SAFETY EVALUATION REPORT

FOR THE STANDARDIZED ADVANCED NUHOMS® SYSTEM CERTIFICATE OF COMPLIANCE RENEWAL

DOCKET NO. 72-1029

Office of Nuclear Material Safety and Safeguards
United States Nuclear Regulatory Commission

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CONTENTS

TABLES

Table Page

ABBREVIATIONS AND ACRONYMS

ACI	American Concrete Institute
AHSM	advanced horizontal storage module
AHSM-HS	advanced horizontal storage module – high seismic
AMA	aging management activity
AMID	Aging Management Institute of Nuclear Power Operations Database
AMP	aging management program
AMR	aging management review
ASME	American Society of Mechanical Engineers
B&PV	boiler and pressure vessel
C	Celsius
CFR	*Code of Federal Regulations*
CISCC	chloride-induced stress corrosion cracking
CoC	certificate of compliance
DOE	U.S. Department of Energy
DSC	dry shielded canister
DSS	dry storage system
E-C	embedded in concrete
E-M	embedded in metal
EPRI	Electric Power Research Institute
F	Fahrenheit
FE	fully encased or lined
GW	groundwater/soil
HAZ	heat affected zones
HBU	high burnup

HDRP	High Burnup Dry Storage Cask Research and Development Project
HE	helium
HSM	horizontal storage module
INPO	Institute of Nuclear Power Operations
ISFSI	independent spent fuel storage installation
ISG	interim staff guidance
ITS	important to safety
MAPS	managing aging processes in storage
MIC	microbially induced corrosion
MMC	metal matrix composite
MOX	mixed-oxide
NEI	Nuclear Energy Institute
NITS	not important to safety
NRC	U.S. Nuclear Regulatory Commission
OD	air-outdoor
PEO	period of extended operation
PWR	pressurized water reactor
QA	quality assurance
RAI	request for additional information
SER	safety evaluation report
SH	sheltered
SNF	spent nuclear fuel
SSC	structure, system, and component
TC	transfer cask
TLAA	time-limited aging analysis
TS	technical specifications

UFSAR	updated final safety analysis report

EXECUTIVE SUMMARY

In accordance with 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 Certificate of Compliance No. 1029 (CoC 1029) for 20 years for the Standardized Advanced NUHOMS® System for dry storage of spent nuclear fuel in an independent spent fuel storage installation (ISFSI) at power reactor sites to persons authorized to possess or operate nuclear power reactors under 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," and 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," in accordance with 10 CFR Part 72, Subpart K, "General License for Storage of Spent Fuel at Power Reactor Sites." The CoC will expire on February 5, 2023.

By letter dated May 22, 2019, as supplemented on December 4, 2019, and July 10, 2020 (TN Americas LLC, 2019b, 2019c, 2020), the current CoC holder, TN Americas LLC (referred to as the "applicant" in this report), submitted an application to the NRC for renewal of CoC No. 1029, for a period of 40 years beyond the initial certificate period. The applicant submitted the renewal application in accordance with the regulatory requirements of 10 CFR 72.240, "Conditions for spent fuel storage cask renewal." Because the renewal application was submitted more than 30 days before the certificate's expiration date, pursuant to 10 CFR 72.240(b), this application constitutes a timely renewal. The application documented the technical bases for renewal of the certificate and the applicant's commitments to manage the potential aging of the systems, structures, and components (SSCs) of the dry storage system (DSS) to ensure that these SSCs will maintain their intended functions during the period of operation that extends beyond the length of the term certified by the current certificate (referred to in this report as the period of extended operation or extended storage).

The Standardized Advanced NUHOMS® System is a canister-based DSS for spent nuclear fuel. The system has two principal components, a welded stainless steel dry shielded canister (DSC) and a horizontal storage module (HSM). The Standardized Advanced NUHOMS® System uses transfer casks approved under CoC No. 1004 for DSC loading in the spent fuel building and transfer of the DSC to the storage pad. The DSC is stored in an HSM, which is a prefabricated, reinforced concrete vault that provides shielding for the DSC to minimize the radiation emissions from the ISFSI and to allow passive cooling for the DSC. The HSM is a low-profile structure designed to withstand all normal and off-normal loads, as well as loads potentially created by earthquakes, tornado missiles, and other loads during design-bases accident conditions. The HSM includes a steel-lined door that can be removed for insertion and retrieval of the DSC using a transfer cask.

In the renewal application, the applicant presented general information about the DSS design with a scoping analysis to determine the SSCs that are in scope of the renewal and subject to an aging management review (AMR). The applicant further screened the in-scope SSCs to identify and describe the subcomponents that support the in-scope SSC intended function(s). The applicant documented the technical bases for renewal of the CoC and proposed actions for managing potential aging of the SSCs of an ISFSI that are within the scope of license renewal to ensure that these SSCs will maintain their intended functions during the period of extended operation. For each in-scope SSC subcomponent, the applicant provided one of the following to assure that the SSC will maintain its intended function(s) during the period of extended operation: (1) an analysis that shows that no aging management is necessary because no aging effects are relevant for the SSC, (2) an updated time-limited aging analysis, (3) a supplemental aging analysis to justify the proposed aging management approach, or (4) an aging management program (AMP).

The NRC staff reviewed the technical bases for safe operation of the DSS for an additional 40 years beyond the current CoC term of 20 years. This safety evaluation report summarizes the results of the staff's review for compliance with 10 CFR 72.240. In its review, the staff followed the guidance in 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), and NUREG-2214, Revision 0, "Managing Aging Processes in Storage (MAPS) Report," issued July 2019 (NRC 2019).

NUREG-2214 establishes a generic technical basis for the safety review of ISFSI licenses and DSS CoC renewal applications, in terms of the evaluation of (1) aging mechanisms and effects that could impact the ability of ISFSI and DSS SSCs to fulfill their intended functions in the period of extended operation (i.e., credible aging mechanisms and effects) and (2) AMPs to manage the aging effects, including examples of AMPs 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 and proposed AMPs and compared it to the generic technical basis in NUREG-2214. For that comparison, the staff ensured that the design features, operating environments, aging mechanisms, and operating experience for the 1029 CoC are bounded by those evaluated in NUREG-2214.

This safety evaluation report is organized into six sections. Section 1 provides the staff's review of the general information on the DSS design. Section 2 presents the staff's review of the scoping evaluation performed to determine which SSCs are within the scope of the CoC renewal. Section 3 provides the staff's evaluation of the applicant's AMR for assessment of aging effects and aging management activities for SSCs within the scope of renewal. Section 4 documents the additions and changes to the license that resulted from the review of the license renewal application. Section 5 presents the staff's conclusions from its review. Section 6 lists the references supporting the staff's review and technical determinations.

1 GENERAL INFORMATION

1.1 Certificate of Compliance and Certificate of Compliance Holder Information

On May 22, 2019 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19148A484), as supplemented on December 4, 2019 (ADAMS Accession No. ML19338E132), and July 10, 2020 (ADAMS Accession No. ML20192A127), Orano TN Americas LLC (TN or the applicant) submitted an application to renew Certificate of Compliance (CoC) No. 1029 for the Standardized Advanced NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel. The application is subject to the provisions of 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," Subpart K, "General License for Storage of Spent Fuel at Power Reactor Sites," and Subpart L, "Approval of Spent Fuel Storage Casks."

The applicant requested renewal of the initial Standardized Advanced NUHOMS® Storage System CoC and Amendments 1, 3, and 4. The U.S. Nuclear Regulatory Commission (NRC) issued the initial CoC (Amendment 0) on February 5, 2003, for the Standardized Advanced NUHOMS® Horizontal Modular Storage System. Subsequently, the NRC has issued three amendments (1, 3, and 4) to the Standardized Advanced NUHOMS® System CoC. In its renewal application, TN provided a description of the licensing basis for the Standardized Advanced NUHOMS® System initial issuance, as well as general descriptions of the changes and reasons for each amendment, including the dates of the applications and associated supplements, the date of issue of the CoC and CoC amendments, and the corresponding updated final safety analysis report (UFSAR) revisions in which the changes were incorporated. Chapter 1 of the application lists the amendments and provides a description for each amendment along with references. Chapter 2 of the application provides further details on the scope of each amendment.

1.2 Safety Review

The objective of this safety review is to determine whether there is reasonable assurance that the dry storage system (DSS) will continue to meet the requirements of 10 CFR Part 72 during the period of extended operation. The NRC staff safety review is a detailed and in-depth assessment of the technical aspects of the Standardized Advanced NUHOMS® System renewal application. Pursuant to 10 CFR 72.240(c)(2) and (c)(3), an application for renewal of a spent fuel storage cask CoC must be accompanied by a safety analysis report that includes the following: (1) time-limited aging analyses (TLAAs) demonstrating that structures, systems, and components (SSCs) important to safety (ITS) will continue to perform their intended function for the requested period of extended operation, and (2) a description of the aging management programs (AMPs) to address issues associated with aging that could adversely affect ITS SSCs.

The applicant stated that the CoC renewal application is consistent with guidance in 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 (ADAMS Accession No. ML16179A148) (NRC 2016). In addition, the applicant stated that credible aging mechanisms for the material/environment combinations for the SSCs included in the scope of the renewal followed the guidance in NUREG-2214, “Managing Aging Processes in Storage (MAPS) Report,” issued July 2019 (ML19214A111) (NRC 2019). The applicant provided a scoping evaluation, an aging management review (AMR), TLAAs, and AMPs to assure that the SSCs within the scope of renewal will continue to perform their intended function during the period of extended operation. This safety evaluation report (SER) documents the staff’s evaluation of the applicant’s scoping and screening evaluation, AMR, and supporting TLAAs and AMPs according to the guidance in NUREG-1927, Revision 1 (NRC 2016), as informed by NUREG-2214 (NRC 2019).

1.3 Application Content

The applicant’s license renewal application provided the following:

- general information
- scoping evaluation
- AMRs
- aging management tollgates
- TLAAs and other supplemental evaluations
- AMPs
- changes to the CoC 1029 UFSAR
- changes to the CoC 1029 technical specifications (TS)

The applicant also provided UFSAR revisions for all CoC amendments, which incorporated all changes to the Standardized Advanced NUHOMS® System previously made without prior NRC approval in accordance with 10 CFR 72.48(c) and (d). The UFSAR supplement and changes document provided in Attachment A of the application details the changes and additions for the Standardized Advanced NUHOMS® System. In addition, during the staff’s review of the renewal application, the applicant submitted its 2019 biennial update to the UFSAR (TN Americas LLC, 2019a). The staff considered these additional UFSAR revisions in its review of the applicant’s scoping evaluation and AMR.

1.4 Interim Staff Guidance

The staff, industry, and other interested stakeholders gain experience and develop lessons learned from operating independent spent fuel storage installations (ISFSIs) and DSSs, as well as each renewal review. The lessons learned address issues related to the licensing goals of maintaining safety, improving effectiveness and efficiency, reducing regulatory burden, and increasing public confidence. The staff develops interim staff guidance (ISG) to clarify or to address issues not addressed in standard review plans, including NUREG-1536, “Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility,” Revision 1, issued July 2010 (ADAMS Accession No. ML101040620) (NRC 2010), and NUREG-1927 (NRC 2016). The staff, industry, and other interested stakeholders are to use ISGs until they are incorporated into staff guidance documents such as regulatory guides and standard review plans. The applicant specifically referenced ISG-11, “Cladding Considerations for the Transportation and Storage of Spent Fuel,” Revision 3, issued November 2003 (ADAMS Accession No. ML033230335) (NRC 2003).

1.5 Evaluation Findings

The staff reviewed the general information in Chapter 1 of the renewal application according to the guidance in NUREG-1927, Revision 1. Based on its review, the staff finds the following:

F1.1 The information presented in the renewal application satisfies the requirements of 10 CFR 72.48, "Changes, tests, and experiments," and 10 CFR 72.240, "Conditions for spent fuel storage cask renewal."

F1.2 The applicant has provided a tabulation of all supporting information and docketed material incorporated by reference, in compliance with 10 CFR 72.240.

2 SCOPING EVALUATION

As described in NUREG-1927, Revision 1, a scoping evaluation is necessary to identify the SSCs subject to an AMR, which assesses the effects of aging. More specifically, NUREG-1927, Revision 1, states that the scoping evaluation is used to identify SSCs meeting any of the following criteria (Scoping Criteria 1 and 2):

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

   i. maintain the conditions required by the regulations or the CoC to store spent fuel safely;

   ii. prevent damage to the spent nuclear fuel during handling and storage; or

   iii. provide reasonable assurance that spent fuel can be received, handled, packaged, stored, and retrieved without undue risk to the health and safety of the public.

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

The applicant stated that the ITS functions include (1) subcriticality control, (2) radiation shielding, (3) confinement, (4) heat-removal capability, (5) structural integrity, and (6) retrievability.

After the determination of in-scope SSCs, the SSCs are screened to identify and describe the subcomponents that support the SSC intended functions.

2.1 Scoping and Screening Methodology

Chapter 2 of the license renewal application provides the following information on the applicant's scoping evaluation:

- a description of the scoping and screening methodology for the inclusion of SSCs and SSC subcomponents in the scope of renewal review;
- a list of sources of information used for the scoping evaluation;
- descriptions of the SSCs; and
- a list of the SSCs identified to be 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 license renewal application. The following section discusses the staff's review and findings on the applicant's scoping evaluation.

2.1.1 Scoping Process

In Section 2.2 of the license renewal application, the applicant discussed the scoping evaluation process and methodology it used to determine the SSCs and associated subcomponents and subcomponent parts that are within the scope of renewal. The applicant's scoping evaluation process and methodology identified SSCs as either being scoped into the review under Scoping Criteria 1 and 2, or not scoped into the review for not important to safety items (NITS) that did not meet Scoping Criterion 2.

The staff reviewed the applicant's scoping process and determined that the process was acceptable because the applicant followed the guidance in NUREG-1927, Revision 1, Section 2.4. To determine the accuracy and completeness of the scoping evaluation, the staff also used the information in NUREG/CR-6407, "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety," issued February 1996 (ADAMS Accession No. ML15127A114) (NRC 1996), as a reference for classifying components as ITS.

2.1.2 Scoping Results

The applicant summarized the results of the scoping evaluation in the CoC 1029 renewal application, Table 2-1 and Section 2.3. The applicant provided detailed scoping analysis results for the 24PT1, 24PT4, and 32PTH2 dry shielded canisters (DSCs) in Tables 2-2 through 2-4 of the CoC 1029 renewal application. Similarly, the applicant included detailed scoping analysis results for the advanced horizontal storage module (AHSM) and advanced horizontal storage module high burnup and high seismic (AHSM-HS) in Tables 2-5 and 2-6 of the application. Table 2-7 of the CoC 1029 renewal application presents the detailed scoping analysis results for the spent fuel assemblies.

The applicant stated that the sources of information reviewed for the scoping evaluation that describe the approved design basis and the intended functions of the SSCs (and associated subcomponents) include the following:

- Standardized Advanced NUHOMS® Horizontal Modular Storage System UFSAR, Revision 9, issued March 2019 (ADAMS Accession No. ML19073A200) (TN Americas, 2019a)
- CoC 1029 and TS for each amendment as follows:
    - Amendment 0: ADAMS Accession Nos. ML030100440, ML030100468, ML030100472
    - Amendment 1: ADAMS Accession Nos. ML051520118, ML051520131
    - Amendment 3: ADAMS Accession Nos. ML15054A469, ML15054A513
    - Amendment 4: ADAMS Accession Nos. ML19036A559, ML19036A558
- NRC SERs for all amendments (ADAMS Accession Nos. ML030100459, ML051520145, ML15054A499, ML17338A121)

The applicant referred to Tables 2.5-1, A.2.5-1, and B.2.5-1 of the UFSAR (ADAMS Accession No. ML19073A200) when determining if an SSC was ITS or NITS. SSCs that were ITS were determined to be within the scope of renewal per Criterion 1. The applicant provided additional information for concluding that the ISFSI basemat should be within scope under Criterion 2 in Section 2.3.6 of the CoC 1029 renewal application.

The staff reviewed the scoping results to determine whether the applicant examined all SSCs in the approved design bases and whether the conclusions regarding the out-of-scope SSCs accurately reflected the design bases in the UFSAR. SER Table 2.1-1 lists the SSCs included and excluded from the scope of renewal review according to the CoC 1029 renewal application. SER Section 2.1.3 provides the staff's conclusions on SSCs (and SSC subcomponents) within the scope of renewal review, as defined in SER Table 2.1-1. SER Section 2.1.4 presents the staff's conclusions regarding SSCs (and SSC subcomponents) outside the scope of renewal review.

Table 2.1-1. SSCs/Contents within and not within the scope of renewal review

SSC/Contents	Criterion 1	Criterion 2	In-Scope (Yes/No)
Dry Shielded Canister (DSC)[1]	Yes	N/A	Yes
Horizontal Storage Module (HSM)[2]	Yes	N/A	Yes
Transfer Casks (TCs)[3]	N/A	N/A	No
TC Lifting Yoke	No	No	No
Spent Fuel Assemblies	Yes	N/A	Yes
ISFSI Basemat	No	Yes	Yes
ISFSI Approach Slab	No	No	No
Other Transfer Equipment[4]	No	No	No
Auxiliary Equipment[5]	No	No	No
Miscellaneous Equipment[6]	No	No	No

[1] DSC includes (but is not limited to) the DSC shell, top/bottom cover plates, purge and vent block, and grapple ring. The three types of DSCs include the 24PT1, 24PT4, and the 32PTH2.

[2] HSM subcomponents include (but are not limited to) the HSM reinforced concrete walls, roof, and end shield walls; heat shield panels, DSC steel structure support assembly; HSM accessories (DSC seismic retainer, shielded door assemblies, and door supports); and associated attachment/installation hardware (tie rods, bolts, nuts, washers, embedment assemblies, mechanical splices).

[3] TCs are renewed under the 72-1004 CoC.

[4] Other transfer equipment includes a hydraulic ram system, a transfer trailer, a prime mover for transfer trailer towing, cask support skid, auxiliary equipment mounted on the skid, and skid positioning system.

[5] Auxiliary equipment includes a vacuum drying system and an automated welding system.

[6] Miscellaneous equipment includes ISFSI security fence and gates, lighting, lightning protection, communications, monitoring, and alarm systems.

2.1.3 Structures, Systems, and Components within the Scope of Renewal Review

According to the scoping evaluation process and methodology, as discussed in Section 2.2 of the license renewal application, the applicant identified the SSC subcomponents considered to be within the scope of renewal review. As discussed in SER Section 2.1.1, the staff considers this approach to be consistent with the criteria defined in NUREG-1927, Revision 1. These subcomponents are tabulated in Tables 2-2 to 2-7 of the license renewal application and in the supplement to be incorporated in the 72-1029 UFSAR upon license renewal.

The following discussions address the applicant's basis for inclusion of an SSC within the scope of renewal review. The discussions also clarify the staff's review of that basis for inclusion.

Dry Shielded Canister

The applicant included the DSCs within the scope of the renewal review because these are classified as ITS in accordance with the CoC 1029 renewal application, Table 2-1. The applicant clarified that DSC subcomponents support ITS functions of confinement, radiation shielding, subcriticality control, structural integrity, heat-removal capability, and retrievability. The staff confirmed that the DSC subcomponents are within the scope of renewal review because these are classified as ITS in accordance with Tables 2.5-1, A.2.5-1, and B.2.5-1 of the Standardized Advanced NUHOMS® System UFSAR (ADAMS Accession No. ML19073A200). The staff confirmed that the applicant provided scoping evaluation results for the DSCs in Tables 2-2, 2-3, and 2-4 of the CoC renewal application.

Horizontal Storage Module

The applicant stated that the HSMs are within the scope of the renewal review because these are classified as ITS in accordance with Standardized Advanced NUHOMS® System UFSAR (ADAMS Accession No. ML19073A200). In Table 2-1 of the CoC renewal application, the applicant clarified that HSM subcomponents support ITS functions of radiation shielding, heat-removal capability, structural integrity, and retrievability. The staff confirmed that HSM subcomponents are scoped within the renewal review because these are classified as ITS in accordance with Tables 2.5-1, A.2.5-1, and B.2.5-1 of the Standardized Advanced NUHOMS® System UFSAR. The staff verified that the applicant provided scoping evaluation results for the DSCs in Tables 2-5 and 2-6 of the CoC 1029 renewal application.

Spent Fuel Assemblies

The applicant stated that the subcomponents of the spent fuel assemblies have intended functions required to maintain the conditions required by the regulations to store the spent fuel safely. Therefore, the spent fuel assemblies satisfy Criterion 1 and are in scope. The applicant provided a scoping evaluation of the subcomponents of the spent fuel assemblies in Table 2-7 of the CoC renewal application.

The staff noted that the subcomponents of the spent fuel assemblies are not classified as ITS in accordance with Tables 2.5-1, A.2.5-1, and B.2.5-1 of the Standardized Advanced NUHOMS® System UFSAR (ADAMS Accession No. ML19073A200). Nevertheless, the applicant's classification of the spent fuel assemblies as ITS is consistent with NUREG-1927, Section 2.4.2, which notes that safety analyses (e.g., criticality and shielding) rely on the spent fuel having a specific physical configuration. The staff confirmed that the applicant provided a scoping evaluation of the subcomponents of the spent fuel assemblies in Table 2-7 of the CoC renewal application.

ISFSI Basemat

The applicant stated that the ISFSI basemat (storage pad) and approach slab are classified as NITS, because the HSM is not anchored to the basemat. The applicant clarified that the ISFSI basemat provides a level and stable surface for placement and storage of HSMs with reinforcement on the top and bottom of the slab. The applicant concluded that differential settlement of the ISFSI basemat could affect retrievability. Therefore, the applicant concluded that the basemat is within the scope of renewal with respect to assessing the potential for and effects of differential settlement on retrievability, as indicated in Table 2-1 of the UFSAR.

The staff confirmed that the ISFSI basemat is classified as a NITS structure in Tables 2.5-1, A.2.5-1, and B.2.5-1 of the Standardized Advanced NUHOMS® System UFSAR. The staff reviewed the applicant's assessment for including the ISFSI basemat under Scoping Criterion 2 and determined that this assessment is appropriate because failure of the ISFSI basemat could affect structural integrity and retrievability functions.

Scoping Findings

The staff reviewed the applicant's screening of the SSCs to identify subcomponents within the scope of renewal review. The staff's review considered the intended function of the subcomponent, its safety classification per the UFSAR or fabrication drawings or basis for inclusion in the scope of renewal review, and design-bases information in the UFSAR. The staff's safety review followed the guidance in NUREG-1927, Revision 1 (NRC 2016), and was informed by NUREG-2214 (NRC 2019). The staff noted that NUREG-2214 includes aging management tables developed per the UFSAR drawings for the Standardized Advanced NUHOMS® CoC which provide a generic basis for scoping of the CoC SSCs. The staff compared the applicant's scoping evaluation results to the Standardized Advanced NUHOMS® CoC aging management tables in NUREG-2214. Based on this review, the staff finds that the applicant screened the in-scope SSCs in a manner consistent with NUREG-1927, Revision 1. Therefore, the staff finds the screening results for in-scope SSC subcomponents to be acceptable.

