RAI 2-6 Follow-up

Provide a justification for the acceptance criteria in the 100U Concrete aging management program (AMP) for radiation surveys for detecting degradation of subgrade shielding material (i.e., soil).

In response to RAI 2-6, the applicant updated the 100U Concrete AMP to include dose rate measurements for monitoring the degradation of the subgrade shielding material. The subgrade is credited in the shielding analyses of the HI-STORM 100 Final Safety Analysis Report (FSAR). The applicant stated in the AMP that "the acceptance criteria for radiation surveys are dose rates that are less than a 10% increase from the previously measured dose rates."

The staff needs to understand the basis for this acceptance criteria. Based on the comparison of the ranking of the dominating isotopes as cooling time increases, as presented in Table 11 of NUREG/CR-6700, "Nuclide Importance to Criticality Safety, Decay Heating, and Source Terms Related to Transport and Interim Storage of High-Burnup LWR Fuel" (ADAMS Accession No. ML010330186), the staff expects to see that dose rates decrease with time, if soil integrity is maintained. Additionally, it is unclear to NRC staff as to whether the 10% increase from previously measured dose rates will be compared to a baseline measurement, or will be compared to the last survey. If the 10% increase acceptance value is based on the last survey rather than a baseline measurement, provide justification that this would provide adequate management of potential degradation to the subgrade shielding material over the period of extended operation.

The staff needs this information to determine if the HI-STORM 100U meets the regulatory requirements of 10 CFR 72.240(c).

Holtec Response:

The 100U Concrete AMP has been updated to remove reference to the 10% dose increase acceptance criterion. The first inspection in the period of operation is considered the baseline. The 100U AMP is updated to reflect the new acceptance criteria:

- Baseline measurements shall be lower than the dose measurements taken at the time of cask loading.
- Radiation survey dose rate measurements for all the subsequent inspections shall be less than the baseline dose rate measurements.

A reference to dose point location 1, that is 1 meter adjacent to the VVM inlet vent as shown in Figure 5.I.1 of HI-STORM 100 FSAR, is included in the AMP as a reference to show specifically where the radiation survey shall be conducted. These same changes are reflected in the AMP Section of CH. 9 of Appendix D, which comprises of the proposed FSAR text changes.

RAI 3-5 Follow-up

Clarify the discrepancy between the renewal application and FSAR for the fabrication material for the Overpack Lid Stud.

The applicant responded to RAI 3-5 and indicated that the material for the Lid Stud in Table 3.3-2 has been changed to "SA 193-B7/ SA 564-630" to match the material specification from FSAR Table 2.2.6 and licensing drawing BM-1575.

The staff reviewed the "Lid Stud" component in Table 3.3-2 of the revised renewal application (i.e., HI-2188877, Rev. 0A) and noted the material is listed as "SA 564-630/SA 193-B8," which is inconsistent with the applicant's response to RAI 3-5 and FSAR Table 2.2.6. SA-193 grades B7 and B8 are chromium-molybdenum and austenitic stainless steels, respectively, and thus they may be susceptible to different aging mechanisms.

This information is required to demonstrate compliance with 10 CFR 72.240(c).

Holtec Response:

Table 3.3-2 of the renewal application has been revised to identify the material specification for the "Lid Stud" as "SA 193-B7/ SA 564-630" in accordance with FSAR Table 2.2.6 and licensing drawing BM-1575.

RAI 3-6 Follow-up

Provide additional justification to demonstrate that the Holtite-A qualification tests support the conclusion that cracking due to radiation embrittlement, loss of fracture toughness and loss of ductility due to thermal aging, and loss of shielding due to boron depletion are not credible aging effects for the Holtite-A components in the HI-STORM 100 system during the period of extended operation.

The applicant responded to RAI 3-6 by revising its renewal application (i.e., HI-2188877, Rev. 0A) to include reference to Holtec Report HI-2002396, "Holtite-A: Development History and Thermal Performance Data," Revision 5, as a form of supporting analysis to address potential aging mechanisms for Holtite-A. The applicant indicated in its response that this report demonstrates bounding conditions for Holtite-A qualification tests in terms of radiation flux and temperature and concluded that Holtite-A is thermally stable for use in the HI-STORM 100 cask and is suitable for the radiation exposure expected throughout the period of extended operation.

However, the applicant did not adequately address the staff's request in RAI 3-6. Specifically, the applicant did not provide adequate information to demonstrate that the conclusions from the Holtite-A qualification tests discussed in Holtec Report HI-2002396 are applicable or bounding when compared to the cumulative radiation and thermal exposures that will be experienced by the Holtite-A components in the HI-STORM 100 system during the period of extended operation.

