 2021, the staff discussed its review of Holtec Position Paper DS-307 and questioned its use of an analytical method to predict material properties after the onset of necking. The staff also asked if there are any components in the system that experience non-uniform strains in the drop, and noted that this information would help the staff understand the extent to which the staff's concerns on the analytical approach during non-uniform elongation are relevant to the HI-STORM FW system.

Holtec Response to Request for Clarification (dated 8/2/2021)

In addition, the following key facts validate that the material true-stress-true-strain construction and the corresponding inputs used for the HI-STORM cask components render conservative results and ensure the safety case with high level of confidence:

1. It is important to note that the results from the accidental drops, shown in Figures 7 through 9 for the HI-STORM drop and Figures 16 through 18 for the HI-TRAC drop, respectively, show minimal strain in the cask components including the cask internals viz. the MPC and the basket. In other words, none of these results indicate excessive deformation resulting in component necking.
2. Separately, the material benchmark analysis conducted in support of the HI-STAR ATB 1T package licensing which is documented in Holtec report [Ref-3], concluded the following:
    a. The strength properties of actual tested materials (based on Certified Mill Test Reports) are typically 10-15% higher than the minimum ASME properties.
    b. The benchmark report further validated that the method to derive the material true-stress-true-strain used as input for this analysis is reasonably accurate. Furthermore, the benchmark report [Ref-3] presented that this method of material true-stress-true-strain derivation accurate for distinct (varied) material strengths and ductility.

It is, therefore, concluded that the material inputs, true-stress-true-strain derivation and the safety analysis performed in support of Amendment 6 render conservative safety results. Appendix E has been added to Holtec Report HI-2200647 to reflect the above discussion.

[Ref-1] K.S. Zhang and Z.H. Li, "Numerical Analysis of the Stress-Strain Curve and Fracture Initiation for Ductile Metal," Engineering Fracture Mechanics, 49, 235-241, 1994.
[Ref-2] Atlas of Stress-Strain Curves," Second Edition, ASM International.
[Ref-3] Holtec Report HI-2210251, Revision 0.

RAI-3-6 (dated 11/6/2020)

Specify the preload or pre-tension required of the anchor studs for the HI-STORM FW Version E anchored variant.

As discussed throughout Holtec Report HI-2188720, the structural evaluation of the anchored HI-STORM FW system relies on the friction contact between the top surface of the independent spent fuel storage installation (ISFSI) pad embedded plate and the bottom surface of the baseplate of the anchored cask. An important step of the seismic evaluation described in HI-2188720 is determining that the friction force is greater than the seismic lateral force, and thus, the seismic lateral force on the cask does not impart shear loading directly on the anchorage in the ISFSI pad. The system maintains this friction contact partially by the preload of the anchor studs. As the preloading of the anchor studs is necessary to validate the seismic analysis, the staff requests that the preload of the anchor studs be specified and that the SAR be updated as needed.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.236(b).

Holtec Response (dated 12/21/2020)

The preload range is specified in Table 3.1.15 of the revised FSAR (Proposed FSAR revision 7.B). Holtec Report HI-2188720 uses pre-tension in the range of 46-56 ksi on the anchor studs. For Level A service conditions, upper bound pre-tension of 56 ksi yields higher stresses in the studs and the compression block. Lower bound pre-tension of 46 ksi yield lower slip resistance for Level D service conditions. Hence, for Level A, upper bound 56 ksi pre-tension is used; whereas for Level D, lower bound pre-tension of 46 ksi is used.

Appendix A of report HI-2188720 is updated with this range of pretension used therein. Subsequently, the Finite Element analysis presented in Appendix C of the report is also updated for the lower bound pretension value of 46 ksi for Level D conditions.

NRC Request for Clarification (Conversation Record dated 3/8/2021)

During a phone call on March 8, 2021, the staff noted that the preload information provided in Holtec's initial response to Structural RAI 3-6 may need to be added to the design drawings of the HI-STORM FW system.

