RAI 2-1
Justify the exclusion of three multi-purpose canister (MPC) and HI-STAR 100 overpack subcomponents from the scoping evaluation and aging management review, or revise the renewal application, as appropriate.

HI-STAR 100 Final Safety Analysis Report (FSAR) Table 2.2.6 provides a list of subcomponents for the MPC and HI-STAR 100 overpack, in which the damaged fuel container, pocket trunnion plug plate, and pocket trunnion are listed with a safety class of “ITS” (important to safety). However, these subcomponents are excluded from the scope of renewal review in the renewal application.

Section 2.1 of the renewal application states that ITS structures, systems, and components (SSCs) were considered to be within the scope of renewal, and thus it is unclear to the staff why the above ITS SSCs were excluded. Provide justification for the scoping results or revise the renewal application to include the SSCs in scope and perform an aging management review.

This information is needed to confirm compliance with 10 CFR 72.240(c).

Holtec Response:

The renewal application has been revised to include the damaged fuel container in the scoping evaluation, and the pocket trunnion plug plate and pocket trunnion in the scoping evaluation and aging management review. The damaged fuel container is evaluated in Table 2.1-3 where in accordance with the HI-STAR 100 FSAR, the component is only needed for operational reasons. Therefore, this component was not included in the aging management review in Chapter 3. The pocket trunnion plug plate and pocket trunnion are now incorporated into Table 2.1-4 as part of the scoping evaluation, as well as in Table in 3.3-3 as part of the aging management review. For both components, it was determined that there are no identified aging mechanisms and no required aging management activity. This is due to the fact that for both component material options (SA240-304 and SA705-630,17-4 pH or SA564-630, 17-4 pH), the selected materials have adequate corrosion resistance throughout the period of extended operation.

RAI 2-2
Clarify the materials of construction for the HI-STAR 100 overpack closure plate seal and relief device in Table 3.3-3 of the renewal application.

Table 3.3-3 of the renewal application lists the material for the closure plate seal as Alloy X750; however, the material designation of the subcomponent in FSAR Table 2.2.6 is “commercial.” Similarly, Table 3.3-3 of the renewal application and FSAR Table 2.2.6 list the material for the relief device (rupture disk) as “commercial”; while the material designation of the subcomponent in FSAR Table 3.4.2 is brass.

To clarify the design bases for the above subcomponents and support the staff’s review of the scoping and aging management review results, provide the design-basis documentation or other information that defines the materials of construction.

This information is needed to confirm compliance with 10 CFR 72.240(c).

Holtec Response:
In reference to the closure plate seal, the material of construction is Alloy X750 as defined in Table 3.3-3 of the renewal applications. The commercial designations in the FSAR refer to the seal be produced by an external vendor. The vendor information for the seal is contained in HI-STAR 100 SAR Appendix 4.B.

The rupture disc is commercially procured to achieve its intended function of overpressure protection. Brass was a potential material of commercially procured rupture disc and therefore it discussed in the material compatibility Table 3.4.2. All the HI-STAR(s) deployed to date have used Stainless steel rupture discs. Stainless steel compatibility is covered under other components within the HI-STAR 100 system. Table 9.1.2 indicates that the rupture discs are to be replaced every 5 years, so they are not required to perform over the entire 60-year design life. The license renewal application has been updated to include the material as stainless steel in Table 3.3-3. The FSAR will be updated separately to address the inconsistency.

RAI 2-3

Clarify the design bases of the aluminum heat conduction elements and revise the renewal application scoping table to include these subcomponents.

Section 1.2.2.1 of the renewal application states, in part:

> Between the periphery of the basket, the MPC shell, and the basket supports, heat conduction elements are optionally installed. The heat conduction elements are installed along the full length of the MPC basket, except at the drain pipe location, to create a nonstructural thermal connection which facilitates heat transfer from the basket to shell. In their operating condition, the heat conduction elements will conform to and contact the MPC shell and basket walls.

Table 3.3-2 of the renewal application includes “optional heat conduction elements,” but it is unclear to the staff how optional SSCs can be relied on to fulfill an important to safety function. The staff notes that FSAR Section 3.4.1 describes these SSCs as optional, but they are not described as such in other sections of the FSAR. Drawings 3926 (MPC-24) and 3928 (MPC-68/68F/68FF) describe these elements as required for storage. Conversely, Section 3.3.1.2 of the renewal application states that the heat conduction elements are only used on some MPCs.

