



SAFETY EVALUATION REPORT

FOR THE
TN-32 DRY STORAGE CASK
CERTIFICATE OF COMPLIANCE RENEWAL

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CONTENTS

EXECUTIVE SUMMARY.....	iv
1 GENERAL INFORMATION.....	1-1
1.1 CoC and CoC Holder Information.....	1-1
1.2 Safety Review.....	1-1
1.3 Application Content.....	1-2
1.4 NRC Guidance Documents.....	1-2
1.5 Evaluation Findings.....	1-3
2 SCOPING EVALUATION.....	2-1
2.1 Scoping and Screening Methodology.....	2-1
2.1.1 Scoping Process.....	2-2
2.1.2 Scoping Results.....	2-2
2.1.3 Structures, Systems, and Components Within the Scope of the renewal Review.....	2-3
2.1.4 Structures, Systems, and Components Not Within the Scope of the Renewal Review.....	2-5
2.2 Evaluation Findings.....	2-7
3 AGING MANAGEMENT REVIEW.....	3-1
3.1 Review Objective.....	3-1
3.2 Aging Management Review Process.....	3-1
3.3 Aging Management Review Results.....	3-2
3.3.1 Materials and Service Environments.....	3-2
3.3.2 Operating Experience.....	3-6
3.3.3 Aging Mechanisms and Aging Effects.....	3-6
3.3.4 Supplemental Evaluation.....	3-32
3.4 Evaluation Findings.....	3-33
3.5 Time-Limited Aging Analyses Evaluation.....	3-34
3.5.1 Boron Depletion in the in the borated aluminum plates.....	3-34
3.5.2 Establishment of fuel cladding temperature limits.....	3-35
3.5.3 Ensure cavity pressure remains above one atmosphere on the coldest day at the end of the storage period.....	3-36
3.5.4 Evaluation Findings.....	3-37
3.6 Aging Management Programs.....	3-38
3.6.1 TN-32 AMP.....	3-39
3.6.2 Storage pad AMP.....	3-44
3.6.3 Earthen berm AMP.....	3-50
3.6.4 Changes to the Updated Final Safety Analysis Report.....	3-54
3.6.5 Evaluation Findings.....	3-54
4 CONDITIONS TO ADDRESS RENEWAL.....	4-1
4.1 Changes to Certificate of Compliance.....	4-1
4.2 Changes to Technical Specifications.....	4-2
5 CONCLUSIONS.....	5-1
6 REFERENCES.....	6-1

TABLES

Table	Page
2.1-1 SSCs/contents within and not within the scope of the renewal review	2-3
3.3-1 Aging management review—materials	3-4
3.3-2 Aging management review—environments	3-5
3.3-3 Summary of the aging mechanisms and aging effects for steel	3-17
3.3-4 Summary of the aging mechanisms and aging effects for stainless steel	3-18
3.3-5 Summary of the aging mechanisms and aging effects for aluminum.....	3-19
3.3-6 Summary of the aging mechanisms and aging effects for nickel alloys	3-20
3.3-7 Summary of the aging mechanisms and aging effects for polymer materials	3-21
3.3-8 Summary of the aging mechanisms and aging effects for borated aluminum	3-21
3.3-9 Summary of the aging mechanisms and aging effects for concrete	3-22
3.3-10 Summary of the aging mechanisms and aging effects for spent fuel assembly cladding materials	3-23
3.3-11 Summary of the aging mechanisms and aging effects for spent fuel assembly hardware materials	3-24
3.3-12 Summary of the aging mechanisms and aging effects for soil materials	3-25
3.3-13 Aging mechanisms and effects that require aging management—TN-32 Dry Storage Cask	3-27
3.3-14 Aging mechanisms and effects that require aging management—ISFSI Storage pad	3-29
3.3-15 Aging mechanisms and effects that require aging management—Earthen Berm.....	3-31

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 TN Americas LLC a Certificate of Compliance for 20 years, with an expiration date of April 19, 2020. The NRC approved the TN-32 Dry Storage Cask design under 10 CFR Part 72, Subpart K for storage of spent nuclear fuel (SNF) 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 or 10 CFR Part 52.

By letter dated March 5, 2020 (Agencywide Documents Access and Management System (ADAMS) Accession Number ML20065J427), as supplemented by letters dated November 11, 2020 (ADAMS Accession Number ML20316A030), February 5, 2021 (ADAMS Accession Number ML21036A237), and March 17, 2021 (ADAMS Accession Number ML21076A040), TN Americas LLC (applicant) submitted an application to the NRC for renewal of Certificate of Compliance (CoC or certificate) No. 1021, 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.” Under 10 CFR 72.240(b), because the applicant submitted the renewal application more than 30 days before the Certificate’s expiration date, this application constitutes a timely renewal. In the application, the applicant documented the technical bases for renewal of the certificate and commitments to actions for managing the potential aging effects of the systems, structures, and components (SSCs) of the dry storage system 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 hereafter as the period of extended operation (PEO) or extended storage).

The TN-32 Dry Storage Cask is a bolted lid, metal cask dry storage system (DSS). The TN-32 Dry Storage Cask has integrated trunnions that allow the cask to be lowered into the spent fuel pool for loading, and transferred to the storage pad after drying, and inerting. The TN-32 Dry Storage Cask has integrated gamma and neutron shielding to minimize the radiation dose rate from the ISFSI. The TN-32 Dry Storage Cask is designed to withstand all normal, off-normal, and credible accident conditions.

In the renewal application, the applicant presented general information about the DSS design with a scoping analysis to determine the SSCs that are within the 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 effects on the SSCs that are within the scope of renewal to ensure that these SSCs will maintain their intended functions during the PEO. 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 PEO: (1) an analysis which supports finding that no aging management is necessary because no aging effects are relevant for the SSC; (2) updated, time-limited aging analyses (TLAA); (3) a supplemental aging analysis; or (4) an aging management program (AMP).

The NRC staff (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 (SER) summarizes the results of the staff’s review for compliance with 10 CFR 72.240. In its

review of the application and development of the SER, the staff followed the guidance provided in NUREG-1927, Revision 1, "Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel," dated June 2016 (NRC, 2016a) (ADAMS Accession No. ML16179A148), and (2) NUREG-2214, "Managing Aging Processes In Storage (MAPS) Report," issued July 2019 (NRC, 2019) (ADAMS Accession No. ML19214A111). NUREG-2214 establishes a generic technical basis for the safety review of ISFSI license and DSS CoC renewal applications, in terms of the evaluation of (1) aging mechanisms and effects that could affect the ability of ISFSI and DSS SSCs to fulfill their safety functions in the PEO (i.e., credible aging mechanisms and effects) and (2) aging management approaches to address credible aging effects, including examples of aging management programs that are considered generically acceptable to address the credible aging effects to ensure that the design bases will be maintained in the PEO. The staff evaluated the applicant's technical basis for its aging management review and proposed aging management programs and compared it to the generic technical basis in NUREG-2214. For comparison to the generic technical basis in NUREG-2214, the staff ensured that the design features, environmental conditions, and operating experience for the TN-32 Dry Storage Cask are bounded by those evaluated in NUREG-2214.