Holtec Response to Request for Clarification (dated 8/2/2021)

Holtec agrees that the preload requirements for the anchored HI-STORM FW Version E anchor studs provided in the initial RAI response dated 12/21/20 should be added to Holtec Drawing 11695; the drawing has been revised accordingly.

Thermal Evaluation

RAI-4-1 (dated 9/24/2020)

Specify the allowable temperature limits are for normal or short term conditions in the HI-STORM FW, Amendment No. 6, Appendix A, Technical Specification (TS), Limiting Condition for Operation (LCO) 3.1.2, "SFSC Heat Removal System," required action C.2.3, and in the associated bases B 3.1.2, "SFSC Heat Removal System," for action C.2.3, on page 13.A-21 of the application, that are applicable to all components and contents.

In the HI-STORM FW, Amendment No. 6, Appendix A, Technical Specification 3.1.2, required action C.2.3, the applicant describes that an engineering evaluation shall be performed using the models and methods in the HI-STORM FW final safety analysis report (FSAR) to demonstrate, through this analysis, that all components and contents remain below allowable temperature limits and that the completion time is 24 hours. The allowable temperature limits for normal or short-term conditions for the associated completion time have not been specified.

The bases B 3.1.2, action C.2.2, on page 13.A-20, of the application describes that the completion time of 24 hours reflects the completion time from required action C.2.1 to ensure that component temperatures remain below their short-term temperature limits for the respective decay heat loads. However, the bases B 3.1.2, action C.2.3, on page 13.A-21, of the application describes the following:

1) an engineering evaluation may be performed to demonstrate that all component and content temperatures remain below temperatures that would prevent the component from performing its design function; and

2) if none of the components (and not described, the contents) exceed the temperatures determined above, the MPC can remain in the overpack.

Therefore, it is not clear in the HI-STORM FW, Appendix A, TS 3.1.2, required action C.2.3, or in the bases B 3.1.2, action C.2.3 of the application, if the temperature limits and the temperatures which would prevent it from performing its design function are short-term.

These clarifications are necessary to provide reasonable assurance that the HI-STORM FW spent fuel storage cask reasonably maintains the following:

1) adequate heat removal capacity without active cooling systems for clearly described temperature limits,

2) intact fuel cladding, and

3) the confinement of radioactive material under normal, off-normal, and credible accident conditions.

This information is necessary to determine compliance with 10 CFR 72.236(f) and 72.236(l).

Holtec Response (dated 12/21/2020)

Required Action C.2.3 of LCO 3.1.2 is applicable when 50% or more of each vent is blocked. Consistent with the HI-STORM FW FSAR, this is an accident condition. Accident conditions are subject to accident condition pressure and temperature limits, which are provided in HI-STORM FW FSAR Tables 2.2.1 and 2.2.3. Required Action C.2.3 is modified to state "… all component and content temperatures remain below allowable accident condition temperature limits and the MPC internal pressure remains below the accident condition pressure limit." In HI-STORM FW FSAR Chapter 13, B3.1.2, the first sentence of Action C.2.3 is modified to state "… all component and content temperatures remain below accident condition temperature limits in Table 2.2.3 and the MPC internal pressure remains below the accident condition pressure limits in Table 2.2.1."

NRC Request for Clarification (Conversation Record dated 3/8/2021)

During a phone call on March 8, 2021, the staff asked the applicant to explain the conditions in which the system would be inoperable, assuming the criteria corresponding to Condition B (partial vent blockage; a blockage greater than or equal to 50%) is met. The staff mentioned that the applicant assumed that a partial vent blockage corresponded to abnormal conditions and 100% vent blockage corresponded to accident conditions. The staff pointed out that it seemed to be an inconsistency in terms of the conditions that may render the system inoperable. The applicant pointed out that it understood the questions and it would take a look at the response. The applicant also mentioned that it may be a matter of referring to these limits consistently with their basis and defining off-normal and accident conditions. The staff asked the applicant to provide supporting information in the safety analysis report (SAR).