For example, information regarding the cumulative radiation and thermal exposures of the HI-STORM 100 system through the period of extended operation are not available to the staff for comparison with the qualification tests. Provide this comparison and supporting justification, so the staff is able to assess the applicant's basis that cracking due to radiation embrittlement, loss of fracture toughness and loss of ductility due to thermal aging, and loss of shielding due to boron depletion are not credible aging effects for the Holtite-A components in the HI-STORM 100 system during the period of extended operation.

This information is required to demonstrate compliance with 10 CFR 72.240(c).

Holtec Response:

Thermal exposure

The Holtite-A in the HI-STAR 100 system was initially qualified in the HI-STAR 100 FSAR using the results from HI-2002396R5. Appendix 1.B of the HI-STAR 100 FSAR shows that the results from HI-2002396R5 demonstrate that Holtite-A possesses "the necessary thermal and radiation stability characteristics to function as a reliable shielding material in the HI-STAR 100 overpack." In HI-2002396R5, a Holtite-A weight loss calculation was created parameterized by temperature and exposure time based off the testing data using measurements of variations of weight loss at differing temperatures, developing into the following form:

[

PROPRIETARY INFORMATION WITHHELD PER 10 CFR 2.390

]

[

PROPRIETARY INFORMATION WITHHELD PER 10 CFR 2.390

]

Radiation exposure:

Using the conservative total exposure time calculated above (without the extra conservative doubling of exposure time to the final tally) and the bounding loading patterns considered for a 125-ton HI-TRAC loaded with an MPC-32, a shielding analysis (HI-2210382R0) was performed in support of this RAI response to determine the accumulated neutron fluence and gamma dose to the Holtite-A in top lid of 125 ton HI-TRAC during a 60-year period. [

PROPRIETARY INFORMATION WITHHELD PER 10 CFR 2.390

] Thus, the irradiation testing described in HI-2002396R5 subjected the samples to a neutron fluence approximately 110 times the maximum accumulated fluence of the Holtite-A in a HI-TRAC over a 60-year time period. Similarly, the gamma dose to the samples was almost 80 times that expected for the accumulated Holtite-A dose over a 60-year period.

Summary:

Since the average weight loss of the samples used for radiation testing in HI-2002396R5 is above the projected weight loss for the Holtite-A in a HI-TRAC during a 60-year period as calculated above, and the total accumulated neutron fluence and gamma dose to the samples in HI-2002396R5 after thermal aging is greater than those projected in HI-2210382R0 for the Holtite-A in a HI-TRAC during a 60-year period, all conclusions reached in HI-2002396R5 remain valid and the testing conditions bound the conditions experienced by Holtite-A during a 60-year period of usage.

Note that the conclusion of HI-2002396R5 specifies that the post-radiation analysis of the samples tested confirms that "Holtite-A is stable in a radiation environment of both neutron and gamma irradiation, and suitable for long term radiation exposure expected under dry fuel storage." This is due to the fact that the post-irradiation test results showed that the irradiation tests did not result in any change in the appearance of the Holtite-A samples and the samples showed negligible change in dimensions, weight and density. Additionally, the samples showed essentially no depletion of Boron-10 post-irradiation and retained the hydrogen content following exposures to high neutron and gamma radiations. Thus, the post-irradiation results showed negligible effect on the Holtite-A samples and confirm the suitability of Holtite-A during long-term thermal or radiation exposures expected during the period of extended operation.

Section 3.3.4.5 of the License Renewal Application has been updated to summarize the aforementioned conclusions. Additionally, reference [3.3.6] has been added for reference to the new shielding analysis (HI-2210382R0) specified above and reference [3.3.7] has been added for reference to Table 4.III.6 of the HI-STORM 100 FSAR.

RAI 3-12 Follow-up

Provide a justification for why thermal aging of the Basket Shims and Solid Shims is not a credible aging effect that could challenge the shims' structural function during off-normal and accident conditions.

The applicant provided its response to RAI 3-12 related to the Basket Shims and Solid Shims for the multi-purpose canister (MPC)-68M/32M. The applicant indicated that the aluminum alloy basket shims and solid shims used in the MPC do not bear any load under ***normal conditions of storage [emphasis added]*** except for any short-term operations when the cask is transferred horizontally, and the shims are subjected to lateral acceleration from the fuel basket and contained fuel. Thus, the applicant determined that, since the basket shims and solid shims do not bear any load during the period of extended operation, thermal aging is not considered credible and revised the renewal application accordingly.

