FINAL SAFETY EVALUATION REPORT

FOR THE HUMBOLDT BAY

INDEPENDENT SPENT FUEL STORAGE INSTALLATION

LICENSE RENEWAL

DOCKET NO. 72-27

LICENSE NO. SNM-2514

Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission

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CONTENTS

TABLES

ABBREVIATIONS AND ACRONYMS

ACI	American Concrete Institute
ADAMS	Agencywide Documents Access and Management System
AMID	Aging Management Institute of Nuclear Power Operations Database
AMP	aging management program
AMR	aging management review
ASME	American Society of Mechanical Engineers
C	Celsius
CAP	Corrective Action Program
CFR	*Code of Federal Regulations*
CISF	consolidated interim storage facility
CPUC	California Public Utility Commission
DCE	decommissioning cost estimate
DFP	decommissioning funding plan
DOE	U.S. Department of Energy
F	Fahrenheit
GAO	U.S. Government Accountability Office
GTCC	greater-than-class C
GWC	greater-than-class C waste container
HB	Humboldt Bay
HBPP	Humboldt Bay Power Plant
ISFSI	independent spent fuel storage installation
ITS	important to safety
LRA	license renewal application
MIT	Massachusetts Institute of Technology
MPC	multipurpose canister

NRC	U.S. Nuclear Regulatory Commission
OE	operating experience
PG&E	Pacific Gas and Electric Company
QA	quality assurance
RAI	request for additional information
SAR	safety analysis report
SCC	stress-corrosion cracking
SER	safety evaluation report
SNM	special nuclear material
SSC	structure, system, and component
TLAA	time-limited aging analysis

INTRODUCTION

Under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste," the U.S. Nuclear Regulatory Commission (NRC) issued a specific license for the independent spent fuel storage installation (ISFSI) at the Humboldt Bay Power Plant (HBPP), Special Nuclear Material (SNM) License No. SNM-2514, for 20 years, with an expiration date of November 17, 2025. SNM-2514 authorizes the Pacific Gas and Electric Company (PG&E) (the "licensee" or "applicant") to receive, possess, transfer, and store spent fuel and reactor-related greater-than-Class-C (GTCC) wastes from the HBPP in the Humboldt Bay ISFSI. The HBPP site is located near the coastal community of Fields Landing on the eastern shore of Humboldt Bay in Humboldt County, in northwestern California. Eureka, the largest city in Humboldt County, is located approximately 4.8 kilometers (3 miles) north of the ISFSI site. PG&E owns approximately 58 hectares (143 acres) on the shore of Humboldt Bay opposite the bay entrance. PG&E also owns the water areas extending approximately 150 meters (500 feet) into Humboldt Bay from the land area.

By letter dated July 10, 2018 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML18215A202), as supplemented October 22, 2018 (ADAMS Accession No. ML18330A052); July 1, 2019 (ADAMS Accession No. ML19197A028); July 25, 2019 (ADAMS Accession No. ML19221B575); and November 21, 2019 (ADAMS Accession No. ML19337C633), P&GE submitted an application to the NRC for the renewal of License No. SNM-2514 for an additional 40 years beyond the initial license term. The initial license term expires on November 17, 2025. The license renewal, if approved, would authorize the applicant to continue storing spent fuel and GTCC wastes in the Humboldt Bay ISFSI until November 17, 2065. The applicant submitted the license renewal application in accordance with the regulatory requirements of 10 CFR 72.42, "Duration of License; Renewal." This license renewal application constitutes a timely renewal under 10 CFR 72.42(b) and (c), because the applicant submitted it more than 2 years before the license expiration date.

The Humboldt Bay ISFSI consists of an ISFSI storage vault, a cask transporter, and the dry cask storage system. PG&E uses the Holtec International HI-STAR 100 dry cask storage system, as modified for the HBPP spent fuel. The HBPP-specific design, referred to as the HI-STAR HB system, is shorter in length than the standard HI-STAR 100 dry cask storage system in order to accommodate the smaller fuel assemblies used at Humboldt Bay. The NRC certified the HI-STAR 100 System for use by general licensees under Certificate Number 1008 (ADAMS Accession No. ML003711932). The HI-STAR HB System includes a welded multipurpose canister (MPC-HB), canisters designed to store damaged fuel, and a HI-STAR HB storage/transport bolted steel overpack. The MPC-HB and overpack sit in an in-ground concrete storage vault. The Humboldt Bay ISFSI is designed to store up to 400 spent fuel assemblies in five storage casks, with a sixth cask to store HBPP reactor-related GTCC waste. The maximum average fuel burnup per assembly of any fuel that is stored at the ISFSI is less than 23,000 megawatt-days per metric ton of uranium. The maximum average initial fuel assembly enrichment is equal to or less than 2.51 percent of uranium-235.

The license renewal application documents the technical bases for the renewal of the license and actions proposed to manage potential aging effects on the structures, systems, and components (SSCs) of the ISFSI that are important to safety, to ensure that SSCs will maintain their intended functions during the period of extended operation. The application presented general information on the ISFSI design and a scoping evaluation that identified those SSCs within the scope of review for the license renewal (i.e., “in-scope” SSCs). These in-scope SSCs are subject to an aging management review (AMR). The applicant further screened the in-scope SSCs to identify and describe the subcomponents that support the intended functions of the in-scope SSCs. For each in-scope SSC with an identified aging effect, the applicant proposed an aging management program or provided a time-limited aging analysis to ensure that the SSC would maintain its intended function(s) during the period of extended operation.

The NRC staff reviewed the technical bases that support that the ISFSI will operate safely for an additional 40 years beyond the term of the current operating license. This safety evaluation report (SER) summarizes the results of the staff’s review and its determination that the application demonstrates compliance with 10 CFR 72.42. In its review of the license renewal application and preparation of the SER, the staff relied on the guidance in (1) NUREG-1927, Revision 1, “Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel,” issued June 2016 (NRC, 2016), (2) NUREG-2214, Revision 0, “Managing Aging Processes In Storage (MAPS) Report,” issued July 2019 (NRC, 2019), and (3) NUREG-1757, Volume 3, Revision 1, “Consolidated Decommissioning Guidance—Financial Assurance, Recordkeeping, and Timeliness,” issued February 2012 (NRC, 2012). The staff assessed whether the application demonstrates compliance with the NRC’s financial qualification and financial assurance requirements found in 10 CFR 72.22(e) and 10 CFR 72.30, including those associated with decommissioning the ISFSI, as appropriate. NUREG-2214 establishes a generic technical basis for the safety review of ISFSI license renewal applications and certificates of compliance for dry storage systems. It identifies areas that should be evaluated: (1) aging mechanisms and effects that could affect the ability of ISFSI SSCs to fulfill their safety functions in the period of extended operation (i.e., credible aging mechanisms and effects); and (2) aging management approaches which address credible aging effects; and examples of aging management programs that are considered generically acceptable to address the credible aging effects to ensure that the design bases will be maintained in the period of extended operation.

The staff evaluated the applicant’s technical basis for its AMR against the technical basis in NUREG-2214 and applicant’s proposed aging management programs to ensure the design features, environmental conditions, and operating experience for the Humboldt Bay ISFSI are bounded by the generic conditions evaluated in NUREG-2214.

This SER contains six sections. Section 1 documents the staff’s review of the general and financial information presented in the license renewal application. Section 2 documents the staff’s review of the scoping evaluation for determining which SSCs are within the scope of renewal. Section 3 documents the staff’s evaluation of the AMR for assessing aging effects on SSCs within the scope of renewal and the aging management activities address the effects. Section 4 documents additions and changes to the license. Section 5 presents the conclusions from the staff’s review. Section 6 lists the references supporting the staff’s review and technical determinations.

1 GENERAL INFORMATION

1.1 <u>Specific License Holder Information</u>

The license renewal application (LRA) includes general information on the specific license holder, the Pacific Gas and Electric Company (PG&E). The LRA includes the name and address of the applicant; a description of the business of the applicant and the State in which it is incorporated and does business; and the organization and management of the applicant, including the names, addresses, and citizenship of the directors and principal officers.

According to the applicant, the Humboldt Bay (HB) independent spent fuel storage installation (ISFSI) is wholly owned by PG&E. As the owner, PG&E has responsibility for operating and maintaining the HB ISFSI. PG&E is an investor-owned utility, incorporated in the State of California, which provides electricity to approximately 16 million people.

The U.S. Nuclear Regulatory Commission (NRC) staff finds that the applicant provided the information required in Title 10 of the *Code of Federal Regulations* (10 CFR) 72.22 (a)–(d).

1.2 <u>Financial Qualifications</u>

The regulation at 10 CFR 72.22(e) states the following:

> Except for DOE [U.S. Department of Energy], information sufficient to demonstrate to the Commission the financial qualifications of the applicant to carry out, in accordance with the regulations in this chapter, the activities for which the license is sought. The information must state the place at which the activity is to be performed, the general plan for carrying out the activity, and the period of time for which the license is requested. The information must show that the applicant either possesses the necessary funds, or that the applicant has reasonable assurance of obtaining the necessary funds, or that by a combination of the two, the applicant will have the necessary funds available to cover the following:
>
> (1) Estimated construction costs;
>
> (2) Estimated operating costs over the planned life of the ISFSI; and
>
> (3) Estimated decommissioning costs, and the necessary financial arrangements to provide reasonable assurance before licensing, that decommissioning will be carried out after the removal of spent fuel, high-level radioactive waste, and/or reactor-related GTCC [greater-than-class C] waste from storage.

1.2.1 Independent Spent Fuel Storage Installation Construction Cost Estimate

The HB ISFSI consists principally of stainless steel multipurpose canisters (MPCs), bolted steel overpacks, an in-ground concrete storage vault, and the cask transportation system. According to the HB ISFSI safety analysis report (SAR), the applicant does not expect contamination on the storage cask or significant activation of the concrete and steel during the period of extended operation.

Because the HB ISFSI is already constructed and no plans for expansion exist at this time, a staff review of construction costs is not warranted at license renewal.

1.2.2 Independent Spent Fuel Storage Installation Operating Cost Estimate

PG&E's LRA, as supplemented by its response to NRC's request for additional information (RAI) (PG&E, 2019a), conservatively estimated that the annual operating and maintenance costs for the HB ISFSI are approximately $8.9 million ($2018). This estimate considers factors found in the decommissioning cost analyses, including costs associated with ISFSI security, project management, staffing, cask maintenance, equipment surveillances, and infrastructure expenses associated with spent fuel management.

To evaluate the reasonableness of this estimated cost, the staff reviewed the applicant's estimated ISFSI operations costs against costs reported in a 2001 Massachusetts Institute of Technology (MIT) report (MacFarlane 2001); two U.S. Government Accountability Office (GAO) reports that estimate annual operations and maintenance costs for a centralized storage facility (GAO, 2009), and safety and security system and annual operational costs for dry storage at a shutdown reactor site (GAO 2014); a DOE report (DOE, 2016); and actual costs from three ISFSIs with decommissioned reactors (The Yankee Company, n.d.a., n.d.b., n.d.c.).

The 2001 MIT report, "Interim Storage of Spent Fuel in the United States" (Macfarlane, 2001), estimates ISFSI operating costs at a shutdown reactor, with all spent fuel in dry storage, to be approximately $4 million per year. That cost estimate is approximately $5.7 million annually, accounting for inflation through year 2017. GAO-10-48, "Nuclear Waste Management: Key Attributes, Challenges, and Costs for the Yucca Mountain Repository and Two Potential Alternatives" (GAO, 2009), estimates the cost of annual operations and maintenance for a centralized storage facility, also referred to as a or consolidated interim storage facility (CISF). The GAO report estimates the operations costs for a CISF is $8.8 million (GAO, 2009). When accounting for inflation through year 2017, the annual cost estimate is approximately $10 million. The storage capacity of a CISF is approximately 200 times greater than the spent nuclear fuel storage capacity of the HB ISFSI. The staff considered the GAO's CISF estimate a high-end estimate, which bounds the operational costs for the HB ISFSI, because operational costs are expected to be higher at a larger facility, such as a CISF. The GAO estimates the annual operations and related costs at a shutdown reactor site to range from $2.5 to $6.5 million (GAO, 2014). The actual inflation from 2014 through 2015 was negligible, at approximately 2 percent during that period. The DOE considered costs for an interim storage facility and assumed annual maintenance, security, and monitoring costs of $10 million for an ISFSI located at a shutdown reactor site (DOE, 2016).

The NRC staff also reviewed publicly available information for the Connecticut Yankee, Maine Yankee, and Yankee Rowe decommissioned facilities and their associated ISFSIs, which show the annual cost to operate ISFSI is approximately $10 million (The Yankee Company, n.d.a., n.d.b., n.d.c.).

The staff estimates the annual operating costs for an ISFSI at a shutdown reactor range from $2.5 million to $10 million based on its review of estimates presented in the MIT, GAO, and DOE reports, and on operating costs from operating ISFSIs. Expenditures in PG&E's response to the NRC's RAI show an average annual operating cost for the HB ISFSI of approximately

$640 thousand per year (ADAMS Accession No. ML19197A026). The estimate is provided in their most recent Decommissioning Funding Report in Table 8.1[1], line 14 (ADAMS Accession No. ML19087A094), which considers operating and maintenance costs from 2019 through 2033. The staff finds the annual operating cost estimate for the HB ISFSI of approximately $640 thousand (in 2018 dollars) during the period of extended operation, properly provides the information required in 10 CFR 72.22(3). The staff finds the annual estimate is reasonable.

1.2.3 Independent Spent Fuel Storage Installation Operating Funds Availability

The NRC staff reviewed the information in PG&E's RAI response (PG&E, 2019a) to assess whether PG&E demonstrated reasonable assurance that adequate funding will be available to cover the estimated annual operating costs of $8.9 million for the HB ISFSI. PG&E is a public utility and a portion of HB ISFSI's estimated decommissioning costs are funded by rates approved by the California Public Utilities Commission (CPUC) (ADAMS Accession No. ML19197A026). The CPUC approved the collection of funds for decommissioning the HB ISFSI until the decommissioning of the HB facility is completed. The staff relies on the CPUC funding for decommissioning funding assurance. For these reasons, the staff does not anticipate the bankruptcy of PG&E will have a negative impact on decommissioning funding assurance. In addition, PG&E has historically shown a positive net income (profit) of $888 million in 2015, $1.4 billion in 2016, and $1.7 billion in 2017 (PG&E, 2017).

The staff finds reasonable assurance that PG&E demonstrated reasonable assurance that sufficient funds are available to cover the estimated annual operating cost of $8.9 million per year over the period of the renewed license. The staff also finds reasonable assurance that PG&E, a public utility able to collect funds through its ratepaying authority, will maintain funds greater than the estimated maintenance costs of the ISFSI.