This SER is organized into six sections. Section 1 provides the staff's review of the general information of the DSS. Section 2 presents the staff's review of the scoping evaluation performed for determining which SSCs are within the scope of the renewal. Section 3 provides the staff's evaluation of the aging management review for assessment of aging effects and aging management activities for SSCs within the scope of the 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 CoC and CoC Holder Information

On March 5, 2020, (ADAMS Accession Number ML20065J427), as supplemented on November 11, 2020 (ADAMS Accession Number ML20316A030), February 5, 2021 (ADAMS Accession Number ML21036A237), and March 17, 2021 (ADAMS Accession Number ML21076A040), TN Americas LLC (applicant or TN) submitted an application to renew Certificate of Compliance (CoC or certificate) No. 1021 for the TN-32 Dry Storage Cask under the provisions of 10 CFR Part 72, subparts K and L.

The applicant requested renewal of the initial CoC and Amendment No. 1. The NRC issued the initial CoC (Amendment 0) on April 19, 2000, and Amendment No. 1 on February 20, 2001. In its renewal application, TN provided a description of the certification basis for the TN-32 Dry Storage Cask initial issuance; general descriptions of the changes and reasons for Amendment No. 1; the date of CoC and CoC amendment issuance; and the corresponding updated final safety analysis report (UFSAR) revisions which incorporated the changes from Amendment No. 1. The applicant also provided a list of the amendments (i.e., Amendment No. 0 and Amendment No. 1) in Chapter 1 of the renewal application, with details and references.

1.2 Safety Review

The objective of this safety review is to determine whether the TN-32 Dry Storage Cask continues to meet the requirements of 10 CFR Part 72 during the period of operation that extends beyond the length of the term certified by the current certificate (referred to hereafter as the period of extended operation (PEO) or extended storage). The NRC staff safety review is a detailed and in-depth assessment of the technical aspects of the TN-32 Dry Storage Cask conducted for the CoC No. 1021 renewal application. Pursuant to 10 CFR 72.240(c)(1), 72.240(c)(2), and 72.240(c)(3), an application for renewal of a spent fuel storage cask CoC must be accompanied by a safety analysis report (SAR). The SAR must include the following: (i) design-bases information as documented in the most recently updated final safety analysis report as required by 10 CFR 72.248, (ii) time-limited aging analyses (TLAAs) that demonstrate that structures, systems, and components (SSCs) important to safety will continue to perform their intended function for the requested PEO, and (iii) a description of the aging management program(s) (AMP(s)) for management of issues associated with aging that could adversely affect structures, systems, and components important to safety.

The applicant stated that the renewal application Section 1.1 is consistent with guidance provided 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 2016a). In addition, the applicant stated that credible aging mechanisms for the SSC material/environment combinations included in the scope of the renewal was consistent with the evaluation in NUREG-2214, "Managing Aging Processes in Storage (MAPS) Report," issued July 2019 (ADAMS Accession No. ML19214A111) (NRC 2019). The applicant provided a scoping evaluation; an aging management review (AMR); and TLAAs and AMPs to assure that the SSCs within the scope of the renewal will continue to perform their intended function during the PEO.

The applicant stated that the renewal application is based on the continuation of the approved design basis throughout the PEO in accordance with NUREG-1927. In addition, the applicant stated that the identification and management of potential aging degradation mechanisms for different material/environment combinations was consistent with the generic evaluation in NUREG-2214 in support of the renewal application. This review documents the staff's evaluation of the applicant's scoping and screening evaluation, AMR, and supporting TLAAs, and AMPs per the guidance in NUREG-1927, as informed by NUREG-2214.

1.3 Application Content

The applicant's renewal application provided the following:

- general information
- scoping evaluation
- operating experience (OE) review
- AMR
- TLAAs and other supplemental evaluations
- AMPs
- changes to the TN-32 Dry Storage Cask UFSAR
- changes to the TN-32 Technical Specifications (TS)

The applicant had previously provided UFSAR revisions for all CoC amendments. The UFSAR revisions incorporated all changes to the TN-32 Dry Storage Cask previously made without prior NRC approval in accordance with 10 CFR 72.48(c) and (d). The applicant included the UFSAR changes for the updated TLAAs and AMPs in Attachment A of the renewal application. The applicant included proposed changes to the TS and CoC conditions in Attachment B of the renewal application.

1.4 NRC Guidance Documents

The staff relied on the guidance in NUREG-1927 to conduct the review of the renewal application. Specifically, the staff used the guidance in NUREG-1927, Chapter 2, Scoping Evaluation, to review the process used by the applicant for the scoping evaluation and the scoping evaluation results. The guidance in NUREG-1927, Chapter 3, Aging Management Review, was used to evaluate the applicant's AMR process, and results. The guidance in NUREG-1927, Section 3.4, Materials, Service Environments, Aging Mechanisms and Effects, and Aging Management Activities, was used to review the applicant's evaluation of aging mechanisms and effects of the materials and service environments for the SSCs and their subcomponents that were in the scope of renewal. The guidance in NUREG-1927, Section 3.5, Time-Limited Aging Analyses, was used to review the applicant's updated TLAAs, and supplemental analyses and the guidance in Section 3.6, Aging Management Programs, was used to review the applicant's AMPs.

The staff used the information in NUREG-2214 to inform its use of the guidance in NUREG-1927. NUREG-2214 is a technical basis document that provides additional guidance to NRC staff to improve the effectiveness and efficiency of the renewal process for the dry storage of SNF. NUREG-2214 provides a generic evaluation of the aging mechanisms that have the potential to challenge the ability of the dry storage system (DSS) SSCs to fulfill their important-to-safety functions. NUREG-2214 also describes acceptable generic AMPs that an applicant may use to maintain the approved design bases of its storage system during the 20- to 60-year

PEO. The staff used the information in NUREG-2214 to inform the review of the information in the renewal application related to the identification of materials, environments, aging mechanisms, and aging effects for the SSCs and their subcomponents within the scope of renewal. The staff used the example aging management programs in NUREG-2214, Chapter 6, Example Aging Management Programs, to supplement the guidance on AMPs in NUREG-1927, Section 3.6.

The staff developed Interim Staff Guidance (ISG) to clarify or to address issues not addressed in a Standard Review Plans (SRP), which includes NUREG-1536, "Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility," Revision 1 (NRC 2010) (ADAMS Accession No. ML101040620), and NUREG-1927. ISGs are to be used by the staff, industry, and other interested stakeholders until incorporated into staff guidance documents such as an NRC Regulatory Guide (RG) and SRPs. The applicant specifically referenced ISG-2, Revision 0 (ADAMS Accession No. ML092800367) (NRC 1998), and ISG-11, Revision 3 (ADAMS Accession No. ML033230335) (NRC 2003). Therefore, the staff used the guidance contained in these ISGs to review the applicant's evaluation of retrievability and fuel cladding temperatures in the renewal application.

In addition to NUREG-2214, ISG-2, and ISG-11 described above, the staff also used information included in additional NRC documents and other references to inform the guidance in NUREG-1927. These additional references are cited in this SER with descriptions of the information in these references and how the staff used the information to inform the guidance in NUREG-1927.