However, the staff noted that the applicant did not address the intended functions of the Basket Shims and Solid Shims for the MPC-68M/32M ***during off-normal and accident conditions [emphasis added]*** during the period of extended operation. For example, FSAR Section 3.1.2.1.2 and Table 3.1.3 describes accident condition loading scenarios for the fuel basket, and it is unclear to the staff whether a change in aluminum properties due to thermal aging would affect the basket performance in these events.

This information is required to demonstrate compliance with 10 CFR 72.240(c).

Holtec Response:

Holtec appreciates the additional clarification provided. The response below addresses off-normal and accident events defined in HI-STORM 100 FSAR.

There are no off-normal events defined in HI-STORM 100 FSAR where the shims bear any load beyond their self-weight. The governing accident condition where the shims bear significant loading is the non-mechanistic tipover accident. Therefore, this is the only condition discussed below.

Per HI-STORM 100 FSAR reference [3.III.2], the specific aluminum shim material 2219-T8511 in the extruded form does not suffer significant strength degradation at temperatures of 500°F or lower for a duration up to 10,000 hours. In addition, the Young's modulus of the material remains constant over time under the elevated temperature condition. According to Chapter 4 of the FSAR, the average basket periphery temperature remains below 500°F. Therefore, the average shim temperatures also remain below 500°F. It is also noted that the shim temperature drops over time, and the initial temperature drop is expected to be more rapid. Strictly speaking, the shim is not a structural member because it does not withstand any tensile loads, and the shim is in a confined space which would prevent its uncontrolled deformation under load. As an example, the 68M fuel basket structural analysis for the tip-over condition was performed by modeling the shim as an elastic material with a Young's modulus value corresponding to a bounding temperature of 550°F. The maximum stress in the shim obtained from the analysis is reported to be 8,798 psi (per Supplement 65 of HI-2012787), which is significantly smaller than the yield strength (14,000 psi) of the material at 550°F for 10,000 hours (per HI-STORM 100 FSAR reference [3.III.2]). Since the shim remains elastic during the tip-over event and the Young's modulus of the shim material does not change over time, any potential local strength degradation in the shim, due to thermal aging, would not affect the deformation (controlled by stress and Young's modulus) or the function of the shim. Therefore, potential strength degradation of the fuel basket shim material during the period of extended operation, including after a non-mechanistic tip-over accident, is not a safety concern and the determination that no aging management is required for the basket shims or the solid shims specified in Table 3.3-1 of the renewal application remains valid. Note that a similar reasoning was provided for response to RAI 8-4 (Holtec Letter 5014827) during the Amendment 11 CoC review process.

RAI D-1 Follow-up

Update the proposed FSAR supplement in Appendix D of the renewal application to include the following information:

a. In response to RAI D-1, Part 2, the applicant added references to the renewal application in the proposed FSAR supplement. In the FSAR supplement, the applicant includes reference 9.A.1 to the renewal application (HI-2188877, "HI-STORM 100 License Renewal Application," ***Latest Revision***) **[*emphasis added*].** In a January 12, 2021, call (ADAMS Accession No. ML21025A332), the applicant noted that, per its quality assurance program, it would develop a final revision to HI-2188877 for its records after the CoC renewal becomes effective.

   The NRC staff reviews the renewal application submitted on the docket, which forms the basis of NRC's decision on the renewal. In the safety evaluation report (SER) supporting the renewal decision, the NRC staff will reference the versions of the renewal application that it reviewed and based its renewal decision on (i.e., Rev. 0A of HI-2188877, or a future Rev. 0B if Holtec makes any

changes in response to these clarification RAIs). Also, in NRC's oversight role, NRC inspectors would typically verify that the CoC holder implemented the conditions of the renewed CoC (e.g., that the CoC holder updated the FSAR with the proposed FSAR supplement provided in the renewal application that NRC staff reviewed). Therefore, referencing the "latest revision" of the renewal application in the FSAR could result in inconsistencies with the version of the application that NRC staff reviewed, based its renewal decision on, and referenced in the SER. This could also create uncertainty for general licensees in their implementation of the renewed CoC, and for NRC's inspection of the CoC holder's and general licensees' implementation of the renewed CoC.

Revise the proposed FSAR supplement to incorporate by reference the specific version of the latest renewal application submitted on the docket or, alternatively, copy the referenced information into the FSAR.

b. In the proposed FSAR supplement, Table 9.A.1-1 MPC AMP, Element 10, there are 2 references to the renewal application that are not included in the proposed FSAR supplement (i.e., references C.1.1 and C.1.2 in the renewal application). Revise the proposed FSAR supplement to include those references.

This information is required to demonstrate compliance with 10 CFR 72.240(c).