1.2.4 Decommissioning Funding Assurance

Under 10 CFR 72.30(c), each holder of, or applicant for, a license under 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste," must submit for NRC review and approval a decommissioning funding plan (DFP) containing information on how the applicant has reasonable assurance that funds will be available to decommission its ISFSI. At the time of license renewal and at intervals not to exceed 3 years, the licensee must submit the DFP with adjustments as necessary to account for changes in decommissioning costs and the extent of contamination. The DFP must update the information submitted with the original or previously approved plan under 10 CFR 72.30(b). In addition, the DFP must specifically consider the effect on decommissioning costs of (1) spills of radioactive material producing additional residual radioactivity in onsite subsurface material, (2) facility modifications, (3) changes in authorized possession limits, and (4) actual remediation costs that exceed the previous cost estimate. 10 CFR 72.30(b)(2) states the DFP must contain a detailed decommissioning cost estimate in an amount reflecting (1) the cost of an independent contractor to perform all decommissioning activities, (2) an adequate contingency factor, and (3) the cost of meeting the unrestricted use criteria in 10 CFR 20.1402, "Radiological Criteria for Unrestricted Use" (or the cost of meeting the restricted use criteria in 10 CFR 20.1403, "Criteria

[1] Table 8.1 also has separate line items for costs related to security (13), staffing/engineering/contracts (15) and infrastructure (16) which would, if included with O&M, raise the average annual cost estimate to $8.9 million per year.

for License Termination under Restricted Conditions," provided the licensee can demonstrate its ability to meet these criteria).

The licensee's DFP must also identify and justify using the key assumptions contained in the decommissioning cost estimate (DCE) (10 CFR 70.30(b)(3)). Further, the DFP must describe the method of assuring funds for ISFSI decommissioning, including the means for adjusting cost estimates and associated funding levels periodically over the life of the ISFSI (10 CFR 70.30(b)(4)). Finally, the DFP must specify the volume of onsite subsurface material containing residual radioactivity that will require remediation to meet the criteria for license termination, and the DFP must contain a certification that financial assurance for ISFSI decommissioning has been provided in the amount of the DCE (10 CFR 70.30(b)(5)-(6)).

PG&E provided its original DFP for review and approval on December 17, 2012 (ADAMS Accession No. ML12353A316). Under 10 CFR 72.30(c), HB updated its DFP, including the DCE for the ISFSI, as part of the LRA. PG&E estimated the cost to decommission the HB ISFSI for unrestricted use to be $1.2 million (in 2017 dollars), which included a 25-percent contingency factor (ADAMS Accession No. ML18351A380). The staff's review of PG&E's updated DFP considered guidance in NUREG-1757, Volume 3, Revision 1 (NRC, 2012). In this regard, the staff concluded that the DCE (1) appears to be based on reasonable costs, (2) includes an adequate contingency factor of 25 percent, and (3) is considered reasonable based on documented assumptions described in detail within the licensee's submittal.

PG&E currently relies on an external sinking trust fund as financial assurance for ISFSI decommissioning, a method authorized by 10 CFR 72.30(e). The external sinking trust fund is based on site-specific cost estimates that include estimated ISFSI decommissioning costs. The NRC staff reviewed the licensee's updated DFP and finds that the aggregate dollar amount of each of the licensee's financial instruments provides adequate financial assurance to cover its updated DCEs.

As part of the LRA, PG&E provided decommissioning funding assurance in the form of a trust for the HB ISFSI. These reports include total funds in the trusts (as of December 31, 2018) allocated for radiological decommissioning. The staff notes that PG&E clearly delineated the funds designated for radiological decommissioning expenses and that the aggregate amount exceeds the ISFSI decommissioning cost estimate of $1.2 million. Based on the amount of funds, the staff finds that the applicant has demonstrated decommissioning funding assurance for the HB ISFSI. Additionally, in Section 13.1.1.2 of the NRC safety evaluation report (SER) issued November 2005, the NRC concludes "…that the CPUC will likely approve justifiable requests for additional rate recovery as necessary to fully fund the decommissioning trust for circumstances that could not be foreseen or reasonably avoided by PG&E."

Based on the review of the application and all associated documentation, the NRC staff finds that the applicant has provided both a reasonable cost estimate for the radiological decommissioning of the HB ISFSI and reasonable assurance that funds will be available for radiological decommissioning of the ISFSI at the time of license termination.

1.2.5 Conclusion

Based on an independent analysis of the information in the application, the NRC staff finds that there is reasonable assurance that PG&E is financially qualified to engage in the proposed activities with regard to the HB ISFSI, as described in the LRA, for the additional 40-year period and that PG&E has successfully demonstrated decommissioning funding assurance, meeting the requirements in 10 CFR 72.22(e) and 10 CFR 72.30(c).

1.3 Environmental Review

Regulations in 10 CFR 72.34, "Environmental Report," require that each application for an ISFSI license under this part be accompanied by an environmental report that meets the requirements of Subpart A, "National Environmental Policy Act—Regulations Implementing Section 102(2)," of 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." The applicant submitted an environmental report supplement as part of the LRA. The environmental report contained sufficient information to aid the staff in its independent analysis. In April 2020, the staff issued an environmental assessment (NRC, 2020) for the ISFSI LRA.

1.4 Safety Review

The objective of this safety review is to determine whether there is reasonable assurance that the ISFSI will continue to meet the requirements of 10 CFR Part 72 during the requested period of extended operation. Under 10 CFR 72.42(a), an application for ISFSI license renewal must include the following:

- time-limited aging analyses (TLAAs) that demonstrate structures, systems, and components (SSCs) important to safety (ITS) will continue to perform their intended functions for the requested period of extended operation

- a description of the aging management program (AMP) for management of issues associated with aging that could adversely affect ITS SSCs

The applicant stated that it prepared the LRA in accordance with applicable provisions of 10 CFR Part 72 and NUREG-1927, Revision 1 (NRC, 2016). The applicant performed a scoping evaluation and aging management review (AMR) to identify all SSCs within the scope of the license renewal and pertinent aging mechanisms and effects, respectively. The applicant developed AMPs and evaluated TLAAs to ensure that the SSCs identified to be within the scope of renewal will continue to perform their intended functions during the period of extended operation. This review documents the staff's evaluation of the applicant's scoping analysis, AMR, and supporting AMPs and TLAAs.

1.5 Application Content

The applicant's LRA, as supplemented, provided the following information:

- general and financial information
- scoping evaluation
- AMR
- AMPs
- TLAAs
- results of preapplication inspections
- environmental report supplement
- proposed license changes and evaluation of technical specifications
- SAR supplement

- ISFSI DFP

Safety Review Evaluation Findings

The staff reviewed the information in the LRA and supplemental documentation. The staff's review followed the guidance in NUREG-1927, Revision 1 (NRC, 2016), and NUREG-1757, Volume 3, Revision 1 (NRC, 2012). Based on its review, the staff determined that the applicant provided sufficient information with adequate details to support the LRA with the follow findings:

F1.1 The information presented in the LRA satisfies the requirements of 10 CFR 72.2, "Scope"; 10 CFR 72.22, "Contents of Application: General and Financial Information"; 10 CFR 72.30, "Financial Assurance and Recordkeeping for Decommissioning"; 10 CFR 72.34; and 10 CFR 72.42, "Duration of License; Renewal."

F1.2 The applicant has tabulated all supporting information and docketed material incorporated by reference in accordance with 10 CFR 72.42.

2 SCOPING EVALUATION

As described in NUREG-1927, Revision 1 (NRC, 2016), the scoping evaluation identifies the SSCs subject to an AMR, through which the effects of aging are assessed. More specifically, the scoping evaluation is used to identify SSCs meeting either of the following two criteria:

(1) SSCs that are classified as ITS, as they are relied on to carry out one of the following functions:

- Maintain the conditions required by the regulations, specific license, or Certificate of Compliance to store spent fuel safely.
- Prevent damage to the spent fuel during handling and storage.
- Provide reasonable assurance that spent fuel can be received, handled, packaged, stored, and retrieved without undue risk to public health and safety.

(2) SSCs that are classified as not ITS but, according to the design bases, whose failure could prevent fulfillment of a function that is ITS

After the determination of in-scope SSCs, subcomponents of the SSCs are screened to identify those that have intended functions that support the ITS SSCs.

2.1 <u>Scoping and Screening Methodology</u>

In LRA Section 2, the applicant performed a scoping evaluation and provided the following information:

- a description of the scoping methodology for the inclusion of SSCs and SSC subcomponents in the renewal scope
- a list of sources of information used for the scoping evaluation
- descriptions of the SSCs
- a list of the SSCs identified as within and outside the scope of renewal review and the basis for the scope determination

The staff reviewed the scoping process and results provided in the application. The section below discusses the staff’s review and findings on the applicant’s scoping evaluation.

2.1.1 Scoping Process

In LRA Section 2.2, the applicant described the review of the following documents to identify SSCs with safety functions meeting either scoping criterion 1 or 2, as defined above:

- HB ISFSI Final Safety Analysis Report (FSAR) Update, Revision 6, and associated evaluations of the design changes made under 10 CFR 72.48, “Changes, Tests, and Experiments”
- Materials License No. Special Nuclear Material (SNM)-2514

- technical specifications

- docketed licensing correspondence (NRC Docket No. 72-27)

Table 2-1 lists the SSCs the applicant included and excluded from the scope of renewal review and identifies the scoping criterion met by each in-scope SSC.

Table 2-1 SSCs Within and Outside the Scope of Renewal Review

SSCs	Criterion 1[1]	Criterion 2[2]	In Scope
Spent Fuel Assemblies	Yes	N/A	Yes
Damaged Fuel Container	Yes	N/A	Yes
MPC-HB	Yes	N/A	Yes
HI-STAR 100 HB Overpack	Yes	N/A	Yes
Process Waste Container	Yes	N/A	Yes
HI-STAR HB GTCC Waste Container	Yes	N/A	Yes
HI-STAR 100 HB GTCC Overpack	Yes	N/A	Yes
ISFSI Storage Vault	Yes	N/A	Yes
Cask Transportation System	Yes	N/A	Yes
Helium Fill Gas	Yes	N/A	No
Lid Retention Device	Yes	N/A	Yes
Loose Fuel Debris	No	No	No
Process Waste	No	No	No
GTCC Waste	No	Yes[3]	Yes
Security Systems	No	No	No
Fencing	No	No	No
Lighting	No	No	No
Electric Power	No	No	No
Communication Systems	No	No	No
Automated Welding System	No	No	No
MPC Forced Helium Dehydration System	No	No	No
Overpack Vacuum Drying System	No	No	No
Rail Dolly	No	No	No
ISFSI Storage Vault Drainage Pipe	No	No	No

[1] SSC is ITS.
[2] SSC is not ITS, but its failure could prevent an ITS function from being fulfilled.
[3] The configuration of the GTCC waste is relied on in the shielding analysis.
N/A = not applicable.

The staff reviewed the scoping results to determine whether the applicant included all SSCs in the approved design bases and whether the conclusions on the out-of-scope SSCs accurately reflect the design-bases documentation. The discussion below provides the staff's conclusions on the SSCs excluded from the scope of renewal review.

- helium fill gas

The applicant stated that helium is used to fill the MPC-HBs and the HI-STAR 100 HB Overpacks, and it is defined as ITS in the FSAR to ensure its quality and ability to prevent long-term aging. However, the applicant did not include the helium as an SSC within the scope of the renewal review.

The staff does not consider a controlled gas environment to be an SSC. Although the applicant credits the inert helium environment in its thermal analyses and for preventing aging of the storage system components, any change in that environment over the period of extended operation would be caused by degradation of the storage system components, specifically the overpack seals and MPC-HB confinement boundary (which the applicant included in the scope of renewal). As a result, because the staff does not consider an environment to be an SSC, and any change in that environment would be due to degradation of storage systems SSCs (e.g., seals) that the applicant has included in scope, the staff finds the applicant's conclusion not to include the helium fill gas as an in-scope SSC to be acceptable.

- waste (fuel debris and process waste)

The applicant stated that it did not include the fuel debris and process waste contents as SSCs within the scope of renewal because the contents (and their configuration) are not relied on in the safety analysis. The staff finds the applicant's conclusion to be acceptable because (1) the contents of the storage system are the waste products and (2) the design-basis documentation verified that neither the contents nor its configuration within the enclosures are not relied on to perform a safety function. The staff also does not consider the waste to be capable of failing in a manner that could prevent the ITS storage system SSCs from fulfilling their safety functions.

- miscellaneous site equipment

The applicant stated that security systems, fencing, lighting, power, communication systems, welding systems, drying systems, rail dolly, and drainage pipe are not ITS and not within the scope of renewal. The staff reviewed the applicant's design-basis documentation and noted that Table 4.5-1 of the ISFSI FSAR identifies these SSCs as not ITS. The staff also evaluated the implications of the failure of these not-ITS SSCs and finds that any malfunction of these SSCs would not affect an ITS function. Therefore, the staff finds the applicant's determination that this miscellaneous site equipment is not in scope to be acceptable.

<u>Scoping Findings</u>

Based on this review, the staff finds that the applicant has identified the in-scope SSCs in a manner consistent with NUREG-1927, Revision 1; therefore, the staff finds the scoping results to be acceptable. The applicant screened the in-scope SSCs to identify and describe the subcomponents that support the SSCs' intended functions. Section 2.1.2 describes the SSC subcomponents within and outside the scope of the renewal review.

Subcomponents Within the Scope of the Renewal Review

Based on the scoping process discussed in Section 2.1 of the LRA, the applicant identified 11 SSCs as within the scope of renewal review. These SSCs consist of several subcomponents, not all of which support an intended function and need be considered in the AMR. The applicant screened the in-scope SSCs to identify the subcomponents that support an intended function. Table 2-2 describes the subcomponents of each of the in-scope SSCs that the applicant identified as supporting an intended function, and Table 2-3 describes the subcomponents that the applicant identified as not supporting an intended function.

The staff reviewed the applicant's screening of the in-scope SSCs to identify subcomponents that support an intended function and require an AMR, as recommended in NUREG-1927, Revision 1. The staff's review considered the intended function of the SSCs, the SSCs' safety classification or basis for inclusion in the scope of renewal review, and the design-basis information in the ISFSI FSAR (including the design drawings for each of the SSCs). Based on this review, the staff finds that the applicant screened in the SSC subcomponents that support a safety function and are within the scope of renewal in a manner consistent with NUREG-1927, Revision 1. Therefore, the staff finds the screening results to be acceptable.