To provide clarity in the design bases for these subcomponents in the period of extended operation, state the function of these subcomponents and when they are required. In addition, the staff notes that these subcomponents appear to be missing in the results of the scoping evaluation in Table 2.1-3 of the renewal application, “MPC Basket Subcomponents.” Resolve this apparent inconsistency.

This information is needed to confirm compliance with 10 CFR 72.240(c).

Holtec Response:

The aluminum conduction elements were a part of the MPC design at an earlier time in the licensing process. Originally, there was NRC concern with crediting the convection mechanism inside the MPC, and so Holtec included the aluminum heat conduction elements to improve the conduction-radiation performance of the basket, in the event that convection couldn’t be

credited. The elements were never needed to maintain temperatures below limits, only if credit was not taken for any convection. Because the NRC staff did approve the use of the convection mechanism, the aluminum conduction elements are not credited with any safety function and are optional for all MPCs of any allowable heat load in the HI-STAR 100 system.

RAI 2-4

Revise the scoping and aging management review tables in the renewal application to clearly identify the subcomponents that were determined not to be within the scope of renewal.

In the renewal application, the scoping tables (Tables 2.1-2 through 2.1-6) and the aging management review tables (Tables 3.3-1 through 3.3-4) appear to include all the subcomponents in the HI-STAR 100 system, including those that do not meet the criteria for being within the scope of renewal (e.g., overpack nameplate, thermal expansion foam).

In many instances, it is unclear to the staff whether an aging effect was not identified for a subcomponent because of a technical assessment of potential degradation mechanisms or, rather, the subcomponent was determined not to be within scope. Also, because the aging management programs reference the aging management review tables to define the subcomponents within the scope of those programs, the staff notes that this has the potential to create confusion in future implementation and oversight of the aging management activities.

To support the staff's review of the scoping and aging management review results and to provide greater clarity on the scope of aging management activities, revise the Chapter 2 and 3 tables to clearly identify the subcomponents that were determined not to be within the scope of the renewal review.

This information is needed to confirm compliance with 10 CFR 72.240(c).

Holtec Response:

The tables in Chapter 3 have been updated to remove any of the sub-components that were already determined to be out of scope. The tables in Chapter 2 list all the sub-components involved and their functions. Those components which are NITS and whose failure does not prevent an ITS function from being fulfilled are considered out of scope and are not considered in the Chapter 3 aging management review. The scoping tables in Chapter 2 have also been updated to help clarify.

RAI 3-1

Justify the basis for excluding galvanic, pitting, and crevice corrosion as credible aging mechanisms for steel overpack subcomponents exposed to an outdoor environment, or revise the renewal application, as appropriate.

In Table 3.3-3 of the renewal application, general (uniform) corrosion is identified as the only aging mechanism that requires management for steel overpack subcomponents exposed to outdoor air. However, the staff notes that steels generally are considered to also be susceptible to localized corrosion mechanisms. For example, there appear to be locations with dissimilar metal contacts in the overpack, such as the contact between the nickel alloy trunnion and the carbon steel cask body, that may support galvanic corrosion. In addition, steel is considered to be susceptible to pitting and crevice corrosion in the presence of moisture and local component

geometries, coating defects, and contaminants that can establish corrosion cells (EPRI, 2006; NRC, 2019).

Provide the basis for concluding that galvanic, pitting, and crevice corrosion are not credible aging mechanisms for the exterior steel overpack subcomponents. The staff recognizes that the acceptance criteria in the Overpack Exterior Aging Management Program (AMP) includes the absence of pitting and crevice corrosion. However, the AMP incorporates Table 3.3-3 by reference to define the scope of the inspections, and that table identifies only uniform corrosion as a credible aging mechanism. The staff notes that the identification of credible localized corrosion mechanisms may inform whether inspections should seek out specific crevice locations or dissimilar metal contacts.

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

References

EPRI. Non-Class 1 Mechanical Implementation Guideline and Mechanical Tools, Revision 4, Electric Power Research Corporation Report 1010639, Palo Alto, California, January 2006.

NRC. NUREG-2214, “Managing Aging Processes in Storage (MAPS) Report,” Nuclear Regulatory Commission, Washington DC, July 2019.