The staff evaluated the information included in the renewal application by comparing the description of the AMR process and results to the guidance in NUREG-1927 as informed by NUREG-2214, ISG-2, and ISG-11, as well as additional NRC documents and other references as necessary. The staff determined that the information and descriptions in the renewal application that followed the guidance in NUREG-1927 were acceptable. For the evaluation and descriptions of materials, environments, aging mechanisms, aging effects, and AMPs for the SSCs and their subcomponents within the scope of renewal, the staff determined that the information and description provided in the renewal application was acceptable if it was consistent with, or bounded by, the generic evaluation in NUREG-2214.

1.5 Evaluation Findings

The staff reviewed the general information provided in Chapter 1 of the renewal application. The staff performed its review following the guidance provided in NUREG-1927, and relevant ISGs. Based on its review, the staff finds:

- 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, "Conditions for spent fuel storage cask renewal".

2 SCOPING EVALUATION

As described in NUREG-1927, Chapter 2, a scoping evaluation is necessary to identify the SSCs subject to an AMR, where the effects of aging are assessed. More specifically, NUREG-1927, Section 2.4.2, states that the scoping evaluation is used to identify SSCs (and associated subcomponents) meeting any of the following criteria (scoping criteria 1 and 2):

- (1) SSCs (and associated subcomponents) that are classified as important to safety (ITS), as they are relied on for one of the following functions:
 - i. maintain the conditions required by the regulations or the specific license, or CoC to store spent fuel safely;
 - ii. prevent damage to the spent 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 (and associated subcomponents) that are classified as not important to safety (NITS) 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) sub-criticality control, (2) radiation shielding, (3) confinement, (4) heat-removal capability, (5) structural integrity, and (6) retrievability. If SSCs and associated subcomponents satisfy one of these criteria, they are within the scope of the renewal review.

After the determination of in-scope SSCs, the SSCs are screened to identify and describe the subcomponents that support the SSC intended functions. This screening identifies the SSC subcomponents that the applicant evaluates for potential aging effects and mechanisms that may require an aging management activity in the PEO.

2.1 Scoping and Screening Methodology

In Section 2 of the renewal application, the applicant performed a scoping evaluation and provided the following information:

- a description of the scoping and screening methodology for the inclusion of SSCs and SSC subcomponents in the scope of the 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 the renewal review and the basis for the scope determination.

The staff reviewed the scoping process and results provided in the 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 renewal application, the applicant discussed the scoping evaluation process and methodology used to determine the SSCs and associated subcomponents and subcomponent parts that are within the scope of the 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 NITS items that did not meet scoping criterion 2.

The staff reviewed the applicant's scoping process and determined that the applicant's process followed the guidance described in NUREG-1927, Section 2.4, and was acceptable.

2.1.2 Scoping Results

The applicant provided a summary of the results of the scoping evaluation in the renewal application, Table 2-1, and Section 2.3. The applicant provided detailed scoping analysis results for all the TN-32 Dry Storage Cask variants including the TN-32, TN-32A, and TN-32B in renewal application, Table 2-2. The applicant provided the detailed scoping analysis results for the spent fuel assemblies in renewal application, Table 2-3.

The applicant stated that, as part of the scoping evaluation, it reviewed the following sources of information which describe the approved design basis and the intended safety functions of the SSCs (and associated subcomponents):

- TN-32 Dry Storage Cask UFSAR, Revision 6, April 2014. (ADAMS Accession No. ML14108A025).
- CoC No. 1021 Certificate and TN-32 TS for each amendment as follows.
 - Amendment 0 CoC and TS: (ADAMS Accession No. ML003696874).
 - Amendment 1: CoC (ADAMS Accession No. ML010460308) and TS (ADAMS Accession No. ML010460423).
- NRC SERs for Amendment 0 (ADAMS Accession No. ML003696918) and Amendment 1 (ADAMS Accession No. ML010460317).

The applicant stated that, in defining if SSCs and their subcomponents were ITS or NITS, it used the drawings in Section 1.5 and Table 2.3-1 of the UFSAR as the source of both the TN-32 Dry Storage Cask SSCs and subcomponents, the material specifications, and safety classification. SSCs that were ITS were determined to be within the scope of the renewal per criterion 1. The applicant provided additional information concluding that the storage pad for the ISFSI should be scoped in under criterion 2 in the renewal application Section 2.3.3. The applicant stated that while the TN-32 Dry Storage Cask does not require the use of an earthen berm to meet regulatory dose limits, Section 10.2 of the TN-32 UFSAR does contain analyses modeling a berm. In the renewal application, the applicant presumes that if a general licensee chose to rely on an earthen berm to meet regulatory dose limits, the berm would be classified as an ITS structure and would satisfy criterion 1.

The staff reviewed the scoping results to determine whether the applicant reviewed all SSCs in the approved design bases and whether the conclusions regarding the out-of-scope SSCs accurately reflected the design bases in the TN-32 UFSAR. SER Table 2.1-1 lists the SSCs included and excluded from the scope of the renewal review per the renewal application. SER

Section 2.1.3 provides the staff’s conclusions regarding SSCs (and SSC subcomponents) within the scope of the renewal review. SER Section 2.1.4 provides the staff’s conclusions regarding SSCs (and SSC subcomponents) outside the scope of the renewal review.

Table 2.1-1. SSCs/Contents Within and Not Within the Scope of the renewal Review

SSC / Contents	Criterion 1	Criterion 2	In-Scope (Yes / No)
TN-32 Dry Storage Cask ¹	Yes	N/A	Yes
Spent Fuel Assemblies	Yes	N/A	Yes
ISFSI Concrete Storage Pad	No	Yes	Yes
Auxiliary Equipment ²	No	No	No
Miscellaneous Equipment ³	No	No	No
Earthen Berm ⁴	Yes	N/A	Yes

¹ Includes the TN-32, TN-32A, and TN-32B Dry Storage Casks.

² Auxiliary equipment used to facilitate cask loading, draining, drying, inerting, and sealing operations include, but are not limited to, special lifting devices, vertical cask transporter, and vacuum drying/helium leak test equipment.

³ Miscellaneous Equipment includes ISFSI security fence and gates, lighting, lightning protection, communications, and monitoring equipment.

⁴ This is in-scope if an earthen berm is credited by the general licensee in meeting regulatory dose limits. If the general licensee does not credit it, it is not in-scope.

2.1.3 Structures, Systems, and Components Within the Scope of the renewal Review

Per the scoping evaluation process and methodology, as discussed in Section 2.2 of the renewal application, the applicant identified the SSCs and subcomponents considered to be within the scope of the renewal review. As previously discussed in SER Section 2.1.1, this approach is consistent with the criteria defined in NUREG-1927. The applicant provided the scoping evaluation of TN-32 Dry Storage Cask system SSCs in renewal application, Table 2-1. The scoping evaluation of the TN-32 Dry Storage Cask subcomponents and the spent fuel assembly subcomponents are tabulated in renewal application, Tables 2-2 and 2-3, respectively.