2.1.2 Evaluation Findings

The NRC staff reviewed the scoping evaluation in the LRA and supplemental documentation. The staff's review followed the guidance in NUREG-1927, Revision 1. The staff also used the information in NUREG/CR-6407 (NRC, 1996), in its review as a reference for classifying components as ITS to determine the accuracy and completeness of the scoping evaluation. Based on its review, the staff determined that the applicant provided sufficient information to support the LRA with the follow findings:

F2.1 The applicant identified all ITS SSCs and SSCs for which the failure could prevent an SSC from fulfilling its safety function, in accordance with 10 CFR 72.3, "Definitions"; 10 CFR 72.24, "Contents of Application: Technical Information"; 10 CFR 72.42; 10 CFR 72.120, "General Considerations"; 10 CFR 72.122, "Overall Requirements"; 10 CFR 72.124, "Criteria for Nuclear Criticality Safety"; 10 CFR 72.126, "Criteria for Radiological Protection"; and 10 CFR 72.128, "Criteria for Spent Fuel, High-Level Radioactive Waste, Reactor-Related Greater-than-Class C Waste, and Other Radioactive Waste Storage and Handling," as applicable.

F2.2 The justification for any SSC determined to be outside the scope of the renewal review is adequate and acceptable.

Table 2-2 SSC Subcomponents Within the Scope of the Renewal Review

Spent Fuel Assembly Upper tie plate Channel Fuel spacers Fuel cladding Lower tie plate **Damaged Fuel Container** Top ring Tube Pan-base Pan-side Pan-top Mesh Lock bolt Lock plate Mesh ring Baseplate Mesh plate Base feet **HI-STAR HB GTCC Waste Container** MPC base plate MPC shell Inner shell MPC lid top MPC lid bottom Sleeve insert Closure ring Drain shield block Vent drain tube Vent drain cap Port cover plate	**MPC-HB** Base plate Shell Lid Closure ring Drain shield block Vent/drain tube Vent/drain cap Port cover plate Vent shield block Vent shield spacer Upper fuel spacers Fuel basket supports Fuel spacer Fuel basket cell spacer plates Fuel basket spacer angle plates Fuel basket cell plates Sheathing Neutron absorber (poison plates) **HI-STAR 100 HB GTCC Overpack** Bottom plate Shell Top flange Lifting trunnion Intermediate shells Toe-ring plate Closure lid Lid bolts **GTCC Waste** Upper core guide hangers Inner upper core guide Outer upper core guide Upper shroud	**HI-STAR 100 HB Overpack** Bottom plate Port plugs Port plug seals Port covers Port cover seals Port cover bolts Inner shell Top flange Flange overlay Lifting trunnion Intermediate shell Toe-ring plate Neutron shield cover plate Neutron rib Rupture plate Rupture side Rupture disk Top ring plate Neutron shield Closure plate Closure plate overlay Closure plate inner seal Closure plate outer seal Closure plate bolts **Process Waste Container** Shell Quick disconnect body Vacuum drying insert Top plate	**ISFSI Storage Vault** Shell base plate Shell Shell lid ring Shell drain ring Shell anchor block Shell gusset Shell stop plate Shell guide plates Shell alignment plates (seismic restraints) Lid base and top plates Lid center bar Lid outer shell Lid rib plate Lid bolts Lid washers Lid shield block Lid view port plug Vault **Cask Transportation System** Cask restraint system Overhead beam Lift towers (structure), bolting Chassis Wedge lock assembly HI-STAR lift links Cask transporter lift links Connector pins **Lid Retention Device** Retention plate Retention plate bolt

Table 2-3 SSC Subcomponents Not Within the Scope of the Renewal Review

Spent Fuel Assembly Fuel pellets Guide spring Locking tab washer Expansion spring Plenum spring Fuel rod wafer Tie rods Hex nuts Hex head cap screw and lockwasher Lockwire **Damaged Fuel Container** Washer Hexnut **HI-STAR HB GTCC Waste Container** Waste pipes Lift lug shim Lift lug base plate Lift lug Waste cover plate Waste shell top Waste lid lift lug Drain tube guide Drain guide funnel Connector tube Plate, closure, connector Coupling Drain line Seal washer Seal bolt Port cover bolt Lock washer Drain tube guide support Lid lift hole plug Top handling hole plug	**MPC-HB** Lug lift shim Lift lug base plat Lift lug Drain port coupling Drain line Vent port seal washer Vent port seal bolt Vent port cap screw Drain tube plate Drain guide tube Lid lift hole plug Vent port seal lock washer Lid shim Top handling hole plug **HI-STAR 100 HB Overpack** Base plugs Top flange screw Flange top plug Neutron foam Storage plate Transport plate Closure plate washer Closure plate plug **HI-STAR 100 HB GTCC Overpack** Base plate plugs Top flange screws Flange top plug Storage plate Transport plate Lid washers Lid plug Drain plug	**Process Waste Container** Pipe cap Sleeve Cap lifting lug Filter assembly Gasket Flange Dowel pin Nut **ISFSI Storage Vault** Shell alignment (seismic) shims Shell thermocouple Shell thermal conduit Shell lid guide Shell gusset guide Shell guide screw Lid stud pipe Lid bolt access port Lid bolt access cap Lid lift lugs Lid view port tube Lid view port ring Lid view port cap Lid plug lift Lid bolt stud plug Soil	**Cask Transportation System** Operator station Personnel ladders Fuel tank Tow eyes Adjustable cask bumpers Diesel engine Hydraulic reservoir Intertractor track assembly MPC pulley system Hydraulic cylinders Counterbalance valves Seismic tie down lugs **Lid Retention Device** None **GTCC Waste** None

3 AGING MANAGEMENT REVIEW

3.1 Review Objective

The objective of the staff's evaluation of the applicant's AMR is to determine whether the applicant adequately performed a review of materials, environments, and aging mechanisms and effects, and proposed adequate aging management activities for in-scope SSCs. The AMR addresses aging mechanisms and effects that could adversely affect the ability of the SSCs and the associated subcomponents to perform their intended functions during the period of extended operation.

3.2 Aging Management Review Process

In LRA Section 3.1, the applicant described its AMR process as consisting of four steps:

(1) identification of in-scope components requiring AMRs
(2) identification of materials and environments
(3) identification of aging effects requiring management
(4) determination of the activities required to manage the effects of aging

The applicant stated that the AMR identified the aging mechanisms and effects applicable to each in-scope SSC subcomponent, based on the material and environment combinations present as defined by a review of plant documentation, such as the ISFSI FSAR, drawings, technical reports, and vendor manuals. Then, the applicant identified aging mechanisms and effects (the manifestation of aging mechanisms) based on a review of topical reports, reference books, and standards. Finally, for each of these aging mechanisms and effects, the applicant identified aging management activities to ensure that the intended function of the SSC would be maintained during the period of extended operation.

The staff reviewed the applicant's AMR process, including a description and the design-bases references. Based on its review, the staff finds that the applicant's AMR process is acceptable because it is consistent with the methodology recommended in NUREG-1927, Revision 1 (NRC, 2016) and adequate for identifying credible aging effects for the SSCs within the scope of renewal.

3.3 Aging Management Review Results: Materials, Service Environment, Aging Effects, and Aging Management Programs

The staff evaluated the applicant's technical basis for its AMR, in part, by comparing it to the generic technical basis in NUREG-2214 (NRC, 2019) for the HI-STAR 100 storage system. In this evaluation, the staff identified which design features, environmental conditions, and operating experience (OE) for the HB ISFSI are bounded by those evaluated for the HI-STAR 100 storage system in NUREG-2214. The staff recognizes that the HB ISFSI uses a version of the HI-STAR 100 storage casks in a manner unique to its site (e.g., shorter casks, storage within underground vaults), and thus the staff review considered the differences in design and exposure environments from the NUREG-2214 generic evaluation.

The applicant defined the SSC exposure environments in Table 3.1-2 of the LRA. Table 3-1 of this SER summarizes these environments and compares them to the environments evaluated in NUREG-2214. The staff considered this comparison in its determination of whether the HI-STAR 100 storage system evaluations in NUREG-2214 are bounding for the HB ISFSI.

Table 3-1 AMR—Environments

LRA Environment	Description	Equivalent Environment in NUREG-2214
Air—outdoor	The atmosphere outside the ISFSI vaults; exposed to the outdoor weather (insolation, wind, rain, snow, ice, ambient air)	Air—outdoor
Embedded	Instances where materials are encased, embedded, or sealed within another material	Embedded in concrete, metal, or neutron shielding material
Enclosed air	The environment inside the HI-STAR HB GTCC Overpack, which was bolted shut but is not leaktight; considered to be saline air (from proximity to the ocean)	Partially equivalent to “sheltered” environment in NUREG-2214 but without significant venting to the outdoor air environment
Helium	Environments that have been dried and backfilled with inert helium gas; the interior of the MPC-HB and HI-STAR 100 HB Overpack, HI-STAR HB GTCC Waste Container, and HI-STAR HB Process Waste Container	Helium
Soil	The soil environment outside the ISFSI vaults, above the water table and measured to contain nonaggressive levels of chlorides, sulfate, and pH	Ground water/soil
Sheltered	Saline ambient air within the ISFSI vaults, which is protected from direct exposure to the outside environment (e.g., wind, rain, snow) and which enters the vaults through the drainage system Also, the environment within buildings in which some SSCs are stored	Sheltered

Tables 3-2 through 3-12 below summarize the results of the applicant’s AMR and identify the disposition of each potential aging effect for SSC subcomponent materials within the scope of renewal review. These tables incorporate the AMR results tables in the LRA and the discussions in LRA Section 3.0.

Table 3-2 AMR Results—Spent Fuel Assemblies

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
Stainless steel[1] and zirconium-based alloy	Helium	Oxidation	Loss of load-bearing capacity	No	Yes	AMP/TLAA not necessary
		Corrosion (general, pitting, galvanic)	Loss of material	No	Yes	AMP/TLAA not necessary
		Stress-corrosion cracking	Cracking	No	Yes	AMP/TLAA not necessary
		Delayed hydride cracking	Cracking	No	Yes	AMP/TLAA not necessary
		Fatigue	Cracking	No	Yes	AMP/TLAA not necessary
		Mechanical overload	Cracking	No	Yes	AMP/TLAA not necessary
		Hydride-induced embrittlement[2]	Loss of ductility	No	Yes	AMP/TLAA not necessary
		Thermal creep[2]	Change in dimensions	No	Yes	AMP/TLAA not necessary
		Low-temperature creep	Change in dimensions	No	Yes	AMP/TLAA not necessary
		Radiation embrittlement	Loss of strength	No	Yes	AMP/TLAA not necessary
		Hydriding	Change in dimensions[3]	No	Yes	AMP/TLAA not necessary

[1] The AMR results include the stainless steel fuel assembly components other than cladding. Stainless steel fuel cladding does not have a safety function and is stored as loose fuel debris.

[2] NUREG-2214 identifies hydride reorientation and thermal creep as credible aging mechanisms only for high burnup fuel; HB does not store high burnup fuel.

[3] The applicant identified "change in dimensions" as the applicable aging effect for hydriding of fuel assembly hardware materials, whereas NUREG-2214 states that a loss of ductility is the applicable aging effect for this mechanism. Regardless, NUREG-2214 concludes that hydriding is not a credible aging mechanism.

Table 3-3 AMR Results—Damaged Fuel Container

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214[1]	Disposition
Stainless steel	Helium	Creep	Change in dimensions	No	Yes	AMP/TLAA not necessary
		Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)

[1] NUREG-2214 concluded that thermal aging is a credible aging mechanism for precipitation-hardened martensitic stainless steels; however, the HB damaged fuel container is not constructed of that type of stainless steel but of austenitic stainless steel.

Table 3-4 AMR Results—MPC-HB

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
Stainless steel	Helium	Creep	Change in dimensions	No	Yes	AMP/TLAA not necessary
		Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
Metamic™ neutron poison plates	Helium	Boron depletion	Loss of criticality control	No	Not evaluated in NUREG-2214	TLAA (See SER Section 3.4.1)
		General corrosion	Loss of material	No	Yes	AMP/TLAA not necessary
		Creep	Change in dimensions	No	Yes	AMP/TLAA not necessary
		Thermal aging	Loss of strength	No	Yes	AMP/TLAA not necessary
		Radiation embrittlement	Loss of fracture toughness and ductility	No	Yes	AMP/TLAA not necessary

Table 3-5 AMR Results—HI-STAR 100 HB Overpack

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
Carbon steel with coating	Sheltered	General corrosion	Loss of Material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP (See SER Section 3.4.4)
		Galvanic corrosion	Loss of Material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Crevice corrosion	Loss of Material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Pitting corrosion	Loss of Material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
	Helium	Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
	Embedded (in Holtite-A™)	Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
Carbon steel	Sheltered	Microbiologically influenced corrosion	Loss of Material	No	Yes	AMP/TLAA not necessary
		General corrosion	Loss of Material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Crevice corrosion	Loss of Material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Pitting corrosion	Loss of Material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Stress relaxation	Loss of Preload	No	No	AMP/TLAA not necessary (See SER Section 3.3.1.1)

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
		Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
	Embedded (in Holtite-A™)	Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
Stainless steel	Sheltered	Microbiologically influenced corrosion	Loss of Material	No	Yes	AMP/TLAA not necessary
		Crevice corrosion	Loss of Material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Pitting corrosion	Loss of Material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
		Stress-corrosion cracking	Cracking	Yes[1]	Yes	HB ISFSI External Surfaces Monitoring AMP
	Helium	Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
Nickel alloy, silver plated	Sheltered	Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
		Crevice corrosion	Loss of Material	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary See SER Section 3.3.1.2
		Pitting corrosion	Loss of Material	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary See SER Section 3.3.1.2
	Helium	Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
Nickel alloy	Sheltered	Fatigue	Cracking	No	Not evaluated in NUREG-2214	TLAA See SER Section 3.4.2

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
	Embedded (in metal)	Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
Holtite-A™ neutron shield	Embedded (in carbon steel)	Radiation embrittlement	Cracking	No	No	AMP/TLAA not necessary (See SER Section 3.3.1.3)
		Thermal aging	Loss of fracture toughness and loss of ductility	No	No	AMP/TLAA not necessary (See SER Section 3.3.1.3)
		Boron depletion	Loss of shielding	Yes	Not evaluated in NUREG-2214	TLAA See SER Section 3.4.1
[1] The applicant identified stress-corrosion cracking as a credible aging mechanism only for stainless steel components that have welds or weld heat-affected zones, consistent with the guidance in NUREG-2214						

Table 3-6 AMR Results—Process Waste Container

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
Stainless steel	Helium	Creep	Change in dimensions	No	Yes	AMP/TLAA not necessary
		Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
[1] NUREG-2214 concluded that thermal aging is a credible aging mechanism for precipitation-hardened martensitic stainless steels; however, the process waste container is constructed of an austenitic stainless steel, and thus the container is not considered to be susceptible to this aging mechanism.						