2.1.4 Structures, Systems, and Components Not within the Scope of Renewal Review

According to the scoping evaluation process and methodology, as discussed in Section 2.2 of the CoC renewal application, the applicant identified the SSC subcomponents considered to be not within the scope of renewal review. As previously discussed in SER Section 2.1.1, the applicant's scoping evaluation process and methodology is consistent with the criteria defined in NUREG-1927, Revision 1. In Table 2-1 of the CoC renewal application, the applicant identified subcomponents not needing an AMR. The following discussions address the applicant's basis for exclusion of an SSC from the scope of the renewal review. The discussions also describe the staff's review of that basis for exclusion.

Transfer Casks

The applicant stated that TCs approved for use with the Standardized Advanced NUHOMS® System are the OS197, OS197H, and the OS200FC. The applicant stated that these TCs are within the scope of the CoC 1004 renewal (ADAMS Accession No. ML17338A119), as indicated by the NRC in the SER for the CoC 1004 renewal (ADAMS Accession No. ML17338A121), and therefore, the TCs are not within the scope of the renewal of CoC 1029. The applicant cited the AMR of the TCs in the renewal application for CoC 1004 (ADAMS Accession No. ML16279A372) and stated that this AMR encompasses the materials and environments applicable to or bounding those associated with the Standardized Advanced NUHOMS® System.

The staff confirmed that the applicable TCs for the Standardized Advanced NUHOMS® System include the OS197, OS197H, and the OS200FC. The staff also confirmed that these TCs were included in the scope of the CoC 1004 renewal application and that an AMR was conducted and included in the CoC 1004 renewal application, Section 3.7 (ADAMS Accession No. ML16279A372). In addition, the staff confirmed that aging management activities applicable to the OS197, OS197H, and the OS200FC TCs were included in the CoC 1004 renewal and incorporated into Chapter 12 of the CoC 1004 UFSAR (ADAMS Accession No. ML18079A005). Therefore, the staff determined that the applicant's assessment that the OS197, OS197H, and the OS200FC TCs AMR and relevant aging management activities, including the TC AMP, have been adequately addressed in the CoC 1004 renewal.

ISFSI Approach Slab

The approach slab is a reinforced concrete structure that provides access to the HSM and supports the DSC transfer system. The applicant stated that the approach slab, which is designed and constructed to plant-specific site conditions, does not provide a safety function, and its failure would not prevent fulfillment of a safety function of the HSM loaded with a DSC. Therefore, the approach slabs are not within the scope of the CoC 1029 renewal.

The staff reviewed the Standardized Advanced NUHOMS® System UFSAR and confirmed that the approach slab was designated as a NITS item. Since the approach slab is not relied on to perform a safety function, the staff determined that the applicant's assessment that the approach slab is not within the scope of the renewal is appropriate.

Transfer Cask Lifting Yoke

The applicant stated that the lifting yoke used for handling the TCs within the fuel/reactor building is designed and procured as a "safety-related" component as described in Tables 2.5-1, A.2.5-1, and B.2.5-1 of the Standardized Advanced NUHOMS® System UFSAR (ADAMS Accession No. ML19073A200). The applicant stated that the TC lifting yoke is used by the general licensee under its 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," program and, due to unique site requirements, rigid or sling lifting members may be used to augment the lifting yoke. These members shall be designed, fabricated, and tested in accordance with the same requirements as those for the cask lifting yoke. The applicant cited CoC 1029 Condition 1(b), which states the following:

> With the exception of the TC, fuel transfer and auxiliary equipment necessary for ISFSI operations are not included as part of the Standardized Advanced NUHOMS® System referenced in this [CoC]. Such site-specific equipment may include, but is not limited to, special lifting devices, the transfer trailer, and the skid positioning system.

Based on the procurement and use of the TC lifting yoke and CoC 1029 Condition 1(b), the applicant concluded that the TC lifting yoke is not within the scope of the CoC 1029 renewal.

The staff reviewed the applicant's description of the TC lifting yoke and confirmed that the TC lifting yoke is identified as a safety-related item in accordance with 10 CFR Part 50 in the Standardized Advanced NUHOMS® System UFSAR, Tables 2.5-1, A.2.5-1, and B.2.5-1 (ADAMS Accession No. ML19073A200). The staff also reviewed the CoC 1029 conditions and confirmed that the TC lifting yoke is not included as part of the Standardized Advanced NUHOMS® System. The staff noted that, since the lifting yoke used for handling the TC within the fuel/reactor building is designed and procured as a "safety-related" component, general licensees would address the lifting yoke as part of the AMPs for the 10 CFR Part 50 license. In addition, the staff notes that the TC lifting yoke is not required for retrieval of the canisters from the HSMs. Therefore, the staff conclude that the applicant's assessment that the TC lifting yoke is not within the scope of the CoC 1029 renewal is appropriate.

<u>Other Transfer Equipment</u>

The applicant justified the exclusion of other transfer equipment from the scope of renewal review by noting that the equipment is classified as NITS in the Standardized Advanced NUHOMS® System UFSAR in Tables 2.5-1, A.2.5-1, and B.2.5-1. This transfer equipment necessary for ISFSI operations includes the following:

- transfer trailer
- skid positioning system
- hydraulic ram system
- ram support assembly
- cask support skid

The staff reviewed the justification and the design bases as discussed in the UFSAR and finds the applicant's conclusion that the other transfer equipment is NITS and will not prevent fulfillment of an ITS function to be acceptable because the equipment does not meet any of the scoping criteria that would bring it within the scope of license renewal. The staff notes that transfer equipment outside of the scope of this renewal application review may be necessary for retrieval of the TC. However, such equipment would be designed, constructed, and tested in accordance with good industry practices as described in Section 3.4.4.2 of the Standardized NUHOMS® System UFSAR (ADAMS Accession No. ML19028A062). Therefore, the staff finds the applicant's exclusion of other transfer equipment from the scope of renewal review to be acceptable.

<u>Auxiliary Equipment</u>

Auxiliary equipment used to facilitate canister loading, draining, drying, inerting, and sealing operations includes, but is not limited to, the vacuum drying system, automatic welding equipment, and cask/canister annulus seal. The applicant cited CoC 1029 Condition Part 1(b) which states the following:

> With the exception of the TC, fuel transfer and auxiliary equipment necessary for ISFSI operations are not included as part of the Standardized Advanced NUHOMS® System referenced in this CoC. Such site specific equipment may include, but is not limited to, special lifting devices, the transfer trailer, and the skid positioning system.

The applicant also stated that this equipment is classified as NITS in the Standardized Advanced NUHOMS® System UFSAR, Tables 2.5-1, A.2.5-1, and B.2.5-1 (ADAMS Accession No. ML19073A200), and failure would not prevent the fulfillment of a function that is ITS. Based on the safety classification of the auxiliary equipment in the Standardized Advanced NUHOMS® System UFSAR, CoC 1029 Condition 1(b), and the results of the applicant's scoping analyses, the applicant concluded that the auxiliary equipment is not within the scope of the CoC 1029 license renewal.

The staff reviewed the justification and the design bases as discussed in the UFSAR and finds the applicant's conclusion that the auxiliary equipment is NITS and will not prevent fulfillment of an ITS function to be acceptable because the equipment does not meet any of the scoping criteria that would bring it within the scope of license renewal. Therefore, the staff finds the applicant's exclusion of the auxiliary equipment from the scope of renewal review to be acceptable.

Miscellaneous Equipment

The applicant stated that miscellaneous ISFSI equipment including ISFSI security fences and gates, lighting, lightning protection, communications, and monitoring equipment are not part of the CoC 1029 storage system approved in accordance with 10 CFR Part 72, Subpart L. The miscellaneous equipment is not classified as ITS, nor would its failure prevent the fulfillment of a function that is ITS. Based on the safety classification and the results of the scoping review, the applicant stated that the miscellaneous equipment is not within the scope of the CoC 1029 renewal.

The staff reviewed the applicant's assessment of the miscellaneous ISFSI equipment and noted that this type of equipment is specifically excluded from the scope of license renewal by Section 2.4.3 of NUREG-1927, Revision 1, provided that the equipment does not meet the scoping criteria in Section 2.4.2 of that report. The staff finds that the applicant's conclusion is consistent with the staff's review guidance. Therefore, the staff finds the applicant's exclusion of the miscellaneous equipment from the scope of renewal review to be acceptable.

Scoping Findings

The staff reviewed the applicant's screening of the out-of-scope SSCs. The staff's review considered the intended function of the SSC subcomponent, its safety classification or basis for exclusion from the scope of renewal review, and design-bases information in the UFSAR. Based on this review, the staff finds that the applicant screened the out-of-scope SSC subcomponents in a manner consistent with NUREG-1927, Revision 1. Therefore, the staff finds the screening results for out-of-scope SSC subcomponents to be acceptable.

2.2 Evaluation Findings

The staff reviewed the scoping evaluation in the CoC 1029 renewal application. In its review, the staff followed the guidance in NUREG-1927, Revision 1, and the information in NUREG/CR-6407 (NRC 1996), as a reference for classifying components as ITS.

Based on its review, the staff finds the following:

F2.1 The applicant has identified all ITS SSCs and all SSCs whose failure could prevent an SSC from fulfilling its safety function, per the requirements of 10 CFR 72.3, "Definitions"; 10 CFR 72.124, "Criteria for nuclear criticality safety"; 10 CFR 72.236, "Specific requirements for spent fuel storage cask approval and fabrication; and 10 CFR 72.240.

F2.2 The justification for any SSC determined to be not within the scope of the renewal is adequate and acceptable.

3 AGING MANAGEMENT REVIEW

3.1 Review Objective

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

3.2 Aging Management Review Process

In Section 3.2 of the CoC 1029 renewal application, the applicant described its AMR process as consisting of three steps:

(1) identification of materials and environments
(2) identification of aging mechanisms and effects requiring management
(3) determination of the activities required to manage the effects and mechanisms of aging

In Section 3.3 of the CoC 1029 renewal application, the applicant described the Standardized Advanced NUHOMS® System components. The description includes materials of construction and applicable codes for design, fabrication, and inspection of the subcomponents for the DSCs, HSMs, ISFSI basemat, and spent fuel assemblies, which were identified in Table 2-1 of the renewal application as being within the scope of the renewal.

In Section 3.4 of the CoC 1029 renewal application, the applicant described the Standardized Advanced NUHOMS® System component design and fabrication considerations. These considerations included the description of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code sections used for the DSC design and fabrication. The applicant also included a description of the American Concrete Institute (ACI) codes relevant to the design and construction of the HSM components.

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

3.3 Aging Management Review Results

The applicant identified the materials of construction for the SSCs that were determined to be within the scope of the review. Specifically, the applicant identified materials for the DSCs (24PT1, 24PT4, and 32PTH2), the HSMs (AHSM and AHSM-HS), the ISFSI basemat, and the spent fuel assemblies. The applicant stated that it identified the materials of construction through a review of the drawings in the UFSAR, along with other pertinent design information.

The staff reviewed the materials of construction, the operating environments, and the AMR provided by the applicant and compared this information to the same information for the Standardized Advanced NUHOMS® system for consistency with the technical bases for aging mechanisms and effects in NUREG-2214. If the staff determined that the applicant's conclusions are consistent with expected aging management activities as described in NUREG-2214, then the staff considered the results acceptable, and this SER presents no additional discussion. The following discussions address the applicant's conclusions on aging mechanisms and effects for which the staff was not able to verify consistency with NUREG-2214.

3.3.1 Materials and Environments

The applicant used the environments to which SSCs and associated subcomponents are exposed to determine the potential aging mechanisms and effects. The applicant relied on the information in the Standardized Advanced NUHOMS® System UFSAR (ADAMS Accession No. ML19073A200), Chapter 2, "Principal Design Criteria," to assess the environmental conditions to which the SSCs are normally exposed. Table 3-3 of the CoC 1029 renewal application provides the maximum fuel cladding temperatures during storage, and Table 3-4 shows the bounding normal and off-normal average helium temperature in the DSC cavity for each DSC type. The applicant stated that the helium gas temperature decreases from the beginning of storage through the period of extended operation. Table 3-5 gives the maximum initial HSM temperatures for normal and off-normal conditions of storage. The applicant clarified that these surface temperatures continuously decrease from the beginning of storage through the period of extended operation.

In Section 3.2 of the CoC 1029 renewal application, the applicant outlined the AMR methodology. The AMR follows the methodology in NUREG-1927, Revision 1, and results in an assessment of the aging effects that could adversely affect the ability of the SSCs to perform their intended functions during the period of extended operation. The applicant provided a methodology for identifying materials and environments for the Standardized Advanced NUHOMS® System, aging mechanisms and aging effects for these materials, and environment combinations. To identify the necessary activities to manage the effects of aging, the applicant also considered operating experience.

The staff compared the materials identified in Section 3.2.1 of the CoC 1029 renewal application to the list of materials in NUREG-2214, Table 2-1. SER Table 3.3-1 identifies the materials of construction for the SSCs within the scope of renewal that were included in Table 3-2 of the renewal application, which provides a description of the materials groups used in the assessment of potential aging mechanisms. SER Table 3.3-1 also compares the materials in the CoC 1029 renewal application and the materials evaluated in NUREG-2214. The staff determined that the materials of construction identified by the applicant were considered in NUREG-2214 for the assessment of aging mechanisms and aging effects of the storage system components.

The staff compared the environments identified in Section 3.2.1 of the CoC 1029 renewal application to determine their equivalency to the environments evaluated in NUREG-2214, Table 2-2. SER Table 3.3-2 identifies the environments considered for SSC subcomponents, as defined in Section 3.2.1 of the renewal application. SER Table 3.3-2 also shows a comparison of the SSC operating environment in the renewal application with the SSC operating environments evaluated in NUREG-2214. The staff determined that the operating environments for the SSCs identified by the applicant in the renewal application are consistent with the environments considered in NUREG-2214 for the assessment of aging mechanisms and aging effects of the storage system components, and therefore are acceptable.

Table 3.3-1. Aging management review—materials

Material group in the CoC 1029 Renewal Application	Material Description in the CoC 1029 Renewal Application, Section 3.2.1	Equivalent Material(s) in NUREG-2214
Steel	Carbon steels, alloy steels, high-strength low-alloy steels, galvanized steel, aluminum-coated steel, and electroless nickel-plated steel	Steel
Stainless steel	Austenitic, martensitic, and chrome-plated stainless steel	Stainless steel
Aluminum	Commercially pure aluminum (1100) and precipitation-hardened alloys 6061 and 6063	Aluminum
Lead	Material that meets ASTM International B29 Specification	Lead[1]
Boral® and aluminum metal matrix composite (MMC)	BORAL® is a laminate composite that is used as a neutron poison material. It consists of a core of aluminum and B4C powder sandwiched between sheets of aluminum. MMC is a B4C-aluminum metal matrix composite for neutron poison applications.	Boral® Boralyn® (MMC)
Concrete	A mixture of hydraulic cement, aggregates, and water, with or without admixtures, fibers, or other cementitious materials	Concrete
Spent fuel assembly cladding	Stainless steel Zirconium-based materials such as Zircaloy-4, OPTIN™, ZIRLO™, and M5™	Stainless steel Zirconium-based alloys
Spent fuel assembly hardware	Stainless steel Zirconium-based alloys Nickel alloys	Stainless steel Zirconium-based alloys Nickel alloys
Boron carbide	A B_4C compound in a powder or pellet form	Incorporated in Boral® and aluminum MMCs

[1] NUREG-2214, Table 2-1, does not list lead; however, NUREG-2214, Chapter 3, "Evaluation of Aging Mechanisms," does evaluate lead.

Table 3.3-2. Aging management review—environments

Environment in CoC 1029 Renewal Application	Description of the Environment in the CoC 1029 Renewal Application, Section 3.2.1	Equivalent Environment in NUREG-2214
Air-Outdoor	The components are directly exposed to all outdoor weather conditions including insolation, wind, rain, snow, and plant-specific ambient air conditions including moist, possibly salt-laden atmospheric air, ambient temperatures, and humidity.	Air-Outdoor (OD)
Embedded-in-concrete	One or more surfaces of a component are in contact with concrete.	Embedded in concrete (E-C)
Embedded-in-metal[1]	One or more surfaces of a component are in contact with another component or material. While this may prevent ingress of water and contaminants to the embedded surface, the materials in this environment are treated as though they are exposed to the surrounding environment.	Embedded in metal (E-M)
Fully encased	The component is fully enclosed inside another component, or the surface between two components is sealed or fully lined by another material which prevents ingress of water and contaminants.	Fully encased or lined (FE)
Helium	The component surface is exposed to the helium fill gas inside the canister and trace quantities of other gases, such as nitrogen, oxygen, argon, and fission product gases.	Helium (HE)
Ground water/soil	The component surface is exposed to a soil environment with ground water. Soil is a mixture of organic and inorganic materials produced by the weathering of rock and clay minerals or the decomposition of vegetation.	Ground water/soil (GW)
Sheltered	The component surfaces are within the confines of a shielding structure. The sheltered environment may be open to outdoor air, but components in the sheltered environment are shielded from direct exposure to precipitation. This environment may contain moisture, salts, and other contaminants from the outdoor air.	Sheltered (SH)
[1] For the embedded-in-metal environment, the applicant assumed that the materials are treated as though they are exposed to the environment surrounding the embedding material.		

3.3.2 Aging Mechanisms and Aging Effects

The applicant described the Standardized Advanced NUHOMS® System component design and the fabrication considerations in Sections 3.3 and 3.4 of the CoC 1029 renewal application. In Section 3.5 of the renewal application, the applicant evaluated the materials of construction, the environments, and the potential aging effects and associated aging mechanisms for each SSC and associated subcomponent within the scope of renewal. In Section 3.5.3 of the renewal application, the applicant assessed the possible aging mechanisms for the materials used in the Standardized Advanced NUHOMS® System. The applicant evaluated aging mechanisms deemed credible to determine if they could result in aging effects requiring management in the period of extended operation. Table 3-6 of the renewal application summarizes the aging mechanisms for materials used in the Standardized Advanced NUHOMS® System.

The staff evaluated the applicant's technical basis for its AMR by comparing it to the generic technical basis in NUREG-2214. In this evaluation, the staff ensured that the materials, design features, environmental conditions, and operating experience for the Standardized Advanced NUHOMS® System are bounded by those evaluated in NUREG-2214. The staff conducted this evaluation by comparing the information in the CoC 1029 renewal application to the information in NUREG-2214, Chapter 2, for the description of materials, environments, aging mechanisms, and aging effects, as well as Chapter 3 for the evaluation of aging mechanisms for the material/environment combinations. The staff reviewed the applicant's operational experience review included in Appendix 3C of the renewal application and used it to support the assessment of aging mechanisms and aging effects. As noted by the applicant, the operational experience review in the CoC renewal application takes credit for the operational experience review conducted as part of the CoC 1004 renewal application (ADAMS Accession No. ML17338A119), and the review included various sources for new age-related degradation operational experience. The staff compared the list of operational experience cited by the applicant to Section 3.6.1.10 of NUREG-1927, Revision 1. Section 3.3.3 of this SER further discusses the staff's review of the applicant's consideration of operating experience in its AMR. The staff determined that the operational experience listed is consistent with the sources identified in NUREG-1927, Revision 1, and found the operating experience reviewed by the applicant to be acceptable.

The staff reviewed the aging mechanisms and aging effects identified by the applicant for the material and environment combinations relevant to the Standardized Advanced NUHOMS® System SSCs. SER Tables 3.3-3 through 3.3-10 summarize the aging mechanisms and aging effects for the material and environment combinations for the components and subcomponents that are within the scope of the AMR. In addition, SER Tables 3.3-3 through 3.3-10 identify whether the applicant's approach is consistent with the aging mechanism and aging effects analysis in NUREG-2214 for the comparable material and environment combination. For all cases in which the applicant's approach differs from that in NUREG-2214, the table notes offer additional information.

SER Table 3.3-3 summarizes the aging mechanisms and aging effects for carbon steel. The staff noted that the applicant stated that stress relaxation and wear of carbon steel were not credible aging mechanisms for the Standardized Advanced NUHOMS® System. The evaluation of stress relaxation in NUREG-2214, Section 3.2.1.10, is limited to bolts and assumes that the bolts are torqued and placed in service under an applied tensile load. The staff noted that in Section 3.5.3.1.10 of the CoC 1029 renewal application, the applicant indicated that HSM structural component anchorages are installed snug-tight per HSM installation specifications. Because there are no heavily loaded bolts or other structures, stress relaxation is not a credible aging mechanism for the Standardized Advanced NUHOMS® System. The assessment of wear in NUREG-2214, Section 3.2.1.11, indicates that wear is a credible aging mechanism for moving components such as doors used on TCs. The applicant indicated in renewal application Section 3.5.3.1.11 that rolling contact wear results from the repeated mechanical stressing of the surface of a body rolling on another body. Because there are no moving components while the DSCs are in storage, the applicant found that wear is not a credible aging mechanism for the Standardized Advanced NUHOMS® System. The staff reviewed this information and determined that the applicant's assessment of aging effects and aging mechanisms for carbon steel materials is acceptable because the applicant followed the guidance in NUREG-2214 and provided acceptable justification for the exclusion of stress relaxation and wear consistent with the design and operation of the Standardized Advanced NUHOMS® System.

SER Table 3.3-4 summarizes the aging mechanisms and aging effects for stainless steel. The staff reviewed the operational environments and potential aging mechanisms provided by the applicant. The applicant stated that thermal aging and wear of stainless steel are not credible aging mechanisms for the Standardized Advanced NUHOMS® System. The evaluation of thermal aging of stainless steels in NUREG-2214, Section 3.2.2.8, for precipitation-hardened stainless steels indicates that for operating temperatures between 243 and 316 degrees Celsius (C) (470 to 600 degrees Fahrenheit (F)), Olender et al. (2015) recommend an evaluation of conditions on a per-component basis considering operating temperature, exposure time, operating environment, stress levels, and material composition. Section 3.5.3.2.8 of the CoC 1029 renewal application indicates that the maximum possible temperatures of the precipitation-hardened stainless steel components estimated using a conservative thermal model (assuming 16 kilowatts for 24PT1 DSC instead of the allowed heat load of 14 kilowatts) and normal maximum ambient air temperatures are marginally above 243 degrees Celsius (C) (470 degrees Fahrenheit (F)), which is the lower bound temperature where thermal aging could be expected. The applicant clarified that this would be a transient event rather than a long-term event because of ambient temperature fluctuations and the gradual decrease in decay heat. In addition, the applicant provided an evaluation showing that the maximum component temperatures were below the reported threshold temperature of 500 °F necessary for transformation to have an effect on material properties.

The evaluation of wear in NUREG-2214, Section 3.2.2.11 and Table 4-6, indicates that wear is a credible aging mechanism for TC components such as rails that are subjected to repeated transfer operations. Section 3.5.3.2.11 of the CoC 1029 renewal application indicates that rolling contact wear results from the repeated mechanical stressing of the surface of a body rolling on another body. The applicant stated that, for the Standardized Advanced NUHOMS® System, there are no bodies rolling on another body while the DSCs are in storage. The staff determined that the applicant's assessment of aging effects and aging mechanisms for stainless steel materials is acceptable because the applicant's assessment followed the guidance in NUREG-2214 and the applicant provided acceptable justification for the exclusion of thermal aging and wear consistent with the design and operation of the Standardized Advanced NUHOMS® System.