The following discussions address the applicant’s basis for inclusion of an SSC and its subcomponents within the scope of the renewal review and clarify the staff’s review of that basis.

TN-32 Dry Storage Cask

The applicant included the TN-32 Dry Storage Casks within the scope of the renewal review because these are classified as ITS in accordance with renewal application, Table 2-1. The applicant clarified that the TN-32 Dry Storage Casks are within the scope of renewal under criterion 1. The applicant stated that the ITS functions provided by the TN-32 Dry Storage Casks and its subcomponents include confinement, radiation shielding, sub-criticality control, structural integrity, heat-removal capability, and retrievability. The applicant provided a scoping evaluation for the TN-32 Dry Storage Casks subcomponents in renewal application, Table 2-2.

The scoping evaluation included the subcomponent classification, the subcomponent safety function (if any), the subcomponent material, and if the failure of the subcomponent would affect the function of another ITS subcomponent (i.e., criterion 2 in NUREG 1927, Section 2.4.1). For the NITS TN-32 Dry Storage Cask subcomponents that were not screened in under criterion 2, the applicant provided a description of these subcomponents along with an analysis of the consequences of a failure of these subcomponents to support the determination for the subcomponents were categorized as NITS and not screened in under criterion 2.

The staff confirmed that the TN-32 Dry Storage Casks subcomponents are scoped within the renewal review because these are classified as ITS in accordance with drawings in Section 1.5 and Table 2.3-1 of the TN-32 Dry Storage Cask UFSAR. The staff compared the ITS functions 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, 1996a), as a reference for classifying components as ITS. The staff reviewed that the applicant's description and analysis for the NITS subcomponents not screened in under criterion 2. The staff determined that the applicant's assessment of these subcomponents followed the guidance in NUREG-1927, Section 2.4.2, which includes equipment associated with cask loading and unloading; instrumentation and other active components/systems; and miscellaneous hardware that does not support or perform any function that is ITS. The staff confirmed that the applicant provided scoping evaluation results for the subcomponents of the TN-32 Dry Storage Casks in Table 2-2 of the renewal application. Therefore, the staff determined that the applicant's screening assessment for the TN-32 Dry Storage Cask subcomponents followed the guidance in NUREG-1927, Chapter 2, and the results of the applicant's scoping evaluation were acceptable.

Spent Fuel Assemblies

The applicant included the spent fuel assemblies within the scope of the renewal review because the ITS functions for the fuel assemblies include confinement, sub-criticality control, structural integrity, and heat-removal capability as shown in renewal application, Table 2-1. Therefore, the applicant stated that the spent fuel assemblies satisfy criterion 1 and are within the scope of the renewal review. The applicant provided a scoping evaluation of the subcomponents of the spent fuel assemblies in Table 2-3 of the renewal application.

The staff noted that, in accordance with drawings in Section 1.5 and Table 2.3-1 of the TN-32 UFSAR, the subcomponents of the spent fuel assemblies are not classified as ITS. Nevertheless, the applicant's classification of the spent fuel assemblies as ITS is consistent with NUREG-1927, Section 2.4.2, which states that the renewal application should demonstrate that the analyzed fuel configuration relied on in the safety analyses will be maintained. In addition, NUREG-1927, Section 2.4.2.1, states that the spent fuel cladding and assembly hardware provide structural support to ensure that the spent fuel is maintained in a known geometric configuration and that the criticality and shielding safety analyses for a DSS may rely on the fuel assembly having a specific configuration. The staff confirmed that the applicant provided a scoping evaluation of the subcomponents of the spent fuel assemblies in Table 2-3 of the renewal application.

ISFSI Concrete Storage Pad

The applicant stated that the ISFSI concrete storage pad is classified as NITS; however, the applicant clarified that a portion of the pad is included in the thermal models. The applicant

stated that failure of the pad could affect the heat removal capability of the system. Therefore, the reinforced concrete storage pad meets criterion 2 and is within the scope of the renewal review as indicated in the CoC renewal application, Table 2-1.

The staff noted that, in accordance with drawings in Section 1.5 and Table 2.3-1 of the TN-32 UFSAR, the ISFSI concrete storage pad is not classified as ITS. The staff reviewed the applicant's assessment for including the ISFSI concrete storage pad under scoping criterion 2 and determined that this assessment is appropriate because a portion of the ISFSI concrete storage pad is credited in the analysis for heat removal capability.

Earthen Berm

The applicant stated that while the TN-32 Dry Storage Cask does not require the use of an earthen berm to meet regulatory dose limits, Section 10.2 of the UFSAR does contain analyses modeling a berm and indicates that a berm may be used as necessary to keep the site boundary dose rate within the 25 mrem/year limit. The applicant stated that the renewal application presumes that if a general licensee chose to rely on an earthen berm to meet regulatory dose limits, the berm will be classified as an ITS structure. Therefore, the applicant determined that if an earthen berm is credited, it satisfies criterion 1 and is within the scope of the renewal review.

The staff noted that the optional earthen berm is not included in the drawings in Section 1.5 nor is the berm identified in Table 2.3-1 of the TN-32 UFSAR. Therefore, the staff's review of the applicant's assessment of the optional berm was limited to the information provided in the renewal application. The staff reviewed the applicant's assessment for the optional earthen berm under scoping criterion 1 and determined that this assessment is appropriate because a general licensee may choose to rely on an earthen berm to meet regulatory dose limits.

Scoping Findings

The staff reviewed the applicant's screening of the SSCs and subcomponents within the scope of the renewal review. The staff's safety review followed the guidance in NUREG-1927. The staff reviewed the intended function of the SSC and subcomponent; its safety classification per the UFSAR, and the basis for inclusion in the scope of the renewal review; and design-bases information in the UFSAR. The staff notes that NUREG-2214 includes aging management tables developed using the UFSAR drawings for the TN-32 Dry Storage Cask which provide a generic basis for scoping of the SSCs. The staff compared the applicant's scoping evaluation results to the TN-32 Dry Storage Cask aging management tables in NUREG-2214. Based on this review, the staff finds that the applicant screened the in-scope SSCs and subcomponents in a manner consistent with NUREG-1927. Therefore, the staff finds the screening results for in-scope SSCs and subcomponents to be acceptable.

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

Per the scoping evaluation process and methodology, as discussed in Section 2.2 of the renewal application, the applicant identified the SSCs and subcomponents considered to be not within the scope of the renewal review. As previously discussed in SER Section 2.1.1, this approach is consistent with the criteria defined in NUREG-1927. Consistent with that scoping evaluation, the applicant identified these SSCs and subcomponents as not needing an AMR. These SSCs are identified in Table 2-1 of the CoC renewal application. The following

discussions address the applicant's basis for exclusion of an SSC from the scope of the renewal review. The discussions also provide clarifications on the staff's review of that basis for exclusion.