Holtec Response to Request for Clarification (dated 8/2/2021)

When 50% or less of the inlet and outlet vent area is blocked (i.e., 50% to 100% of the vents are open), the heat removal system is considered operable, the blockage is considered a partial blockage, and the system is subject to off-normal condition limits in FSAR Tables 2.2.1 and 2.2.3. When greater than 50% of the inlet or outlet vent area is blocked (i.e., <50% of the vents are open), the heat removal system is considered inoperable, the blockage is considered a complete blockage and consistent with the HI-STORM FW FSAR, is considered an accident condition. As such, the system is subject to accident condition limits in FSAR Tables 2.2.1 and 2.2.3. The Applicable Safety Analysis of the Bases for LCO 3.1.2 in Chapter 13 of the Proposed HI-STORM FW FSAR has been revised to include the above clarification.

RAI-4-2 (dated 9/24/2020)

Provide the following regarding HI-STORM FW, Amendment No. 6, Appendix A, TS 3.1.2, required action C.2.3 of LCO 3.1.2:

a) Summarize the technical bases to demonstrate that a completion time of 24 hours is acceptable to perform an engineering evaluation.

b) Explain how an engineering evaluation is performed to demonstrate that component temperatures are within allowable limits.

c) Describe what type of engineering evaluation is needed to demonstrate that component temperatures are within allowable limits.

The HI-STORM FW, Amendment No. 6, Appendix A, TS 3.1.2, required action C.2.3 of LCO 3.1.2 notes that one option to return the system to operable condition would be to perform an engineering evaluation within 24 hours. It is not clear to the staff how an engineering evaluation, and what type of engineering evaluation that includes analysis and results, could be realistically performed in 24 hours (especially due to the complexity of the thermal model, if it is used in the evaluation).

The staff needs assurance that no safety limit would be exceeded during normal, short-term, off-normal, or accident conditions. See the response provided to RAI 4-1 in ADAMS Accession No. ML19311C517 and the associated page changes in ADAMS Accession No. ML19311C519.

This information is necessary to determine compliance with 10 CFR 72.236(b) and 72.236(f).

Holtec Response (dated 12/21/2020)

a) The 100% vent blockage evaluation in Subsection 4.6.2.4 of the HI-STORM FW FSAR demonstrates that up to 32 hours of complete vent blockage is an acceptable duration. The completion time for Required Action C.2.3 of LCO 3.1.2 is determined to be 24 hours by subtracting the completion time for Action B.1 of LCO 3.1.2 (8 hours) from 32 hours, so the total duration of the two actions is equal to the duration evaluated in the FSAR. As for realistically performing the required analysis in 24 hours, the evaluation may be performed ahead of time using actual loaded cask decay heat loads and actual site ambient temperatures. It is expected that the option to perform an evaluation will be used mostly by sites subject to large snowfall where more than 32 hours may be needed to safely clear a large snowfall.

b) The evaluation would be performed either (1) by using the cask thermal model described in Chapter 4 of the HI-STORM FW FSAR or (2) by comparison to a previously-evaluated similar condition (i.e., a previously evaluated bounding blockage event). If performing a new evaluation (Option 1 above) the model inputs would be modified to reflect actual or bounding expected site conditions including bounding expected amount of blockage, actual decay heat load and actual or expected ambient temperature. This discussion is added to HI-STORM FW FSAR Chapter 13, B3.1.2.

c) Accident condition pressure and temperature limits from HI-STORM FW FSAR Tables 2.2.1 and 2.2.3 apply (see response to RAI 4-1 above).

NRC Request for Clarification (Conversation Record dated 3/8/2021)

During a phone call on March 8, 2021, the staff mentioned that the basis provided for the "UMAX" system (on a related topic) may also be applicable to the HISTORM FW. The applicant pointed out that it would look at the "UMAX" and evaluate if the same change can be made for the HISTORM FW.