Table 3-7 AMR Results—HI-STAR HB GTCC Waste Container

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
Stainless steel	Helium	Creep	Change in dimensions	No	Yes	AMP/TLAA not necessary
		Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
	Enclosed air	Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
		Crevice corrosion	Loss of material	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.3.1.4)
		Pitting corrosion	Loss of material	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.3.1.4)
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)

Table 3-8 AMR Results—HI-STAR 100 HB GTCC Overpack

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
Carbon steel with coating	Sheltered	General corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP (See SER Section 3.4.4)
		Galvanic corrosion[1]	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Crevice corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Pitting corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
		Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
	Enclosed air	Crevice corrosion	Loss of material	No	Not discussed in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.3.1.4)
		Pitting corrosion	Loss of material	No	Not discussed in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.3.1.4)
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
		Radiation embrittlement	Cracking	No	Yes[2]	AMP/TLAA not necessary
	Embedded (in metal)	Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
Carbon steel	Sheltered	General corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Crevice corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Pitting corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
		Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
	Enclosed Air	Crevice corrosion	Loss of material	No	Not discussed in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.3.1.4)
		Pitting corrosion	Loss of material	No	Not discussed in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.3.1.4)
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
		Radiation embrittlement	Cracking	No	Yes[2]	AMP/TLAA not necessary
	Embedded (in metal)	Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
Nickel alloy	Sheltered	Crevice corrosion	Loss of material	No	Yes[3]	AMP/TLAA not necessary
		Pitting corrosion	Loss of material	No	Yes[3]	AMP/TLAA not necessary
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
		Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
	Embedded (in metal)	Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)

[1] Galvanic corrosion is credible where dissimilar metal contacts exist.

[2] Although the internal environment of the HI-STAR HB GTCC (enclosed air) differs from the HI-STAR 100 Overpack evaluated in NUREG-2214 (helium), the NUREG-2214 conclusion on the susceptibility to radiation embrittlement of the carbon steel overpack is considered to be applicable.

[3] NUREG-2214 did not evaluate nickel alloys exposed to a sheltered environment. However, NUREG-2214 concluded that nickel alloys exposed to an outdoor air environment are not susceptible to corrosion. That conclusion is considered to also be applicable to the applicant's sheltered environment, which is less severe.

Table 3-9 AMR Results—ISFSI Storage Vault

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
Carbon steel with coating	Sheltered	General corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP (See SER Section 3.4.4)
		Crevice corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Pitting corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
		Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
	Air—Outdoor	General corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Crevice corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Pitting corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
		Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
Carbon steel	Embedded (in concrete)	General corrosion	Loss of material	Yes	Yes[1]	HB ISFSI External Surfaces Monitoring AMP
		Crevice corrosion	Loss of material	Yes	Yes[1]	HB ISFSI External Surfaces Monitoring AMP
		Pitting corrosion	Loss of material	Yes	Yes[1]	HB ISFSI External Surfaces Monitoring AMP
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
		Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
	Air—Outdoor	General corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Crevice corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Pitting corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
		Radiation embrittlement	Cracking	No	Yes	AMP/TLAA not necessary
Concrete (with and without reinforcement)	Embedded (in metal)	None	None	Not applicable[2]	Yes	AMP/TLAA not necessary
	Air—Outdoor	Leaching of calcium hydroxide	Change in material properties	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Increase in porosity and permeability	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Loss of strength	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Reduction in concrete pH	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
		Aggressive chemical attack	Cracking	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Loss of material	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP (See SER Section 3.4.4)
			Loss of strength	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
			Reduction in concrete pH	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
		Differential settlement	Cracking	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
		Freeze-thaw	Cracking	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Loss of material	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
		Reaction with aggregates	Cracking	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Loss of strength	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
		Salt scaling	Loss of material	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
		Delayed ettringite formation	Cracking	No	Yes	AMP/TLAA not necessary
			Loss of material	No	Yes	AMP/TLAA not necessary
			Loss of strength	No	Yes	AMP/TLAA not necessary
		Shrinkage	Cracking	No	Yes	AMP/TLAA not necessary
		Fatigue	Cracking	No	Yes	AMP/TLAA not necessary
		Radiation damage	Cracking	No	Yes	AMP/TLAA not necessary
			Loss of strength	No	Yes	AMP/TLAA not necessary
Concrete (reinforced)	Soil	Leaching of calcium hydroxide	Change in material properties	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
			Increase in porosity and permeability	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Loss of Strength	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Reduction in concrete pH	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
		Aggressive chemical attack	Cracking	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Loss of material	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Loss of strength	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Reduction in concrete pH	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
		Differential settlement	Cracking	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
		Freeze-thaw	Cracking	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Loss of material	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
		Reaction with aggregates	Cracking	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Loss of strength	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
		Salt scaling	Loss of material	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
		Microbiological degradation	Increase in porosity and permeability	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
			Loss of material	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Loss of strength	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Reduction in concrete pH	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
		Delayed ettringite formation	Cracking	No	Yes	AMP/TLAA not necessary
			Loss of material	No	Yes	AMP/TLAA not necessary
			Loss of strength	No	Yes	AMP/TLAA not necessary
		Shrinkage	Cracking	No	Yes	AMP/TLAA not necessary
		Fatigue	Cracking	No	Yes	AMP/TLAA not necessary
		Radiation damage	Cracking	No	Yes	AMP/TLAA not necessary
			Loss of strength	No	Yes	AMP/TLAA not necessary
Reinforcing steel[3]	Soil	Corrosion	Cracking	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Loss of concrete/steel bond	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Loss of material	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP
			Loss of strength	Yes	Yes	HB ISFSI Reinforced Concrete Structures AMP

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
[1] Some steel components are embedded in concrete that is fully encased in a liner (e.g., vault lid rib plates). For this case, NUREG-2214 concluded that corrosion of the embedded steel is not credible because the encasement prevents water intrusion into the concrete. However, the applicant conservatively concluded that corrosion is credible. [2] The applicant did not identify any potential aging mechanisms for the concrete vault lid shield block that is fully encased in a steel liner. NUREG-2214 evaluated several potential aging effects for this configuration, but it concluded that none were credible. As a result, the applicant's conclusion is consistent with NUREG-2214. [3] The applicant identified corrosion of reinforcing steel as a credible aging mechanism that can lead to cracking, loss of concrete/steel bond, loss of material, and loss of strength. LRA Table 3.9-1 associates this aging mechanism and effects with the reinforcing steel; however, the staff notes that the aging mechanism and effects are associated with the concrete surrounding the steel (per NUREG-2214). Regardless, the applicant will use an AMP to monitor for evidence of reinforcing steel corrosion, consistent with NUREG-2214.						

Table 3-10 AMR Results—Cask Transportation System

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
Carbon steel	Sheltered	General corrosion	Loss of material	Yes	Yes	Cask Transportation System AMP
		Galvanic Corrosion	Loss of material	Yes	Yes	Cask Transportation System AMP
		Crevice Corrosion	Loss of material	Yes	Yes	Cask Transportation System AMP
		Pitting corrosion	Loss of material	Yes	Yes	Cask Transportation System AMP
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
		Stress relaxation (bolts)	Loss of preload	Yes	Yes	Cask Transportation System AMP
Stainless steel	Sheltered	Galvanic corrosion	Loss of material	Yes	Yes	Cask Transportation System AMP
		Crevice corrosion	Loss of material	Yes	Yes	Cask Transportation System AMP

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
		Pitting corrosion	Loss of material	Yes	Yes	Cask Transportation System AMP
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
		Stress-corrosion cracking (nonwelded)	Cracking	No	Yes[1]	AMP/TLAA not necessary
Nickel alloy	Sheltered	Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
Polymer	Sheltered	--	Change in material properties	Yes	Not evaluated in NUREG-2214	Cask Transportation System AMP (See SER Section 3.3.1.5)
K-Spec® Fiber	Sheltered	Wear	Loss of material	Yes	Not evaluated in NUREG-2214	Cask Transportation System AMP (See SER Section 3.3.1.6)

[1] NUREG-2214 concluded that stress-corrosion cracking is a credible aging mechanism for welded austenitic stainless steels; however, the stainless steel components of the cask transportation system do not contain welds.

Table 3-11 AMR Results—Lid Retention Device

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
Carbon steel	Sheltered	General corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Galvanic corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Crevice corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Pitting corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)
Stainless steel	Sheltered	Crevice corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Pitting corrosion	Loss of material	Yes	Yes	HB ISFSI External Surfaces Monitoring AMP
		Fatigue	Cracking	No	Not evaluated in NUREG-2214	AMP/TLAA not necessary (See SER Section 3.4.3)

Table 3-12 AMR Results—GTCC Waste

Material	Environment	Aging Mechanism	Aging Effect	Applicant Defined as Credible	Consistent with Conclusion of NUREG-2214	Disposition
Stainless steel	Helium	None	None	NA	Yes	AMP/TLAA not necessary

The staff reviewed the applicant's AMR results for consistency with the technical bases for aging mechanisms and effects in NUREG-2214. When the results of applicant's aging evaluation of the credible aging mechanisms and effects are consistent with the generic bases in NUREG-2214, the staff concludes the applicant's results are acceptable. For these reasons, these acceptable results are not discussed further in this SER. However, when the results of the evaluation of aging mechanisms and effects were not verified by the staff as consistent with NUREG-2214, the staff undertook further consideration of aging issues. The following sections discuss the additional assessments made by the staff.

3.3.1 Technical Bases/Supplemental Analyses

The applicant provided technical bases and supplemental analyses to support its conclusion that certain aging mechanisms and effects are not credible and do not need to be managed. In the SER sections below the adequacy of each technical basis is evaluated.

3.3.1.1 *Loss of Preload due to Stress Relaxation of Port Cover Bolting*

In LRA Section 3.5.4.2, the applicant stated that the carbon steel port cover bolting in the HI-STAR 100 HB Overpack could be subject to loss of preload (clamping force); however, bolting inspections are not proposed for the period of extended operation. The applicant justified this by stating that the ISFSI storage vault lacks thermal fluctuations that could cause loss of preload. In addition, Holtec, the designer and fabricator of the HI-STAR 100 System, has not identified the loss of preload of port cover bolting in its OE. Furthermore, the applicant's preapplication inspection of the HB ISFSI did not find see evidence of loss of preload.

The staff reviewed the technical support for the proposition that certain aging mechanisms and effects are not credible, and an AMP is not needed to assess them. NUREG-2214 concludes that the loss of preload due to stress relaxation of steel bolts is associated with normal service temperatures above 100 degrees Celsius (C) (212 degrees Fahrenheit (F)). The thermal analysis of the storage system in FSAR Section 4.2.3.3.5 for the HB ISFSI shows the overpack bolts would not reach temperatures that could cause relaxation of the bolt material. The HB MPCs are significantly cooler than the HI-STAR 100 MPCs that were evaluated in NUREG-2214. The staff verified that loss of preload is not credible for the HI-STAR 100 HB Overpack under normal service temperatures. For these reasons, the staff finds that the applicant's determination not to manage loss of preload is acceptable.

3.3.1.2 *Loss of Material due to Pitting and Crevice Corrosion of Metallic Seals*

The LRA Section 3.5.4.1, states the loss of material due to pitting and crevice corrosion is not credible for the nickel alloy outer closure seals of the HI-STAR 100 HB Overpack, when sheltered within the vault. The applicant does not propose any aging management activities for the seals.

The staff reviewed the technical support for the conclusion that an AMP is not necessary to evaluate the aging of the seals. Although NUREG-2214 did not evaluate the effects of aging of nickel in sheltered environments, the effects of harsher outdoor environments were evaluated. NUREG-2214 concluded that the loss of material of nickel alloy closure seals in an outdoor environment is not credible, due to the high corrosion resistance of nickel. The seals at the HB ISFSI are sheltered within the ISFSI vaults, which is less aggressive than an outdoor environment exposed to precipitation and airborne contaminants. The staff concludes that an

AMP is not necessary to manage the aging of the seals because the harsher environment is bounding.

3.3.1.3 *(1) Loss of Fracture Toughness and Loss of Ductility due to Thermal Aging of Holtite-A™ Shielding Material and (2) Cracking due to Radiation Embrittlement of Holtite-A™ Shielding Material*

LRA Section 3.5.4.3 states that loss of fracture toughness, loss of ductility, and cracking of the Holtite-A™ shielding material in the HI-STAR 100 HB Overpack are not credible in the period of extended operation. Holtite-A™ is composed of boron carbides and aluminum hydroxide particulates in an epoxy polymer matrix. The application referenced proprietary and nonproprietary studies that evaluated the effects of heat and radiation on Holtite-A™ as support for its conclusion (Holtec, 2000). In a response to an RAI, the applicant calculated the thermal effects of weight loss of the Holtite-A™ material to show that the amount of potential weight loss is within the acceptable limits established in the Holtite-A qualification program. In addition, the applicant calculated neutron fluence and gamma dose that the Holtite-A material would be exposed to for a period of 60 years. The calculated fluence and dose were compared to allowable thresholds, established by irradiation testing.

The staff reviewed the applicant's technical basis for the conclusion that the Holtite-A™ shielding material is not subject to aging that requires management. NUREG-2214 concludes that cracking due to thermal aging and radiation embrittlement is a credible aging effect for Holtite-A™ materials in the HI-STAR 100 System. However, the staff found the allowable heat loads of the HB casks are about an order of magnitude lower than the heat loads approved for the HI-STAR 100 storage system. The HI-STAR 100 storage system has a maximum heat load of 19,000 Watts, whereas the HB spent fuel has 2,000 Watts heat load per canister (PG&E, 2018a; Holtec, 2013). These differences in heat load are due to the fact that the HB fuel has much lower burnup and was cooled for 32 years before loading into dry casks. As a result, the Holtite-A™ thermal and irradiation environments for the HB casks are less severe than the environments under which Holtite-A™ was approved for use in the general HI-STAR 100 Certificate of Compliance. Specifically, the HB ISFSI FSAR states the maximum service temperature for the Holtite-A™ in the HB casks is 91 degrees C (195 degrees F), compared to 134 degrees C (274 degrees F) for the HI-STAR 100 Certificate of Compliance in normal conditions of storage. (PG&E, 2018a; Holtec, 2013).