In response (ADAMS Accession No. ML20192A127) to a request for additional information (RAI), the applicant revised the assessment of the susceptibility of microbiologically influenced corrosion (MIC) for stainless steel in an embedded-in-concrete environment described in Section 3.5.3.2.4 of the renewal application. The applicant clarified that there are no stainless steel subcomponents embedded in concrete that are continuously wet such as the below-grade portions of the basemat. In addition, because the stainless steel subcomponents embedded in concrete are intermittently wetted, the assessment of MIC relies on arguments similar to those used for air-outdoor and sheltered environments. Therefore, the applicant concluded that MIC of stainless steel is not credible in an embedded-in-concrete environment.

The staff reviewed the information provided by the applicant for stainless steel embedded in concrete. The staff determined that the applicant's assessment of the potential for MIC for stainless steel embedded in concrete in above-grade applications is consistent with the assessment of MIC for steels and stainless steels in NUREG-2214. Therefore, the staff finds that the applicant's assessment of MIC is acceptable.

SER Table 3.3-5 summarizes the aging mechanisms and aging effects for aluminum alloys. The staff reviewed the operational environments and potential aging mechanisms provided by the applicant. The applicant stated that change in dimensions of aluminum materials as a result of creep is a credible aging mechanism and addressed it in a TLAA in Appendix 3A to the CoC 1029 renewal application. The evaluation of thermal aging of precipitation-hardened aluminum alloys in NUREG-2214, Section 3.2.3.7, indicates that alloys such as 6061-T6 will have reduced strength after prolonged exposure to temperatures above 177 degrees C (350 degrees F). The staff noted that Section 3.5.3.3.7 of the renewal application indicates that Type 6061 subcomponents are based on mechanical properties corresponding to annealed Type 6061 (6061-O), regardless of the temper, to account for the time-dependent changes resulting from elevated temperature exposure. Based on its review, the staff determined that the assumption of annealed material properties is sufficient to account for the long-term effects of thermal aging because the strength of the fully annealed material will bound the strength of the aged alloy. The staff determined that the applicant followed the guidance in NUREG-2214. Therefore, the staff finds that the applicant's assessment of aging effects and aging mechanisms for aluminum alloys is acceptable.

SER Table 3.3-6 summarizes the aging mechanisms and aging effects for Boral® and boron containing MMC material. The staff reviewed the operational environments and potential aging mechanisms provided by the applicant. The applicant stated that while the AMR determined that boron depletion of the neutron absorber materials is not credible, boron depletion of the neutron absorber materials is addressed in a TLAA in Appendix 3A to the CoC 1029 renewal application. Based on its review, the staff determined that the applicant followed the guidance in NUREG-2214. Therefore, the staff finds that the applicant's assessment of aging effects and aging mechanisms for Boral® and boron containing MMC materials is acceptable.

SER Table 3.3-7 summarizes the aging mechanisms and aging effects for concrete. The staff reviewed the operational environments and potential aging mechanisms provided by the applicant. The applicant indicated that, while the AMR determined that radiation damage of concrete is not credible, a TLAA in Appendix 3A to the CoC 1029 renewal application addresses radiation damage of concrete. NUREG-2214, Section 3.5.1.4, states that differential settlement of concrete exposed to sheltered and outdoor air environments is not considered credible although the effects of differential settlement may be observed in air-outdoor (OD) and sheltered (SH) environments. Section 3.5.3.6.4 of the renewal application indicates that differential settlement is considered credible in OD and SH environments. Based on its review, the staff determined that the inclusion in Section 3.5.3.6.4 of differential settlement as a credible aging mechanism in sheltered and outdoor air environments is conservative and acceptable. The evaluation of delayed ettringite formation (DEF) in NUREG-2214, Section 3.5.1.13, states that ACI design and construction codes are sufficient to preclude this aging mechanism. The applicant indicated in Section 3.5.3.6.13 of the renewal application that DEF is considered credible for the basemat in OD, SH, and ground water (GW) environments but not for the AHSM or the AHSM-HS. Based on its review, the staff determined that the applicant's inclusion of DEF as a credible aging mechanism for the basemat, as indicated in renewal application Section 3.5.3.6.13, is conservative and acceptable.

SER Table 3.3-8 summarizes the aging mechanisms and aging effects for spent fuel assembly cladding materials. The staff reviewed the operational environments and potential aging mechanisms provided by the applicant. The staff determined that the applicant followed the guidance in NUREG-2214. Therefore, the staff finds that the applicant’s assessment of aging effects and aging mechanisms for spent fuel assembly cladding materials is acceptable.

SER Table 3.3-9 summarizes the aging mechanisms and aging effects for spent fuel assembly hardware materials. The staff reviewed the operational environments and potential aging mechanisms provided by the applicant. The staff determined that the applicant followed the guidance in NUREG-2214. Therefore, the staff finds that the applicant’s assessment of aging effects and aging mechanisms for spent fuel assembly hardware materials is acceptable.

SER Table 3.3-10 summarizes the aging mechanisms and aging effects for lead and poison rodlets with boron carbide materials. The staff reviewed the operational environments and potential aging mechanisms provided by the applicant. The staff determined that the applicant followed the guidance in NUREG-2214. Therefore, the staff finds that the applicant’s assessment of aging effects and aging mechanisms for lead and poison rodlets with boron carbide materials is acceptable.

Table 3.3-3. Summary of the aging mechanisms and aging effects for carbon steel

Aging Mechanism	Aging Effect	CoC 1029 Renewal Application, Section 3.5.3.1		Consistent with NUREG-2214, Section 3.2.1
		Credible Environments[1]	Noncredible Environments[1]	
General corrosion	Loss of material	OD, SH, E-C	HE, FE	Yes
Pitting and crevice corrosion	Loss of material	OD, SH, E-C	HE, FE	Yes
Galvanic corrosion	Loss of material	OD, SH[2]	E-C, HE, FE	Yes
Microbiologically influenced corrosion	Loss of material	E-C+ GW[3]	OD, SH, HE, FE	Yes
Stress-corrosion cracking and hydrogen embrittlement	Cracking	none	OD, SH, E-C, HE, FE	Yes
Creep	Change in dimensions	none	OD, SH, E-C, HE, FE	Yes
Fatigue	Cracking	none	OD, SH, E-C, HE, FE	Yes
Thermal aging	Loss of fracture toughness and loss of ductility	none	OD, SH, E-C, HE, FE	Yes
Radiation embrittlement	Loss of fracture toughness and loss of ductility	none	OD, SH, E-C, HE, FE	Yes
Stress relaxation	Change in dimensions	none	OD, SH, E-C, HE, FE	No[4]
Wear	Loss of material	none	OD, SH, E-C, HE, FE	Yes[5]

1 Section 3.5.3.1 of the CoC 1029 renewal application indicates that the relevant environments for carbon steel materials include air-outdoor (OD), sheltered (SH), embedded-in-concrete (E-C), exposed to ground water (GW), helium (HE), and fully encased (FE).

2 Section 3.5.3.1 of the CoC 1029 renewal application indicates that galvanic corrosion of carbon steel is only possible when the carbon steel component is connected to a more noble material.

3 Section 3.5.3.1.4 of the CoC 1029 renewal application indicates that MIC of carbon steel in an E-C environment is credible only if the embedment is below grade where the concrete is exposed to ground water.

4 The analysis of stress relaxation of bolts in NUREG-2214, Section 3.2.1.10, assumes that the bolts are torqued and are placed in service under an applied tensile load. Section 3.5.3.1.10 of the CoC 1029 renewal application indicates that HSM structural component anchorages are installed snug-tight per HSM installation specifications. Because there are no heavily loaded bolts or other structures, stress relaxation is not a credible aging mechanism for the Standardized Advanced NUHOMS® System.

5 NUREG-2214, Section 3.2.1.11, indicates that wear is a credible aging mechanism for moving components such as doors used on TCs. Section 3.5.3.1.11 of the CoC 1029 renewal application indicates that rolling contact wear results from the repeated mechanical stressing of the surface of a body rolling on another body. Because there are no moving components while DSCs are in storage, wear is not a credible aging mechanism for the Standardized Advanced NUHOMS® System.

Table 3.3-4. Summary of the aging mechanisms and aging effects for stainless steel

Aging Mechanism	Aging Effect	CoC 1029 Renewal Application, Section 3.5.3.2		Consistent with NUREG-2214, Section 3.2.2
		Credible Environments[1]	Noncredible Environments[1]	
General corrosion	Loss of material	none	OD, SH, E-C, HE, FE	Yes
Pitting and crevice corrosion	Loss of material	OD, SH	E-C, HE, FE	Yes
Galvanic corrosion	Loss of material	OD, SH[2]	E-C, HE, FE	Yes[2]
Microbiologically influenced corrosion	Loss of material	none	OD, SH, E-C, HE, FE	Yes[3]
Stress-corrosion cracking	Cracking	OD, SH,	E-C, HE, FE	Yes
Creep	Change in dimensions	none	OD, SH, E-C, HE, FE	Yes
Fatigue (DSC cylindrical shell)	Cracking	SH, HE, FE	OD, E-C	Yes
Fatigue (all components except DSC cylindrical shell)	Cracking	none	OD, SH, E-C, HE, FE	Yes
Thermal aging	Loss of fracture toughness and ductility	none	OD, SH, E-C, HE, FE	Yes[4]
Radiation embrittlement	Loss of fracture toughness and ductility	none[5]	OD, SH, E-C, HE, FE	Yes
Stress relaxation	Change in dimensions	none	OD, SH, E-C, HE, FE	Yes
Wear	Loss of material	none	OD, SH, E-C, HE, FE	Yes[6]

[1] Section 3.5.3.2 of the CoC 1029 renewal application indicates that the relevant environments for stainless steel materials include air-outdoor (OD), sheltered (SH), embedded-in-concrete (E-C), helium (HE), and fully encased (FE).

[2] Galvanic corrosion is considered credible for stainless steel DSCs in contact with DSC support structure rails coated with dry film lubricant.

[3] NUREG-2214, Table 3-2, does not evaluate the potential for MIC for stainless steel in an E-C environment. Section 3.5.3.2.4 of the CoC 1029 renewal application indicates that there are no stainless steel subcomponents embedded in below-grade portions of the basemat that could be continuously wet as a result of exposure to ground water.

[4] Section 3.5.3.2.8 of the CoC 1029 renewal application indicates that, because the peak temperatures for stainless steel components exposed to OD, SH, E-C, and FE environments are below the temperature required for the phase changes associated with thermal aging and embrittlement of stainless steels, thermal aging is not considered credible for these subcomponents. The applicant provided a specific analysis for precipitation-hardened stainless steel material.

[5] The applicant stated that while the AMR determined that radiation embrittlement is not credible, radiation embrittlement of stainless steel is addressed in a TLAA in Appendix 3A to the CoC 1029 renewal application.

[6] NUREG-2214, Section 3.2.2.11 and Table 4-6, indicates that wear is a credible aging mechanism for TC components such as rails that are subjected to repeated transfer operations. Section 3.5.3.2.11 of the CoC 1029 renewal application indicates that rolling contact wear results from the repeated mechanical stressing of the surface of a body rolling on another body. The applicant stated that there are no bodies rolling on another body while DSCs are in storage.

Table 3.3-5. Summary of the aging mechanisms and aging effects for aluminum

Aging Mechanism	Aging Effect	CoC 1029 Renewal Application, Section 3.5.3.3		Consistent with NUREG-2214, Section 3.2.3
		Credible Environments[1]	Noncredible Environments[1]	
General corrosion	Loss of material	none	HE	Yes
Pitting and crevice corrosion	Loss of material	none	HE	Yes
Galvanic corrosion	Loss of material	none	HE	Yes
MIC	Loss of material	none	HE	Yes
Creep	Change in dimensions	HE[2]	-	Yes
Fatigue	Cracking	none	HE	Yes
Thermal aging	Loss of fracture toughness and loss of ductility	none	HE	Yes[3]
Radiation embrittlement	Loss of fracture toughness and loss of ductility	none	HE	Yes

[1] Section 3.5.3.3 of the CoC 1029 renewal application indicates that the relevant environments for aluminum materials are limited to helium (HE).

[2] The applicant stated that a TLAA in Appendix 3A to the CoC 1029 renewal application addresses the change in dimensions of aluminum materials as a result of creep.

[3] NUREG-2214, Section 3.2.3.7, indicates that precipitation-hardened aluminum alloys such at 6061-T6 will have reduced strength after prolonged exposure to temperatures above 177 degrees C (350 degrees F). Section 3.5.3.3.7 of the CoC 1029 renewal application indicates that Type 6061 subcomponents are based on mechanical properties corresponding to annealed Type 6061 (6061-O) regardless of the temper to account for the time-dependent changes as a result of exposure to elevated temperature.

Table 3.3-6. Summary of the aging mechanisms and aging effects for Boral® and MMC material

Aging Mechanism	Aging Effect	CoC 1029 Renewal Application, Section 3.5.3.5		Consistent with NUREG-2214, Sections 3.4.1 and 3.4.2
		Credible Environments[1]	Noncredible Environments[1]	
General corrosion	Loss of material	none	HE	Yes
Galvanic corrosion	Loss of material	none	HE	Yes
Wet corrosion and blistering[2]	Change in dimensions	none	HE	Yes
Boron depletion	Loss of neutron absorber	none[3]	HE	Yes
Creep	Change in dimensions	none	HE	Yes
Thermal aging	Loss of fracture toughness and loss of ductility	none	HE	Yes
Radiation embrittlement	Loss of fracture toughness and loss of ductility	none	HE	Yes

[1] Section 3.5.3.5 of the CoC 1029 renewal application indicates that the relevant environments for Boral® and metal matrix composite materials are limited to helium (HE).

[2] The applicant stated that wet corrosion and blistering are relevant only for the Boral® material.

[3] The applicant stated that while the AMR determined that boron depletion of the neutron absorber materials is not credible, a TLAA in Appendix 3A to the CoC 1029 renewal application addressed boron depletion of the neutron absorber materials.

Table 3.3-7. Summary of the aging mechanisms and aging effects for concrete

Aging Mechanism	Aging Effect	CoC 1029 Renewal Application, Section 3.5.3.6		Consistent with NUREG-2214, Section 3.5.1
		Credible Environments[1]	Noncredible Environments[1]	
Freeze-thaw	Cracking and loss of material	OD, GW	SH	Yes
Creep	Cracking	none	OD, SH, GW	Yes
Reaction with aggregates	Cracking, loss of strength, loss of material, and increase in porosity and permeability	OD, SH, GW	-	Yes
Differential settlement	Cracking and loss of form	OD, SH, GW	-	No[2]
Aggressive chemical attack	Cracking, loss of strength, loss of material, increase in porosity and permeability, and reduction in concrete pH	OD, GW	SH	Yes
Corrosion of reinforcing steel	Cracking and loss of material	OD, GW	SH	Yes
Shrinkage	Cracking	none	OD, SH, GW	Yes
Leaching of calcium hydroxide	Loss of strength. increase in porosity and permeability, and reduction in concrete pH	OD, SH, GW	-	Yes
Radiation damage	Cracking and loss of strength	none[3]	OD, SH, GW	Yes
Fatigue	Cracking	none	OD, SH, GW	Yes
Dehydration at high temperature	Cracking and loss of strength	none	OD, SH, GW	Yes
Microbiological degradation	Loss of material and increase in porosity and permeability	GW	OD, SH	Yes
Delayed ettringite formation	Cracking and loss of material	OD, SH, GW (Basemat)	OD, SH (HSM)	No[4]
Salt scaling	Loss of material	OD, GW	SH	Yes

[1] Section 3.5.3.6 of the CoC 1029 renewal application indicates that the relevant environments for concrete include air-outdoor (OD), sheltered (SH), and ground water/soil (GW).

[2] NUREG-2214, Section 3.5.1.4, states that differential settlement of concrete exposed to SH and OD environments is not considered credible, although the effects of differential settlement may be observed in OD and SH environments. Section 3.5.3.6.4 of the CoC 1029 renewal application indicates that differential settlement is considered credible in OD and SH environments.

[3] The applicant indicated that, while the AMR determined that radiation damage of concrete is not credible, a TLAA in Appendix 3A to the CoC 1029 renewal application addressed radiation damage of concrete.

[4] NUREG-2214, Section 3.5.1.13, states that ACI codes are sufficient to preclude DEF. CoC 1029 renewal application Section 3.5.3.6.13 states that DEF is considered credible for the basemat in OD, SH, and GW environments but not for the HSM in OD and SH environments.

Table 3.3-8. Summary of the aging mechanisms and aging effects for spent fuel assembly cladding materials

Aging Mechanism	Aging Effect	CoC 1029 Renewal Application, Section 3.5.3.7		Consistent with NUREG-2214, Section 3.6.1
		Credible Environments[1]	Noncredible Environments[1]	
Hydride-induced embrittlement	Loss of fracture toughness and loss of ductility	HE (high-burnup fuel with zirconium alloy cladding)	HE (low-burnup fuel with stainless steel or zirconium alloy cladding)	Yes
Delayed hydride cracking	Cracking	none	HE	Yes
Thermal creep	Change in dimensions	HE (high-burnup fuel with zirconium alloy cladding)	HE (low-burnup fuel with stainless steel zirconium alloy cladding)	Yes
Low-temperature creep	Change in dimensions	none	HE	Yes
Mechanical overload	Cracking	none	HE	Yes
Oxidation	Loss of material	none	HE	Yes
Pitting corrosion	Loss of material	none	HE	Yes
Galvanic corrosion	Loss of material	none	HE	Yes
Stress-corrosion cracking	Cracking	none	HE	Yes
Radiation embrittlement	Loss of fracture toughness and loss of ductility	none	HE	Yes
Fatigue	Loss of material	none	HE	Yes

[1] Section 3.5.3.7 of the CoC 1029 renewal application indicates that the relevant environment for zirconium alloy and stainless steel spent fuel assembly cladding materials is limited to helium (HE).

Table 3.3-9. Summary of the aging mechanisms and aging effects for spent fuel assembly hardware materials

Aging Mechanism	Aging Effect	CoC 1029 Renewal Application, Section 3.5.3.8		Consistent with NUREG-2214, Section 3.6.2
		Credible Environments[1]	Noncredible Environments[1]	
Creep	Change in dimensions	none	HE	Yes
Hydriding	Cracking	none	HE	Yes
General corrosion	Loss of material	none	HE	Yes
Stress-corrosion cracking	Cracking	none	HE	Yes
Radiation embrittlement	Loss of fracture toughness and loss of ductility	none	HE	Yes
Fatigue	Cracking	none	HE	Yes

[1] Section 3.5.3.8 of the CoC 1029 renewal application indicates that the relevant environment for spent fuel assembly hardware materials is limited to helium (HE).

Table 3.3-10. Summary of the aging mechanisms and aging effects for lead and poison rodlets with boron carbide

Material	Aging Mechanism	Aging Effect	CoC 1029 Renewal Application, Sections 3.5.3.4 and 3.5.3.9		Consistent with NUREG-2214, Sections 3.2.6 and 3.3.1
			Credible Environments[1,2]	Noncredible Environments[1,2]	
Lead	None	None	none	FE	Yes[3]
Poison rodlets (B_4C encased in stainless steel)	Boron depletion	Reduction of neutron absorbing capacity	none	HE, FE	Yes[4]

[1] Section 3.5.3.4 of the CoC 1029 renewal application indicates that the relevant environment for lead in the 24PT1 DSC is fully encased (FE).

[2] Section 3.5.3.9 of the CoC 1029 renewal application indicates that the relevant environments for the poison rodlets are helium (HE) and FE.

[3] NUREG-2214, Section 3.2.6, described the operating environment for lead as embedded in metal (E-M) and states that there are no credible aging mechanisms for lead in E-M environments. Based on the definition in Section 3.2.1 of the CoC 1029 renewal application, the E-M environment will bound the FE environment.

[4] Section 3.5.3.9.1 of the CoC 1029 renewal application indicates that the relevant boron depletion analysis in Section 3.5.3.5.4 of the renewal application is also applicable to the poison rodlets. The applicant included a boron depletion analysis in a TLAA in Appendix 3A to the renewal application. The applicant's approach is consistent with NUREG-2214, Section 3.3.1.

3.3.3 Aging Management Review Results

The applicant used the assessment of the possible aging mechanisms described in Section 3.5.3 of the CoC renewal application in the AMR for the DSCs, HSMs, ISFSI basemat, and spent fuel assemblies. The applicant provided the results of the AMR in Sections 3.6 through 3.9 of the Standardized Advanced NUHOMS® System renewal application and summarized the AMR results for these components in Tables 3-7 through 3-10 of the CoC renewal application. The applicant also provided detailed AMR results for the 24PT1, 24PT4, and 32PTH2 DSCs in Tables 3-11 through 3-13 of the CoC 1029 renewal application. Similarly, Tables 3-14 and 3-15 of the application contain detailed AMR results for the AHSM and AHSM-HS. Detailed AMR results for the ISFSI basemat and the spent fuel assemblies appear in the Standardized Advanced NUHOMS® System renewal application, Tables 3-16 and 3-17, respectively.

In Section 3.10 of the CoC 1029 renewal application and its Appendix 3C, the applicant also discussed the review of operating experience conducted for the renewal application. The sources of operating experience reviewed by the applicant include the following:

- internal and industrywide condition reports
- relevant international and nonnuclear operating experience
- previous ISFSI inspection results
- licensee event reports
- vendor-issued safety bulletins
- NRC generic communications
- updated consensus codes, standards, or guides
- applicable industry initiatives

The applicant stated that the review did not identify any aging mechanisms or effects that were not already identified in NUREG-2214. Nor were any incidents identified in which aging effects led to the loss of as-intended function for a Standardized Advanced NUHOMS® System SSC. Based on this review, the applicant concluded that the aging effects identified in the AMR will be managed so that the intended functions of the SSCs will be maintained during the period of extended operation.

The staff evaluated the applicant's technical basis for its AMR by comparing it to the generic technical basis in NUREG-2214. In this evaluation, the staff confirmed that the materials, design features, environmental conditions, and operating experience for the Standardized Advanced NUHOMS® System are bounded by those evaluated in NUREG-2214. The staff conducted this evaluation by comparing the information provided by the applicant in the Standardized Advanced NUHOMS® System renewal application to the information in NUREG-2214, Chapter 2, for the description of materials, environments, aging mechanisms, and aging effects; Chapter 3 for the evaluation of aging mechanisms for the material/environment combinations; and Chapter 4, Section 4.2, for the AMR results for the Standardized Advanced NUHOMS® System, Section 4.7 for the concrete pad, and Section 4.8 for spent fuel assemblies.

As previously noted in SER Section 3.3.2, SER Tables 3.3-3 through 3.3-10 summarize the aging mechanisms and aging effects for the material and environment combinations for the components and subcomponents that are within the scope of the AMR. SER Tables 3.3-11 through 3.3-14 show the results of the applicant's AMR for DSCs, HSMs, ISFSI basemat, and spent fuel assembly materials. Aging mechanisms and aging effects that were evaluated to be noncredible for the material-environment combinations as shown in SER Tables 3.3-3 through 3.3-10 are excluded. Rather, SER Tables 3.3-11 through 3.3-14 show only the aging mechanisms and aging effects for the material-environment combinations that the applicant determined to be credible and which require an aging management activity. SER Tables 3.3-11 through 3.3-14 identify the aging management activity, such as a TLAA or an AMP, necessary to address the aging effect. Finally, these tables identify whether the applicant's evaluation of aging management activities for each credible aging effect is consistent with the generic technical bases and conclusions discussed in NUREG-2214.