Holtec Response:

a. To prevent any discrepancies, Holtec has updated and issued Revision 1 of HI-2188877 (which includes all changes made during the renewal application review process since the initial application submittal, including the changes made as part of these RAI follow-up responses). This renewal application report revision (Revision 1 of HI-2188877) is submitted along with these responses to the request for clarification. Going forward, if there is further correspondence with the NRC prior to the renewal application approval that requires changes to the renewal application, the application renewal will be updated to revision 2 based off any changes needed in support, and that same report and revision number will be submitted to the NRC in the next response. This will maintain continuity between the exact revisions of our internal copy of the application report, and the revision of the report the NRC is reviewing at the time. That being said, reference 9.A.1 has been updated in Appendix D to specify Revision 1 of the HI-STORM 100 License Renewal Application, HI-2188877.

b. References 9.A.2 and 9.A.3 have been added to the Section 9.A.3 reference list in the proposed FSAR supplement (the same references as C.1.1 and C.1.2 in the renewal application). The 2 references in Element 10 of Table 9.A.1-1 have been revised to reference these newly added references, 9.A.2 and 9.A.3.

RAI E-1 Follow-up:

Revise the proposed TS 5.8/5.4 and the proposed CoC condition #14 in Appendix E of the renewal application to include a clear timeframe for implementation by the CoC holder and general licensees.

a. Regarding the timing for development of procedures, the applicant provided revised language in the TS 5.8/5.4:

"The general licensee shall establish and implement these written procedures within 365 days after the effective date of the renewal of the CoC or 365 days of the

20th anniversary of the loading of the first dry storage system at its site, whichever is later."

The applicant responded to RAI E-1, noting, "The requirement in TS 5.4/5.8 was intended to cover the actual development of procedures and evaluations of the aging management program, ***which need to be implemented before the site enters the period of extended storage [emphasis added]***, but not necessarily at the same time that the renewed license is issued."

The NRC staff agrees that procedures should be implemented before the site enters the period of extended operation (PEO), which is consistent with the guidance in NUREG-1927, Section 3.6.3. However, the proposed TS language (i.e., "365 days of the 20th anniversary of the loading of the first dry storage system") may be overly prescriptive, in that it may not allow development of procedures earlier than 365 days before the PEO begins. In addition, it is not clear why performing this task 365 days *after* the PEO begins is a necessary option in the TS, given the clause already included in the proposed TS "within 365 days after the effective date of the renewal of the CoC… whichever is later" addresses the scenario of a site that is already in the PEO (or is soon approaching it) when the renewed CoC is issued. It is also unclear why a site with potentially several years available to prepare their procedures would need the option to do so 365 days after the 20th anniversary of loading. Therefore, language similar to "prior to entering the period of extended operation or no later than one year after the effective date of the CoC renewal, whichever is later" may be clearer for general licensees' implementation of the renewed CoC.

b. Regarding the timing for update of the 10 CFR 72.212(b)(5) evaluation, the applicant noted that:

"The Condition 14 requirements are for simple compliance with the renewed CoC. When the NRC issues the renewed CoC, all users will have to update the 72.212 report to ensure they are referencing the renewed CoC, which supersedes the existing approved CoC, regardless of when that system was loaded. If this step is not performed, the site may be out of compliance with 72.214."

The NRC staff notes that the current proposed condition does not include a clear timeframe for when general licensees would update the 72.212 report. In a January 12, 2021, call (ADAMS Accession No. ML21025A332), the applicant clarified that it proposes that general licensees do this within 1 year after the effective date of the renewal.

The NRC staff notes that requiring all general licensees (including those not close to entering the PEO) to update the 72.212 report within 1 year after the effective date of renewal is inconsistent with NRC's guidance in NUREG-1927, Appendix E.2, which states:

"The general licensee should update the 10 CFR 72.212(b)(5) evaluation ***before entering the period of extended operation [emphasis added]***. Considering timely renewal provisions (See Section 1.4.5), update of the 10 CFR 72.212(b)(5) evaluation before the loaded systems enter the period of extended operation may not be possible. In such cases, the reviewer should ensure that timing for update of the 10 CFR 72.212(b)(5) evaluation is addressed in the application in a clear manner."

Therefore, language similar to, "The general licensee shall complete this condition prior to entering the period of extended operation or no later than one year after the effective date of the CoC renewal, whichever is later" may be clearer for general licensees' implementation of the renewed CoC.

This information is required to demonstrate compliance with 10 CFR 72.240(c).

Holtec Response:

a. TS 5.4 and 5.8 have been revised to include similar language to the recommended language provided above.

b. Note (d) has been added to Condition 14 of the CoC to include similar language to the recommended language provided above.