The staff also reviewed the technical data on Holtec International's qualification of Holtite-A™ as a neutron shielding material. These data include proprietary and nonproprietary studies performed on the NS-4-FR shielding material, which were the basis for the Holtite-A™ formulation (Momma et. al, 1998; Yamada et. al, 2004; Holtec, 2000). Holtec performed both thermal and radiation tests on the Holtite-A™ material (Holtec, 2000). The laboratory tests were performed at neutron fluence and temperatures that were much higher than that of the casks used at the HB ISFSI. Holtec subjected samples of Holtite-A™ to combined temperatures and radiation levels that greatly exceeded the expected exposure conditions of the HB casks (e.g., 162.8 degrees C (325 degrees F) and 1.50×10^{15} neutrons per square centimeter neutron fluence test exposure versus a maximum 91 degrees C (195 degrees F) and 1.06×10^{13} neutrons per square centimeter neutron fluence in the HB casks) (Holtec, 2000; PG&E, 2019 b). Holtec's tests showed no significant changes in appearance, dimensions, density, or hydrogen content of the Holtite-A™ samples. Also, radiation-only tests on Holtite-A™ did not identify significant loss of boron by neutron attenuation examination. The applicant noted that elevated temperature exposures did result in weight loss, with weight loss occurring rapidly at first, and levelling off to reach a total loss of about 4 percent. Based on these test data, the applicant estimates weight loss for the Holtite-A™ in the HB casks will be less than 1 percent over 60 years of storage. In calculating the weight loss estimate, the applicant used a conservative service temperature for the 60-year license term; the maximum 91 degrees C (195 degrees F) service temperature for Holtite-A™ on initial loading was assumed to remain constant, rather than decaying with time.

The staff's review of Holtite-A™ test data and the actual service conditions of the HB ISFSI, the staff finds no credible aging effects on the Holtite-A™ neutron shielding material inside the dry casks at the HB ISFSI. The staff finds the heat and radiation testing performed on Holtite-A™ provide an upper bound for the conditions on the HB casks. The actual heat and radiation conditions for the HB casks are significantly lower because the casks were loaded with fuel that cooled for 32 years. Holtec's testing results did not identify significant changes in the appearance, dimensions, density, hydrogen content, and neutron attenuation capacity of Holtite-A™. Based on these results, the staff finds reasonable assurance that the Holtite-A™ will continue to perform its shielding function in the period of extended operation.

The staff notes that the HB ISFSI Reinforced Concrete Structures AMP (documented in SER Section 3.5.2) includes radiation survey activities that provide defense in depth. These surveys offer an additional means of confirming shielding performance. The staff also notes that general licensees that use the HI-STAR 100 casks are required to perform shielding effectiveness tests every 5 years, according to Section 9.2.5 of the HI-STAR 100 SAR (Holtec, 2013). In the AMPs discussed in SER Section 3.5, the applicant will evaluate industry OE in the Aging Management Institute of Nuclear Power Operations Database over the course of the license term. Those evaluations will provide an opportunity for the applicant to incorporate up-to-date industry OE on Holtite-A™ and to adjust its aging management activities, as necessary.

3.3.1.4 *(1) Loss of Material due to Pitting and Crevice Corrosion of HI-STAR HB GTCC Waste Container External Surfaces and (2) Loss of Material due to Pitting and Crevice Corrosion of the HI-STAR 100 HB Greater-Than-Class C Overpack Internal Surfaces*

In LRA Sections 3.7.4.1 and 3.8.4.1, the applicant stated that loss of material due to pitting and crevice corrosion is not credible for the stainless steel external surfaces of the HI-STAR HB GTCC Waste Container (GWC) and carbon steel internal surfaces of the HI-STAR 100 HB GTCC Overpack. The staff notes that these two groups of SSCs are exposed to the same air gap between the GWC and its overpack. The applicant stated that the subcomponents are exposed to enclosed air within the HI-STAR HB GTCC Overpack and that this environment is similar to the "embedded" environment described in NUREG-2214 (for which NUREG-2214 concluded that there are no credible aging effects).

In addition, in response to a request for supplemental information (PG&E, 2018b), the applicant stated that the HI-STAR GTCC Overpack does not contain closure lid seals; however, the overpack closure comprises mating machined steel surfaces that minimize gaps through which water and oxygen may traverse to enter the overpack cavity. The applicant also stated that the HI-STAR GTCC Overpack is located within the ISFSI vault, which protects the overpack from direct exposure to the outside environment (e.g., rain, snow).

The staff reviewed the technical basis and references in support of the conclusion that an AMP is not needed for addressing the corrosion of the steel surfaces exposed to the air gap between the GWC and its overpack.

For the stainless steel GWC external surfaces, NUREG-2214, Section 3.2.2.2, states that pitting and crevice corrosion are not expected to lead to the penetration of stainless steel shells during the period of extended operation; however, pitting and crevice corrosion can be a precursor to stress corrosion cracking (SCC). The staff notes that, for SCC to operate in austenitic stainless steels, chlorides and an aqueous electrolyte (e.g., water) must be present. The staff also notes that, for outdoor contaminants and moisture to reach the GWC, they must first enter the sheltered region within the ISFSI vault through the vault drain lines, then pass between the mating steel surfaces of the HI-STAR GTCC Overpack closure. Because of the isolated nature of the GWC, which limits ingress of both moisture and chloride contaminants that can cause SCC, the staff finds that pitting and crevice corrosion are not credible aging mechanisms for the stainless steel GWC and, therefore, finds the applicant's conclusion to be acceptable.

For the carbon steel overpack internal surfaces, Section 3.2.1.2 of NUREG-2214 states that pitting and crevice corrosion can occur in the presence of an aqueous electrolyte (e.g., water), especially in the presence of chlorides. As stated in the discussion of stainless steel above, because of the isolated nature of the internal surfaces of the overpack, which limits exposure to moisture and contaminants, loss of material of the overpack internal surfaces is not considered to be likely. In addition, the staff notes that the applicant's inspections of the external surfaces of the overpack are expected to identify any leading indicators of potential degradation that would affect the internal surfaces, which are exposed to a more benign service environment. This would allow for timely corrective actions prior to a loss of the structural and shielding functions of the overpack. As a result, the staff finds that pitting and crevice corrosion are not credible aging mechanisms for the overpack internal surfaces and, therefore, finds the applicant's conclusion to be acceptable.

3.3.1.5 *Change in Material Properties of Polymer Cask Restraint System Bumpers*

In LRA Tables 3.10-1 and A-3, the applicant stated that the adjustable bumpers in the cask transportation system may experience changes in material properties during the period of extended operation. For this reason, the Humboldt Bay Cask Transportation System AMP requires that bumpers older than 20 years be replaced, prior to the start of a cask transfer campaign. LRA Table 3.1-1 states that the bumper material is Delrin®, which is a polyoxymethylene polymer.

The applicant concluded that changes in the material properties of the bumpers is the only credible aging effect, and the staff reviewed the underlying technical support. NUREG-2214 does not evaluate the aging degradation of the polymer bumper material, but NRC guidance on aging management of power reactor components states that changes in material properties for polymers may include hardening and cracking (NRC, 2010). For this reason, the staff reviewed the manufacturer's data on environmental effects on Delrin® performance (DuPont). These data show that the mechanical properties of Delrin® are strongly resistant to a variety of solvents, oils, greases, other petroleum hydrocarbons, and weak acids and bases. DuPont's testing also showed indoor room-temperature air has no effect on the mechanical properties of Delrin® over a period of 20 years. After assessing environmental effects on Delrin® performance, the staff finds that the applicant conservatively determined additional aging effects on material properties are credible.

The staff notes that, because the polymer bumpers may not exceed 20 years of age, the guidance in NUREG-1927 would support excluding this SSC from having to undergo an AMR and have an AMP. The staff recognizes that the applicant is using the AMP as a mechanism to ensure that the bumpers are replaced before deterioration occurs. The staff finds the applicant's approach to ensuring that the bumpers will perform their intended function in the period of extended operation to be acceptable. The manufacturer's test data show that the bumpers are not subject to credible aging effects in the first 20 years of their life, and the applicant's AMP will ensure the bumpers are replaced prior to use if they reach 20 years of age.

3.3.1.6 *Wear of Cask Restraint System Slings*

In LRA Table 3.10-1, the applicant stated that the cask restraint slings in the cask transportation system may experience a loss of material due to mechanical wear. However, exposure to water, sunlight, chemicals, and elevated temperatures are not credible mechanisms for the degradation of cask restraint slings. The applicant stated the cask transportation system is stored indoors, the slings are isolated from chemicals, and temperatures are limited to the extremes of the central California ambient environment.

The staff reviewed the technical bases supporting the conclusion that wear on cask restraint slings is the only credible aging mechanism for the slings. The staff notes that NUREG-2214 does not evaluate the aging of proprietary K-Spec® synthetic fiber sling material. However, NUREG-2214 states that polymers, in general, may be susceptible to changes in properties when exposed to elevated temperatures and radiation, because elevated temperatures can lead to molecular scission (breaking) and cross-linking in polymer structures. Because the slings are housed indoors and experience only brief outdoor exposure adjacent to the overpack external surfaces during cask transfer operations, the staff does not consider changes to the sling material due to heat and radiation to be credible. In addition, the staff reviewed the available technical data from the K-Spec® manufacturer (Slingmax, 2011) and notes that the material was tested for 6 months with exposures to water, several common chemicals, and temperatures up to 65 degrees C (150 degrees F). No significant change in properties were reported. The staff finds the polymer material, in the cask restraint slings at the HB ISFSI, is not exposed to environments or chemicals that are capable of altering the material properties under normal conditions. For these reasons, the staff finds loss of material due to degradation is the only credible aging effect

3.3.2 Evaluation Findings

The staff reviewed the AMR in the LRA and verified that the materials, environments, and aging effects on the in-scope SSCs were adequately described. Based on its review of the LRA, as supplemented, the staff finds the following:

F3.1 The applicant's AMR process is comprehensive in identifying the materials of construction and associated operating environmental conditions for those SSCs within the scope of renewal, and the applicant has provided a summary of the information in the LRA and the FSAR supplement.

F3.2 The applicant's AMR process is comprehensive in identifying all pertinent aging mechanisms and effects applicable to the in-scope SSCs, and the applicant has provided a summary of the information in the LRA and the FSAR supplement.

3.4 <u>Time-Limited Aging Analyses Evaluation</u>

The staff reviewed the applicant's analyses in support of conclusions on potential aging effects for SSCs and SSC subcomponents within the scope of renewal. The staff reviewed the analyses to determine those meeting all six criteria in 10 CFR 72.3 for valid TLAAs. The applicant identified the following TLAAs:

(1) Loss of Criticality Control due to Boron Depletion in Neutron Poison Plates
(2) Loss of Shielding due to Boron Depletion in the Neutron Shield
(3) Fatigue of the HI-STAR 100 HB Overpack Closure Bolts

The applicant also provided the following two analyses that were not identified as a TLAA under 10 CFR 72.3, but they were nevertheless analyzed to demonstrate that the MPCs and overpacks are not subject to fatigue and that anticipated degradation of the overpacks and concrete vaults would not significantly impact the shielding function of the storage system:

(4) Fatigue of the MPC-HB and Overpack
(5) Loss of Shielding due to Steel and Concrete Degradation

Based on its review of the design-basis documents, the staff confirmed that the TLAAs identified by the applicant meet all six criteria in 10 CFR 72.3. The staff concludes that the applicant's TLAAs are appropriate and acceptable. The staff's evaluation of the TLAAs and the applicant's additional non-TLAA evaluations are presented below.

3.4.1 Loss of Criticality Control (Metamic™) and Loss of Shielding (Holtite-A™) due to Boron Depletion

In LRA Section 4.4.1, the applicant summarized the results of its TLAA on boron depletion and its effect on the criticality control provided by the Metamic™ neutron absorber in the MPC-HB and on shielding performance provided by Holtite-A™ in the HI-STAR 100 HB Overpack. The LRA referenced the boron depletion analyses for neutron absorbers in Section 4.2.3.3.7 of the ISFSI FSAR, the HI-STORM 100 FSAR (Holtec, 2018), and the HI-STAR 100 Transportation FSAR (Holtec, 2016b). The original analyses demonstrated that boron depletion is negligible during the first 50 years of storage. The applicant provided an updated calculation to show that the fraction of Boron-10 atoms depleted over 60 years is less than 5×10^{-8} for the two materials and is therefore negligible.

The staff reviewed the applicant's boron depletion analyses, which scaled up the original boron depletion by a factor of 6/5 (60 years/50 years) to arrive at the 5×10^{-8} depletion fraction. The staff notes that this approach to scaling the original calculation result is expected to provide a conservative estimate of depletion because the rate of depletion in the last 10 years of storage (years 50 to 60) will be lower than that of the first 50 years, as the radiation source term decreases with time. As a result, because the applicant conservatively extended the original depletion analysis, and the updated analysis shows that depletion will have a negligible effect on criticality control and shielding, the staff finds that the applicant demonstrated that boron depletion of the Metamic™ and Holtite-A™ materials is not a credible aging mechanism.

3.4.2 Fatigue of the HI-STAR 100 HB Overpack Closure Bolts

In LRA Section 4.4.2, the applicant summarized the results of its TLAA on fatigue of the HI-STAR 100 HB Overpack closure bolts. The ISFSI FSAR does not provide fatigue-related discussions for the closure bolts but instead incorporates by reference the HI-STAR 100 Transportation FSAR (Holtec, 2016b) fatigue analysis. The HI-STAR 100 Transportation FSAR states that a fatigue analysis of the closure bolts was performed in accordance with American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code) Section III, and it concluded that the allowable number of torqueing/untorqueing cycles for the bolts is 166.

In its evaluation of fatigue for the period of extended operation, the application stated that no torqueing or untorqueing of the overpack closure bolts has taken place since the original overpack loading. In addition, the applicant anticipated no additional torqueing until the potential future unloading of the overpack. Nevertheless, the applicant conservatively assumed that 20 torqueing cycles were imposed on the bolts during the initial 20-year storage term and an additional 20 cycles may be imposed during the period of extended operation. Using this conservative estimate (40 cycles total), the fatigue limit of 166 cycles would not be reached.

The staff reviewed the TLAA to verify that the applicant appropriately addressed the design-bases fatigue analysis of the closure bolts. The staff notes that the guidance in NUREG-1927 states that an applicant may address a TLAA by demonstrating that the existing analysis remains valid for the period of extended operation. The staff notes that the original fatigue analysis covers the expected loading throughout the period of extended operation due to its conservatism. Thus, the staff finds that the applicant appropriately addressed the TLAA and demonstrated that cracking due to fatigue of the closure bolts is not credible.

3.4.3 Fatigue of Other Metallic Subcomponents

In LRA Section 4.5, the applicant stated that no TLAA is associated with fatigue for SCCs, other than the overpack closure bolts discussed above. The applicant also stated that the temperature fluctuations and mechanical loadings to which the storage system components are exposed are not capable of leading to fatigue failure. The applicant attributed the loading mechanisms to ambient temperature fluctuations and isolation cycling, which the applicant concluded impart only insignificant thermal stresses and cycling of internal pressures within enclosure vessels.