SER Table 3.3-11 shows the aging mechanisms and effects that require aging management for the Standardized Advanced NUHOMS® System DSCs. The staff reviewed the AMR provided by the applicant in Tables 3-7, 3-11, 3-12, and 3-13 of the CoC 1029 renewal application. The staff determined that the applicant's identification of aging mechanisms and effects requiring aging management activities for DSCs is consistent with the guidance in NUREG-2214 and is therefore acceptable.

SER Table 3.3-12 shows the aging mechanisms and effects that require aging management applicable to the Standardized Advanced NUHOMS® System HSMs. The staff reviewed the AMR provided by the applicant in Tables 3-8, 3-14, and 3-15 of the Standardized Advanced NUHOMS® renewal application. The staff found that the applicant's identification of aging mechanisms and effects requiring aging management activities for the HSMs either (1) follows the guidance in NUREG-2214 or (2) is conservative with respect to the guidance in NUREG-2214, and is therefore acceptable.

SER Table 3.3-13 shows the aging mechanisms and effects that require aging management applicable to the ISFSI basemat for the Standardized Advanced NUHOMS® System. The staff reviewed the AMR provided by the applicant in Tables 3-9 and 3-16 of the Standardized Advanced NUHOMS® renewal application. The staff found that the applicant's identification of aging mechanisms and effects requiring aging management activities for the ISFSI basemat either (1) follows the guidance in NUREG-2214 or (2) is conservative with respect to the guidance in NUREG-2214, and is therefore acceptable.

SER Table 3.3-14 shows the aging mechanisms and effects that require aging management applicable to the spent fuel assemblies. The staff reviewed the AMR provided by the applicant in Tables 3-10 and 3-17 of the Standardized Advanced NUHOMS® System renewal application. The staff found that the applicant's identification of aging mechanisms and effects requiring aging management activities for the spent fuel assemblies follows the guidance in NUREG-2214, and is therefore acceptable.

Table 3.3-11. Aging mechanisms and effects that require aging management—DSC

Material	Environment	Aging Mechanism	Aging Effect	Subcomponent Parts[1]	Aging Management (TLAA, AMP)	Consistent with NUREG-2214, Table 4-3
Stainless steel	Helium	Fatigue	Cracking	DSC cylindrical shell	TLAA	Yes
Stainless steel	Fully encased	Fatigue	Cracking	DSC cylindrical shell	TLAA	Yes
Stainless steel	Sheltered	Fatigue	Cracking	DSC cylindrical shell	TLAA	Yes
Stainless steel	Sheltered	Pitting/Crevice corrosion	Loss of material	All components exposed to a sheltered environment	DSC AMP	Yes
Stainless steel	Sheltered	Stress-corrosion cracking	Cracking	All components exposed to a sheltered environment	DSC AMP	Yes
Stainless steel	Sheltered	Galvanic corrosion	Loss of material	DSC cylindrical shell, outer bottom cover plate, inner bottom cover plate	DSC AMP	Yes
All metal components	Helium/ Sheltered/ Fully encased	Irradiation embrittlement	Change in properties	All metal components of the DSC including the DSC shell, lids, basket, bottom shield plug outer casing	TLAA[2]	Yes
Aluminum	Helium	Creep	Change in dimensions	Aluminum alloy basket plates, shims, and transition rails	TLAA	Yes
BORAL® plates	Helium	Boron depletion	Reduction of neutron-absorbing capacity	BORAL® plates in the 24PT1 and 24PT4 DSCs	TLAA[3]	Yes

[1] Tables 3-11, 3-12, and 3-13 of the CoC 1029 renewal application contain a complete list of DSC subcomponent parts.

[2] The applicant stated that while the AMR determined that radiation embrittlement is not credible, radiation embrittlement of stainless steel is addressed in a TLAA in Appendix 3A to the CoC 1029 renewal application.

[3] The applicant stated that while the AMR determined that boron depletion of the neutron absorber materials is not credible, a TLAA in Appendix 3A to the CoC 1029 renewal application addressed boron depletion of the neutron absorber materials.

Table 3.3-12. Aging mechanisms and effects that require aging management—HSM

Material	Environment	Aging Mechanism	Aging Effect	Subcomponent Parts[1]	Aging Management (TLAA, AMP)	Consistent with NUREG-2214, Table 4-5
Steel	Embedded in concrete	General corrosion	Loss of material	Hardware, rebar, vent covers, embedments[2]	HSM AMP	Yes
Steel	Embedded in concrete	Pitting and crevice corrosion	Loss of material	Hardware, rebar, vent covers, embedments[2]	HSM AMP	Yes
Steel	Sheltered	General corrosion	Loss of material	DSC support structure assembly hardware[3]	HSM AMP	Yes
Steel	Sheltered	Pitting and crevice corrosion	Loss of material	DSC support structure assembly hardware[3]	HSM AMP	Yes
Steel	Sheltered	Galvanic corrosion	Loss of material	DSC support structure assembly hardware[3]	HSM AMP	Yes
Steel	Air-Outdoor	General corrosion	Loss of material	AHSM and AHSM-HS hardware[4]	HSM AMP	Yes
Steel	Air-Outdoor	Pitting and crevice corrosion	Loss of material	AHSM and AHSM-HS hardware[4]	HSM AMP	Yes
Steel	Air-Outdoor	Galvanic corrosion	Loss of material	AHSM and AHSM-HS hardware[4]	HSM AMP	Yes
Stainless steel	Sheltered	Pitting and crevice corrosion	Loss of material	DSC support structures, heat shields and hardware[5]	HSM AMP	Yes
Stainless steel	Sheltered	Stress-corrosion cracking	Cracking	DSC support structures, heat shields and hardware[5]	HSM AMP	Yes
Stainless steel	Air-Outdoor	Pitting and crevice corrosion	Loss of material	Hardware shield block, shield wall, door, and vents[6]	HSM AMP	Yes
Stainless steel	Air-Outdoor	Stress-corrosion cracking	Cracking	Hardware shield block, shield wall, door, and vents[6]	HSM AMP	Yes
Concrete	Sheltered	Reaction with aggregates	Cracking Loss of strength	Door core, base walls and roof	HSM AMP	Yes
Concrete	Sheltered	Differential settlement	Cracking	Door core, base walls and roof	HSM AMP	No[7]

Table 3.3-12. Aging mechanisms and effects that require aging management—HSM

Material	Environment	Aging Mechanism	Aging Effect	Subcomponent Parts[1]	Aging Management (TLAA, AMP)	Consistent with NUREG-2214, Table 4-5
Concrete	Sheltered	Leaching of calcium hydroxide	Loss of strength Increase in porosity and permeability Reduction in concrete pH	Door core, base walls, and roof	HSM AMP	Yes
Concrete	Air-outdoor	Freeze-Thaw	Cracking Loss of material	Door core, vent covers, walls, and roof[8]	HSM AMP	Yes
Concrete	Air-outdoor	Reaction with aggregates	Cracking Loss of strength	Door core, vent covers, walls, and roof[8]	HSM AMP	Yes
Concrete	Air-outdoor	Differential settlement	Cracking	Door core, vent covers, walls, and roof[8]	HSM AMP	No[7]
Concrete	Air-outdoor	Aggressive chemical attack	Cracking Loss of strength Loss of material Reduction in concrete pH	Door core, vent covers, walls, and roof[8]	HSM AMP	Yes
Concrete	Air-outdoor	Corrosion of reinforcing steel	Loss of concrete/ steel bond Loss of material Cracking Loss of strength	Door core, vent covers, walls, and roof[8]	HSM AMP	Yes
Concrete	Air-outdoor	Leaching of calcium hydroxide	Loss of strength Increase in porosity and permeability Reduction in concrete pH	Door core, vent covers, walls, and roof[8]	HSM AMP	Yes
Concrete	Air-outdoor	Salt scaling	Loss of material	Door core, vent covers, walls, and roof[8]	HSM AMP	Yes

Table 3.3-12. Aging mechanisms and effects that require aging management—HSM

Material	Environment	Aging Mechanism	Aging Effect	Subcomponent Parts[1]	Aging Management (TLAA, AMP)	Consistent with NUREG-2214, Table 4-5
Concrete	Air-outdoor	Radiation damage	Cracking and loss of strength	Door core, vent covers, walls, and roof[8]	TLAA[0]	Yes

[1] Tables 3-14, and 3-15 of the CoC 1029 renewal application contain a complete list of HSM subcomponent parts.

[2] Includes deformed bar anchors, hardware, outlet vent covers, lower vent cover, wall embedment, door rail extension embedment, mechanical splice, and rebar in walls and roof sections.

[3] Includes DSC support structure assembly hardware, adjustable DSC axial retainer, module-to-module connection hardware, and wall attachment hardware.

[4] Includes attachment hardware for top shield block, shield wall, door, and walls.

[5] Includes DSC support structure and hardware, heat shields and hardware, door attachment hardware, roof, and shield wall connection hardware.

[6] Includes top shield block attachment hardware, door attachment hardware, outlet vent hardware, and shield wall attachment hardware.

[7] NUREG-2214, Section 3.5.1.4, states that although portions of concrete structures in contact with air can exhibit the effects of settlement, the direct interaction with the underlying soil is the mechanism that causes the aging. As a result, differential settlement of concrete exposed to SH and OD environments is not considered credible. The applicant's inclusion of differential settlement as a credible aging mechanism for concrete in OD and SH environments is conservative and does not require justification.

[8] Includes door core, outlet vent cover, base walls, roof, end walls, rear wall, lower vent cover, corner wall, door, outlet vent cover, transition roof, and transition walls.

[9] The applicant indicated that, while the AMR determined that radiation damage of concrete is not credible, a TLAA in Appendix 3A to the CoC 1029 renewal application addressed radiation damage of concrete.

Table 3.3-13. Aging mechanisms and effects that require aging management—ISFSI basemat

Material	Environment	Aging Mechanism	Aging Effect	Subcomponent Parts	Aging Management (TLAA, AMP)	Consistent with NUREG-2214, Table 4-24
Steel	Embedded in concrete	General corrosion	Loss of material	Rebar	Basemat AMP	Yes
Steel	Embedded in concrete	Pitting and crevice corrosion	Loss of material	Rebar	Basemat AMP	Yes
Concrete	Sheltered	Reaction with aggregates	Cracking Loss of strength	Reinforced concrete	Basemat AMP	No[1]
Concrete	Sheltered	Differential settlement	Cracking	Reinforced concrete	Basemat AMP	No[2]
Concrete	Sheltered	Leaching of calcium hydroxide	Loss of strength Increase in porosity and permeability Reduction in concrete pH	Reinforced concrete	Basemat AMP	No[1]
Concrete	Sheltered	Delayed ettringite formation[3]	Loss of material Loss of strength Cracking	Reinforced concrete	Basemat AMP	No[4]
Concrete	Air-Outdoor	Freeze-Thaw	Cracking Loss of material	Reinforced concrete	Basemat AMP	Yes
Concrete	Air-Outdoor	Reaction with aggregates	Cracking Loss of strength	Reinforced concrete	Basemat AMP	Yes
Concrete	Air-Outdoor	Differential settlement	Cracking	Reinforced concrete	Basemat AMP	No[2]
Concrete	Air-Outdoor	Aggressive chemical attack	Cracking Loss of strength Loss of material Reduction in concrete pH	Reinforced concrete	Basemat AMP	Yes
Concrete	Air-Outdoor	Corrosion of reinforcing steel	Loss of concrete/steel bond Loss of material Cracking Loss of strength	Reinforced concrete	Basemat AMP	Yes

Table 3.3-13. Aging mechanisms and effects that require aging management—ISFSI basemat

Material	Environment	Aging Mechanism	Aging Effect	Subcomponent Parts	Aging Management (TLAA, AMP)	Consistent with NUREG-2214, Table 4-24
Concrete	Air-Outdoor	Leaching of calcium hydroxide	Loss of strength Increase in porosity and permeability Reduction in concrete pH	Reinforced concrete	Basemat AMP	Yes
Concrete	Air-Outdoor	Salt Scaling	Loss of material	Reinforced concrete	Basemat AMP	Yes
Concrete	Air-Outdoor	Delayed ettringite formation[3]	Loss of material Loss of strength Cracking	Reinforced concrete	Basemat AMP	No[4]
Concrete	Ground water/ soil	Freeze-Thaw	Cracking Loss of material	Reinforced concrete	Basemat AMP	Yes
Concrete	Ground water/ soil	Reaction with aggregates	Cracking Loss of strength	Reinforced concrete	Basemat AMP	Yes
Concrete	Ground water/ soil	Differential settlement	Cracking	Reinforced concrete	Basemat AMP	Yes
Concrete	Ground water/ soil	Aggressive chemical attack	Cracking Loss of strength Loss of material Reduction in concrete pH	Reinforced concrete	Basemat AMP	Yes
Concrete	Ground water/ soil	Corrosion of reinforcing steel	Loss of concrete/steel bond Loss of material Cracking Loss of strength	Reinforced concrete	Basemat AMP	Yes
Concrete	Ground water/ soil	Leaching of calcium hydroxide	Loss of strength Increase in porosity and permeability Reduction in concrete pH	Reinforced concrete	Basemat AMP	Yes

Table 3.3-13. Aging mechanisms and effects that require aging management—ISFSI basemat

Material	Environment	Aging Mechanism	Aging Effect	Subcomponent Parts	Aging Management (TLAA, AMP)	Consistent with NUREG-2214, Table 4-24
Concrete	Ground water/ soil	Microbiological degradation	Loss of strength Loss of material Increase in porosity and permeability Reduction in concrete pH	Reinforced concrete	Basemat AMP	Yes
Concrete	Ground water/ soil	Delayed ettringite formation[3]	Loss of material Loss of strength Cracking	Reinforced concrete	Basemat AMP	No[4]
Concrete	Ground water/ soil	Salt scaling	Loss of material	Reinforced concrete	Basemat AMP	Yes

[1] NUREG-2214 does not consider sheltered environments for the ISFSI concrete pad, and as a result, Table 4-24 in the NUREG does not address aging mechanics and effects for concrete in a sheltered environment on the ISFSI pad. Reaction with aggregate and leaching of calcium hydroxide is considered for concrete in a sheltered environment in the Standardized Advanced NUHOMS® HSM in NUREG-2214, Table 4-5. The applicant's inclusion of reaction with aggregates as a credible aging mechanism for concrete in a sheltered environment on the ISFSI pad is consistent with NUREG-2214 and does not require justification.

[2] NUREG-2214, Section 3.5.1.4, states that although portions of concrete structures in contact with air can exhibit the effects of settlement, the direct interaction with the underlying soil is the mechanism that causes the aging. As a result, differential settlement of concrete exposed to sheltered and outdoor air environments is not considered credible. The applicant's inclusion of differential settlement as a credible aging mechanism for concrete in air-outdoor and sheltered environments is conservative and does not require justification.

[3] The applicant indicated that, based on an ISFSI-specific evaluation, the general licensee may rule out DEF as a credible aging mechanism.

[4] NUREG-2214, Section 3.5.1.13, states that in addition to the adequate placement and curing standards, no occurrences of DEF-related degradation of concrete have been reported in nuclear applications. Thus, DEF of concrete is not considered credible in outdoor, sheltered, ground water or soil (below grade), and fully encased (lined) environments, and therefore, aging management is not required during the 60-year timeframe. The applicant's inclusion of DEF as a credible aging mechanism for concrete in ground water or soil environments is conservative and does not require justification.

Table 3.3-14. Aging mechanisms and effects that require aging management—spent fuel assemblies

Material	Environment	Aging Mechanism	Aging Effect	Subcomponent Parts [1]	Aging Management (TLAA, AMP)	Consistent with NUREG-2214, Table 4-25
Zirconium alloy[2]	Helium	Hydride-induced embrittlement	Loss of ductility	Spent fuel Assembly cladding	TLAA[3] HBU AMP[4]	Yes
Zirconium alloy[2]	Helium	Thermal creep	Change in dimensions	Spent fuel Assembly cladding	TLAA[3] HBU AMP[4]	Yes

[1] The applicant indicated that the components are limited to intact spent fuel assemblies. Cladding of failed fuel assemblies is not able to perform any intended function and is, therefore, not considered in scope for renewal.

[2] Zirconium alloy claddings, including Zircaloy-4, OPTIN™, M5™, or Zirlo™.

[3] Cladding temperature limits for fuel stored in the 24PT1 DSC.

[4] For high-burnup (HBU) fuel only. See NUREG-2214 Sections 3.6.1.1 (Hydride Reorientation) and 3.6.1.3 (Thermal Creep).

3.3.4 Supplemental Evaluation

The applicant provided supplemental evaluations to show that chloride-induced stress-corrosion cracking (CISCC) will not result in a loss of confinement or prevent retrieval of a CoC 1029 DSC during the period of extended operation, for a total of 60 years of storage. The applicant stated that the evaluation is not intended to be used as an aging management activity, but rather to support the proposed inspection frequency for the DSC AMP. The applicant addressed the following parameters in a supplemental evaluation to support the CoC 1029 renewal application:

- DSC shell temperatures
- critical temperatures, relative humidity, and chloride concentration
- time for CISCC initiation
- CISCC crack growth rate
- DSC shell thickness to maintain the ASME Code limits during retrieval

The applicant performed a supplemental evaluation to review the CISCC supporting analyses done for the CoC 1004 renewal application to determine if the results and conclusions were applicable to the DSCs licensed under CoC 1029. The applicability review determined whether the CoC 1004 evaluation was dependent on the DSC and HSM design or literature data. For parameters that were dependent on the DSC and HSM design, the applicant stated that the evaluation showed that the dimensions and parameters of the CoC 1029 DSC and HSM were within the range of dimensions and parameters used in the CoC 1004 renewal application. Therefore, the applicant concluded that the supplemental evaluation used in the CoC 1004 renewal application evaluation was valid for the CoC 1029 renewal application.

The staff reviewed the applicant’s supplemental evaluation to assess whether there was reasonable assurance that CISCC will not result in a loss of confinement or prevent retrieval of a CoC 1029 DSC during the period of extended operation, for a total of 60 years of storage. As noted in the CoC 1029 renewal application, the analysis was based on the CoC 1004 renewal application (ADAMS Accession No. ML16279A372), which the staff previously evaluated and documented in the CoC 1004 renewal application SER (ADAMS Accession No. ML17338A121). Specifically, Section 3.3.2 of the CoC 1004 renewal application SER addresses the staff’s evaluation of the applicant’s analysis of (1) DSC shell temperatures, (2) critical temperatures, relative humidity, and chloride concentration, (3) time for CISCC initiation, and (4) CISCC crack growth rate. Likewise, Section 3.4.13 of the CoC 1004 renewal application SER addresses the staff’s evaluation of the applicant’s analysis for DSC shell thickness to maintain the ASME Code limits during retrieval.

The staff also reviewed the applicant’s assessment that it relied on to support its conclusion that the evaluations conducted for the CoC 1004 renewal application are valid for the Standardized Advanced NUHOMS® System and sufficient for the CoC 1029 renewal application. The following paragraphs describe the staff’s evaluation of each parameter.

For the DSC shell temperatures, the applicant used Appendix 3G to the CoC 1004 renewal application (ADAMS Accession No. ML16279A372), which determined the minimum and maximum DSC shell weld temperatures for DSCs for a range of initial decay heat loads. The applicant also compared the dimensions of the DSCs and HSM airflow paths evaluated in the CoC 1004 renewal application to the Standardized Advanced NUHOMS® System. The staff reviewed the DSC and HSM designs, allowed contents, and heat loads. The staff determined that the designs share many similarities that support the applicant's assessment. Therefore, the staff determined that the DSC temperature evaluation conducted for the CoC 1004 renewal application is applicable to the Standardized Advanced NUHOMS® System.

To identify the environmental parameters (critical temperature, relative humidity, and chloride concentration) needed for CISCC initiation on a DSC, the applicant used Appendix 5A to the CoC 1004 renewal application (ADAMS Accession No. ML16279A372). The staff reviewed the DSC and HSM designs. The staff noted that a significant difference between these systems is that the CoC 1004 DSCs are constructed from type 304 stainless steel, whereas the CoC 1029 DSCs are constructed from type 316 stainless steel, which has greater corrosion resistance than type 304 stainless steel. The staff determined that because the same parameters were used for both systems without consideration of the differences in DSC materials, the analysis conducted for the CoC 1004 renewal application is conservative and applicable to the Standardized Advanced NUHOMS® System.

To evaluate the time to CISCC initiation, the applicant used Appendix 5A to the CoC 1004 renewal application (ADAMS Accession No. ML16279A372), which uses the critical environmental parameters and an empirical equation of chloride salt deposition and DSC shell temperatures. The staff noted that the applicant's analysis considered average windspeed, airborne salt concentration range, and distance from the sea. The applicant determined that the same parameters used to support the CoC 1004 renewal application apply to the Standardized Advanced NUHOMS® System. The staff noted that a significant difference between these systems is that the CoC 1004 DSCs are constructed from type 304 stainless steel, whereas the CoC 1029 DSCs are constructed from type 316 stainless steel. The staff determined that because the same parameters were used for both systems without consideration of the differences in DSC materials, the analysis conducted for the CoC 1004 renewal application is conservative and applicable to the Standardized Advanced NUHOMS® System.

In response to an RAI (ADAMS Accession No. ML20192A127), the applicant clarified details of the earlier testing reported in EPRI-1011820, "Effects of Marine Environments on Stress Corrosion Cracking of Austenitic Stainless Steels," issued September 2005 (EPRI 2005), which reported results showing that iron contamination could potentially affect CISCC initiation. Based on the parameters, the applicant stated that the results in EPRI-1011820 showing that the presence of iron was a contributor to stress-corrosion cracks in stainless steel was most likely caused by the iron contributing to the formation of pitting or crevice corrosion of the stainless steel. The applicant stated that Section 3.2.2.2 of NUREG-2214 indicates that pitting and crevice corrosion are known precursors to stress-corrosion cracking and that the AMR for CoC 1029 renewal application determined that loss of material due to pitting and crevice corrosion was an aging effect that required management via an AMP. The staff reviewed the information provided by the applicant in the RAI response and determined that the response was acceptable because the applicant's AMP for the stainless steel canisters specifically identifies pitting and crevice corrosion as indications of aging requiring management.