Holtec Response to Request for Clarification (dated 8/2/2021)

Only minor substantive differences exist between the HI-STORM FW and HI-STORM UMAX Technical Specification Bases. Nevertheless, some text from the Bases in the HI-STORM UMAX FSAR has been added to the Bases for LCO 3.1.2 in the Proposed HI-STORM FW FSAR to more closely align the two systems.

Materials Evaluation

RAI-4-1 (dated 11/6/2020)

Clarify the standards used for the construction of the Independent Spent Fuel Storage Installation (ISFSI) pad.

The staff wanted to confirm the standards applicable to the design of the concrete structures and their ability to withstand outdoor conditions. The applicant noted the following:

1) Section 2 of the application includes information regarding the applicability of the code.

2) ACI 318-05 is used for the strength analysis of the ISFSI pad.

3) the analysis considers concrete behavior due to outdoor exposure.

4) the maximum concrete compression is assumed to be 7,000 psi.

For the pad, the assumptions and analyses allow to construct the pad in any place in the U.S.

The staff pointed out that the question was mainly about the fabrication requirements of the storage system. The staff noted that the safety analysis report does not contain specific requirements for the pad to be designed and constructed in accordance with ACI durability requirements to account for outdoor exposures. The applicant noted that the applicable code was ACI-318 for fabrication and that it intended to follow the durability requirements in that code. The applicant will be adding information in the safety analysis report (SAR) to clarify the applicable code for outdoor durability considerations.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.236(b).

Holtec Response (dated 12/21/2020)

As described in FSAR Section 2.0.4.2, ACI 318-05 is used in the design, evaluation, and construction of the concrete ISFSI pad. Chapter 4, Durability Requirements, of ACI 318-05 lists the design requirements for various environmental conditions. It also discusses the minimum concrete compressive strength for special exposure conditions. These exposure conditions require a minimum concrete compressive strength ranging from 4000 psi to 5000 psi dependent on conditions. The FW ISFSI pad data in Table 2.2.9 lists a maximum compressive strength of 7000 psi, which is greater than the highest minimum compressive strength required due to exposure conditions. All components used during construction of the ISFSI pad are subject to the durability requirements Chapter 4 of ACI 318-05. Section 2.0.4.1 of the FSAR has been clarified to state that Chapter 4 of ACI 318-05 applies.

NRC Request for Clarification (Conversation Record dated 3/8/2021)

During a phone call on March 8, 2021, the staff asked the applicant to explain further the meaning of the 7,000 psi parameter provided in the RAI response for the independent spent fuel storage installation (ISFSI pad). This parameter is mentioned in the mechanistic tip over analysis for the HISTORM FW storage system in the SAR. The staff asked to clarify if this parameter was a design parameter for the ISFSI pad or if it was used only for analyzing the non-mechanistic tip over and also describe the damage to the system under this condition.

Holtec Response to Request for Clarification (dated 8/2/2021)

The 7,000 psi parameter provided in Holtec's initial RAI response dated 12/21/20 was extracted from FSAR Table 2.2.9 and corresponds to the maximum ISFSI pad concrete compressive strength at which the non-mechanistic tipover analysis for the HI-STORM FW system would remain acceptable. This compressive strength is used solely as an input to the tip-over analysis to maximize the stiffness of the target and thus maximize the loading on the cask. These parameters are not considered general ISFSI design parameters. Because the pad design may be customized to meet the requirements of a particular site, the parameters in Table 2.2.9 are reference values only and can be modified in site-specific analyses. If all site-specific ISFSI pad strength properties are less than or equal to the values in Table 2.2.9, a separate site-specific tipover analysis is not required.

The 4,000 – 5,000 psi compressive strength range provided in Holtec's initial RAI response dated 12/21/20 is the acceptable range required to meet the minimum durability requirements in Chapter 4, Durability Requirements, of ACI-318-05, taking other exposure conditions into consideration. An increased compressive strength of 7,000 psi, as specified above, would not adversely affect the durability of the ISFSI pad concrete.