The applicant addressed the ASME Code analyses that were originally discussed in its ISFSI FSAR (and the HI-STAR 100 FSAR incorporated by reference). The applicant discussed how those original fatigue analyses meet the ASME Code requirements for the requested period of extended operation. For example, the applicant reviewed the HI-STAR 100 Transportation Package FSAR (Holtec, 2016b), which follows ASME Code Section III Subarticle NB-3200 to screen the SSCs using six criteria, to determine whether a detailed fatigue analysis for the MPC-HB is required. The applicant stated that the extended storage term does not change the results of the original NB-3200 screen. The original screen determined a detailed analysis is not required for the period of extended operation because the screening conclusions are not affected additional storage time, but are dependent on the material and loading conditions. Thus, the applicant concluded that no TLAA is required to address fatigue.

The staff reviewed the applicant's fatigue evaluation to confirm it is not subject to a TLAA. Specifically, the staff reviewed the applicant's evaluation of relevant portions of the ASME Code (e.g., Subarticle NB-3200 for the MPC-HB) and finds that the ASME Code does not require a detailed fatigue evaluation for the period of extended operation. The staff notes that the placement of the storage casks within underground vaults greatly limits the degree to which outside temperature fluctuations and isolation cycling could cause thermal stresses on the storage system components. Since the original design basis has no time-limited fatigue calculations that must be addressed for the period of extended operation, the staff finds the applicant's conclusion that a fatigue TLAA is not necessary to be acceptable.

3.4.4 Loss of Shielding due to Steel and Concrete Degradation

In the AMR tables in LRA Section 3, the applicant identified credible aging degradation mechanisms for the steel overpacks, vault liner, and vault concrete. The staff notes that this has the potential to degrade the shielding performance of the storage system. As a result, in LRA Appendix D, the applicant proposed revising FSAR Section 7.5 to evaluate the annual dose received by a real individual beyond the controlled area boundary in the period of extended operation, taking into account potential effects of steel and concrete degradation.

The staff notes that the design basis for the initial storage period described in FSAR Section 7.5 calculates doses at the controlled area boundary and nearest resident during normal operation (all casks within their underground vaults), during maintenance activities (vault lid removed), and during loading operations (when casks are aboveground). In that initial FSAR analysis, the applicant concluded that it met the dose limits prescribed in 10 CFR 72.104, "Criteria for Radioactive Materials in Effluents and Direct Radiation from an ISFSI or MRS [monitored retrievable storage];" however, the time the casks are aboveground must be limited to ensure compliance with the regulatory requirements in 10 CFR 72.104.

In its RAI dated April 30, 2019 (ADAMS Accession No. ML19122A230), the staff requested that the applicant demonstrate that the storage system will meet the requirements of 10 CFR 72.104 under potential conditions of component degradation. The applicant's RAI response (PG&E, 2019b), provided a new shielding analysis that considers the potential material degradation effects for the period of extended operation. In this revised analysis, the applicant used the same codes used in the original safety analyses, namely SAS2H for the source calculation and MCNP 4A for the shielding analysis. However, the applicant reduced the density of all carbon steel by 20 percent and concrete by 10 percent in the revised analysis. In the revised shielding analysis, the calculated offsite dose falls within regulatory requirements. Both the original and the revised analyses limit the period of time that casks are allowed aboveground to ensure annual dose limits in 10 CFR 72.104 are not exceeded.

The staff reviewed the applicant's analysis to verify that adequate shielding performance is demonstrated and that potential degradation during the period of extended operation was considered. The staff reviewed the existing and proposed FSAR, the RAI responses, and the proprietary dose assessment analysis referenced in the applicant's FSARs.

The staff reviewed the results of the preapplication inspections described in LRA Appendix E. On the basis of the review, the staff finds the use of the 20-percent reduced carbon steel density and 10-percent reduced concrete density in the revised shielding analysis provides a conservative result. Specifically, the inspection results did not identify any significant material degradation of the storage systems after 9 years in service. The licensee commits to performing periodic inspections of the steel overpacks, vault liner, and vault concrete in its AMPs, to ensure the SSCs of the HB ISFSI continue to perform their intended shielding function in the period of extended operation. In Section 3.5 of this SER, the staff concludes these inspection activities to be capable of ensuring that any degradation is identified in a timely manner and necessary corrective actions are conducted. Therefore, the staff finds the applicant's analysis of potential shielding material degradation to be acceptable.

3.4.5 Evaluation Findings

The staff reviewed the LRA and design-bases documentation to confirm that the applicant did not omit any TLAAs that were part of the approved design bases. The staff's review followed the guidance in NUREG-1927, Revision 1.

Based on its review of the LRA, as supplemented, the staff finds the following:

F3.3 The applicant appropriately evaluated all aging mechanisms and effects pertinent to SSCs within the scope of renewal that had the potential to involve TLAAs. Therefore, the applicant's evaluation provides reasonable assurance that the SSCs will maintain their intended functions for the period of extended operation, require no further aging management activities, and meets the requirements in 10 CFR 72.42(a)(1).

3.5 Aging Management Programs

Under 10 CFR 72.42(a)(2) requirements, the applicant must describe AMPs for managing issues associated with aging that could impair the abilities of ITS SSCs to perform their intended functions. The applicant provided the following AMPs in the LRA:

(1) HB ISFSI External Surfaces Monitoring AMP
(2) HB ISFSI Reinforced Concrete Structures AMP
(3) Cask Transportation System AMP

The staff conducted the safety review for the AMPs in the application based on the guidance in NUREG-1927, Revision 1. In addition, as applicable, the staff informed its review with the example AMPs in NUREG-2214 (NRC, 2019), which provide one acceptable approach to managing the identified effects of aging. For example, the Monitoring of Metallic Surfaces AMP and the Reinforced Concrete Structures AMP in NUREG-2214 closely align with the applicant's first two AMPs listed above.

When the staff determines that an AMP element is fully consistent with the guidance in NUREG-2214, this SER simply notes the consistency without providing further detailed discussions.

3.5.1 Humboldt Bay Independent Spent Fuel Storage Installation External Surfaces Monitoring Aging Management Program

In LRA Section A.2, the applicant described the HB ISFSI External Surfaces Monitoring AMP for managing the degradation of the external surfaces of the HI-STAR 100 HB Overpacks, HI-STAR 100 HB GTCC Waste Overpack, and the ISFSI storage vault SSCs. The applicant stated that it based the AMP on the External Surfaces Monitoring of Metallic Components AMP from draft NUREG-2214 (NRC, 2017b). The staff notes it renamed this as Monitoring of Metallic Surfaces in the final version of NUREG-2214 (NRC, 2019).

The staff's evaluation of each of the program elements follows.

(1) Scope of Program

The applicant stated that the scope of the program consists of the external surfaces of subcomponents exposed to an embedded, sheltered, or outdoor air environment as described in LRA Tables 3.2-1 through 3.9-1 and LRA Table 3.11-1. The covered components include the following:

- exterior of the HI-STAR 100 HB Overpacks and HI-STAR 100 HB GTCC Waste Overpack
- ISFSI storage vault cell liners, vault lid bolting, and vault lid caulking
- MPC lid retention device

The staff reviewed the scope of the program to verify that the applicant adequately described the components covered under the program, as recommended in NUREG-1927, Revision 1. Based on its confirmation that the scope of the program is consistent with the applicant's AMR and that the applicant accurately specified the details of the components addressed under the program, the staff finds the scope of the program to be acceptable.

(2) Preventive Actions

The applicant stated that the program is a condition-monitoring program, and it does not provide guidance for the prevention of aging.

The staff reviewed the preventive actions program element and confirmed that the program does not rely on preventive actions to manage the effects of aging. The staff finds the applicant's preventive actions program element to be acceptable because, consistent with the recommendations in NUREG-1927, Revision 1, condition-monitoring programs do not need to have preventive actions.

(3) Parameters Monitored or Inspected

The applicant stated that the parameters monitored or inspected include visual evidence of deterioration of accessible surfaces (including coatings) and missing or displaced bolts. Signs of degradation include discontinuities, imperfections, rust staining, coating degradation (e.g., blisters, cracking, flaking), and relief device disk deformation. The applicant stated that the aging effects monitored by these activities are loss of material and cracking.

The staff reviewed the parameters monitored or inspected program element to confirm that the parameters will be capable of identifying degradation before a loss of intended function and that they provide a clear link to the aging effects identified in the scope of the program, as recommended in NUREG-1927, Revision 1.

The staff reviewed the applicant's revised radiation shielding calculations and found the shielding assumptions used in the calculations (e.g., 20-percent reduction in steel density) are conservative and shielding performance is acceptable, as documented earlier in SER Section 3.4.4. The results show that, even with an unlikely loss of material on the steel overpacks and vault liner, the dose rates at the controlled area boundary and nearest resident would not increase significantly during normal operation. The staff considered that the visual inspections of the overpack and vault liner surfaces will be able to timely discover a loss of 20 percent of the steel. The staff notes that the HB ISFSI Reinforced Concrete Structures AMP includes the applicant's radiation monitoring activities to provide defense in depth to assess potential degradation of SSCs relied on for radiation shielding (including the overpack and vault). SER Section 3.5.2 documents the staff's evaluation of the radiation monitoring activities.

The staff finds the applicant’s parameters monitored or inspected program element to be acceptable because the described visual inspection parameters are capable of identifying the initiation or progression of loss of material of the external surfaces. These parameters are consistent with those recommended in the NUREG-2214 AMP, “Monitoring of Metallic Surfaces from NUREG-2214. In addition, for the welded stainless steel overlays that are managed for stress corrosion cracking, the staff finds that the program’s visual inspections are capable of identifying localized pitting and crevice corrosion, which is considered to be a precursor to stress corrosion cracking. This proposed approach to manage cracking through visual inspections for localized corrosion is consistent with the recommendations in the NUREG-2214 AMP, “Localized Corrosion and Stress Corrosion Cracking of Welded Stainless Steel Dry Storage Canisters.”

(4) Detection of Aging Effects

The applicant stated that it will conduct visual inspections to identify the aging mechanisms.

For the overpacks and the vault surfaces, the inspections include the following:

- Annually, the applicant will conduct visual inspections with a video probe through the vault cell access ports for all six cells. The video probe inspections will meet the resolution standards of ASME VT-3 requirements to provide a general area assessment of surface conditions of every vault and overpack, including the identification of any evidence of water intrusion (to verify the effectiveness of lid caulking).
- Every 5 years, the applicant will remove one vault lid (same lid for each interval) for a thorough visual inspection. It will conduct ASME VT-3 inspections of 100 percent of accessible areas with a video probe.

The applicant stated that the overpack bottoms and underlying vault liner are not accessible for inspection; however, the condition of accessible surfaces will be indicative of the conditions of the inaccessible areas. In addition, 100 percent of the vault lid bolting will be inspected at 5-year intervals, and 100 percent of the caulking sealant around vault lids will be inspected annually to identify gaps, tears, and thin spots to ensure that the caulking is capable of preventing water intrusion that could lead to corrosion. The entire surface of the MPC lid retention device is visually examined prior to use with ASME VT-3 methods. The lid retention devices may be used in fuel unloading operations under FSAR Sections 4.4.1.2.5 and 5.1.1.4).

The applicant described the training and qualification requirements of the personnel performing the above inspections, specifying degree requirements for engineers and structural inspection experience. Inspections of overpacks and vault surfaces will be performed by VT-3-certified personnel. Personnel that conduct inspections coatings will have NACE coating qualifications, will have completed Electric Power Research Institute’s coatings coursework, or will be qualified as a coating specialist consistent with Regulatory Guide 1.54 (NRC, 2017a).

The staff’s review of the inspection methods, sample sizes, and frequency of inspection of overpacks and vault surfaces for the HB ISFSI finds these are acceptable to detect the aging effects identified as within the scope of the AMP. The staff finds the inspections to monitor metallic surfaces are conducted as frequently or more frequently than the recommendations in NUREG-2214. NUREG-2214 AMP, “Monitoring of Metallic Surfaces,” recommends general visual inspections be conducted at least every 5 years and that procedures be in place in order to verify that the visual inspections are capable of identifying the degradation of surfaces prior to a loss of function.

The staff concludes the training and certification of HB's inspection personnel are consistent with the recommendations in NUREG-2214. Additionally, the staff finds the applicant has procedures in place to identify potential aging conditions, to evaluate inspection findings for overpacks and vault surfaces against the acceptance criteria in NUREG-2214, and to initiate corrective actions. For these reasons, the staff finds the detection of aging effects element is capable of verifying that SSCs maintain their intended functions for the period of extended operation and is acceptable as designed.

(5) Monitoring and Trending

The applicant stated that a baseline inspection will be conducted before the beginning of the period of extended operation, except for the lid retention device, which is inspected prior to use. The AMP requires monitoring and trending the condition of SSCs. All observations are recorded as part of inspection procedures. When degradation is observed that will exceed that of a properly maintained component, the degraded condition is entered into the site's Corrective Action Program (CAP). Degraded conditions are trended in accordance with the CAP. For the 5-year overpack and vault inspections, the applicant will remove the same vault lid at each 5-year inspection interval to facilitate trending.

The staff reviewed the applicant's monitoring and trending activities to confirm that the extent of aging is evaluated and that timely corrective or mitigative actions are taken as necessary. The staff notes that baseline visual inspections and the results of trending inspections in the future will be measured against baseline measurements, which will allow for the effective identification and remediation of the effects of aging. The staff finds the monitoring and trending program element to be acceptable because these activities will ensure adequate evaluation of the rate of degradation. Specifically, the commitment to conduct future inspections and repair components before a loss of functions occurs, is consistent with the guidance in NUREG-1927, Revision 1, and NUREG-2214 AMP, Monitoring of Metallic Surfaces.

(6) Acceptance Criteria

The applicant stated that the acceptance criteria for the overpack, vault, vault lid bolting, and lid retention device metallic surfaces are no detectable loss of material, including uniform wall thinning and localized corrosion. In addition, for the overpack and vault metallic surfaces, additional criteria include no coating defects, no indications of loose or displaced parts, and (4) no indications of premature overpack relief device rupture (bubbling, deformation). An alternative to the criterion of no coating defects is for a qualified coating inspector to conduct an evaluation of the coating to determine whether the degradation of the coating is significant or insignificant. The criteria for vault lids include no gaps, tears, or thin spots of the vault lid caulking.