Holtec Response:

Table 3.3-3 of the renewal application has been revised to include galvanic, pitting and crevice corrosion as credible aging mechanisms along with general corrosion for steel overpack subcomponents- bottom plate, top flange, closure plate, removable shear ring, removable shear ring bolt, enclosure shell return, port cover and port cover bolt. The aging mechanisms incorporated are in compliance with Table 4-9 of NUREG-2214.

RAI 3-2

Demonstrate that an inert helium environment is maintained to ensure the integrity of the MPC confinement boundary, MPC internals, and the fuel assemblies for the proposed period of extended operation (for a total 60-year operating period). Alternatively, address the potential aging effects for the MPC and its contents and revise the renewal application accordingly.

The renewal application notes that the MPC confinement boundary and its contents are in an inert helium environment and concludes that there are no credible aging effects. The HI-STAR 100 FSAR states that the leak tightness requirements of the MPC and the overpack were specifically selected to ensure an inert helium atmosphere was maintained during the initial design life, as follows:

> FSAR Section 3.4.11 (excerpt)
> The required mass quantity of helium backfilled into the canister at the time of closure as defined in the Technical Specification contained in Chapter 12, and the associated leak tightness requirements for the canister defined in the Technical Specification contained in Chapter 12, are specifically set down to assure that an inert helium atmosphere is maintained in the canister throughout a 40-year service life.
>
> FSAR Section 4.1 (excerpt)

> Both the MPC confinement boundary and the overpack helium retention boundary are required to meet maximum leakage rate Technical Specifications included in Chapter 12 of this FSAR. These leakage rate criteria are selected to ensure the presence of helium during the entire storage life.

The HI-STAR 100 design bases credit the presence of the inert helium atmosphere to ensure that SSCs are not degraded by an oxidizing atmosphere or elevated temperatures due to reduced heat transfer performance. For example, FSAR Sections 3.4.11 and 7.22 credit the helium for preventing MPC corrosion, spent fuel cladding oxidation, and excessive spent fuel cladding temperatures. Also, FSAR Table 3.4.2 cites the presence of an inert atmosphere in concluding that there are no adverse reactions for the MPC, basket subcomponents, and neutron absorbers. Finally, FSAR Appendix 12.A, "Technical Specification Bases," Sections B 2.1.1, "Multi-Purpose Canister (MPC)" and B 2.1.2, "Overpack", state that the long-term integrity of the fuel cladding depends on the inert atmosphere in the MPC and the heat transfer provided by the helium in the annulus between the MPC and the overpack.

Based on the FSAR references above, the integrity of the MPC and its contents appear to be based on an analysis of potential helium loss over time, with the leakage rate criteria in the Technical Specifications being selected to ensure sufficient helium would be present, and oxygen ingress would be prevented, throughout the initial 40-year design life. Provide an analysis to show that sufficient helium is maintained within the MPC and overpack to prevent aging of the MPC confinement boundary, MPC internals, and the fuel assemblies over the proposed total 60-year operating period. Alternatively, address the potential aging effects and revise the LRA accordingly.

This information is needed to determine compliance with 10 CFR 72.240(c).

Holtec Response:
The HI-STAR 100 is initially sealed with a leak rate acceptance criterion of 4.3 x 10^{-6} atm cm^3/s for helium within the annulus space. The standard for Leakage testing of radioactive packages for shipping was consulted.

Equation B.2 is used to estimate volume leakage rate at the average pressure.

$$L_a = (F_c + F_m)(P_u - P_d)\ cm^3/s, \qquad (B.2)$$

where

$$F_c = [2.49 \times 10^6\ D^4]/(a\mu)\ cm^3/atm{\cdot}s, \qquad (B.3)$$

and

$$F_m = [3.81 \times 10^3\ D^3\ (T/M)^{0.5}]/(aP_a)\ cm^3/atm{\cdot}s. \qquad (B.4)$$

Using the equation from the leakage standard at initial temperature of 273 K and atmospheric pressure of 1 atm, the diameter of a leakage hole was calculated to provide an estimate. The estimate hole diameter 4.2 X 10^{-4} cm was the estimated hole size.

Using the design pressure from Table 2.0.2 of the FSAR and Normal Storage Maximum Temperature from Table 4.4.10, the hole size was used to determine a conservative leakage rate during storage.