Additionally, element 4 of the MPC and Overpack AMP in Appendix A and CH. 9 of Appendix D in the renewal application, and Section C.2 of Appendix C of the renewal application have been revised to include similar proposed language for the inspection criteria.

MPC AMP RAI #2 Follow-up

Revise the renewal application to clearly specify that the visual examinations performed as part of the MPC AMP will be in accordance with ASME Code Section XI, Article IWA-2200, VT-1 and VT-3. Otherwise, revise the renewal application to indicate a site-specific non-Code procedure that will be used along with a description of the inspection controls (e.g., lighting, distance, resolution) that are required to ensure that the aging effects can be detected.

In response to MPC AMP RAI #2, the applicant revised its MPC AMP in the revised renewal application (i.e., HI-2188877, Rev. 0A). Specifically, Program Element 4 - Detection of Aging Effects of the MPC AMP in the revised renewal application states "Visual examination procedures ***should*** [***emphasis added***] follow ASME Code Section XI, Article IWA-2200 for VT-1 and VT-3 examinations."

The staff noted that use of visual examination procedures consistent with ASME Code Section XI, Article IWA-2200 for VT-1 and VT-3 examinations for the MPC AMP appears to be left to the discretion of the CoC holder or a general licensee implementing the AMP. The staff requires clarity on whether the AMP includes ASME Code inspections. If the intent is to provide an option in the AMP to follow a site-specific non-Code procedure, then revise the AMP to describe the inspections controls (e.g., lighting, distance, resolution) that are required to ensure that the aging effects can be detected.

This information is required to demonstrate compliance with 10 CFR 72.240(c).

Holtec Response:

MPC AMP Element 4 "Detection of Aging Effects" has been revised to clearly specify that the visual examinations performed "shall" be in accordance with ASME Code Section IX, Article IWA-2200, VT-1 and VT-3.

100U Concrete AMP RAI #1 Follow-up

(1) Provide a justification that groundwater chemistry monitoring of the 100U Concrete AMP can directly manage concrete degradation. Otherwise, revise the renewal application and clarify the purpose of the groundwater chemistry monitoring of the 100U Concrete AMP. (2) Revise the renewal application to clarify the discrepancy for the frequency of visual inspections conducted by the 100U Concrete AMP.

In response to 100U Concrete AMP RAI #1 the applicant revised its 100U Concrete AMP and provided it in its revised renewal application (i.e., HI-2188877, Rev. 0A). The revised renewal application indicates that

groundwater chemistry monitoring of the 100U Concrete AMP can directly manage concrete degradation. However, the staff noted that the purpose of the groundwater chemistry monitoring is to identify conditions (i.e., aggressive environment) that is conducive to below-grade (underground) aging mechanisms. Thus, it is not clear how the groundwater chemistry monitoring of the 100U Concrete AMP directly manages concrete degradation. Specifically, the following is stated in the revised renewal application:

- Program Element 3 - Parameters Monitored/Inspected
    - "For inaccessible areas, groundwater monitoring is performed every 5 years to determine if any degradation from the inaccessible portions is occurring."
- Program Element 4 - Detection of Aging Effects
    - "Groundwater chemistry monitoring shall be performed every 5 years to determine if any degradation of the system from inaccessible areas is occurring."
- Program Element 6 - Acceptance Criteria
    - "Any groundwater indications of concrete degradation will be entered into the corrective action program."

The staff notes that ACI 349.3R-02 (the standard cited by the AMP) includes groundwater chemistry monitoring to identify aggressive environments that may warrant increased concrete inspection frequency – not as a means to identify evidence of degradation.

Additionally, based on revisions to the 100U Concrete AMP, the staff noted a discrepancy in the frequency of inspections. Specifically, in Program Element 4 - Detection of Aging Effects, the 100U Concrete AMP indicates that the visual inspections will be "conducted every 5 years" and "conducted annually."

This information is required to demonstrate compliance with 10 CFR 72.240(c).

Holtec Response:

100U Concrete AMP of the renewal application has been revised to include the purpose of the groundwater chemistry program specified above and remove any explicit language that referenced the test as a means to determine the condition of concrete degradation. Additionally, the discrepancy in the frequency of visual inspections of readily accessible surfaces of the ISFSI pad in Element 4 "Detection of Aging Effects" of 100U Concrete AMP was resolved and the frequency was updated to 5 years to be consistent with other elements of the 100U AMP. These same changes are reflected in the AMP Section of CH. 9 of Appendix D, which comprises of the proposed FSAR text changes.