The staff reviewed the applicant's acceptance criteria to verify that they provide specific benchmarks to prompt corrective actions before a loss of intended functions. The staff notes that the criteria are consistent with the NUREG-2214 example AMP, "Monitoring of Metallic Surfaces," which recommends the evaluation of any detectable degradation. The staff considers that using criteria of an absence of degradation is capable of triggering corrective actions in a timely manner, well before there is a loss of SSC functions. The applicant provided clear criteria against which to evaluate the need for corrective actions, consistent with the recommendations in NUREG-1927, Revision 1, and NUREG-2214. For these reasons, the staff finds the acceptance criteria program element to be acceptable.

(7) Corrective Actions

The applicant stated that the CAP requirements are established in accordance with its Quality Assurance (QA) Program, which complies with the requirements of 10 CFR Part 72, Subpart G, "Quality Assurance." Conditions that do not meet the AMP acceptance criteria will be entered into the CAP.

The staff reviewed the CAP element and finds that it is consistent with the recommendations in NUREG-1927, Revision 1, and the NUREG-2214 AMP, "Monitoring of Metallic Surfaces. Therefore, the staff finds the CAP element to be acceptable.

(8) Confirmation Process

The applicant stated that confirmatory actions needed to ensure that corrective actions are appropriate, completed, and effective are implemented by the licensee's CAP. The CAP includes procedures for evaluating the implementation of corrective actions, root cause evaluations, and prevention of recurrence.

The staff reviewed the confirmation process program element and finds that it is consistent with the recommendations in NUREG-1927, Revision 1, and the NUREG-2214 AMP, "Monitoring of Metallic Surfaces. Therefore, the staff finds the program element to be acceptable.

(9) Administrative Controls

The applicant stated that administrative controls (e.g., document controls, inspector requirements, instrument calibration, and maintenance) under the licensee's QA Program and CAP provide a formal review and approval process. Administrative controls are implemented in accordance with the requirements of 10 CFR Part 72, Subpart G.

The staff reviewed the administrative controls program element and finds that it is consistent with the recommendations in NUREG-1927, Revision 1, and the NUREG-2214 AMP, "Monitoring of Metallic Surfaces. Therefore, the staff finds the program element to be acceptable.

(10) Operating Experience

The applicant discussed the OE it gathered during routine ISFSI inspections, preapplication inspections, and a review of the HB CAP, NRC inspection reports, and industry OE.

The applicant cited the discovery of water on the floor in one of the vault cells in a 2012 inspection, which the applicant resolved by adding caulking to all vault lids, to prevent rain water intrusion. A preapplication inspection in 2017 did not identify service-related caulking degradation.

In LRA Appendix E, the applicant described the results of preapplication inspections of the overpacks and vaults conducted in 2017. Inspections included borescope examinations through vault access ports and a detailed visual inspection of one vault with the lid removed, using a magnetic crawler to examine the space between the overpack and vault wall. These examinations found that the casks and vault liners were in good condition and coatings generally were intact, although minor mechanical damage unrelated to aging was noted. Some minor rust staining of the overpack and vault liner was present. In response to the discovery of rust on the vault lid bolts and bolt holes, the applicant added a visual inspection of all lid bolts every 5 years to the AMP.

The applicant described how it will perform an AMP effectiveness review on a 5-year basis to determine whether the AMP is effectively managing the aging effects. In addition, an ISFSI program health report will be prepared on an annual basis. The program health report will evaluate the OE at HB ISFSI, as well as industry OE, through the Aging Management Institute of the Nuclear Power Operations Database (AMID). The health report will include a determination of whether the applicant should adjust the frequency of inspections and whether it should establish new inspections.

The staff reviewed the OE described by the applicant (e.g., inspections, OE, CAPs) and finds that it is sufficiently thorough to support the effectiveness of AMP activities. The framework for conducting future OE reviews to evaluate AMPs will be adjusted as the results of new analyses, experiments, and inspection activities becomes available. Therefore, the staff finds the OE program element to be acceptable.

Conclusion

The staff concludes that the applicant adequately addressed the 10 program elements of an AMP described in NUREG-1927, Revision 1. The staff finds reasonable assurance that the AMP is adequate for managing the aging mechanisms and effects of the in-scope SSCs identified by the AMR. Specifically, the staff finds reasonable assurance that the in-scope SSCs will continue to perform their intended functions during the requested period of extended operation.

3.5.2 Humboldt Bay Independent Spent Fuel Storage Installation Reinforced Concrete Structures Aging Management Program

In LRA Section A.3, the applicant described the HB ISFSI Reinforced Concrete Structures AMP for managing the degradation of the concrete storage vault SSCs. The applicant stated that it based the AMP on the NUREG-2214 AMP, “Reinforced Concrete Structures. The staff’s evaluation of each of the AMP program elements follows.

(1) Scope of Program

The applicant described the scope of the program as addressing all intended functions of the concrete subcomponents identified in LRA Table 3.9-1. The intended functions include radiation shielding and structural integrity. The scope of the HB ISFSI Reinforced Concrete Structures AMP includes (1) visual inspection, (2) radiation monitoring, and (3) soil sample analyses.

The staff reviewed the scope of the program to verify that the applicant adequately described the components covered under the program, as recommended in NUREG-1927, Revision 1. Based on the staff’s confirmation that the scope of the program is consistent with the applicant’s AMR and that the applicant accurately specified the details of the components addressed under the program, the staff finds the scope of the program to be acceptable.

(2) Preventive Actions

The applicant stated that the program does not include any preventive actions to manage the degradation of the concrete structures. Rather, the concrete aging effects are managed with condition monitoring activities.

The staff reviewed the preventive actions program element and confirmed that the program does not rely on actions that prevent aging, but in effect manages the effects of aging as they are identified. The staff verified that the program uses radiation monitoring, visual inspections, and soil sampling as an alternative approach to manage concrete degradation. The staff finds the applicant's preventive actions program element to be acceptable because, consistent with the recommendations in NUREG-1927, Revision 1, preventive actions are not required for condition-monitoring programs, because these programs monitor and remedy degradation OR aging after it is identified.

(3) Parameters Monitored or Inspected

The applicant defined the parameters of three monitoring and inspection activities: vault inspections, radiation monitoring, and soil samples. The applicant will perform visual inspections of the accessible areas of the ISFSI storage vault concrete (including the concrete vault lid view port plugs) to identify the presence of concrete degradation. The parameters of the inspections (e.g., affect surface area, geometry, and depth of defects) are consistent with Electric Power Research Institute's guidance and the American Concrete Institute (ACI) code 349.3R-18 (ACI, 2018a). Visual inspections will also monitor for signs of any surface geometries that may support water ponding and potentially increase the rate of degradation. These aging effects inspections will monitor for loss of material, cracking, change in material properties, increase in porosity and permeability, loss of strength, reduction of concrete pH, and loss of the concrete/steel bond.

The applicant will also perform periodic radiation surveys of an overpack closure plate and vault cell lid. The applicant included this radiation monitoring activity as a defense-in-depth measure to provide additional verification that the materials in the overpacks and vaults continue to perform their shielding function. The applicant proposed a radiation survey of an overpack closure and vault lid every 5 years, which aligns with the concrete inspection frequency.

Finally, the applicant will take soil samples at a 5-year frequency to verify that pH and concentrations of chlorides and sulfates are indicative of noncorrosive soil. The results of the sampling are used to inform the scope and frequency of the AMP inspections.

The staff reviewed the parameters of the program element monitored or inspected and confirmed that the parameters will be capable of identifying concrete degradation before a loss of intended function occurs. These parameters provide a clear link to the aging effects identified in the scope of the program, as recommended in NUREG-1927, Revision 1. The staff notes the proposed visual inspection parameters are consistent with those recommended in the ACI code and NUREG-2214 and, therefore, are appropriate leading indicators of concrete degradation. The applicant included radiation surveys for defense in depth. Specifically, the results of radiation surveys of an overpack closure plate and vault cell lid will be used to confirm the applicant's conclusions that the Holtite-A™ shielding material will continue to perform its intended function. The SER Section 3.3.1.3 discusses these surveys in more detail. The staff finds that those surveys provide additional assurance of the continued shielding effectiveness of the storage system components in the period of extended operation. Therefore, the staff finds the applicant's parameters monitored or inspected to be acceptable.

(4) Detection of Aging Effects

The applicant proposed to manage concrete degradation by a combination of visually inspecting exposed portions of the storage vault concrete, monitoring the radiation level at the top of the vaults, and sampling soil to verify the lack of an aggressive environment.

For the vault concrete inspections, all accessible concrete will be visually inspected every 5 years in accordance with ACI 349.3R-18 (ACI, 2018a). These inspections use feeler gauges, crack comparators, or other suitable quantification methods, when necessary. When inaccessible concrete is exposed during excavations, these areas are inspected. The qualifications of the vault inspection personnel are consistent with the recommendations in ACI 349.3R-18. The vault lid view port plug inspectors are degreed engineers with one or more years of structural inspection experience.

Every 5 years the applicant will also measure the radiation levels at the surface of the vault cell lid and overpack closure plate, which is accessible by removing the vault lid; the timing of the visual inspections of the vault liner and overpack is aligned.

In addition, soil samples will be evaluated every 5 years to confirm the absence of an aggressive environment, as defined in ACI 349.3R-18 (ACI, 2018a). When an aggressive soil environment is identified (due to high chlorides, high sulfates, or low pH), an AMP will be developed specifically to address the potential for more rapid concrete degradation.

The staff reviewed the detection of aging effects program element and finds that the proposed visual inspection methods and inspection frequency are in accordance with ACI 349.3R-18 and staff guidance in the NUREG-2214 AMP, "Reinforced Concrete Structures. In addition, the staff finds that the radiation monitoring component of the HB ISFSI Reinforced Concrete Structures AMP will provide additional means to detect significant internal degradation of the shielding components. The staff finds the radiation survey activities described in this AMP will provide information on the collected combined degradation of concrete, steel, and other shielding components (including the Holtite-A™ shielding material in the overpacks). The staff finds that the radiation survey component, when added to the ongoing thermoluminescent dosimeter measurements at the site, provides additional assurance that the concrete structures and other components will continue to provide their radiation shielding function.

On these bases, the staff finds the program element is adequate to detect the loss of the intended functions and therefore to be acceptable.

(5) Monitoring and Trending

The applicant stated that it will perform baseline inspections before the beginning of the period of extended operation. It will trend the periodic concrete inspection results consistent with concrete defect evaluation guides and standards (e.g., ACI, 2007a, 2007b, 2008, 2018b). Also, the applicant will compare radiation measurements to design-basis limits and previously measured levels, which provide a baseline for the effective detection of a loss of the intended shielding function.

The staff finds that the monitoring and trending program element is consistent with the staff guidance in the NUREG-2214 AMP, "Reinforced Concrete Structures, and, therefore, the staff finds it to be acceptable.

(6) Acceptance Criteria

The applicant stated that the acceptance criteria for the vault inspections will be consistent with ACI 349.3R-18 (ACI, 2018a), these include the quantitative three-tier acceptance criteria of (1) acceptance without further evaluation, (2) acceptance after review, and (3) acceptance requiring further evaluation. Conditions meeting or exceeded Tier 2 will be entered into the site's CAP. In addition, the applicant stated that the soil sample acceptance criteria will be less than or equal to 500 parts per million (ppm) chlorides, less than or equal to 1,500 ppm sulfates, and a soil pH greater than or equal to 5.5.

The staff finds that the acceptance criteria program element is consistent with the staff guidance in the NUREG-2214 AMP, "Reinforced Concrete Structures, and, therefore, the staff finds it to be acceptable.

For the radiation surveys the applicant has proposed using the following acceptance criteria:

- Less than 1.5 microsievert (µSv)/hour (0.15 millirem (mrem)/hour) dose rate for the external vault monitoring. This acceptance criterion was established based on the calculated dose rate as discussed in Section 7.3.2.1 of the HB ISFSI FSAR update for meeting the requirements of 10 CFR Part 20, "Standards for Protection Against Radiation."

- Less than 99 µSv/hour (9.9 mrem/hour) dose rate for monitoring at the overpack lid.

These acceptance criteria are established based on the calculated dose rates as discussed in the HB ISFSI FSAR update, Table 7.3-1, Point 4, at the overpack lid for meeting the requirements of 10 CFR Part 20. The staff reviewed the proposed acceptance criteria for a radiation survey and found the dose rate limit values to be consistent with the applicant's shielding calculation (Holtec, 2016a). On this basis, the staff found that the proposed acceptable dose rate limits are consistent with the calculated results and are therefore acceptable.

(7) Corrective Actions

The applicant stated that the CAP requirements are established in accordance with its QA Program, which complies with the requirements of 10 CFR Part 72, Subpart G. Conditions that do not meet the AMP acceptance criteria will be entered into the CAP, which may use ACI rehabilitation guides or standards.

The staff reviewed the CAP element and finds that it is consistent with the recommendations in NUREG-1927, Revision 1, and the NUREG-2214 AMP, "Reinforced Concrete Structures. Therefore, the staff finds the CAP element to be acceptable.

(8) Confirmation Process

The applicant stated that confirmatory actions that are needed to ensure that corrective actions are appropriate, completed, and effective are implemented as part of the licensee's CAP. The

CAP includes procedures for evaluating the implementation of corrective actions, root cause evaluations, and prevention of recurrence.

The staff reviewed the confirmation process program element and finds that it is consistent with the recommendations in NUREG-1927, Revision 1, and the NUREG-2214 AMP, “Reinforced Concrete Structures. Therefore, the staff finds the program element to be acceptable.

(9) Administrative Controls

The applicant stated that administrative controls (e.g., document controls, inspector requirements, instrument calibration, and maintenance) under the licensee’s QA Program and CAP provide a formal review and approval process. Administrative controls are implemented in accordance with the requirements of 10 CFR Part 72, Subpart G.

The staff reviewed the administrative controls program element and finds that it is consistent with the recommendations in NUREG-1927, Revision 1, and the NUREG-2214 AMP, “Reinforced Concrete Structures. Therefore, the staff finds the program element to be acceptable.

(10) Operating Experience

The applicant reviewed its OE gathered during routine ISFSI inspections; in preapplication inspections; and after a review of the HB CAP, NRC inspection reports, and industry OE. The applicant noted that the HB ISFSI has only minor concrete cracking and no evidence of settlement. LRA Section E.5.5 describes the vault concrete preapplication inspections.

The applicant will perform an AMP effectiveness review at a 5-year interval to determine whether the AMP is effectively managing aging effects. In addition, the annual ISFSI Program Health Report will include an evaluation of HB ISFSI OE, as well as industry OE through AMID. The health report will include an assessment of whether the applicant will need to adjust the frequency of inspections and whether new inspections will need to be established.

The staff’s review of OE reported by the applicant finds the OE supports the effectiveness of AMP activities. In addition, the AMP includes a framework for future OE reviews; the AMP will be adjusted as new analyses, experiments, and inspection activities become available.