Auxiliary Equipment

The applicant stated that auxiliary equipment used to facilitate cask loading, draining, drying, inerting, and sealing operations include, but are not limited to, special lifting devices, vertical cask transporter, and vacuum drying/helium leak test equipment. The applicant cited CoC No. 1021 condition 1(b) which states, "The auxiliary equipment necessary for ISFSI operation is not included as part of the TN-32 Dry Storage Cask reviewed for a Certificate of Compliance under 10 CFR Part 72, Subpart L. Such equipment may include, but is not limited to, special lifting devices, transfer trailers or equipment, and vacuum drying/helium leak test equipment." Based on condition 1(b) in CoC No. 1021 and the results of the applicant scoping evaluation, the applicant concluded that the auxiliary equipment is not within the scope of the CoC No. 1021 renewal.

The staff reviewed the applicant's description in the renewal application and CoC condition 1(b). The staff noted that the TN-32 UFSAR Table 2.3-1 does not provide a safety classification for the auxiliary equipment. Nevertheless, the staff finds that the applicant's determination 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 the renewal review. Thus, the staff determined that the identification of the auxiliary equipment as NITS is consistent with the guidance in NUREG-1927, Section 2.4.3 which states that such equipment may be excluded from the scope of renewal review. This equipment is necessary for cask loading, drying, and transfer operations but are not relied on for ITS functions in cask storage operations. Therefore, the staff finds the applicant's exclusion of the auxiliary equipment from the scope of the 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 TN-32 Dry Storage Cask approved in accordance with 10 CFR Part 72, Subpart L. The applicant further stated that this 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 evaluation, the applicant stated that the miscellaneous equipment is not within the scope of the CoC No. 1021 renewal review.

The staff reviewed the applicant's assessment of the miscellaneous ISFSI equipment and noted that the guidance in NUREG-1927, Section 2.4.3, states that this type of equipment is specifically excluded from the scope of the renewal review 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 determination is consistent with staff's review guidance. The staff determined that the miscellaneous ISFSI equipment identified by the applicant—including ISFSI security fences and gates, lighting, lightning protection, communications, and monitoring equipment—are not part of the TN-32 Dry Storage Cask, the miscellaneous equipment is NITS, and failure of the miscellaneous equipment would not affect an ITS function. Therefore, the staff finds the applicant's exclusion of the miscellaneous equipment from the scope of the 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 SSC and subcomponent; its safety classification per the UFSAR, or basis for inclusion in the scope of the renewal review; and design-bases information in the UFSAR. Based on this review, the staff finds that the applicant screened the out-of-scope SSCs and subcomponents in a manner consistent with NUREG-1927. Therefore, the staff finds the screening results for out-of-scope SSCs and subcomponents to be acceptable.

2.2 Evaluation Findings

The staff reviewed the scoping evaluation provided in the renewal application. The staff performed its review following the guidance provided in NUREG-1927. To determine the accuracy and completeness of the scoping evaluation, the staff also used the information in NUREG/CR-6407, as a reference for classifying components as ITS.

Based on its review, the staff finds the following:

- F2.1 The applicant has identified all SSCs important to safety 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, "Conditions for spent fuel storage cask renewal".
- 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, as well as to determine whether the applicant has 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 PEO.

3.2 Aging Management Review Process

In the renewal application Section 3.2, the applicant described its AMR methodology 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

The applicant stated that the AMR follows the methodology provided in NUREG-1927, which provides an acceptable methodology for applicants to use, and which results in an assessment of the aging effects that could adversely affect the ability of the SSCs to perform their intended safety functions during the PEO. The applicant provided a description of the SSCs and their subcomponents within the scope of renewal. For each SSC subcomponent, the applicant identified the materials of construction and the operating environments. The applicant also reviewed OE as part of the AMR process. For the TN-32 Dry Storage Casks, the fuel assemblies, the ISFSI concrete pad, and the earthen berm, the applicant identified aging mechanisms and aging effects for these material and environment combinations along with the necessary activities to manage the effects of aging.

The staff reviewed the applicant's AMR process, including a description of the review process, and the design-bases references. The staff determined that the applicant evaluated the SSCs and their subcomponents using the SSC design, intended function of the subcomponent, and the subcomponent materials and operational environments. The staff then evaluated potential aging mechanisms and effects identified for these SSCs and their subcomponents to determine whether aging management was required to ensure that the intended functions of these SSCs and subcomponents were maintained throughout the PEO. Based on its review, the staff finds that the applicant's AMR process was consistent with the methodology in NUREG-1927, and was acceptable for identifying credible aging effects for the SSCs within the scope of the renewal. The staff determined that the applicant's AMR process was consistent with the generic evaluations for the TN-32 Dry Storage Cask components, spent fuel assemblies and hardware, and ISFSI concrete pad included in NUREG-2214. In addition, the staff determined that the applicant's AMR process for the earthen berm was consistent with appropriate OE, NRC guidance, and industry guidance on earthen structures. 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 and the subcomponents that were determined to be within the scope of the review. Specifically, the applicant identified the materials for the subcomponents of the TN-32 Dry Storage Casks, the ISFSI concrete pad, the optional earthen berm, and the spent fuel assemblies to be within the scope. The applicant stated that the materials of construction and the operating environments for the SSCs and their subcomponents were identified through a review of the drawings provided 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. To conduct this review the staff compared the information provided by the applicant to the guidance in NUREG-1927, Chapter 3, Aging Management Review, and the information included in NUREG-2214, Chapter 2, Definitions, and Chapter 3, Evaluation of Aging Mechanisms, along with appropriate industry guidance. If the staff determined that the applicant's conclusions were consistent with expected aging management activities per NUREG-2214, the staff considered the results acceptable, and this determination is documented in this SER. The discussions in the following sections address the applicant's AMR results including materials and environments in SER Section 3.3.1, OE in SER Section 3.3.2, and aging mechanisms and effects in SER Section 3.3.3.

3.3.1 Materials and Service Environments

In the renewal application Section 3.2.1, the applicant stated that the first step in the AMR process was to identify the materials of construction for each subcomponent of the in-scope SSCs and the environments to which those materials are exposed during normal storage conditions. The applicant then used these combinations of materials and environments to identify the potential aging effects that require management during the PEO.

In the renewal application Section 3.3.1, the applicant provided a description of the TN-32 Dry Storage Cask and its subcomponents. The applicant's description included the materials of construction and applicable codes for design, fabrication, and inspection. The applicant cited the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code sections used for the TN-32 Dry Storage Cask design and fabrication. The applicant provided a listing of the TN-32 Dry Storage Cask subcomponents in renewal application Table 3-5, which included the material group and the operating environment(s) for each subcomponent.

The applicant described the ISFSI reinforced concrete storage pad in renewal application Section 3.3.2. The applicant stated that the storage pad is a 3-foot thick (minimum) reinforced concrete structure designed and constructed in accordance with codes and standards set by the general licensee, and is subject to site-specific foundation analyses and design considerations, including licensee-specific TN-32 cask loading configurations. The applicant stated that the reinforced concrete pad was composed of concrete and steel reinforcement and identified the operating environments for these materials in renewal application Table 3-7.

The applicant described the spent fuel assemblies and their subcomponents in renewal application Section 3.3.3. The applicant stated that the TN-32 Dry Storage Cask is designed to store 32 pressurized water reactor (PWR) spent fuel assemblies with or without burnable poison rod assemblies or thimble plug assemblies. The applicant provided the fuel types, cladding material, and burnup limits approved for storage in the TN-32 Dry Storage Casks in renewal

application Table 3-1. The applicant provided a listing of the spent fuel assembly subcomponents, the subcomponent material group, and the operating environment in renewal application Table 3-8.