For the CISCC crack growth rate, the applicant used Appendix 5B to the CoC 1004 renewal application (ADAMS Accession No. ML16279A372), which considers environmental conditions, stress, and material condition. The applicant also reviewed the operational experience with stress-corrosion cracking of piping focusing on events at Turkey Point Nuclear Generating Station, St. Lucie Plant, and San Onofre Nuclear Generating Station. The applicant found that the environmental conditions for canisters in dry storage are more benign than those for piping at the mentioned nuclear power plants. For example, relative humidity is lower at the DSC surface due to internal heating, and there is no significant temperature cycling inside the HSM. The applicant concluded that direct application of the operational experience with stress-corrosion cracking of piping to the potential for canister CISCC is not appropriate in estimating the crack initiation time for the DSCs. To estimate the crack growth rate, the applicant used an Arrhenius-type, temperature-dependent crack growth rate model. The staff reviewed the applicant's assessment and noted again the differences in DSC materials for the systems. The staff determined that the use of an Arrhenius-type, temperature-dependent crack growth rate model is acceptable because the crack growth rates for stainless steels have been observed to be temperature dependent. The staff noted that this is also true for many other alloy-environment combinations where stress-corrosion cracking growth rates have been measured. In addition, the staff noted that the applicant used a baseline crack growth rate at 80 degrees C (176 degrees F) and a relatively low activation energy, which would result in conservative estimations of crack growth rates at the lower temperatures. Because the applicant used the crack growth rate assessment for the less corrosion-resistant type 304 stainless steel and conservative parameters to assess the type 316 stainless steel used in the DSCs for the Standardized Advanced NUHOMS® System, the staff determined that the analysis is conservative for the Standardized Advanced NUHOMS® System.

For the DSC shell thickness to maintain the ASME Code limits during retrieval, the applicant referenced Appendix 3N to the CoC 1004 renewal application (ADAMS Accession No. ML16279A372), which, it stated, showed that the minimum DSC shell thickness is acceptable to maintain ASME Code limits during DSC retrieval operations. The staff noted that the applicant reviewed the analysis in the CoC 1004 renewal application and determined that the key parameters for the Standardized Advanced NUHOMS® System (except the off-normal design pressure for the 24PT4 DSC) are bounded by or are equivalent to those used in the analysis summarized in Appendix 3N to the CoC 1004 renewal application. The applicant stated that by crediting the decay in internal pressure during the initial license period of 20 years, the off-normal pressure for the 24PT4 would be less than the value assumed in the evaluation summarized in Appendix 3N to the CoC 1004 renewal application, and determined that the analysis for the minimum shell thickness used to support the CoC 1004 renewal application is applicable to the Standardized Advanced NUHOMS® System. The staff reviewed the applicant's assessment and noted that the mechanical properties of the DSC materials in these systems are similar. In addition, the staff determined that while the overall designs of the DSCs are similar, the size and weight of the bounding CoC 1004 DSC are greater than the largest CoC 1029 DSC, and therefore, the analysis used to support the CoC 1004 renewal application is bounding. Based on this assessment, the staff determined that the analysis used to support the CoC 1004 renewal application is conservative and applicable to the Standardized Advanced NUHOMS® System.

3.3.5 Evaluation Findings

The staff reviewed the AMR provided in the license renewal application and supplemental documentation to verify that it adequately identifies the materials, environments, and aging effects of the in-scope SSCs. The staff performed its review following the guidance in NUREG-1927, Revision 1, and NUREG-2214. Based on its review, 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 summarized the information in the license renewal application and UFSAR supplement.

F3.2 The applicant's AMR process is comprehensive in identifying all pertinent aging mechanisms and effects applicable to the SSCs within the scope of renewal, and the applicant summarized the information in the license renewal application and UFSAR supplement.

3.4 Time-Limited Aging Analyses Evaluation

The applicant reviewed the initial application for TLAAs (i.e., calculations or analyses) used to demonstrate that in-scope SSCs will maintain their intended functions throughout an explicitly stated period of operation. To be considered "in-scope" for TLAAs, the applicant stated that the calculations/analyses must meet all six of the following criteria as defined in 10 CFR 72.3, which are:

1. Involve structures, systems, and components important to safety within the scope of the license renewal, as delineated in subpart F of Part 72, or within the scope of the spent fuel storage certificate renewal, as delineated in subpart L of Part 72, respectively;
2. Consider the effects of aging;
3. Involve time-limited assumptions defined by the current operating term, for example, 40 years;
4. Were determined to be relevant by the licensee or certificate holder in making a safety determination;
5. Involve conclusions or provide the basis for conclusions related to the capability of structures, systems, and components to perform their intended safety functions; and
6. Are contained or incorporated by reference in the design bases.

The applicant identified the following analyses, listed in the renewal application Section 3A.3, as meeting all six criteria for a TLAA:

(1) Boron Depletion in the BORAL® Plates in the 24PT1 and 24PT4 DSCs
(2) Creep Analysis for Aluminum Components in the 32PTH2 Basket
(3) Fatigue Analyses for the 24PT1, 24PT4, and 32PTH2 DSC Shells
(4) Irradiation Embrittlement of Metals in the 24PT1, 24PT4, and 32PTH2 DSCs
(5) Irradiation Effects on the Concrete in the AHSM and AHSM-HS
(6) Establishment of Cladding Temperature Limits for Fuel Stored in the 24PT1 DSC

The staff reviewed the TLAAs provided by the applicant in support of conclusions on the potential aging effects for SSCs and SSC subcomponents within the scope of renewal. Based on its review of the design-bases documents, the staff confirmed that the applicant identified all calculations and analyses that met all six criteria in 10 CFR 72.3 and therefore concludes that the applicant identified all TLAAs. The following subsections provide the staff's review of the applicant's TLAAs.

3.4.1 Boron Depletion in the BORAL® Plates in the 24PT1 and 24PT4 Dry Shielded Canisters

The applicant stated that the Standardized Advanced NUHOMS® System UFSAR, Sections 6.3.2 and A.6.3.2, evaluated the potential of boron (B)-10 depletion due to neutron capture in the poison plates of the 24PT1 and 24PT4 baskets, respectively. The applicant's analysis showed that the fraction of the original B-10 that would be depleted (1.1×10^{-6}) after 1,000 years would be negligible. The applicant also stated that the approved design basis for the 32PTH2 DSC does not include an analysis of B-10 depletion. The applicant pointed to the analyses for the 24PT1 and 24PT4 DSCs, which use similar boron-containing materials, and the generic evaluation in Section 3.4.2.4 of NUREG-2214 to support the finding that boron depletion is not a significant aging mechanism and no aging management activity for boron depletion is required for the poison plates in the 32PTH2 DSC.

The staff reviewed the applicant's analysis for the 24PT1 and 24PT4 baskets and the justification provided for the 32PTH2 DSC. Based on the analysis for the 24PT1 and 24PT4, the staff determined that the depletion of boron from the neutron absorber materials in the baskets 24PT1 and 24PT4 DSCs is not credible, and therefore, aging management is not required during the 60-year timeframe.

The staff reviewed the justification provided by the applicant for the 32PTH2 DSC and the generic analysis in NUREG-2214, Section 3.4.2.4. The staff noted that in the generic analysis in NUREG-2214, which was conducted using the highest expected neutron flux and the lowest B-10 concentration as a worst case scenario, only 0.02 percent of the available B-10 atoms would be depleted after 60 years, which is too small to challenge the criticality control function of the neutron poisons. NUREG-2214 concluded that boron depletion for borated aluminum alloys, aluminum metal matrix composites, and Boral® is not expected to result in significant changes in the criticality control function. The staff determined that the analysis in NUREG-2214, Section 3.4.2.4, is bounding for the 32PT2 DSC. Based on that bounding analysis, the staff determined that boron depletion of the 32PT2 DSC is not credible, and therefore, aging management is not required during the 60-year timeframe.

3.4.2 Creep Analysis for Aluminum Components in the 32PTH2 Basket

The applicant stated that the standardized Advanced NUHOMS® System UFSAR, Section B.3.6.1.2.8, evaluated the creep strain effects due to long-term storage of the 32PTH2 basket aluminum components. The applicant stated that for the creep strain analysis, the basis for maximum allowable stress for all basket materials is 100 percent of the average stress that produces a cumulative 1-percent strain in 555,000 hours for aluminum 1100 material. The applicant conservatively used the mechanical properties of aluminum 1100 in the analysis to bound stress limits for aluminum type 6061. The applicant stated that since the existing analysis is for 555,000 hours (63.3 years), the analysis remains valid for the period of extended operation and demonstrates that the basket will continue to perform its intended safety functions through the end of that period. The applicant stated that the analysis validated that the basket assembly design is structurally adequate for long-term storage loads and determined that the creep strain effect is negligible.

The staff reviewed the applicant's analysis for creep and confirmed that it conservatively used the properties for aluminum 1100 material. The staff determined that the analysis based on the properties of aluminum 1100 is sufficient to bound the effects of elevated temperature exposure that could alter the mechanical properties of the precipitation-hardened aluminum 6061 alloy. The staff determined that the applicant's TLAA is sufficient for the period of extended operation because the applicant's original analysis bounds the period of extended operation and uses conservative properties to bound the aluminum alloys used in the 32PTH2 DSC.

3.4.3 Fatigue Analyses for the 24PT1, 24PT4, and 32PTH2 Dry Shielded Canister Shells

The applicant stated that a thermal fatigue TLAA is incorporated in Sections 3.6.1.3, A.3.6.1.3, and B.3.6.1.1.8 of the UFSAR, which documents the evaluation of the DSC for temperature fluctuations in accordance with the provisions of NB-3222.4(d) of the ASME B&PV Code. The applicant clarified that thermal fatigue is the progressive and localized structural damage that occurs when a material is subjected to cyclic loading associated with thermal cycling. Seasonal and daily ambient temperature fluctuations are the only potential source of DSC thermal fatigue.

In Section 3A.4.3 of the CoC 1029 renewal application, the applicant stated that the design-basis calculations for the 24PT1 and 24PT4 included a fatigue analysis assuming a 50-year operation. This fatigue analysis was updated because the 50-year assumption is less than the 60-year period of extended operation in the CoC 1029 renewal. For the 32PTH2 shell, the applicant stated that there were no significant pressure fluctuations, such that a TLAA need not be updated or revised.

The applicant stated that for the fourth criterion in NB-3222.4(d), the design-basis calculations for all three DSCs assume the use of a conservative number of cycles when obtaining a value for the allowable amplitude of the alternating stress intensity component that is sufficient to bound a 60-year period of extended operation. Based on this assessment, the applicant determined that the fatigue analysis for the fourth criterion for the 24PT1, 24PT4, and the 32PTH2 shells does not need to be updated or revised.

The applicant provided a revised fatigue exemption evaluation of the 24PT1 and 24PT4 DSC shells for a service life of 100 years in Section 3A.6 of the CoC 1029 renewal application. The applicant explained that, consistent with NB-3222.4(d) of the ASME Code, fatigue effects need not be specifically evaluated provided that the six criteria in NB-3222.4(d) are met. The applicant referenced Appendix C.4.1 to the Standardized Advanced NUHOMS® System UFSAR (TN Americas LLC, 2018), which addressed these daily and seasonal temperature fluctuations on thermal fatigue, looking at the six criteria in NB-3222.4(d) of the ASME Code for applicability. Since all of the six ASME Code criteria are complied with over a 100-year ISFSI operating period, the applicant concluded that thermal fatigue of the DSC does not need to be managed during the period of extended operation and that the ASME Code fatigue requirements are satisfied for the DSC confinement boundary.

The staff reviewed the methodology, assumptions, and conclusions of the applicant's fatigue analysis. As noted in NUREG-2214, Section 3.2.2.7 and Chapter 5, a fatigue evaluation that follows the guidance in ASME B&PV Code, Subsection NB-3222.4(d), is appropriate for the Standardized Advanced NUHOMS® System DSCs. Therefore, the staff determined that the applicant's analysis for fatigue of the DSCs is acceptable and consistent with the technical basis in NUREG-2214.

3.4.4 Irradiation Embrittlement of Metals in the 24PT1, 24PT4, and 32PTH2 Dry Shielded Canisters

The applicant stated that the Standardized Advanced NUHOMS® System, UFSAR Sections 3.3.1.1 and A.3.3.1.1, evaluated the radiation effects from fast neutrons on the metals in the 24PT1 and 24PT4 DSCs. The cited UFSAR sections state that the integrated fast neutron fluence inside the DSCs after 50 years of service is on the order of 1×10^{15} neutrons/square centimeter (n/cm^2), which is below the threshold of 10^{17} n/cm^2 and thus damage is not expected. Since the 50-year assumption is less than the 60-year period of extended operation, the applicant updated the irradiation embrittlement analyses for the 24PT1 and 24PT4 DSCs. The applicant described the adjustments to the referenced analysis in Section 3A.7.3 of the Standardized Advanced NUHOMS® System renewal application. The applicant showed that the bounding neutron fluence for the 24PT1 and 24PT4 DSCs in the revised analysis remained below the threshold value of 1×10^{17} n/cm^2 for a period of 100 years. The applicant concluded that irradiation embrittlement of metals in the 24PT1 and 24PT4 DSCs will not lead to a loss of their intended functions during a 100-year service life.

The applicant stated that the Standardized Advanced NUHOMS® System UFSAR, Section B.3.3.1.1, evaluated the radiation effects from fast neutrons on the metals in the 32PTH2 DSC. The cited UFSAR section states that the integrated fast neutron fluence inside the 32PTH2 DSC after 60 years of service is on the order of 1×10^{15} n/cm^2, which is below the threshold of 10^{17} n/cm^2 and thus damage is not expected to occur. The applicant stated that since the evaluation is based on a 60-year service life, it remains valid for the period of extended operation and no additional analysis is required for the 32PTH2 DSC.

The staff reviewed the methodology, assumptions, and conclusions of the calculations for radiation embrittlement of the Standardized Advanced NUHOMS® DSCs. As noted in NUREG-2214, Section 3.2.2.9, a conservative calculation for DSS components shows that radiation embrittlement of stainless steels is not credible for a period of 100 years. The staff noted that the applicant's analysis is consistent with the conservative analysis in NUREG-2214. Therefore, the staff determined that the applicant's analysis of radiation embrittlement of the DSC shell is acceptable.

3.4.5 Irradiation Effects on the Concrete in the Advanced Horizontal Storage Module and the Advanced Horizontal Storage Module-HS

In Section 3A.4.5 of the CoC 1029 renewal application, the applicant stated that the Standardized Advanced NUHOMS® System UFSAR, Sections 3.3.2.1 and A.3.3.2.1, evaluated the radiation effects from fast neutrons and gamma rays on the concrete in the AHSM. The cited UFSAR sections state that the accumulated neutron flux over a 40-year service life is estimated to be 1.5×10^{14} n/cm^2, and a gamma energy flux of 3.0×10^{-4} watt/cm^2 is estimated. The Standardized Advanced NUHOMS® System UFSAR, Sections 3.3.2.1 and A.3.3.2.1, states that the temperature rise in concrete due to this level of radiation is negligible (American National Standards Institute/American Nuclear Society (ANSI/ANS)-6.4-1977, "American National Standard Guidelines on the Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants"). The 40-year period discussed in the Standardized Advanced NUHOMS® System UFSAR is less than the 60-year period of extended operation. As a result, the applicant updated the evaluation of radiation damage for the AHSM concrete to account for 100 years of operation and described the adjustments to the reference analysis in the CoC 1029 renewal application, Section 3A.7.3. The applicant showed that the bounding neutron fluence AHSM in the revised analysis remained below the threshold values of 1×10^{19} n/cm^2 and a gamma dose below the threshold value of 1×10^{10} rad where gamma radiation could affect concrete properties (NRC 2019). The applicant concluded that irradiation effects on the concrete in the AHSM will not lead to a loss of intended functions for a 100-year service life.

The Standardized Advanced NUHOMS® System UFSAR, Section B.3.3.3.1, evaluated the radiation effects from fast neutrons and gamma rays on the concrete in the AHSM-HS. Section B.3.3.2.1 of the cited UFSAR states that the accumulated neutron flux over a 60-year service life is estimated to be 2.27 × 10^{14} n/cm^2, and a gamma energy flux of 1.57 × 10^{-2} watt/cm^2. This section of the UFSAR also states that the temperature rise in concrete due to this level of radiation is negligible (ANSI/ANS-6.4-1977), and thus, radiation effects on concrete strength are not evaluated further for the AHSM-HS design. In Section 3A.4.5 of the CoC 1029 renewal application, the applicant stated that since the evaluation is based on a 60-year service life, it remains valid for the period of extended operation and no additional analysis is needed for the AHSM-HS.

The staff reviewed the methodology, assumptions, and conclusions for radiation embrittlement of the Standardized Advanced NUHOMS® System HSMs. As noted in NUREG-2214, Section 3.5.1.9, a conservative calculation for DSS components shows that radiation effects for concrete DSS components are not considered credible for a period of 100 years. The staff determined that the applicant's analysis is consistent with the conservative analysis in NUREG-2214. Therefore, the staff determined that the applicant's analysis of radiation damage for the concrete AHSM and AHSM-HS structures is acceptable.

3.4.6 Establishment of Cladding Temperature Limits for Fuel Stored in the 24PT1 Dry Shielded Canister

The Standardized Advanced NUHOMS® System UFSAR, Section 3.5.1.1.1, states that the peak cladding temperature limit at the beginning of long-term storage for the Westinghouse 14x14 mixed-oxide Zircaloy clad fuel in the 24PT1 DSC was determined in accordance with the methodology in PNL-6189, "Recommended Temperature Limits for Dry Storage of Spent Light Water Reactor Zircaloy-Clad Fuel Rods in Inert Gas," issued May 1987 (Levy et al. 1987). The applicant stated that the limit of 326 degrees C (618 degrees F) was derived based on a 50-year design life. The applicant also noted that the Standardized Advanced NUHOMS® System UFSAR, Section 3.5.1.2.1, states that the peak cladding temperature limit at the beginning of long-term storage for the Westinghouse 14x14 stainless steel clad fuel in the 24PT1 DSC was determined in accordance with the methodology in EPRI TR-106440, "Evaluation of Expected Behavior of LWR Stainless Steel-Clad Fuel in Long-Term Dry Storage," issued April 1996 (EPRI 1996), and the limit of 366 degrees C (690 degrees F) was derived based on a 50-year design life.

The applicant stated that while the cladding temperature limits were based on a 50-year storage design life, the methodology used predates the currently accepted limit for low burnup fuel in ISG-11, Revision 3 (ADAMS Accession No. ML033230335), which is 400 degrees C (752 degrees F). The applicant noted that because the CoC 1029 TS for the 24PT1 DSC limits the burnup of the Zircaloy clad fuel to 25 gigawatt days/metric ton of uranium (GWd/MTU) and stainless-steel clad fuel to 45 GWd/MTU, the fuel stored in the 24PT1 DSCs is not considered to be HBU fuel. The applicant concluded that since the fuel clad temperature limits applied to the fuel stored in the 24PT1 DSC are less than the currently accepted limit identified in ISG-11 Revision 3, they remain valid for the period of extended operation and demonstrate that the cladding will continue to perform its intended functions through the end of that period.

The staff reviewed the methodology, assumptions, and conclusions of analyses for temperature limits for the spent fuel cladding in the 24PT1 DSCs. As noted in NUREG-2214, Sections 3.6.1 and 3.6.2, no aging effects are considered credible for spent fuel cladding or spent fuel assembly hardware for assemblies with burnups that do not exceed 45 GWd/MTU. The staff noted that the original basis for the maximum cladding temperatures has not been changed and is conservative (i.e., a lower maximum allowed temperature) with respect to ISG-11, Revision 3. The staff determined that the applicant's analysis of temperature limits for the spent fuel cladding materials in the 24PT1 DSCs is consistent with the technical basis in NUREG-2214 and is therefore acceptable.

3.4.7 Evaluation Findings

The staff reviewed the license renewal application and design-bases documentation to confirm that the applicant did not omit any TLAAs that were part of the approved design bases. In its review, the staff followed the guidance in NUREG-1927, Revision 1, NUREG-2214, ISG-11 and ISG-2.

Based on its review, 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. The methods and values of the input parameters for the applicant's TLAAs are adequate. 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 meet the requirements in 10 CFR 72.240(c)(2).

3.5 Aging Management Programs

Under 10 CFR 72.240 requirements, the applicant must provide a description of AMPs for management of issues associated with aging that could adversely affect ITS SSCs. The applicant provided the following AMPs in the license renewal application:

(1) DSC AMP
(2) HSM AMP
(3) Basemat AMP
(4) HBU fuel AMP

The staff compared the content of the AMPs provided by the applicant to the results of the AMR. The staff determined that these AMPs are consistent with the results of the AMR for SSCs within the scope of the renewal and that they address credible aging effects that were not dispositioned with TLAAs or supplemental analyses. The staff followed the guidance in NUREG-1927, Revision 1, in conducting the safety review of the proposed AMPs in the license renewal application. The staff also evaluated the proposed AMPs and compared them to the generically acceptable example AMPs in NUREG-2214.

3.5.1 Review of Dry Shielded Canister Aging Management Program

For each AMP element, the staff conducted the safety review of the applicant's DSC AMP in the license renewal application according to the guidance in NUREG-1927, Revision 1, Section 3.6.1. In addition, the staff compared the DSC AMP provided by the applicant to the generically acceptable example AMP in NUREG-2214, Section 6.5 and Table 6-2, for localized corrosion and stress-corrosion cracking of welded stainless steel dry storage canisters.

Scope of program: The applicant stated that the AMP specifies visual inspection of the external surfaces of the DSC. In the CoC 1029 renewal application, Table 4-3 identifies the subcomponents within the scope of the renewal, the material and environments for each subcomponent, the intended functions of the subcomponents, credible aging mechanisms, and the aging effects to be managed. The aging effects and mechanisms managed by the DSC

AMP are loss of material due to pitting, crevice, and galvanic corrosion and cracking due to stress-corrosion cracking of the stainless steel DSC.

The staff reviewed the applicant's description of the scope of program for the DSC AMP and determined that the description was acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.1, and is consistent with the example AMP in NUREG-2214, Table 6-2. The staff determined that the description identified the subcomponents covered by the AMP, specific materials of the subcomponents, intended functions to be maintained, operating environments, and the aging mechanisms and effects to be managed.

<u>Preventive actions</u>: The applicant stated that the DSC AMP is a condition-monitoring program that does not include preventive actions.

The staff determined that the applicant's description is acceptable and noted that NUREG-1927 Revision 1, Section 3.6.1.2, states that some condition or performance monitoring programs do not rely on preventive actions and thus this information need not be provided. The staff determined that the applicant's preventive actions element for the DSC AMP is also consistent with the example AMP in NUREG-2214, Table 6-2, and is therefore acceptable.

<u>Parameters monitored or inspected</u>: The applicant stated that the DSC AMP consists of visual inspections to monitor for material degradation. The normally inaccessible areas of the DSC will undergo remote visual inspection for discontinuities and imperfections. The applicant noted that areas of localized corrosion, including pitting corrosion and crevice corrosion, cracking, or discolorations, are documented and the appearance and location of atmospheric deposits on the DSC surfaces are recorded. The areas inspected include the following:

- portions of the DSC surfaces, welds and heat-affected zones (HAZs), and crevice locations near the DSC support rails
- portions of the outer top cover plate, closure welds, and HAZs
- portions of the outer bottom cover plate, grapple ring assembly, and their welds and HAZs
- portions of the DSC shell bottom surface including the edge of DSC support rails and HAZs

The inaccessible areas of the DSC include the following:

- the upper surface of the DSC shell where atmospheric particulates may settle
- the majority of the outer top cover plate, welds, and HAZs
- the majority of the outer bottom cover plate, grapple ring assembly, and their welds and HAZs
- the DSC shell crevice locations such as where the DSC shell rests on the DSC support rail

The staff reviewed the applicant's description of the parameters monitored and inspected for the DSC AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.3, and is consistent with the example AMP in NUREG-2214, Table 6-2. The staff determined that the program element identifies the specific parameters that will be monitored or inspected and includes indications of pitting and crevice corrosion. While pitting and crevice corrosion are unlikely to compromise the intended functions of the DSC, both pitting and crevice corrosion are recognized as possible precursors to CISCC of welded stainless steel components. The staff determined that because the applicant's AMP includes examination for pitting and crevice corrosion, the parameters monitored and inspected will be capable of identifying degradation or potential degradation before a loss of intended function.