<u>Conclusion</u>

The staff reviewed the 10 elements of the applicant’s Reinforced Concrete Structures AMP for managing the degradation of the concrete storage vault SSCs to address aging mechanisms and effects of potential aging that could adversely affect the ability of the SSCs and the associated subcomponents to perform their intended functions. The staff concludes the applicant’s AMP addresses the recommended elements in NUREG-1927, Revision 1 and is adequate to identify credible aging effects for the SSCs that are within the scope of renewal. Therefore, the staff finds reasonable assurance that the storage vault SSCs will continue to perform their intended functions during the requested period of extended operation.

3.5.3 Cask Transportation System Aging Management Program

In LRA Section A.4 and Table A-3, the applicant stated that the Cask Transportation System AMP will ensure that the SSCs used to transport the HI-STAR 100 HB are not degraded during the period of extended operations. The staff's evaluation of each of the program elements follows.

(1) Scope of Program

The applicant stated that the scope of the program consists of the external surfaces of subcomponents exposed to a sheltered environment, as described in LRA Table 3.10-1. The covered components include the following:

- cask transporter structure (overhead beam, lift towers, chassis)
- cask restraint system and wedge lock assembly
- lift links and connector pins

The staff reviewed the scope of the program to verify that the applicant adequately described the components covered under the program, as recommended in NUREG-1927, Revision 1. Based on the staff's confirmation that the scope of the program is consistent with the applicant's AMR and that the applicant accurately specified the details of the components addressed under the program, the staff finds the scope of the program to be acceptable.

(2) Preventive Actions

The applicant stated that the program is a condition monitoring program, and it does not provide guidance for the prevention of aging.

The staff reviewed the preventive actions program element and confirmed that the program does not rely on preventive actions to manage the effects of aging. The staff finds the applicant's preventive actions program element to be acceptable because, consistent with the recommendations in NUREG-1927, Revision 1, preventive actions do not need to be provided for condition-monitoring programs.

(3) Parameters Monitored or Inspected

The applicant stated that the parameters monitored or inspected for metallic components include visual evidence of deterioration, size and location of localized corrosion, missing or displaced parts, and appearance of deposits. Visual evidence of deterioration includes discontinuities, imperfections, and rust staining indicative of corrosion. In addition, the K-Spec® fiber cask restraint sling is monitored for visual evidence of damage, such as burns, snags, tears, punctures, wear, and distortion. The aging effects monitored by these activities are loss of material and loss of preload in bolting.

The staff reviewed the parameters monitored or inspected program element to confirm that the parameters will be capable of identifying degradation before a loss of intended function and provide a clear link to the aging effects identified in the scope of the program, as recommended in NUREG-1927, Revision 1. The staff finds the applicant's parameters monitored or inspected program element to be acceptable because the described visual inspections are capable of identifying the initiation or progression of degradation of the cask transportation system components. In addition, the parameters monitored for the metallic components are consistent with the recommendations in the NUREG-2214 AMP, Monitoring of Metallic Surfaces.

(4) Detection of Aging Effects

The inspections conducted under the AMP occur before the first use of the transporter after it reaches 20 years of service and every 5 years thereafter. If the transporter is used less frequently than every 5 years during the period of extended operation, inspections are conducted prior to each use.

For the cask transporter structure, 100 percent of the accessible portions of the structural members (overhead beam, lift link saddles, lift towers, and chassis) are visually inspected in accordance with ASME VT-3 to detect loss of material and loss of preload. Also, 100 percent of accessible bolting will be checked for proper torque to detect loss of preload.

For the cask restraint system and wedge lock assembly, 100 percent of the exterior surfaces are visually inspected in accordance with ASME VT-3 to detect loss of material. Also, visual and tactile inspections of 100 percent of the K-Spec® sling will be conducted to identify loss of material due to wear.

The polymer cask transporter bumpers will not be inspected, but rather they will be replaced prior to the start of each cask transfer campaign if the transporter has been in service for more than 20 years and 5 years have passed since the last replacement. As discussed in SER Section 3.3.1.5, because the polymer bumpers will not be allowed to exceed 20 years of age, the guidance in NUREG-1927 would support excluding this SSC from inspection under an AMP.

For the lift links and connector pins, 100 percent of the lift links and connector pins are visually inspected in accordance with ASME VT-3 to detect the loss of material.

The applicant also described the training and qualification requirements of the personnel performing and evaluating the above inspections, including the use of ASME VT-3 certified inspectors. Personnel certified in accordance with ASME Code Section III requirements will conduct followup visual, surface, or volumetric examinations, and personnel evaluating examination results shall be degreed engineers with structural inspection experience.

The staff reviewed the inspection methods, sample sizes, and frequency for the inspection activities and finds these provide acceptable means to effectively detect the effects identified in the scope of the program. The staff finds that the inspection activities are consistent with the recommendations in NUREG-2214 for monitoring the metallic surfaces of structural components. As recommended in NUREG-2214, the staff considers visual inspections conducted at least every 5 years with requirements to ensure adequate resolution (e.g., ASME VT-3) to be capable of identifying degradation of metallic structures before a loss of function. In addition, visual and tactile inspections of slings and torque checking of bolts are considered capable of identifying the age-related degradation of these components.

The staff concludes the training and certification of HB's inspection personnel are consistent with the recommendations in NUREG-2214 for personnel conducting general visual inspections to assess component conditions. Additionally, the staff finds the applicant has procedures in place to identify potential aging conditions in the Cask Transportation System, to evaluate inspection findings against the acceptance criteria in NUREG-2214, and to initiate corrective actions. For these reasons, the staff finds the detection of aging effects program element is capable of verifying that SSCs in the Cask Transportation System maintain their intended functions for the period of extended operation and is acceptable as designed.

(5) Monitoring and Trending

The applicant stated that a baseline inspection will be conducted prior to the first use of the cask transporter after it has been in service for 20 years, and inspections will continue every 5 years thereafter. The AMP requires monitoring and trending the condition of SSCs. All observations are recorded in inspection procedures and, if it appears that degradation will exceed that of a properly maintained component, the condition is entered into the site's CAP. Degraded conditions are trended in accordance with the CAP.

The staff reviewed the applicant's monitoring and trending activities to ensure that they provide for an evaluation of the extent of aging and the need for timely corrective or mitigative actions. The staff also notes that the baseline visual inspections and trending future inspection results against that baseline can effectively evaluate and respond to any identified effects of aging. On this basis, the staff finds the monitoring and trending program element to be acceptable because activities will be in place to ensure that the rate of degradation will be adequately evaluated such that future inspections will be performed or components will be repaired before a loss of functions, consistent with the guidance in NUREG-1927, Revision 1.

(6) Acceptance Criteria

The applicant stated that the acceptance criteria for all visual inspections of metallic components are the absence of any degradation aging effects, including no detectable loss of material greater than 3.2 millimeters (0.125 inch) from the base metal and no indications of loose or displaced parts. The acceptance criteria for bolting is the torque specified by the original equipment manufacturer. For the K-spec® sling, the acceptance criteria include no distortion, damage, or worn or broken stitching on end fittings and no general damage to the webbing or stitching (e.g., burns, tears, excessive wear).

The staff reviewed the applicant's acceptance criteria to verify that they provide specific benchmarks to prompt corrective actions before a loss of intended functions. The staff considers that using criteria of an absence or minor degradation is capable of triggering corrective actions in a timely manner, well before there is a loss of SSC functions. Therefore, the staff finds the acceptance criteria program element to be acceptable because it provides clear criteria against which to evaluate the need for corrective actions, consistent with the recommendations in NUREG-1927, Revision 1.

(7) Corrective Actions

The applicant stated that it established its CAP requirements in accordance with its QA Program, which complies with the requirements of 10 CFR Part 72, Subpart G. Conditions that do not meet the AMP acceptance criteria will be entered into the CAP.

The staff reviewed the CAP element and notes that NUREG-1927, Revision 1, and NUREG-2214 state that an applicant may reference the use of the CAP approved under 10 CFR Part 72, Subpart G. The NRC guidance also states that all conditions that do not meet AMP acceptance criteria should be entered into the CAP. On these bases, the staff finds the CAP element to be acceptable because inspection and monitoring results that do not meet acceptance criteria will be entered in the CAP, and the QA requirements in 10 CFR Part 72, Subpart G, provide reasonable assurance that appropriate corrective actions will be implemented to manage the aging of the dry storage systems.

(8) Confirmation Process

The applicant stated that confirmatory actions are implemented, as needed, as part of the CAP.

The staff reviewed the details provided for the confirmation process, in the context of the existing QA Program, to ensure that appropriate corrective actions are completed and are effective. The staff notes that NUREG-1927, Revision 1, and NUREG-2214 state that an applicant may reference the use of the CAP approved under 10 CFR Part 72, Subpart G, for its confirmation processes. As a result, the staff concludes that the licensee's CAP, in accordance with the QA requirements in 10 CFR Part 72, Subpart G, provides reasonable assurance that the confirmation process is adequate for managing the aging mechanisms and effects.

(9) Administrative Controls

The applicant stated that administrative controls under the licensee's QA Program and CAP provide a formal review and approval process and are implemented in accordance with the requirements of 10 CFR Part 72, Subpart G.

The staff reviewed the details provided for administrative controls, in the context of the existing QA Program, to ensure that they will be adequate to provide a formal review and approval process. The staff notes that NUREG-1927, Revision 1, and NUREG-2214 state that an applicant may reference the use of the CAP approved under 10 CFR Part 72, Subpart G, for its administrative controls. As a result, the staff concludes that the licensee's QA Program, under the requirements in 10 CFR Part 72, Subpart G, provides reasonable assurance that the administrative controls are adequate for managing the aging mechanisms and effects identified in the scope of the program.

(10) Operating Experience

The applicant discussed the OE it gathered during routine ISFSI inspections and a review of the HB CAP and NRC inspection reports.

The applicant stated that the cask transporter has been in service since 2008 and inspections have identified loose bolting and weld cracking. Following this finding, the bolts were retorqued according to the vendor specifications, and there have been no indications of loose bolts since. Cracking in chassis welds were determined to be in welds that are nonstructural. The applicant continues to inspect the welds and has identified no further cracking.

The applicant's review of its CAP and NRC inspection reports did not identify any additional items associated with SSCs within the scope of renewal.

The applicant described how it will perform an AMP effectiveness review on a 5-year basis to determine whether the AMP is effectively managing the aging effects. In addition, it will issue an annual ISFSI Program Health Report. The program health report will include an evaluation of the HB ISFSI OE as well as industry OE through AMID. The health report will include a determination of whether the frequency of inspections should be adjusted and whether new inspections should be established.

The staff reviewed the OE cited by the applicant and finds that it was sufficient to support the effectiveness of AMP activities and included a framework for future OE reviews to ensure that AMPs will be adjusted as knowledge becomes available from new analyses, experiments, and inspection activities.

Conclusion

The staff evaluated the 10 elements of the applicant's Cask Transportation System AMP that address aging mechanisms and effects of potential aging that could adversely affect the ability of the SSCs and the associated subcomponents to perform their intended functions. The staff concludes the applicant's AMP are consistent with the methodology recommended in NUREG-1927, Revision 1 and are adequate to identify credible aging effects for the SSCs that are within the scope of renewal. Therefore, the staff finds reasonable assurance that the SSCs within the Cask Transportation System AMP will continue to perform their intended functions during the requested period of extended operation.

3.5.4 Evaluation Findings

The staff reviewed the AMPs in the LRA and supplemental documentation, following the guidance in NUREG-1927, Revision 1. Based on its review, the staff finds the following:

F3.4 The applicant has identified programs that provide reasonable assurance that aging effects will be adequately managed during the period of extended operation, in accordance with 10 CFR 72.42(a)(2).

4 LICENSE CONDITIONS TO ADDRESS RENEWAL

This section provides two new license conditions addressing the AMP, which the NRC imposes on ISFSI licensees as part of its the review of the LRA. The details of the AMP have been described throughout this SER. The bases for the addition of two new license conditions is provided in this section of the SER.

4.1 Final Safety Analysis Report Update

The NRC adds the following condition to the license as license condition 18:

> Within 90 days after issuance of the renewed license, PG&E shall submit an updated final safety analysis report (FSAR) to the U.S. Nuclear Regulatory Commission (NRC), in accordance with 10 CFR 72.70(a)(1) and (2). PG&E shall continue to update the FSAR, pursuant to the requirements in 10 CFR 72.70(a), (b), and (c). PG&E will follow the procedures in 10 CFR 72.4 for submitting the FSAR. The updated FSAR shall reflect the information provided in Appendix D of the Humboldt Bay ISFSI License Renewal Application, Revision 4, dated November 4, 2019 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19337C634). The licensee may make changes to the updated FSAR, consistent with 10 CFR 72.48(c).

The applicant proposed changes to the FSAR to address aging management activities that are required as part of the license renewal. The applicant submitted the proposed changes to the HB FSAR in Appendix D to the ISFSI LRA, Revision 4 (PG&E, 2019c). License condition 18 requires the changes to the FSAR be completed within the 90-day period, in accordance with 10 CFR 72.70(a)(1). These changes ensure the licensee develops and implements procedures that are necessary to aging management activities during the period of extended operation.

4.2 Aging Management Program Implementation

The NRC adds the following condition to the license as license condition 19:

> At least one year prior to the period of extended operation, PG&E shall create, update, or revise procedures for implementing the activities in the Aging Management Programs (AMPs) summarized in Appendix D of the license renewal application, and maintained in the updated FSAR. PG&E shall maintain procedures that implement the AMPs throughout the term of this license.
>
> Each procedure for implementing the AMPs shall contain a reference to the specific AMP provision the procedure is intended to implement. The reference shall be maintained if procedures are modified.

This license condition requires the applicant to revise or create a program for implementing the AMPs described in the FSAR supplement. This condition ensures that the program addresses AMP activities required for extended storage operations. The limited timeframe of one (1) year to complete the AMP document(s) ensure the guidance document is developed in a timely manner. This timeframe is consistent with the guidance in NUREG-1927, Revision 1.

5 CONCLUSIONS

Under 10 CFR 72.42(a), the Commission may issue a renewed license if it finds that the applicant identified actions that have been or will be taken and which demonstrate reasonable assurance that the activities authorized by the renewed license will continue to be conducted in accordance with the design bases. In 10 CFR 72.42(a), the NRC requires the application for license renewal to include TLAAs and AMPs, to demonstrate that the SSCs important to safety will continue to perform their intended functions during the period of extended operation.

The NRC staff reviewed the LRA for the HB ISFSI, in accordance with NRC regulations in 10 CFR Part 72. The staff followed the guidance in NUREG-1927, Revision 1. Based on its review of the LRA and the license conditions, the staff has determined that the requirements of 10 CFR 72.42(a) have been met.

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