The applicant described the optional earthen berm in renewal application Section 3.3.4. The applicant described material and operating environments for the optional earthen berm in renewal application Table 3-9.

The staff used the guidance in NUREG-1927, Section 3.4.1.1, Identification of Materials and Environments, to review the SSC subcomponents materials and operational environments provided in the renewal application. The staff also used the information in NUREG-2214, Chapter 2, to inform the review of the applicant's descriptions of materials and environments.

The staff compared the materials identified in the CoC renewal application Section 3.2.1 to the list of materials included in NUREG-2214, Table 2-1. SER Table 3.3-1 identifies the materials of construction for the SSC within the scope of the renewal that were included in renewal application Table 3-2. SER Table 3.3-1 also provides a comparison of the materials in the 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 noted that soil used for the construction of the optional earthen berm was not a material evaluated in NUREG-2214. The staff reviewed the applicant's description of soil used in the construction of the optional earthen berm and determined that the description provided by the applicant was accurate. Therefore, the staff finds the applicant's AMR process for the identification of materials relevant to the TN-32 Dry Storage Cask, spent fuel assemblies, the optional earthen berm, and the concrete storage pad to be acceptable.

The staff compared the environments identified in the CoC renewal application Section 3.2.1 to the environments evaluated in NUREG-2214, Table 2-2, to determine equivalency. SER Table 3.3-2 identifies the environments considered for SSC subcomponents, as defined in the renewal application Section 3.2.1. SER Table 3.3-2 also identifies the comparison results for the SSC operating environment in the renewal application and 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. Therefore, the staff finds the applicant's AMR process for the identification of environments relevant to the TN-32 Dry Storage Cask, spent fuel assemblies, the optional earthen berm, and the concrete storage pad to be acceptable.

Table 3.3-1. Aging Management Review—Materials

Material group in the CoC 1021 Renewal Application	Material Description in the CoC 1021 Renewal Application Section 3.2.1 and Table 3-2	Equivalent Material(s) in NUREG-2214, Table 2-1
Steel	Carbon steels, alloy steels, high-strength low-alloy (HSLA) 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
Concrete	A mixture of hydraulic cement, aggregates, and water, with or without admixtures, fibers, or other cementitious materials.	Concrete
Spent fuel assembly cladding	Zircaloy	Zirconium-based alloys
Spent fuel assembly hardware	Stainless steel, zirconium-based alloys, nickel alloys	Stainless steel, zirconium-based alloys, nickel alloys
Borated aluminum	An aluminum alloy typically containing up to 4.5 weight percent boron used as a neutron poison material. The boron is incorporated in the aluminum matrix as discrete particles of AlB_2 or TiB_2 (for alloys also containing titanium). Aluminum alloys 1100, 6063, and 6351 have been used as base materials for boron additions.	Borated aluminum
Nickel Alloys	This group is limited to the nickel alloy option for the liner of the metallic seals.	Nickel alloys
Polymers	This group includes the polypropylene used in the top neutron shield and the borated polyester used in the radial neutron shield.	Borated polymers
Soil	Soil is a mixture of inorganic materials produced by the weathering of rock and clay minerals, and organic material produced by the decomposition of vegetation.	Not Applicable ¹
¹ Soil is not included in NUREG-2214		

Table 3.3-2. Aging Management Review—Environments

Environment in CoC 1021 Renewal Application	Description of the environment in the CoC 1021 Renewal Application Section 3.2.1	Equivalent Environment in NUREG-2214, Table 2-2
Air-Outdoor	The components are directly exposed to all outdoor weather conditions including insolation, wind, rain, snow, and site-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. This may prevent ingress of water and contaminants to the embedded surface, depending on the permeability of the embedding environment.	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 cask and trace quantities of other gases, such as nitrogen, oxygen, argon, and fission product gases.	Helium (HE)
Groundwater/Soil	The component surface is exposed to a soil environment with groundwater. Soil is a mixture of organic and inorganic materials produced by the weathering of rock and clay minerals or the decomposition of vegetation.	Groundwater/soil (GW)
¹ For the Embedded-in-Metal environment, the applicant assumed that the materials in this environment are treated as though they are exposed to the environment surrounding the embedding material.		

3.3.2 Operating Experience

In the renewal application Section 3.9 and Appendix 3C, the applicant also discussed the review of OE it conducted for the AMR in the renewal application. The sources of OE reviewed by the applicant included:

- Internal and industrywide condition reports
- Relevant international and non-nuclear OE
- Previous independent spent fuel storage installation inspection results at the Prairie Island and North Anna ISFSIs
- Licensee event reports
- Vendor-issued safety bulletins
- NRC generic communications
- Updated consensus codes, standards, or guides
- Applicable industry-initiatives

The applicant stated that the OE review did not identify any aging mechanisms and/or effects that were not already identified in either NUREG-2214 for the TN-32 Dry Storage Cask components, or Electrical Power Research institute (EPRI) 1015078, "Plant Support Engineering: Aging Effects for Structures and Structural Components (Structural Tools)" (EPRI 2007), for the berm. The applicant also stated that no incidents were identified where aging effects led to the loss of intended safety functions of the TN-32 Dry Storage Cask SSCs. Based on this review, the applicant concluded that the aging effects identified in the AMR will be managed so that the SSC intended safety functions will be maintained during the PEO.

The staff reviewed the applicant's OE review. As noted by the applicant, the OE review in the renewal application takes credit for the OE review conducted as part of the Prairie Island ISFSI Renewal Application (ADAMS Accession No. ML11304A068) and North Anna ISFSI Renewal Application (ADAMS Accession No. ML16153A140). The Prairie Island ISFSI uses the TN-40 Dry Storage Casks which has designs and subcomponent materials that are similar to the TN-32 Dry Storage Cask. Because the designs and materials are similar, the OE and aging effects observed in the TN-40 Dry Storage Cask is expected to be a good analog to the TN-32 Dry Storage Cask. The North Anna ISFSI uses TN-32 Dry Storage Casks. The review also included the various sources for new age-related degradation OE. The staff compared the list of sources for OE cited by the applicant to NUREG-1927, Section 3.6.1.10. The staff determined that the OE review by the applicant followed the guidance in NUREG-1927. Therefore, the staff determined that the OE review conducted by the applicant was acceptable.

3.3.3 Aging Mechanisms and Aging Effects

To determine the potential aging mechanisms and effects, the applicant used the environments to which the SSCs and associated subcomponents are usually exposed. The applicant determined the environmental conditions to which the SSCs and subcomponents are typically exposed using the information presented in the TN-32 Dry Storage Cask UFSAR, Chapter 2, Principal Design Criteria, and Chapter 4, Thermal Evaluation, which includes allowable temperature ranges for components under normal conditions and accident conditions. The applicant provided the relevant materials and environments in CoC renewal application Section 3.2.1. More specifically, the applicant provided the maximum component and fuel cladding temperatures during normal storage in renewal application Table 3-3.