Detection of aging effects: The applicant stated that visual inspection will be performed on the normally inaccessible surface areas of a minimum of one DSC. The selection of the DSC for inspection considers factors relevant to the aging mechanisms and effects covered by the AMP. These include time in service, initial heat load, DSC fabrication and design considerations, and the HSM array configuration relative to climatological and geographical features. The applicant noted that the visual examinations to detect the aging mechanisms and effects identified in the AMP scope of program follow procedures consistent with the ASME B&PV Code, Section XI, Subarticle IWA-2210, using visual testing (VT). The applicant stated that VT-3 examinations will be performed on the DSC surfaces within 2 inches (50 mm) of a weld. The applicant stated that supplemental VT-1 examinations are performed on areas with minor corrosion indications within 2 inches (50 mm) of a weld. An augmented examination is performed on a DSC when the visual exams indicate the presence of major corrosion within 2 inches (50 mm) of a weld, which is defined by the applicant in the acceptance criteria AMP element. The augmented examinations will follow procedures consistent with the ASME B&PV Code, Section XI, Subarticles IWA-2220 and IWA-2230, for surface and volumetric examinations with personnel qualified in accordance with IWA-2300. The baseline AMP visual inspection is to be conducted 2 years before the start of the period of extended operation (i.e., the period of extended operation will start 20 years after the first loaded DSC was placed in storage, and subsequent inspections are to be conducted every 5 years ± 1 year or when an engineering evaluation predicts that an identified crack will reach 75-percent through-wall, whichever is sooner, following the baseline inspection.

The staff reviewed the applicant's description of the parameters monitored and inspected for the DSC AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.4, and is consistent with the example AMP in NUREG-2214, Table 6-2. The staff verified that the program element identifies the inspection method, the applicable subsections of the ASME B&PV Code, Section XI, for the inspection requirements, the personnel qualifications as required by the ASME B&PV Code, sample size, data collection, timing of inspections, and inspection frequency. The staff noted that the applicant's selection of an initial 5-year inspection frequency is supported by the applicant's crack growth rate evaluation in Section 3B.5 of the CoC 1029 renewal application, which is reviewed in SER Section 3.3.4. The staff determined that the applicant provided the information and identified activities for the detection of aging effects AMP element that will be capable of identifying and characterizing degradation or potential degradation before a loss of intended function.

Monitoring and trending: The applicant stated that a minimum of one DSC is to be selected for the baseline inspection and subsequent inspections and noted that if the baseline DSC is not available for subsequent inspections, another DSC is to be selected for a new baseline inspection. Conditions adverse to quality that are identified during the inspection and monitoring activities, such as nonconformances, failures, malfunctions, deficiencies, and deviations, will be entered into the licensee's corrective action program. The applicant also stated that the visual inspections consider cumulative operating experience from previous inspections and assessments to monitor and trend the progression of aging effects over time and that data taken for these inspections is to be monitored by comparison to past site data taken, as well as comparison to industry operating experience, including data gathered by the Aging Management INPO [Institute of Nuclear Power Operations] Database (AMID), as discussed in Nuclear Energy Institute (NEI) 14-03, "Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management," Revision 2, issued December 2016 (NEI 2016) (ADAMS Accession No. ML16356A204).

The staff reviewed the applicant's description of the monitoring and trending element of the DSC AMP and determined that the description is acceptable because the applicant provided information consistent with NUREG-1927, Revision 1, Section 3.6.1.5, and the example AMP in NUREG-2214, Table 6-2. The staff confirmed that the AMP element includes a baseline inspection established at the beginning of the period of extended operation. In addition, the staff confirmed that the program element states that conditions adverse to quality that are identified during the inspection and monitoring activities are entered into the licensee's corrective action program.

Acceptance criteria: The applicant provided quantitative criteria used to classify the indication as major, minor, or insignificant corrosion. The AMP provided by the applicant uses this classification to identify the need for additional inspections of the identified indications. The presence of a major corrosion indication within 2 inches of a weld will receive an augmented surface or volumetric examination for the presence of cracking and will be entered into the licensee's corrective action program, and a major corrosion indication more than 2 inches from a weld will be entered into the licensee's corrective action program. A minor corrosion indication within 2 inches from a weld will receive a supplemental VT-1 exam or a surface or volumetric exam to demonstrate that there is no attack of the metal under the corrosion indication.

The applicant stated that the acceptance criteria for the DSC AMP follow the guidance in EPRI 3002008193, "Aging Management Guidance To Address Potential Chloride-Induced Stress Corrosion Cracking of Welded Stainless Steel Canisters," issued March 2017 (EPRI 2017), which focuses on CISCC. The applicant described the three tiers of acceptance criteria for the DSC AMP: (1) visual examination criteria, (2) augmented examination criteria for surface or volumetric examinations, and (3) flaw evaluation criteria that are used if cracking is detected. If a crack is identified, an engineering evaluation will be performed. The applicant cited Section 5.3.2 of EPRI 3002008193 as an acceptable methodology for the flaw evaluation.

In response to an RAI, the applicant stated that the acceptance criterion is used as a threshold value for determining when subsequent AMP inspections are to be performed and is not intended to be an "allowable localized flaw." The DSC AMP acceptance criteria state that acceptability of the crack will be demonstrated via an engineering evaluation and ensure that these conditions will be entered into the licensee's corrective action program. The applicant stated that the requirements for the flaw evaluation in the DSC AMP acceptance criteria are intended to ensure that cracks will not grow beyond the acceptance criteria before the next AMP inspection, thus providing the opportunity to monitor and trend crack growth before a loss of confinement.

The applicant clarified that Section 3B.6 in the CoC 1029 renewal application refers to an evaluation in Appendix 3N to the CoC 1004 renewal application, which evaluates the stresses due to normal and off-normal loads assuming a uniformly reduced DSC shell thickness. The evaluation in Appendix 3N to the CoC 1004 renewal application involves two separate DSC shell thicknesses to determine the limiting shell thickness necessary to accommodate the stresses due to normal and off-normal loads while meeting the ASME Code limits. The applicant stated that the initial evaluation was performed conservatively assuming the initial design internal pressure and storage temperatures. The second evaluation was a further defense-in-depth evaluation in which shell thickness was progressively reduced until the stresses approached the ASME Code allowable limit, but assumed a reduced internal pressure and shell temperature consistent with what would be expected after 20 years of storage.

The applicant compared the evaluation for a crack in the CoC 1004 DSC to the corresponding remaining shell thickness for the CoC 1029 DSCs. The applicant noted that stress-corrosion cracking of the DSC shell is expected to be a localized loss of material associated with the stress areas near a weld, whereas the evaluations of limiting shell thickness conservatively assumed a uniform shell thickness equivalent to a crack around the entire DSC shell. This condition is bounded by the second evaluation in Appendix 3N to the CoC 1004 renewal application, and the criteria for determining when subsequent inspections must be performed ensure confinement and meet the ASME Code stress limits if the DSC was to be withdrawn from the HSM.

The staff reviewed the applicant's description of the acceptance criteria element for the DSC AMP and determined that the description is acceptable because the applicant provided information consistent with NUREG-1927, Revision 1, Section 3.6.1.6, and the example AMP in NUREG-2214, Table 6-2. The staff verified that the acceptance criteria for the DSC AMP are based on accepted ASME B&PV Code, Section XI, requirements and include specific numerical values to ensure that the design bases are maintained. As such, the staff determined that the acceptance criteria for the DSC AMP are adequate to ensure that the intended functions of the DSCs and the approved design bases are maintained during the period of extended operation. In addition, the staff determined that the acceptance criteria include a quantitative basis that is justifiable by consensus codes and standards and the engineering evaluation method includes EPRI 3002008193 (EPRI 2017).

<u>Corrective actions</u>: The applicant stated that the general licensee's quality assurance (QA) procedures, review and approval processes, and administrative controls are implemented according to the NRC's requirements (e.g., 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants"), which ensures that conditions adverse to quality are promptly identified and corrected, including root cause determination and prevention of recurrence. The applicant stated that deficiencies are either corrected or are evaluated to be acceptable for continued service through engineering analysis, which provides reasonable assurance that the intended functions are maintained consistent with current licensing-basis conditions. The applicant stated that evaluations performed to assess conditions associated with aging should utilize the same methodology used in the licensing and design-basis calculations, which are maintained by the CoC holder, to ensure that intended functions are maintained through the period of extended operation. In addition, the applicant stated that the extent of condition investigation per the licensee's corrective action program may result in additional inspections by a different method, increased inspection frequency, or expanded inspection sample size.

The staff reviewed the applicant's description of the corrective actions element for the DSC AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.7, and is consistent with the example AMP in NUREG-2214, Table 6-2. The staff verified that the corrective actions AMP element states that site QA procedures, review and approval processes, and administrative controls are implemented according to the requirements of 10 CFR Part 50, Appendix B. The staff confirmed that the corrective actions for the DSC AMP state that the measures to be taken when the acceptance criteria are not met include root cause determination and prevention of recurrence for significant conditions adverse to quality.

Confirmation process: The applicant stated that the confirmation process will be commensurate with the general licensee's QA program approved under 10 CFR Part 50, Appendix B, which ensures that the confirmation process includes provisions to verify that appropriate corrective actions have been completed and are effective. The general licensee's QA program approved under 10 CFR Part 50, Appendix B, also contains provisions to preclude repetition of significant conditions adverse to quality.

The staff reviewed the applicant's description of the confirmation process element for the DSC AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.8, and is consistent with the example AMP in NUREG-2214, Table 6-2. The staff verified that the confirmation process for the DSC AMP includes provisions to verify that appropriate corrective actions have been completed and are effective and that the process relies on the general licensee's QA program approved under 10 CFR Part 50, Appendix B, which contains provisions to prevent repetition of significant conditions adverse to quality.

Administrative controls: The applicant stated that the administrative controls under the CoC holder or licensee's QA procedures and corrective action program provide a formal review and approval process. The administrative controls are implemented in accordance with the requirements of 10 CFR Part 50, Appendix B, and will continue for the period of extended operation. The applicant stated that licensees and CoC holders use the 10 CFR Part 72 regulatory requirements to determine if a particular aging-related degradation condition or event identified via operating experience, research, monitoring, or inspection is reportable to the NRC.

The staff reviewed the applicant's description of the administrative controls performed in accordance with the general licensee QA program approved under 10 CFR Part 50. The staff determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.9, and is consistent with the example AMP in NUREG-2214, Table 6-2.

Operating experience: The applicant provided a review of operating experience relevant to the Standardized Advanced NUHOMS® System, which included inspections of NUHOMS® System SSCs that have been in service for more than 20 years. While the review identified several age-related conditions, no incidents were identified in which aging effects led to the loss of intended functions of a NUHOMS® System SSC. The applicant stated that the operating experience review supported its conclusion that the effects of aging will be managed so that the intended functions of the SSCs will be maintained during the period of extended operation.

The applicant stated that the DSC AMP will be updated, as necessary, to incorporate new information on degradation due to aging effects identified from plant-specific inspection findings, related industry operating experience, and related industry research. The applicant noted that the licensee's operating experience review process captures future plant-specific and industry aging management and aging-related operating experience. The ongoing review of both plant-specific and industry operating experience will continue through the period of extended operation to ensure that this AMP stays effective in managing the identified aging effects. The applicant provided tollgates for the DSC AMP consistent with the recommendations in NEI 14-03 (NEI 2016). These tollgates are formal evaluations of information from a range of sources with a written assessment of the information, including trends, corrective actions required, and the effectiveness of the DSC AMP. SER Section 3.5.5 presents the staff's review of the applicant's use of tollgates for the DSC AMP.

The staff reviewed the applicant's description of the operating experience element for the DSC AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.10, and is consistent with the example AMP in NUREG-2214, Table 6-2. The staff determined that the applicant appropriately assessed current operating experience and included provisions to capture future plant-specific and industry aging management and aging-related operating experience through the licensee's operating experience review process.

3.5.2 Review of Horizontal Storage Module Aging Management Program

Following the guidance in NUREG-1927, Revision 1, Section 3.6.1, for each AMP element, the staff conducted the safety review of the applicant's HSM AMP in the license renewal application. In addition, the staff compared the HSM AMP provided by the applicant to the generically acceptable example AMP in NUREG-2214 Section 6.6 and Table 6-3 for the review of the HSM reinforced concrete structures and NUREG-2214 Section 6.7 and Table 6-4, for the review of the steel and stainless steel components of the HSM.

<u>Scope of program</u>: In Table 4-4 of the CoC renewal application, the applicant identified the subcomponents within the scope of the renewal for the HSM designs, the material and environments for each subcomponent, the intended functions of the subcomponents, credible aging mechanisms, and the aging effects to be managed. The applicant stated that the HSM AMP specifies visual inspection of the concrete to identify and manage concrete aging effects including loss of material, cracking, loss of strength, reduction in concrete pH, loss of concrete-to-steel bond, and increase in porosity and permeability. These aging effects are associated with a number of aging mechanisms for concrete structures including freeze-thaw, aggressive chemical attack, corrosion of reinforcing steel, salt scaling, reaction with aggregates, differential settlement, and leaching of calcium hydroxide.

The applicant stated that the HSM AMP also specifies visual examination for steel components to identify and manage loss of material due to general, pitting, crevice, and galvanic corrosion. In addition, the AMP specifies visual examination for stainless steel components to identify and manage loss of material due to pitting and crevice corrosion and cracking due to stress corrosion.

The staff noted that the scope of program for the applicant's HSM AMP for concrete components differs from the example AMP in NUREG-2214, Table 6-3. Specifically, the scope of the program for the applicant's HSM AMP does not include general area walkdowns of all reinforced concrete structures, nor does it include radiation surveys to assess concrete shielding performance.

In response to an RAI (ADAMS Accession No. ML20192A126), the applicant justified the exclusion of the radiation surveys and general area walkdowns. The applicant stated that its justification for not including general area walkdowns is based on ACI 349.3R-2018, "Evaluation of Existing Nuclear Safety Related Concrete Structures." The applicant noted that the exterior surfaces of the HSM are exposed to the natural environment, while the interior is exposed to a sheltered environment. The HSM is not continuously exposed to fluids, nor are heavy concentrations of aggressive chemicals expected. Therefore, the applicant concluded that the HSM does not see an environment more aggressive than the "structure exposed to natural environment" category listed in Table 6 of ACI 349.3R-2018. In addition, the applicant noted that ACI 349.3R-2018 does not call for a general area walkdown and the 5-year visual inspection frequency called for in Table 6 of the standard is an appropriate frequency for the HSM AMP.

The applicant's justification for not including radiation surveys was based on the newer HSM designs used in the Standardized Advanced NUHOMS® System. The applicant stated that the referenced NRC evaluation (ADAMS Accession No. ML19072A031) used the conservative approach of assuming the aging effects of concrete resulted in the complete loss of all the cover concrete (i.e., the depth into the concrete from the surface to where the rebar is placed). Even with very conservative assumptions in the referenced NRC evaluation, the evaluation of the newer NUHOMS® designs shows that the dose rates after 20 years of storage are less than those at the time of loading with no concrete aging. In addition, the applicant noted that the internal surfaces of the HSM are in a sheltered environment, and the likelihood is low that the internal surfaces of the HSM concrete would undergo any degradation that would have an impact on the shielding function of the HSM. The applicant also noted that the NRC evaluation (ADAMS Accession No. ML19072A031) states that no operating experience has identified any degradation of the internal surfaces of the concrete that is considered capable of affecting the shielding function of the HSMs.

Although the HSM AMP deviates from the example in NUREG-2214, the staff determined that the applicant's proposed inspection frequency is consistent with ACI 349.3R-2018, Chapter 6, "Evaluation frequency," which indicates that concrete structures and ground water quality should be monitored on a frequency not to exceed 5 years. The staff also determined that the applicant has demonstrated that visual inspections of the concrete per ACI 349.3R-2018 are capable of assessing the shielding performance of the HSM, and thus, the absence of additional radiation surveys is justified. Furthermore, the staff reviewed the applicant's description of the scope of program for the concrete components of the HSM AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.1. The staff verified that the scope of program provided by the applicant identifies the subcomponents covered by the AMP, specific materials of the subcomponents, intended functions to be maintained, operating environments, and the aging mechanisms and effects to be managed. Based on the information in the renewal application and the applicant's response to the NRC's RAI, the staff determined that the applicant has justified the scope of program for the concrete subcomponents covered by the HSM AMP, the specific materials of the subcomponents, intended functions to be maintained, operating environments, and the aging mechanisms and effects to be managed.

The staff reviewed the applicant's description of the scope of the program for the steel and stainless steel components of the HSM AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.1. The staff verified that the scope of program provided by the applicant identifies the subcomponents covered by the AMP, specific materials of the subcomponents, intended functions to be maintained, operating environments, and the aging mechanisms and effects to be managed. In addition, the staff determined that the examination of the steel and stainless steel components covered by the HSM AMP is consistent with the applicable portions of the example AMP in NUREG-2214, Table 6-4.

Preventive actions: The applicant stated that the DSC AMP is a condition-monitoring program that does not include preventive actions.

The staff determined that the applicant's description is acceptable and noted that NUREG-1927, Revision 1, Section 3.6.1.2, states that some condition or performance monitoring programs do not rely on preventive actions, and thus, this information need not be provided. The staff noted that the applicant's preventive actions element for the HSM AMP is consistent with the example AMP in NUREG-2214, Table 6-3, for concrete components of the HSM, and Table 6-4, for the steel and stainless steel components of the HSM.

Parameters monitored or inspected: The applicant stated that the HSM AMP consists of visual inspections to monitor for material degradation identified in the scope of program for the HSM AMP. The applicant identified the normally accessible external HSM components that will be examined by direct visual examination, the normally inaccessible areas of HSM concrete and DSC support structure that will undergo remote visual inspection, and inaccessible areas of the HSM that will not undergo visual inspection.

The staff reviewed the applicant's description of the parameters monitored and inspected for the HSM AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.3. The staff determined that the program element identifies the specific parameters that will be monitored or inspected and includes indications of concrete aging effects as well as aging effects for the steel and stainless steel subcomponents of the HSM. The staff determined that because the applicant's AMP includes examination for evidence of concrete aging mechanisms and corrosion of the steel and stainless steel components, the parameters monitored and inspected will be capable of identifying degradation or potential degradation before a loss of intended function of the HSM SSCs.

Detection of aging effects: The applicant stated that a minimum of one HSM will be selected for the baseline and subsequent visual inspections. The selection of the HSM for baseline and subsequent inspections is to be based on the time in service or the DSC selected for aging management inspections. The applicant stated that the baseline AMP visual inspection is to be conducted within 2 years before 20 years of the first loaded DSC being placed in storage and that subsequent inspections are to be conducted every 5 years ± 1 year following the baseline inspection.

The applicant stated that direct or remote visual inspections using ACI 349.3R (ACI 2018), Section 3.6.1, are conducted for HSM concrete in both outdoor and sheltered environments, allowing for detection of aging effects for subcomponents within the scope of the HSM AMP identified in Table 4-4 of the renewal application. The normally inaccessible internal surfaces of the HSM concrete may be inspected using a video camera, fiber-optic scope, or other remote inspection technology via existing access points of the HSM. For the HSM concrete, crack maps are developed, and dimensions are documented in photographic records by inclusion of a tape measure, crack gauge, or comparator.

The applicant stated that visual examinations are performed to detect aging effects on subcomponents within the scope of the HSM AMP identified in Table 4-4 of the renewal application. As much of the HSM steel surface as can be reasonably accessed is examined to ascertain its general condition. The applicant stated that the remote inspection system is qualified and demonstrated to have sufficient resolution capability and enhanced lighting to resolve the acceptance criteria for the steel components of the HSM AMP.

The applicant stated that within the HSM cavity, certain surface areas may be inaccessible for direct visual and remote inspection. The HSM AMP addresses detection of aging effects for inaccessible areas indirectly by monitoring the inspection findings of similar surfaces within accessible and normally inaccessible areas. The applicant clarified that inaccessible area inspections may only be necessary because of the licensee's corrective action program to ensure that the aging effect is managed and that the component's intended functions are maintained during the period of extended operation.

The staff noted that the detection of aging effects for the applicant's HSM AMP for concrete components differs from the example AMP in NUREG-2214, Table 6-3. Specifically, the applicant's HSM AMP specifies that a minimum of one HSM be selected for inspection. In contrast, the example AMP in NUREG-2214 specifies that a minimum of two of the same structures (i.e., same design bases) are evaluated at the minimum inspection frequency. In response to an RAI (ADAMS Accession No. ML20192A126), the applicant stated that the aging is dependent on the time an SSC is in service and its environment. Because all HSMs at a given site see the same environment, the HSM that has been in service the longest would experience the most aging. The applicant stated that inspecting and monitoring the HSM that has been in service the longest provides a leading indicator of the condition of the remaining HSMs. The applicant also stated that if aging effects are identified on this leading HSM, the licensee's corrective action program will be used to determine the extent of the condition and whether additional HSMs should be inspected.

Although the HSM AMP deviates from the example in NUREG-2214, the staff determined that the applicant's proposed inspection of one HSM for the detection of aging effects is consistent with the prioritization described in ACI 349.3R-2018, Section 3.4. The staff reviewed the applicant's description of the activities included in the detection of aging effects for concrete subcomponents for the HSM AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.4. Based on the information in the renewal application and the applicant's response to the NRC's RAI, the staff determined that the applicant has justified the parameters for the detection of the aging effects element for the concrete subcomponents covered by the HSM AMP. The staff reviewed the applicant's detection of aging effects for the HSM AMP and determined that the description is acceptable because the program element identifies the inspection method and the applicable subsections of ACI 349.3R-2018 (ACI 2018) for the concrete inspections and requires qualification of the remote inspection methods for the steel components that are demonstrated to be sufficient to assess the condition of components with respect to the acceptance criteria. In addition, the staff determined that the detection of aging effects element in the HSM AMP identifies the sample size, timing of inspections, and inspection frequency. The staff determined that the detection of aging effects element in the AMP provides sufficient information and activities that will be able to identify degradation or potential degradation of the HSM subcomponents before a loss of intended function.

The staff reviewed the applicant's description of the activities included in the detection of aging effects for the steel and stainless steel subcomponents for the HSM AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.4, and is consistent with the applicable portions of the example AMP in NUREG-2214, Table 6-4. The staff reviewed the applicant's detection of aging effects for the HSM AMP and determined that the description is acceptable because the program element identifies the inspection method and requires qualification of the remote inspection methods for the steel components that are demonstrated to be sufficient to assess the condition of components with respect to the acceptance criteria. In addition, the staff determined that the HSM AMP detection of aging effects element identifies the sample size, timing of inspections, and inspection frequency. The staff determined that the applicant provided sufficient information and activities for the detection of aging effects AMP element that will be able to identify degradation or potential degradation of the HSM steel and stainless steel subcomponents before a loss of intended function.