The resulting leakage rate was determined to be 7.5 X 10^{-6} cm/s. When considered over the 60-year life of the HI-STAR 100, this would result in a net loss of approximately 11% of helium.

The results prove that the inert helium atmosphere would remain during the time of storage. The MPC has been qualified and tested to meet the ANSI N14.5 Leak tight Criteria (<1 × 10-7 ref·cm^3/s). The leakage over the 60 years life would be negligible to the overall volume of helium with the MPC.

Note that this information is provided as a technical basis. However, this evaluation is not part of any original design basis calculations for the system for the first 20 year life, so it has not been included in the TLAA information.

RAI A-1

Provide an aging management review and aging management activities, if applicable, for the inaccessible (bottom) portion of the HI-STAR 100 overpack.

The aging management review results for the HI-STAR 100 overpack in LRA Table 3.3-3 include a line item for the overpack bottom plate that is exposed to outdoor air. However, the aging management review does not address the portion of the bottom plate that rests on the concrete pad. NUREG-2214 recommends that steel components be managed for loss of material due to corrosion when there may be water ingress.

To address potential degradation of the overpack bottom, provide an aging management review for this material/environment combination, considering available operating experience from previous cask bottom inspections. If credible aging effects are identified, revise the Overpack Exterior AMP to describe how those aging effects will be managed.

This information is required to demonstrate compliance with 10 CFR 72.240(c)(3).

Holtec Response:

Table 3.3-3 of the renewal application has been updated to include the aging mechanisms for the bottom plate exposed to concrete pad. However, it is important to note that the bottom plate is coated with the same material as the external of the overpack, which is exposed to the ambient environment. Therefore, it is expected that any corrosion from those identified mechanism would be seen on the exterior prior to being seen on the portion covered by the concrete pad. So, if the exterior inspection described in the AMP identifies significant corrosion, one of the corrective actions may be to extend the inspection to the embedded areas. The AMP has been updated to identify this as a potential area for consideration for corrective actions. Additionally, an acceptance criterion has been added for evidence of corrosion, such as rust, on the ISFSI pad concrete in the area adjacent to the overpack. This provides additional assurance that the bottom plate area is considered in the inspection.

RAI A-2

Clarify the inspection standard, personnel qualification criteria, and inspection coverage in the ISFSI Pad AMP that demonstrates that potential aging-related degradation will be identified and appropriately evaluated.

The “Detection of Aging Effects” program element of the ISFSI Pad AMP states the visual surveys will be performed in accordance with ACI-349 by qualified individuals. The staff notes that ACI-349, “Code Requirements for Nuclear Safety-Related Concrete Structures,” primarily addresses new structures. ACI-349-13 states:

> While the requirements of this Code pertain primarily to new concrete structures, corresponding recommendations for the evaluation of existing concrete nuclear structures are provided in ACI 349.3R.

As such, ACI 349.3R, “Report on Evaluation and Repair of Existing Nuclear Safety-Related Concrete Structures,” provides recommendations for concrete evaluation procedures, including descriptions of degradation mechanisms, visual examination distance, qualifications of the evaluation team, equipment use, and acceptance criteria (among other recommendations). Regarding personnel qualification, Chapter 7 of ACI 349.3R establishes education, training, and work experience criteria for the responsible engineer and concrete inspector.

Given that ACI 349, rather than ACI 349.3R, is citied in the Detection of Aging Effects program element, it is unclear to the staff what guidance will be followed to inspect and evaluate the condition of the ISFSI pad to ensure its performance in the period of extended operation.

In addition, as neither ACI 349 nor ACI 349.3R have specific requirements for inspection coverage, the staff requires clarification of whether 100 percent of readily accessible surface will be inspected, or some justified lower extent of coverage.

This information is required to demonstrate compliance with 10 CFR 72.240(c)(3).

Holtec Response:

The ISFSI Pad AMP has been updated to include ACI.349.3R as the standard for visual inspection requirements, inspector requirements and evaluation of ISFSI performance during the period of operation.

Inspections will be performed for 100 percent readily accessible surface of the concrete pad.

RAI A-3

Provide justification that the proposed aging management activities in the ISFSI Pad AMP will adequately evaluate the condition of the below-grade concrete that is exposed to a soil environment, or revise the renewal application, as appropriate.