The applicant described the TN-32 Dry Storage Cask design, subcomponents and the fabrication considerations; the reinforced concrete storage pad subcomponents; spent fuel assembly subcomponents; and the earthen berm in CoC No.1021 renewal application Section 3.3. The applicant provided an evaluation of materials of construction, environments, and the potential aging effects, and the associated aging mechanisms for each SSC and associated subcomponents within the scope of the renewal review in renewal application Section 3.4. In Section 3.4.3 of the renewal application, the applicant provided an assessment of the possible aging mechanisms for the materials used in the TN-32 Dry Storage Cask subcomponents, reinforced concrete storage pad, spent fuel assembly subcomponents, and the earthen berm. Aging mechanisms deemed credible were evaluated by the applicant to determine if the aging mechanisms could result in aging effects requiring management in the PEO. The applicant provided a summary of the aging mechanisms for materials used in the TN-32 Dry Storage Cask, concrete storage pad, spent fuel assemblies and the earthen berm in renewal application Table 3-4.

The staff relied on the guidance in NUREG-1927, Section 3.4.1.2, Identification of Aging Mechanisms and Effects, to review the applicant's assessment of the aging mechanisms and effects for the SSC subcomponents. The staff also used the information in NUREG-2214, Section 2.3, Aging Mechanisms, Section 2.4, Aging Effects, and the information in Chapter 3, Evaluation of Aging Mechanisms, to review of the applicant's AMR for the material and environment combinations that relevant to the TN-32 Dry Storage Cask, the reinforced concrete storage pad, and the spent fuel assemblies. In this evaluation, the staff ensured that the materials, design features, environments, and OE for the TN-32 Dry Storage Cask described in the renewal application are bounded by those evaluated in NUREG-2214. The staff conducted this evaluation by comparing the information provided by the applicant for the TN-32 Dry Storage Cask in the renewal application to the information contained 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. NUREG-2214, Chapter 4, Analysis of Dry Storage Systems and Spent Fuel Assemblies, provides AMR tables for those SSCs and their subcomponents for selected DSS designs, concrete storage pads, and fuel assemblies. The AMR tables included in Chapter 4 identify the aging mechanisms and effects that could challenge the capability of each of the SSCs and their subcomponents to fulfill its important-to-safety function(s) in the 20- to 60-year PEO. For those credible aging effects, the AMR tables recommend aging management approaches including AMPs, TLAAs, or supplemental analyses. The staff used the information in NUREG-2214, Section 4.4, TN-32 and TN-68 Systems, that was specifically developed to inform the review of the applicant's AMR results for those dry storage casks. In addition, the staff used the information in Sections 4.7 and 4.8 to inform the review of the applicant's AMR results for the concrete pad and fuel assemblies, respectively.

In addition, the staff reviewed the applicant's AMR of the optional earthen berm using the information included in EPRI-1015078 cited by the applicant. The staff has reviewed EPRI-1015078, Chapter 8, Earthen Structures, and finds that it describes the possible aging mechanisms and effects for earthen structures, such as the earthen berm. The applicant's reliance on it is, therefore, acceptable. The staff also reviewed the information in (1) NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 2.5.4 "Stability of Subsurface Materials and Foundations" (ADAMS Accession No. ML13311B744) (NRC 2014), (2) NRC RG 1.127, Revision 2, "Criteria and Design Features for Inspection of Water Control Structures Associated with Nuclear Power Plants" (ADAMS Accession No. ML15107A412), Section C.5.b. "Onsite Inspection Program," (3) the aging management of the berm at the Prairie Island Nuclear Generating Plant ISFSI

(ADAMS Accession No. ML15285A007), and (4) the staff evaluation of the TN-40 Dry Storage Cask AMP in the Prairie Island Nuclear Generating Plant ISFSI SER (ADAMS Accession No. ML15336A230). Staff used the information in EPRI-1015078 and NUREG-0800, Section 2.5.4, for additional insight into aging mechanisms and effects for earthen structures. The staff used the information in NRC RG 1.127, Section C.5.b, for information on the inspection of earthen embankment structures for the detection of aging effects. As previously noted, the applicant referenced the OE at the Prairie Island Nuclear Generating Plant ISFSI. As noted above, because of the similarities in the design, materials, and operation of the TN-40 Dry Storage Cask and TN-32 Dry Storage Cask, staff compared the TN-32 Dry Storage Cask AMP to the previously approved AMP for the TN-40 Dry Storage Casks AMP in the Prairie Island ISFSI renewal.

SER Tables 3.3-3 through 3.3-12 provide a summary of the aging mechanisms and aging effects for the material and environment combinations for the components and subcomponents from the AMR. In addition, SER Tables 3.3-3 through 3.3-12 identify whether the approach taken by the applicant is consistent with aging mechanism and aging effects analysis included in NUREG-2214 for the comparable material and environment combination. For all cases where the applicant's approach differs from that in NUREG-2214, additional information is provided in the discussion of each material and identified in the footnotes for each table.

Steel Materials

The summary of the aging mechanisms and aging effects for carbon steel included in renewal application Section 3.4.3.1 is shown in SER Table 3.3-3. The applicant's evaluation of corrosion mechanisms, creep, thermal aging, and radiation embrittlement for the steel materials was consistent with the evaluation in NUREG-2214, Section 3.2.1, and is therefore acceptable. Additional details of the applicant's evaluation of fatigue, stress relaxation, and wear of steel subcomponents are provided in the following paragraphs.

NUREG-2214, Section 3.2.1.7 states that reviewer should review all fatigue analyses contained in the applicant's design bases documents to determine whether the renewal application adequately addresses the implications of extending the operating period to 60 years. In renewal application Section 3.4.3.1.7 the applicant stated that the design basis review for the TN-32 Dry Storage Cask review did not identify any fatigue analyses/evaluations for the TN-32 Dry Storage Cask system components. Further the applicant stated that the only source of potential thermal fatigue of the TN-32 cask is ambient seasonal and daily temperature fluctuation but due to the large thermal inertia of the TN-32 cask, it does not experience the full amplitude of ambient temperature cycles, and a gradual, long-term temperature decrease occurs during the course of storage. The staff reviewed the applicant's evaluation and confirmed that the TN-32 Dry Storage Cask did not include a fatigue assessment. The staff determined that thermal fluctuations are insufficient to result in fatigue of the TN-32 confinement boundary. Therefore, the staff determined that no fatigue evaluation is required for the PEO.

The applicant stated in the renewal application Section 3.4.3.1.10 that the TN-32 Dry Storage Cask bolts in contact with the lid and top neutron shield may be at temperatures where stress relaxation could occur. Therefore, the applicant stated that stress relaxation is considered credible for an air-outdoor environment. The applicant stated that there are no bolts used in concrete, helium, or fully encased environments, and therefore, stress relaxation of steel in these environments is not a credible aging mechanism. The staff noted that 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 are placed in service under an applied tensile load but are at

temperatures below those necessary for stress relaxation to occur. Although different from the assessment in NUREG-2214, Section 3.2.1.10, the staff noted that in renewal application Section 3.4.3.1.10, the applicant provided a justification for the evaluation that stress relaxation of bolts is a credible aging mechanism in an air-outdoor environment. Therefore, the staff determined that the applicant's assessment was acceptable, and that stress relaxation is an aging effect that requires aging management in the PEO.