Monitoring and trending: The applicant stated that the inspections and monitoring activities in the HSM AMP are performed periodically to identify areas of degradation. Conditions adverse to quality that are noted during the inspection and monitoring activities, such as nonconformances, failures, malfunctions, deficiencies, and deviations, are entered into the licensee's corrective action program. The applicant noted that the visual inspections appropriately consider cumulative operating experience from previous inspections and assessments so as to monitor and trend the progression of aging effects over time. Data from these inspections are to be monitored by comparison to past site data, as well as comparison to industry operating experience, including data gathered by the Institute for Nuclear Power Operation's AMID as discussed in NEI 14-03 (NEI 2016).

The applicant stated that for HSM concrete, crack maps are monitored and trended as a means of identifying progressive growth of defects that may indicate degradation due to specific aging effects, such as rebar corrosion. The crack maps and photographic records are compared with those from previous inspections to identify accelerated degradation of the concrete during the period of extended operation. The applicant stated that a minimum of one HSM is to be selected for the baseline inspection and subsequent inspections. If the baseline HSM is not available for subsequent inspections or is no longer in service, another HSM will be selected for a new baseline inspection.

In response to an NRC RAI (ADAMS Accession No. ML20192A126) on the monitoring and trending of inspection results, the applicant clarified that all inspections will be performed under the licensee's administrative controls for performance of work at the site. The applicant noted that these work controls include provisions for the documentation of work performed (e.g., collection of logs, notes, observations, photographs, video images, and test data). As a result of these controls, data will be collected on observations made during the inspections. The applicant added that the HSM AMP explicitly requires all conditions that do not meet the listed acceptance criteria to be entered into the licensee's corrective action program for evaluation, as well as monitoring and trending. The listed acceptance criteria for the nonconcrete subcomponents are such that virtually all age-related conditions will be entered into the correction program including any corrosion, corrosion stains on adjacent components, or surface cracks.

The staff reviewed and determined that the applicant's monitoring and trending element for the HSM AMP is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.5. Based on the information in the renewal application and the applicant's response to the NRC's RAI, the staff determined that the applicant has provided an acceptable description of the inspection information for monitoring and trending. The staff reviewed the applicant's description of the monitoring and trending element for the HSM AMP and verified that the AMP element includes a baseline inspection established at the beginning of the period of extended operation, and that conditions adverse to quality identified during the inspection and monitoring activities are entered into the licensee's corrective action program. The staff noted that the licensee's corrective action program will evaluate the inspection results against the AMP acceptance criteria to ensure that the next scheduled inspection will occur before a loss of intended function.

Acceptance criteria: The criteria are directed at the identification and evaluation of degradation that may affect the ability of the HSM to perform its intended functions. The applicant stated that for the steel and stainless steel structural components of the HSMs, any indications of general corrosion, pitting corrosion, crevice corrosion, galvanic corrosion, and stress-corrosion cracking are relevant and are evaluated through the general licensee's corrective action program.

The applicant stated that the concrete acceptance criteria are from the second-tier acceptance criteria in ACI 349.3R, Section 5.2. The applicant stated that general licensees who are not committed to ACI 349.3R and elect to use site-specific criteria for concrete structures should describe the criteria and provide a technical basis for deviations from those acceptance criteria in ACI 349.3R. The applicant stated that for instances when the inspection acceptance criteria are exceeded, the identified issues require further evaluation and are entered into the general licensee's corrective action program.

The staff reviewed the applicant's acceptance criteria for the HSM AMP and determined that the AMP element is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.6. The staff determined that the applicant's acceptance criteria for the steel and stainless steel components in the HSM AMP are consistent with those in the example AMP in NUREG-2214, Table 6-4. The staff determined that the applicant's HSM AMP acceptance criteria for the steel and stainless steel components are acceptable because the applicant clarified that any identified indication of corrosion requires further evaluation through the general licensee's corrective action program. For the concrete components, the staff determined that the applicant's acceptance criteria are acceptable because they are consistent with the ACI 349.3R-2018 second-tier acceptance criteria for the inspection of concrete structures. In addition, the staff noted that ACI 349.3R-2018 states that the use of the second-tier acceptance criteria will aid in identifying degradation at an early stage, while the affected structure is still repairable. Thus, the staff determined that the acceptance criteria for the HSM AMP are adequate to ensure that the HSM's intended functions and the approved design bases are maintained during the period of extended operation.

Corrective actions: The applicant stated that the general licensee's QA procedures, review and approval processes, and administrative controls are implemented according to the requirements of 10 CFR Part 50, Appendix B, which ensures that conditions adverse to quality are promptly identified and corrected. These requirements include root cause determination and prevention of recurrence. Deficiencies are either corrected or are evaluated to be acceptable for continued service through engineering analysis, which provides reasonable assurance that the intended functions are maintained consistent with current licensing-basis conditions. Evaluations performed to assess conditions associated with aging should use the same methodology as in the licensing and design-basis calculations, which are maintained by the CoC holder, to ensure that intended functions continue through the period of extended operation. In addition, the applicant stated that extent of condition investigations per the licensee's corrective action program may result in additional inspections by a different method, increased inspection frequency, or expanded inspection sample size.

The staff reviewed the applicant's description of the corrective action element for the HSM AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.7, which states that an applicant may reference the use of the corrective action program approved under 10 CFR Part 50, Appendix B. The staff verified that the corrective action element for the HSM AMP states the measures to be taken when the acceptance criteria are not met, including root cause determination and prevention of recurrence of significant conditions adverse to quality.

Confirmation process: The applicant stated that the confirmation process will be commensurate with the general licensee's QA program approved under 10 CFR Part 50, Appendix B, which ensures that the confirmation process includes provisions to verify that appropriate corrective actions have been completed and are effective. The general licensee's QA program approved under 10 CFR Part 50, Appendix B, also contains provisions to prevent the repetition of significant conditions adverse to quality.

The staff reviewed the applicant's description of the confirmation process element for the HSM AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.8. The staff found that the confirmation process for the HSM AMP includes provisions to verify that appropriate corrective actions have been completed and are effective and relies on the general licensee's QA program approved under 10 CFR Part 50, Appendix B, which contains provisions to prevent the repetition of significant conditions adverse to quality.

Administrative controls: The applicant stated that the administrative controls under the CoC holder or licensee's QA procedures and corrective action program provide a formal review and approval process. These administrative controls are implemented in accordance with the requirements of 10 CFR Part 50, Appendix B, and will continue for the period of extended operation. The applicant stated that licensees and CoC holders use the 10 CFR Part 72 regulatory requirements to determine if a particular aging-related degradation condition or event identified via operating experience, research, monitoring, or inspection is reportable to the NRC.

The staff reviewed the applicant's description of the administrative controls element for the HSM AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.9, with the administrative controls performed in accordance with the general licensee's QA program approved under 10 CFR Part 50, Appendix B.

Operating experience: The applicant provided a review of operating experience relevant to the Standardized Advanced NUHOMS® System, which included inspections of system SSCs that have been in service for more than 20 years. While the review identified several conditions that were age related, it found no incidents in which aging effects led to the loss of intended functions of a NUHOMS® System SSC. The applicant stated that the operating experience review supported its conclusion that the effects of aging will be managed so that the intended functions of the HSM SSCs will be maintained during the period of extended operation.

In response to the staff's RAI (ADAMS Accession No. ML20192A126), the applicant justified not including tollgates (i.e., formal periodic assessments) for the HSM AMP. NEI 14-03 (NEI 2016) introduced the tollgates concept to address cases in which there are gaps in knowledge about the aging mechanism and effects that cannot be addressed before the start of the renewal storage period. The applicant stated that the aging mechanisms and effects for the concrete and metals used in the HSMs are well understood and, because there are no postulated knowledge gaps that cannot be addressed before the start of the renewal storage period, there is no need for formal tollgate assessments. While no formal tollgate assessments are required, the HSM AMP does include requirements in the operating experience element for the general licensees to update the AMP as necessary to incorporate new information on degradation due to aging effects identified from plant-specific inspection findings, related industry operating experience, and related industry research. The applicant noted that the general licensee's operating experience review process will capture future plant-specific and industry aging management and aging-related operating experience. This ongoing review of both plant-specific and industry operating experience will continue through the period of extended operation to ensure that this AMP stays effective in managing the identified aging effects.

The staff reviewed the applicant's description of the operating experience element for the HSM AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.10. Specifically, the staff determined that the applicant's approach for updating the operating experience applicable to the HSM AMP to incorporate new information on degradation due to aging effects identified from plant-specific inspection findings, related industry operating experience, and related industry research is consistent with the NRC guidance. The staff noted the favorable operating experience to date with many systems that are now in use, including over 1,000 NUHOMS® HSMs in the United States (including HSMs for the 1004, 1029, 1030, and 1042 CoCs, in addition to multiple specifically licensed ISFSIs), some of which have been in service for more than 20 years. Based on the information provided by the applicant, the staff determined that the applicant has assessed current operating experience and included provisions to capture future plant-specific and industry aging management and aging-related operating experience through the general licensee's operating experience review process.

3.5.3 Review of Basemat Aging Management Program

The staff conducted a safety review of the applicant's basemat AMP in the license renewal application based on the guidance in NUREG-1927, Revision 1, Section 3.6.1, for each AMP element. In addition, the staff compared the basemat AMP provided by the applicant to the generically acceptable example AMP in NUREG-2214, Section 6.6 and Table 6-3, for the review of the HSM reinforced concrete structures.

<u>Scope of program</u>: The applicant stated that the basemat AMP specifies visual inspection of the above-ground exposed surface of the basemat to identify and manage a variety of aging effects, including loss of material, cracking, loss of strength, reduction in concrete pH, loss of concrete-to-steel bond, and increase in porosity and permeability. These aging effects are associated with possible aging mechanisms for concrete structures including freeze-thaw, aggressive chemical attack, corrosion of reinforcing steel, salt scaling, reaction with aggregates, differential settlement, delayed ettringite formation, microbiological degradation. and leaching of calcium hydroxide. The applicant stated that the basemat AMP also includes visual examination for loss of material due to general corrosion, pitting corrosion, and crevice corrosion of the steel components.

The staff noted that the scope of program for the applicant's basemat AMP for concrete components differs from the example AMP in NUREG-2214, Table 6-3. Specifically, the scope of the applicant's basemat AMP does not include general area walkdowns of all reinforced concrete structures, nor does it include radiation surveys to assess concrete shielding performance.

In response to an RAI (ADAMS Accession No. ML20192A126), the applicant justified the exclusion of the general area walkdowns based on ACI 349.3R-2018. The applicant noted that the above-grade surface is exposed to the natural environment with the remaining portion located under the HSM. The basemat is not continuously exposed to fluids, nor is it expected to see heavy concentrations of aggressive chemicals. Therefore, the applicant concluded that the basemat does not see an environment more aggressive than the “structure exposed to natural environment” category listed in Table 6 of ACI 349.3R-2018. The applicant stated that the basemat is part of the load-bearing foundation supporting the HSMs. The basemat is classified as a NITS structure, but the scoping evaluation determined that its failure could prevent fulfillment of the structural integrity and retrievability functions. The applicant stated that to prevent fulfillment of these functions, the aging-related degradation would have to be very severe and to have gone undetected for many years. The applicant concluded that, considering the safety significance of the basemat, the degree of aging degradation required to prevent fulfillment of an intended function, and the environment seen by the basemat, the 5-year visual inspection frequency called for in Table 6 of ACI 349.3R-2018 is appropriate.

The staff reviewed the applicant’s description of the scope of program for the basemat AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.1. The staff reviewed the applicant’s RAI response and determined that, while the applicant’s basemat AMP scope of program differs from that of the example AMP in NUREG-2214, Table 6-3, the applicant’s AMP is consistent with the guidance in ACI 349.3R-2018. The staff noted that Table 2-1 of the Standard Advanced NUHOMS® System renewal application indicates that the basemat does not have a shielding function. The staff reviewed the UFSAR for the system and finds that the applicant has correctly identified the intended function of the basemat, which is to provide support to the storage modules. It does not function as a shielding component. Therefore, the staff determined that periodic radiation surveys are not applicable to monitoring aging mechanisms for the basemat. Based on the information in the renewal application and the applicant’s response to the NRC’s RAI, the staff determined that the applicant has justified the scope of program for the concrete subcomponents covered by the basemat AMP, the specific materials of the subcomponents, intended functions to be maintained, operating environments, and the aging mechanisms and effects to be managed.

Preventive actions: The applicant stated that the basemat AMP is a condition-monitoring program that does not include preventive actions.

The staff determined that the applicant’s description is acceptable and noted that NUREG-1927, Revision 1, Section 3.6.1.2, states that some condition or performance monitoring programs do not rely on preventive actions and thus this information need not be provided. The staff noted that the applicant’s preventive actions element for the basemat AMP is consistent with the example AMP in NUREG-2214, Table 6-3, for the reinforced concrete basemat.

Parameters monitored or inspected: The applicant stated that the basemat AMP consists of visual inspections to monitor for material degradation identified in the scope of program for the basemat AMP. The applicant identified that the normally accessible basemat will be examined by direct visual examination.

The staff reviewed the applicant’s description of the parameters monitored and inspected for the basemat AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.3. The staff determined that the program element identifies the specific parameters that will be monitored or inspected and includes indications of concrete aging effects. The staff determined that because the applicant’s AMP includes examination for evidence of concrete aging mechanisms and corrosion of the embedded steel, the parameters monitored and inspected will be capable of identifying degradation or potential degradation before a loss of intended function of the basemat.

Detection of aging effects: The applicant stated that if the ISFSI has more than one basemat for the Standardized Advanced NUHOMS® System, a minimum of one basemat will be selected for the baseline and subsequent visual inspections. The selection of the basemat for baseline and subsequent inspections is to be based on the time in service. The applicant stated that the baseline AMP visual inspection is to be conducted within 2 years before the period of extended operation. Subsequent inspections are to be conducted every 5 years ± 1 year following the baseline inspection.

The applicant stated that direct visual inspection utilizing ACI 349.3R (ACI 2018), Section 3.6.1, is conducted for the above-ground exposed surface of the basemat concrete, allowing for detection of aging effects for subcomponents within the scope of the basemat AMP identified in renewal application Table 4-5. For the basemat concrete, crack maps are developed, and dimensions are documented in photographic records by inclusion of a tape measure, crack gauge, or comparator. Potential degradation of the below-grade portion of the concrete pad is assessed by results of ground water sampling at a minimum of three locations in the area of the ISFSI, which is consistent with the criteria in ACI 349.3R-2018.

The staff reviewed the applicant's detection of aging effects for the basemat AMP and determined that the description is acceptable because the program element identifies the inspection method, the applicable subsections of ACI 349.3R (ACI 2018) for the concrete inspections and monitoring of ground water chemistry for assessing the potential for degradation of the below-grade sections of the basemat. In addition, the staff determined that the basemat AMP detection of aging effects element identifies the personnel qualifications, sample size, timing of inspections, and inspection frequency. The staff determined that the applicant provided information consistent with NUREG-1927, Revision 1, Section 3.6.1.4, and identified activities for the detection of aging effects AMP element that will enable identification and degradation or potential degradation of the basemat before a loss of intended function.

Monitoring and trending: The applicant stated that the inspections and monitoring activities in the basemat AMP are performed periodically to identify areas of degradation. Conditions adverse to quality that are noted during the inspection and monitoring activities, such as nonconformances, failures, malfunctions, deficiencies, and deviations, are entered into the general licensee's corrective action program. The applicant noted that the visual inspections appropriately consider cumulative operating experience from previous inspections and assessments in order to monitor and trend the progression of aging effects over time. Data from these inspections are to be monitored by comparison to past site data, as well as comparison to industry operating experience, including data gathered by AMID as discussed in NEI 14-03 (NEI 2016).

The applicant stated that for basemat concrete, crack maps are monitored and trended to identify progressive growth of defects that may indicate degradation due to specific aging effects, such as rebar corrosion. Crack maps and photographic records are compared with those from previous inspections to identify accelerated degradation of the concrete during the period of extended operation.

In response to an NRC RAI (ADAMS Accession No. ML20192A126) on the monitoring and trending of inspection results, the applicant clarified that all inspections will be performed under the general licensee's administrative controls for performance of work at the site. The applicant noted that these work controls include provisions for the documentation of work performed, including a collection of logs, notes, observations, photographs, video images, and test data. These controls ensure that data will be collected on observations made during the inspections.

The applicant added that the basemat AMP explicitly requires all conditions that do not meet the listed acceptance criteria be entered into the general licensee's corrective action program for evaluation, as well as monitoring and trending.

The staff reviewed and determined that the applicant's monitoring and trending element for the basemat AMP is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.5. Based on the information in the renewal application and the applicant's response to the NRC's RAI, the staff determined that the applicant has provided an acceptable description of the inspection information for monitoring and trending. The staff reviewed the applicant's description of the monitoring and trending element for the basemat AMP and verified that the AMP element includes a baseline inspection established at the beginning of the period of extended operation, and that conditions adverse to quality that are identified during the inspection and monitoring activities are entered into the general licensee's corrective action program. The staff noted that the general licensee's corrective action program will evaluate the inspection results against the AMP acceptance criteria to ensure that the next scheduled inspection will occur before a loss of intended function.

Acceptance criteria: The criteria are directed at the identification and evaluation of degradation that may affect the ability of the basemat to perform its intended functions. The applicant stated that the ACI 349.3R-2018 second-tier acceptance criteria are the basis for the basemat AMP. For instances when the inspection acceptance criteria are exceeded, the identified issue requires further evaluation and is entered into the general licensee's corrective action program.

The staff reviewed the applicant's acceptance criteria for the basemat AMP and determined that the description is acceptable because the applicant provided information consistent with NUREG-1927, Revision 1, Section 3.6.1.6. Furthermore, the staff determined that the acceptance criteria for the basemat AMP are acceptable because they are based on accepted ACI 349.3R-2018 requirements and include specific numerical values to ensure that the design bases are maintained. The staff notes that the use of the second-tier acceptance criteria is assessed in ACI 349.3R-2018, Chapter 5, which indicates that for structures with (1) a large section thickness, (2) concrete cover thicknesses per ACI 349-13, and (3) no exposure to aggressive degradation mechanisms, the use of the second-tier evaluation criteria is acceptable. In addition, the staff noted that ACI 349.3R-2018 states that the use of the second-tier acceptance criteria will aid in identifying degradation at an early stage, while the affected structure is still repairable. As such, the staff determined that the acceptance criteria for the basemat AMP are adequate to ensure that the basemat's intended functions and the approved design bases are maintained during the period of extended operation.

Corrective actions: The applicant stated that the general licensee's QA procedures, review and approval processes, and administrative controls are implemented according to the requirements of 10 CFR Part 50, Appendix B, which ensures that conditions adverse to quality are promptly identified and corrected. These requirements include root cause determination and prevention of recurrence. The applicant stated that deficiencies are either corrected or are evaluated to be acceptable for continued service through engineering analysis, which provides reasonable assurance that the intended functions are maintained consistent with current licensing-basis conditions. The applicant stated that the evaluations performed to assess conditions associated with aging should use the same methodology as in the licensing and design-basis calculations, which are maintained by the CoC holder, to ensure that intended functions continue through the period of extended operation. In addition, the applicant stated that extent of condition investigations per the general licensee's corrective action program may result in additional inspections by a different method, increased inspection frequency, or expanded inspection sample size.

In response to an NRC RAI (ADAMS Accession No. ML20192A126) about the basemat AMP corrective actions, the applicant stated that it is typical for the NUHOMS® HSM arrays that basemats are added as the HSM array sizes are increased for additional storage capacity. The applicant clarified that a site may choose to perform the formal AMP inspection only on the basemat that has been in service the longest. If that inspection identifies age-related degradation, the corrective action program may determine that an expanded AMP inspection on another basemat is necessary.

The staff reviewed the applicant's description of the corrective actions element for the basemat AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.7, which states that an applicant may reference the use of the corrective action program approved under 10 CFR Part 50, Appendix B. Based on the information in the renewal application and the applicant's response to the NRC's RAI, the staff determined that the applicant's corrective actions for the basemat AMP are acceptable because the measures to be taken when the acceptance criteria are not met include root cause determination and actions to prevent the recurrence of significant conditions adverse to quality.

<u>Confirmation process</u>: The applicant stated that the confirmation process will be commensurate with the general licensee's QA program approved under 10 CFR Part 50, Appendix B, which ensures that the confirmation process includes provisions to verify that appropriate corrective actions have been completed and are effective. The applicant stated that the general licensee's QA program approved under 10 CFR Part 50, Appendix B, also contains provisions to prevent repetition of significant conditions adverse to quality.

The staff reviewed the applicant's description of the confirmation process element for the basemat AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.8. The staff verified that the confirmation process for the basemat AMP includes provisions to check that appropriate corrective actions have been completed and are effective and relies on the general licensee's QA program approved under 10 CFR Part 50, Appendix B, which contains provisions to prevent repetition of significant conditions adverse to quality.

<u>Administrative controls</u>: The applicant stated that the administrative controls under the CoC holder or licensee's QA procedures and corrective action program provide a formal review and approval process. The administrative controls are implemented in accordance with the requirements of 10 CFR Part 50, Appendix B, and will continue for the period of extended operation. Licensees and CoC holders use the 10 CFR Part 72 regulatory requirements to determine if a particular aging-related degradation condition or event identified by operating experience, research, monitoring, or inspection is reportable to the NRC.

The staff reviewed the applicant's description of the administrative controls element for the basemat AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.9, with the administrative controls performed in accordance with the general licensee's QA Program approved under 10 CFR Part 50, Appendix B.

Operating experience: The applicant provided a review of operating experience relevant to the Standardized Advanced NUHOMS® System, which includes inspections of system SSCs that have been in service for more than 20 years. While the review identified several conditions that were age related, it found no incidents in which aging effects led to the loss of an intended function for a NUHOMS® System SSC. The applicant stated that the operating experience review supported its conclusion that the effects of aging will be managed so that the SSCs' intended functions will be maintained during the period of extended operation.

In response to an RAI (ADAMS Accession No. ML20192A126), the applicant justified not including tollgates for the basemat AMP. NEI 14-03 (NEI 2016) introduced the tollgates concept to address cases in which there are knowledge gaps related to aging mechanisms and effects that cannot be addressed before the start of the renewal storage period. The applicant stated that the aging mechanisms and effects for the concrete used in the basemat are well understood, and because there are no postulated knowledge gaps that cannot be addressed before the start of the renewal storage period, there is no need for formal tollgate assessments. While no formal tollgate assessments are required, the basemat AMP does include requirements in the operating experience element for the licensee to update the AMP as necessary to incorporate new information on degradation due to aging effects identified from plant-specific inspection findings, related industry operating experience, and related industry research. The applicant noted that future plant-specific and industry aging management and aging-related operating experience are captured through the licensee's operating experience review process, and the ongoing review of both plant-specific and industry operating experience will continue through the period of extended operation to ensure that this AMP remains effective in managing the identified aging effects.

The staff reviewed the applicant's description of the operating experience element for the basemat AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-1927, Revision 1, Section 3.6.1.10. The staff determined that the applicant assessed current operating experience and included provisions to capture future plant-specific and industry aging management and aging-related operating experience through the licensee's operating experience review process.