Table 3.3-5 of the renewal application identifies aging mechanisms and effects for the ISFSI pad exposed to soil environments, and the ISFSI Pad AMP is credited to manage the aging effects. However, the ISFSI Pad AMP does not discuss or include any activities that address the below-grade portion of the ISFSI pad exposed to a soil environment.

The renewal application references the 2002 version of ACI 349.3R, which recommends a 10-year inspection interval for below-grade structures, with a potential increased frequency if aggressive environments exist. Conversely, the 2018 version of ACI 349.3R, "Report on Evaluation and Repair of Existing Nuclear Safety-Related Concrete Structures," Chapter 6, "Evaluation Frequency," and NUREG-2214 recommend that, for structures with non-aggressive exposures, representative samples of below-grade concrete be opportunistically examined when excavated for any reason.

Given the absence of discussion of below-grade structures in the ISFSI Pad AMP, clarify how the AMP manages the effects of aging of below-grade concrete, including any technical bases (e.g. soil/groundwater aggressiveness) that support the proposed aging management approach.

This information is required to demonstrate compliance with 10 CFR 72.240(c)(3).

Holtec Response:

ISFSI Pad AMP has been revised to include the discussions to evaluate the below-grade structures of the concrete pad exposed to the soil environment per the requirements listed in NUREG-2214 and ACI.349.3R.

RAI A-4

Describe any operating experience for the ISFSI pads (e.g., results from any inspections performed on the ISFSI pads at the sites that utilized the HI-STAR 100 system), and revise the renewal application, as appropriate.

ISFSI Pad AMP element 10, Operating Experience, does not include a review of past operating experience. NUREG-1927, Revision 1, Section 3.6.1.10, Operating Experience, recommends that the operating experience element of the program support a determination that the effects of aging will be adequately managed. Operating experience is useful in providing justification for the effectiveness of each AMP program element and critical feedback for enhancement.

It is unclear if any inspections have been performed on the ISFSI pads and whether those inspections identified any indications of degradation. The renewal application should provide any available inspection details (e.g., scope, methodology, and results) that support the adequacy of the proposed aging management activities.

This information is required to demonstrate compliance with 10 CFR 72.240(c)(3) and (d).

Holtec Response:

During preparation of the renewal application, all users of Holtec systems (including those other than the HI-STAR 100) were requested to share operating experience related to all components of the spent fuel storage system. In the information provided, there were no significant issues identified related to the storage pads. Minor localized imperfections were noted at a very small number of sites, and no degradation that would challenge the properties of the pad which support the safety function of the HI-STARs. This information has been included in the ISFSI Pad AMP.

RAI D-1

Update the time-dependent references in the FSAR to reflect the proposed period of extended operation (for a total 60-year operating period) and include the corresponding FSAR change pages in Appendix D of the renewal application. If a time-dependent reference is a time-limited aging analysis (TLAA), demonstrate that the analysis is still valid for the period of extended operation, or alternatively, manage the aging effects through an AMP.

Appendix D of the renewal application includes FSAR change pages to address aging management for the proposed period of extended operation (for a total 60-year operating period). However, Appendix D does not include all of the time-dependent references in the FSAR that currently reflect a less than 60-year operating period. For example, page 3.4-62 of

the FSAR (that was included in Appendix D of the renewal application) contains references to a 40-year service life for the MPC.

The FSAR must clearly reflect the approved design bases, including the period of extended operation if the renewal is approved. In addition, the CoC renewal will include a condition to update the FSAR to incorporate the FSAR page changes in Appendix D of the renewal application, within 90 days after issuance of the renewal, as proposed by the applicant. Therefore, Appendix D of the renewal application must include all FSAR changes related to the renewal.

For each updated time-dependent reference, the applicant should state whether the time dependent reference is a generic reference (e.g., reference to the service life of the system), or if the time-dependent reference is associated with a design-basis evaluation that is considered a TLAA for the renewal. If a TLAA, the applicant should demonstrate that the TLAA is still valid for the requested period of extended option, or alternatively, manage the aging effects through an AMP.

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

Holtec Response:

The FSAR was searched for additional references to the life of the system. No additional TLAAs were identified, but all generic references were updated and the pages included in Appendix D. Additional information was added related to the expected activation of components for decommissioning, however, this is not considered a TLAA because it does not impact any of the safety functions of any components. The provided values are just estimates for sites performing decommissioning, and are not used to demonstrate the safety of any component. However, for completeness, they are updated for 60 years.