3.5.4 Review of High-Burnup Fuel Aging Management Program

Following the guidance in NUREG-1927, Revision 1, Appendix D, the staff conducted the safety review of the applicant's HBU fuel AMP in the license renewal application. In addition, the staff compared the HSM AMP provided by the applicant to the generically acceptable example AMP in NUREG-2214, Section 6.10 and Table 6-7.

Scope of program: The applicant stated that the program relies on the joint EPRI and U.S. Department of Energy HBU Dry Storage Cask Research and Development Project (HDRP) (EPRI 2014). The AMP is conducted in accordance with the guidance in Appendix D to NUREG-1927, Revision 1, as a surrogate demonstration program for monitoring the performance of HBU fuel in dry storage. The HDRP is designed to collect data from a spent nuclear fuel storage system containing HBU fuel in a dry helium environment. The program entails loading and storing an AREVA TN-32B bolted lid cask at Dominion Virginia Power's North Anna Power Station with intact HBU pressurized-water reactor fuel with burnups ranging from 53 to 58 GWd/MTU. The applicant justified the use of the HDRP (EPRI 2014) as a surrogate for the Standardized Advanced NUHOMS® HBU AMP, which considers fuel burnup, cladding type, and fuel temperature limits during drying operations and storage.

The staff reviewed the applicant's description of the scope of program for the HBU AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-2214, Table 6-7, and is consistent with the supplemental guidance in Appendix D to NUREG-1927, Revision 1. The staff noted that, per the CoC TS (ADAMS Accession No. ML19036A558) and safety analysis reports supporting CoC Amendment 3 (ADAMS Accession No. ML16228A020) and Amendment 4 (ADAMS Accession No. ML19073A200), the 24PT1 DSC was approved to store both Zircaloy clad and stainless steel clad fuel. However, the fuel burnup was limited to 45 GWd/MTU, and the fuel was not considered HBU fuel. The 24PT4 and the 32PTH2 DSCs were approved to store HBU fuel with zirconium alloy cladding. The staff determined that the HBU fuel stored in the Standardized Advanced NUHOMS® DSCs is represented by the HDRP (EPRI 2014), as cited by the applicant. The staff determined that the applicant's reliance on the HDRP for the HBU AMP is acceptable because the HDRP is representative of the fuel cladding materials and burnups approved for the Standardized Advanced NUHOMS® and the evaluations conducted by the HDRP apply to assessments of intended functions to be maintained, operating environments, and aging mechanisms and effects for the HBU fuel approved for storage in the 24PT4 and 32PTH2 DSCs.

Preventive actions: The applicant stated that during the initial loading operations of the cask/canister, the design and CoC TS require that the fuel be stored in a dry and inert environment. CoC TS 3.1.1 requires that the cask/canister cavity be dried by maintaining a cavity absolute pressure less than or equal to 3 torr for at least 30 minutes with the cask/canister isolated from the vacuum pump. In addition, CoC TS 3.1.2 requires that the DSC then be backfilled with helium. The applicant stated that these two TS requirements ensure that the HBU fuel is stored in a dry and inert environment, thus preventing cladding degradation due to oxidation mechanisms.

The staff determined that the applicant's description of preventive actions is acceptable because the program element follows the guidance in NUREG-2214, Table 6-7. The staff confirmed that the procedures and TS for spent fuel loading, including the removal of water during drying operations and maintaining an inert environment, are consistent with ISG-22 (ADAMS Accession No. ML061170217). In addition, the principal design criteria for the 24PT4 and the 32PTH2 DSCs is consistent with the NRC guidance in ISG-11, Revision 2 (ADAMS Accession No. ML022110372) or ISG-11, Revision 3 (ADAMS Accession No. ML033230335), including the maximum fuel cladding temperature limits and specific limits on thermal cycling during drying operations. The 24PT4 and the 32PTH2 DSCs design basis and TS for loading operations are sufficient to prevent aging or mitigate the rates of aging for the zirconium alloy cladding in drying operations and during storage.

Parameters monitored or inspected: The applicant stated that the parameters monitored or inspected are as described in the HDRP (EPRI 2014). While the research project cask is on the storage pad, these parameters include temperature measurements at various locations within the cask, and temperature is the key driver for hydride-induced embrittlement and thermal creep. The research project cask is expected to be transported to an offsite fuel examination facility, where the cask will be reopened and the fuel examined for changes that occurred as a result of the drying operation and during storage.

The staff reviewed the applicant's description of the parameters monitored and inspected for the HBU AMP and determined that the applicant's description is acceptable because the program element follows the guidance in NUREG-2214, Table 6-7, and is consistent with the supplemental guidance in Appendix D to NUREG-1927, Revision 1. The staff verified that the program element identifies the specific parameters that will be monitored or inspected and includes parameters that are directly tied to degradation mechanisms for HBU fuel. The staff determined that because the applicant's AMP includes examination of the fuel in the HDRP for evidence of aging mechanisms after a storage period, the parameters monitored and inspected will be able to identify degradation or potential degradation before a loss of intended function of the HBU fuel in the 24PT4 and 32PTH2 DSCs.

Detection of aging effects: As previously noted, the applicant stated that while the research project cask is on the storage pad, temperature is measured at various locations within the cask because temperature is the key driver of hydride-induced embrittlement and thermal creep. The applicant stated that after approximately 10 years of storage at the ISFSI site, the research project cask will likely be transported to an offsite fuel examination facility, where rods will be extracted from the HBU assemblies for nondestructive and destructive examinations. The nondestructive and destructive exams will include cladding profilometry to evaluate creep, rod internal gas pressure, hydride content and orientation, and cladding mechanical property tests. Data from these examinations will directly indicate the susceptibility of HBU fuel to hydride-induced embrittlement and thermal creep.

The staff reviewed the applicant's detection of aging effects for the HBU AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-2214, Table 6-7, and is consistent with the supplemental guidance in Appendix D to NUREG-1927, Revision 1. The staff verified that the program element identifies the inspection method and the data to be collected from the HDRP while the cask is in storage and after the fuel rods are removed from the cask. For these reasons, the staff determined that the activities for the detection of the aging effects AMP element will be able to identify degradation or potential degradation of HBU fuel stored in the CoC 1029 system before a loss of intended function.

Monitoring and trending: The applicant stated that as information and data from a surrogate demonstration program or from other sources such as testing or research results and scientific analyses become available, the general licensees will monitor, evaluate, and trend the information. The general licensees may use their corrective action program to determine what actions to take or to incorporate the information into operating experience. Formal evaluations of the aggregate information from a surrogate demonstration program and other available domestic or international operating experience, including data from monitoring and inspection programs and NRC-generated communications, will be performed at specific times during the period of extended operation, as described in the HBU AMP operating experience element and the HBU AMP tollgates in Table 4-2 of the CoC renewal application.

The staff reviewed the applicant's description of the monitoring and trending element for the HBU AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-2214, Table 6-7. The staff verified that the AMP element identifies the sources of information that will be monitored and trended. In addition, the staff determined that the applicant's HBU AMP tollgates in Table 4-2 of the CoC renewal application are consistent with the timing and information identified in NUREG-1927, Revision 1, Table B-4.

Acceptance criteria: The applicant provided acceptance criteria to be applied to the data obtained from the HDRP (EPRI 2014). These include acceptance criteria for cladding temperature, cladding creep, and hydride reorientation. If any of the fuel performance criteria is not met, the condition will be addressed in accordance with the licensee's corrective action program.

The staff reviewed the applicant's acceptance criteria for the HBU AMP. The staff determined that the acceptance criteria for the HBU AMP are acceptable because the applicant will use the data obtained from the HDRP (EPRI 2014), which was initiated to assess the performance of HBU fuel in dry storage. The staff noted that the applicant's HBU AMP acceptance criteria differ from the acceptance criteria in NUREG-2214, Table 6-7. Specifically, the example AMP in NUREG-2214, Table 6-7, includes criteria for hydrogen content and moisture content. The staff verified that gas sampling for water content and hydrogen generation is included in the HDRP (EPRI 2014) and is also considered in the HBU AMP tollgates in the renewal application for the Standardized Advanced NUHOMS® System. In addition, the staff noted that the CoC includes TS discussed in the preventive actions element of the HBU AMP for drying and helium backfill to ensure that moisture is removed during drying and the fuel is stored in an inert environment that also facilitates heat transfer.

Corrective actions: The applicant stated that the general licensee's QA procedures, review and approval processes, and administrative controls are implemented according to the requirements of 10 CFR Part 50, Appendix B, which ensures that conditions adverse to quality are promptly identified and corrected. The requirements include root cause determination and prevention of recurrence. The applicant stated that deficiencies are either corrected or are evaluated to be acceptable for continued service through engineering analysis, which provides reasonable assurance that the intended functions are maintained consistent with current licensing-basis conditions. Evaluations of conditions associated with aging should use the same methodology as in the licensing and design-basis calculations, which are maintained by the CoC holder, to ensure that intended functions are maintained through the period of extended operation. In addition, the applicant stated that extent of condition investigations per the general licensee's corrective action program may result in additional inspections by a different method, increased inspection frequency, or expanded inspection sample size.

The staff reviewed the applicant's description of the corrective actions element for the HBU AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-2214, Table 6-7, which states that an applicant may reference the use of the corrective action program approved under 10 CFR Part 50, Appendix B. The staff verified that the applicant's HBU AMP tollgates address corrective actions required based on the results from the HDRP (EPRI 2014). In addition, the staff verified that the applicant's HBU AMP tollgates address actions to be taken if the destructive examination data from the HDRP are not obtained in time to support the HBU AMP tollgates.

Confirmation process: The applicant stated that the confirmation process will be commensurate with the general licensee's QA program approved under 10 CFR Part 50, Appendix B, which ensures that the confirmation process includes provisions to verify that appropriate corrective actions have been completed and are effective. The applicant stated that the general licensee's QA program approved under 10 CFR Part 50, Appendix B, also contains provisions to preclude repetition of significant conditions adverse to quality.

The staff reviewed the applicant's description of the confirmation process element for the HBU AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-2214, Table 6-7. The staff verified that the confirmation process for the HBU AMP includes provisions to verify that appropriate corrective actions have been completed and are effective and relies on the general licensee's QA program approved under 10 CFR Part 50, Appendix B, which contains provisions to prevent repetition of significant conditions adverse to quality.

Administrative controls: The applicant stated that the administrative controls under the CoC holder or general licensee's QA procedures and corrective action program provide a formal review and approval process. These administrative controls comply with the requirements of 10 CFR Part 50, Appendix B, and will continue for the period of extended operation. Licensees and CoC holders use the 10 CFR Part 72 regulatory requirements to determine if a particular aging-related degradation condition or event identified via operating experience, research, monitoring, or inspection is reportable to the NRC.

The staff reviewed the applicant's description of the administrative controls element for the HBU AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-2214, Table 6-7, with the administrative controls performed in accordance with the general licensee's QA program approved under 10 CFR Part 50, Appendix B.

Operating experience: The applicant stated that short-term testing and analyses examining the performance of HBU fuel form a foundation for the technical basis that HBU fuel may be stored safely and in compliance with regulations during the period of extended operation. The applicant also stated that there has been relatively little operating experience to date with dry storage of HBU fuel. Consequently, the HDRP (EPRI 2014) is used as a surrogate program to monitor and assess data on HBU fuel performance to confirm that there is no degradation of HBU fuel that would result in an unanalyzed configuration during the period of extended operation.

The applicant stated that the HBU AMP will be updated as necessary to incorporate new information on degradation due to aging effects identified from plant-specific inspection findings, related industry operating experience, and related industry research. The general licensee's operating experience review process will capture future plant-specific and industry aging management and age-related operating experience. Ongoing review of both plant-specific and industry operating experience will continue through the period of extended operation to ensure that this AMP remains effective in managing the identified aging effects. In addition to the ongoing operating experience review, the HBU AMP requires periodic written evaluations, as described in CoC 1029 renewal application Table 4-2, of the aggregate impact of aging-related HBU fuel operating experience, research, monitoring, and inspections on the intended functions of the in-scope HBU fuel subcomponents.

The staff reviewed the applicant's description of the operating experience element for the HBU AMP and determined that the description is acceptable because the program element follows the guidance in NUREG-2214, Table 6-7. The staff determined that the applicant assessed current operating experience and identified the information to be obtained from the HDRP (EPRI 2014) and actions to be taken for alternative information sources if the destructive examination data from the HDRP are not obtained in time to support the HBU AMP tollgates.

3.5.5 Aging Management Program Updates and Tollgates

The applicant stated that all of the AMPs are "learning" AMPs. This means that the AMPs will be updated, as necessary, to incorporate new information on degradation due to aging effects identified in inspection findings, related industry operating experience, and related industry research.

The applicant incorporated periodic tollgate assessments for the DSC and HBU fuel AMPs. Attachment A to the CoC renewal application includes a schedule for these tollgate assessments. These tollgate assessments include ongoing reviews of industry operating experience. The tollgate process will continue on a routine basis throughout the period of extended operation to ensure that both the DSC and HBU fuel AMPs remain effective in managing the identified aging effects. The applicant clarified that future reviews of operating experience via the tollgate process may identify areas where the DSC and HBU fuel AMPs should be enhanced or new programs developed. If the review of operating experience identifies needed enhancements or new programs, then pertinent procedures for implementing these AMPs will be revised to address any lessons learned.

To prepare the tollgate assessments effectively, the applicant stated that the licensee will have access to the industry's AMID via the NUHOMS® vendor, TN Americas. The licensee will review the AMID to obtain and aggregate relevant information to support the preparation of the tollgate assessments and will prepare those assessments as recommended in NEI 14-03 (NEI 2016). The licensee will review AMP effectiveness as part of the tollgate assessment process and will make appropriate changes, subject to the change controls of 10 CFR 72.48, "Changes, tests, and experiments." The licensee will also enter information into AMID as directed by the AMP implementing procedures so that other ISFSI licensees performing tollgate assessments may use the information.

The applicant stated that the licensee intends to use AMID to develop its tollgate assessment but requested flexibility to also use other sources of relevant information in the future to augment AMID. Such information may or may not be available in AMID, based on the distribution restrictions on the information.

The applicant also noted that the tollgate process is not a substitute for other operating experience reviews conducted by the licensee or the licensee's corrective action program. The licensee will review the relevance of operating experience and other information or events pertaining to ISFSI aging-related issues as it becomes aware of them. As a result, actions will be taken in a timeframe commensurate with the safety significance of the issue. The corrective action program will address relevant items, as appropriate. The applicant clarified that the preparation of tollgate assessment reports are not required to be submitted to the NRC, but are available for inspection.

The staff reviewed the applicant's description of actions to ensure that the AMP remains effective during the period of extended operation upon review of new operating experience. The staff noted that the use of tollgates as described in NEI 14-03 (NEI 2016) is consistent with NUREG-1927, Revision 1, Section 3.6.1.10. The staff finds that the implementation of periodic tollgate assessments and the use of AMID, in addition to other periodic operating experience reviews consistent with the licensee's QA program, provide reasonable assurance that the DSC and HSM AMPs will remain effective during the period of extended operation.

3.5.6 Evaluation Findings

The staff reviewed the AMPs in the license renewal application. The staff performed its review following the guidance in NUREG-1927, Revision 1, and NUREG-2214. 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 72.240(c)(3).

4 LICENSE CONDITIONS TO ADDRESS RENEWAL

This section provides a consolidated list of the changes to the CoC conditions and TS resulting from the review of the renewal application. Previous sections of this SER have described some of these changes. This section also describes the different amendments to which the changes apply, since some changes do not apply to all of the CoC amendments. The basis of the changes is provided for those changes that are not described elsewhere in this SER.

4.1 Changes to Certificate of Compliance

1. **Added the following condition to the initial CoC (Amendment 0) and Amendments 1, 3, and 4:**

   UFSAR UPDATE FOR RENEWED COC

   The CoC holder shall submit an updated final safety analysis report (UFSAR) to the Commission, in accordance with 10 CFR 72.4, within 90 days of the effective date of the CoC renewal. The UFSAR shall reflect the changes resulting from the review and approval of the CoC renewal. The CoC holder shall continue to update the UFSAR pursuant to the requirements of 10 CFR 72.248.

   The CoC holder has indicated that changes will be made to the UFSAR to address aging management activities resulting from the renewal of the CoC. This condition ensures that the UFSAR changes are made in a timely fashion to enable general licensees using the storage system during the period of extended operation to develop and implement necessary procedures.

2. **Added the following condition to the initial CoC (Amendment 0) and Amendments 1, 3, and 4:**

   72.212 EVALUATIONS FOR RENEWED COC USE

   Any general licensee that initiates spent fuel dry storage operations with the Standardized Advanced NUHOMS® Horizontal Modular Storage System after the effective date of the CoC renewal, and any general licensee operating a Standardized Advanced NUHOMS® Horizontal Modular Storage System as of the effective date of the CoC renewal, including those that put additional storage systems into service after that date, shall:

   a. as part of the evaluations required by 10 CFR 72.212(b)(5), include evaluations related to the terms, conditions, and specifications of this CoC amendment as modified (i.e., changed or added) as a result of the CoC renewal;

   b. as part of the document review required by 10 CFR 72.212(b)(6), include a review of the UFSAR changes resulting from the CoC renewal and the NRC Safety Evaluation Report related to the CoC renewal; and

c. ensure that the evaluations required by 10 CFR 72.212(b)(7) and (8) capture the evaluations and review described in (a.) and (b.) of this CoC condition.

The general licensee shall complete [this] Condition [11/12] prior to entering the period of extended operation or no later than one year after the effective date of the CoC renewal, whichever is later.

The staff considers it important to ensure that appropriate considerations for the period of extended operation are evaluated in the general licensee's report required by 10 CFR 72.212, "Conditions of general license issued under § 72.210." These considerations arise from the analyses and assumptions in the renewal application regarding operations during the period of extended operation. This includes potential use by general licensees that may use the new Standardized Advanced NUHOMS® Horizontal Modular Storage System after the CoC has been renewed either at a new or an existing general license ISFSI. The renewal of the CoC is based on assumptions and analyses of the DSS and the sites where it is used. Licensees considering the use of the Standardized Advanced NUHOMS® Horizontal Modular Storage System must evaluate it for use at their respective sites. This condition also makes it clear that general licensees that currently use a Standardized Advanced NUHOMS® Horizontal Modular Storage System will need to update their 10 CFR 72.212 reports even if they do not put additional DSSs into service after the renewal's effective date, in accordance with 10 CFR 72.212(b)(11).

3. **Added the following condition to the initial CoC (Amendment 0) and Amendments 1, 3, and 4:**

AMENDMENTS AND REVISIONS FOR RENEWED COC

All future amendments and revisions to this CoC shall include evaluations of the impacts to aging management activities (i.e., time-limited aging analyses and aging management programs) to ensure that they remain adequate for any changes to SSCs within the scope of the CoC renewal.

The CoC may continue to be amended after it has been renewed. This condition ensures that amendments to the CoC also address aging management impacts that may arise from the changes to the system in proposed amendments.

4. **Added the following condition to the initial CoC (Amendment 0) and Amendments 1, 3, and 4:**

USE OF COC 1004 TRANSFER CASKS

General licensees shall not use the OS197, OS197H, and the OS200FC TCs aged 20 years or more to perform the TC functions described in the Standardized Advanced NUHOMS® System UFSAR after the PEO [period of extended operation] for CoC 1004 ends.

The CoC 1004 TC was initially certified for a term of 20 years. The CoC 1004 renewal application included an aging management review and an aging management program for the TC after the initial 20-year period during the period of extended operation. Therefore, staff consider use of the CoC 1004 TC aged 20 years or more to be acceptable for use during the PEO for CoC 1004. Staff consider use of the CoC 1004 TC aged 20 years or older to be prohibited in the absence of additional information to support TC performance after the PEO for the CoC 1004 ends.

5. Added the following condition to the initial CoC (Amendment 0) and Amendments 1, 3, and 4:

> INITIAL TERM
>
> Any Standardized Advanced NUHOMS® System loaded up to and including those loaded on February 5, 2023, shall be considered loaded during the initial term.

The condition is needed to clarify that any Standardized Advanced NUHOMS® System loaded during the period after the renewed effective date and prior to the expiration of the initial CoC term would be certified under the initial CoC.

The CoC holder proposed an additional license condition:

> DSC ORIENTATION DURING STORAGE
>
> The DSC design and supporting safety analyses are based on the DSC being stored in a horizontal orientation.

The NRC staff considered the proposed condition but decided not to include it in the renewed CoC. NUREG-1927 states:

> The reviewer should ensure the specific-license or CoC renewal application does not include any changes to the design bases. Changes to the design bases must be requested through a separate amendment process. However, the renewal application may include editorial changes or corrections that do not change the design bases.

The staff notes that the statement that the analyses assumed the DSC was stored in the horizontal orientation is accurate. The staff also notes that the condition would not change the design bases. However, the condition is considered beyond the scope of an editorial change or correction.

4.2 Changes to Technical Specifications

1. Added the following text to the initial CoC (Amendment 0) and Amendments 1, 3, and 4 in Section 4.3.3, "Transfer Cask":

> The general licensee shall ensure that the requirements of the applicable TRANSFER CASK aging management program (AMP) under the Renewed CoC 1004 have been satisfied.

2. **Added the following section, "Aging Management Program," to the initial CoC (Amendment 0) and Amendment 1 as Section 5.2.6, and to Amendments 3 and 4 as Section 5.2.7**:

Aging Management Program

Each general licensee shall have a program to establish, implement, and maintain written procedures for each aging management program (AMP) described in the updated final safety analysis report (UFSAR). The program shall include provisions for changing AMP elements, as necessary, and, within the limitations of the approved licensing bases, to address new information on aging effects based on inspection findings and/or industry operating experience provided to the general licensee during the renewal period. The program document shall contain a reference to the specific aspect of the AMP element implemented by that program document, and that reference shall be maintained even if the program document is modified.

The general licensee shall establish and implement this program document prior to entering the period of extended operation or no later than one year after the effective date of the CoC renewal, whichever is later. The general licensee shall maintain the program document for as long as the general licensee continues to operate Standardized Advanced NUHOMS® Horizontal Modular Storage Systems in service for longer than 20 years.

The CoC holder proposed a condition to revise or create programs or procedures for implementing the AMPs in the supplement to the final safety analysis report. This specification ensures that programs or procedures address AMP activities required for extended storage operations.

5 CONCLUSIONS

Pursuant to 10 CFR 72.240(d), the design of a spent fuel storage cask will be renewed if (1) the QA requirements in 10 CFR Part 72, Subpart G, “Quality Assurance,” are met, (2) the requirements of 10 CFR 72.236(a) through (i) are met, and (3) the application includes a demonstration that the storage of spent fuel has not had significant adverse effects on ITS SSCs. Additionally, 10 CFR 72.240(c) requires that the safety analysis report accompanying the application contain TLAAs and AMPs demonstrating that the DSS SSCs will continue to perform their intended functions for the requested period of extended operation.

The NRC staff reviewed the renewal application for the Standardized NUHOMS® Storage System, in accordance with 10 CFR Part 72. The staff followed the guidance in NUREG-1927, Revision 1. Based on its review of the renewal application and the CoC conditions, the staff determines that the DSS meets the requirements of 10 CFR 72.240.

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