The assessment of wear in NUREG-2214, Section 3.2.1.11, indicates that wear is a credible aging mechanism for carbon steels used in moving components such as doors used on transfer casks. The applicant indicated in renewal application Section 3.4.3.1.11 that rolling contact wear results from the repeated mechanical stressing of the surface of a body rolling on another body. The applicant stated that wear is not a credible aging mechanism because there are no moving components while the TN-32 Dry Storage Casks are in storage. The staff finds this justification for excluding wear acceptable because the staff confirmed that there are no moving components while the TN-32 Dry Storage Casks are in storage. The staff determined that the applicant's assessment of aging effects and aging mechanisms for carbon steel materials was acceptable because the applicant's assessment is consistent with the evaluation in NUREG-2214 and the applicant provided acceptable justification for the exclusion of wear consistent with the design and operation of the TN-32 Dry Storage Casks. Therefore, the staff determined that no aging management for wear of the steel subcomponents is required for the PEO.

Stainless Steel Materials

The aging mechanisms and aging effects for stainless steel included in renewal application Section 3.4.3.2 are shown in SER Table 3.3-4. The staff reviewed the operational environments and potential aging mechanisms provided by the applicant using the information in NUREG-2214, Section 3.2.2. The applicant's evaluations for general corrosion, pitting and crevice corrosion, galvanic corrosion, creep, fatigue, radiation embrittlement, and stress relaxation for the stainless steel materials were consistent with the evaluation in NUREG-2214, Section 3.2.2, and is therefore acceptable. Additional details of the applicant's evaluation of stress corrosion cracking (SCC), thermal aging, and wear of stainless steel subcomponents are provided in the following paragraphs.

The applicant stated that all austenitic stainless steels are susceptible to chloride-induced SCC in the normal wrought condition and the susceptibility increases when the material is sensitized. The applicant stated that in the welded condition, the heat affected zone (HAZ), which is a thin band located adjacent to the weld, can be sensitized by the precipitation of carbides that extract chromium out of the metal matrix. The applicant stated that there is a lack of halides and very little residual water in internal environments of a TN-32 Dry Storage Cask following drying and refilling with inert helium gas. Thus, the applicant concluded that SCC is not considered credible. Similarly, there is a lack of halides and very little moisture in a fully encased environment and, thus, SCC is not considered credible. The applicant stated that the construction of the TN-32 Dry Storage Cask system does not involve welding of stainless steel material together in an air-outdoor environment. The applicant determined that SCC of the stainless steel material is not credible in air-outdoor, helium, or fully encased environments.

The staff reviewed the TN-32 Dry Storage Cask design and determined that there is no welded stainless steel in an air outdoor environment. The staff note that NUREG-2214 identified multiple sources of applied and residual stresses that could be sufficient for the initiation of stress corrosion crackling. In addition to welding residual stresses, these include from fabrication processes, contacts between components, and bolted structures. However, the staff

note that OE with SCC of stainless steels is usually associated with welds or associated with fabrication processes. The staff determined that because the TN-32 Dry Storage Cask design does not use welded stainless steels exposed to an air-outdoor environment, SCC is not a credible aging mechanism.

The applicant stated that thermal aging of stainless steel was not a credible aging mechanism for the TN-32 Dry Storage Casks. The evaluation of thermal aging of stainless steels in NUREG-2214, Section 3.2.2.8, includes assessments for welded and nonwelded austenitic and precipitation-hardened martensitic stainless steels. The applicant indicated that the TN-32 Dry Storage Casks do not include precipitation-hardened martensitic stainless steels. For the austenitic stainless steels, the applicant indicated that based on the maximum temperatures the austenitic stainless steel will experience, as laid out in Table 3-3 of the renewal application, that the austenitic stainless steels will not reach temperatures where thermal aging could occur. The staff reviewed the material specifications for the subcomponents of the TN-32 Dry Storage Cask and confirmed that precipitation-hardened martensitic stainless steels are not specified and therefore, no evaluation of these materials were required. The staff noted that the applicant's assessment for the austenitic stainless steels is consistent with the evaluation in NUREG-2214, Section 3.2.2.8. The staff determined that the maximum temperature of the austenitic stainless steel components in the TN-32 Dry Storage Casks are below the temperatures necessary for thermal aging and the temperatures of these subcomponents will decrease over time as a result of the gradual decrease in decay heat. Therefore, the staff determined that the applicant's assessment was acceptable, and that thermal aging of the austenitic stainless steel materials is not a credible aging effect and no aging management is required for the PEO.

The evaluation of wear in NUREG-2214, Section 3.2.2.11, and Table 4-11 indicate that wear is a credible aging mechanism for stainless steel materials in components that are subjected to repeated motion such as transfer operations. The applicant indicated in the renewal application Section 3.4.3.2.11 that rolling contact wear results from the repeated mechanical stressing of the surface of a body rolling on another body. The applicant stated that wear is not a credible aging mechanism because there are no moving components while the TN-32 Dry Storage Casks are in storage. The staff finds this justification for excluding wear acceptable because the TN-32 Dry Storage Cask has no moving components in normal storage operations. Therefore, the staff determined that the applicant's assessment was acceptable, and that wear of the steel subcomponents is not a credible aging effect and no aging management is required for the PEO.

The staff determined that the applicant's assessment of aging effects and aging mechanisms for stainless steel materials was acceptable because the applicant's assessment was consistent with the evaluation in NUREG-2214. The staff determined that the applicant provided an acceptable justification for the exclusion of thermal aging and wear of the stainless steel subcomponents consistent with the design and operation of the TN-32 Dry Storage Casks.

Aluminum Materials

The aging mechanisms and aging effects for aluminum alloys included in renewal application Section 3.4.3.3 are shown in SER Table 3.3-5. The staff reviewed the operational environments and potential aging mechanisms provided by the applicant using the information in NUREG-2214, Section 3.2.3. The applicant's evaluations for creep, fatigue, thermal aging, and radiation embrittlement were consistent with the evaluation in NUREG-2214, Section 3.2.3. The staff's review of the applicant's evaluation of general corrosion, pitting and crevice corrosion, galvanic corrosion, and microbiologically influenced corrosion of the aluminum alloys are provided in the

following paragraphs. In addition, information with respect to the applicant's evaluation of creep and thermal aging are also described in the following paragraphs.

The applicant stated that general corrosion, pitting corrosion, crevice corrosion, galvanic corrosion of aluminum are credible in an air-outdoor environment, but are not credible in either a fully encased or a helium environment as a result of the lack of available water. The applicant stated that an air-outdoor environment does not have the continuous electrolyte necessary to sustain microbial activity necessary for microbiologically influenced corrosion. The staff determined that the applicant's assessment of corrosion mechanisms in fully encased and helium environments is consistent with the assessment in NUREG-2214, Section 3.2.3. The staff noted that these corrosion mechanisms were not evaluated for an air-outdoor environment in NUREG-2214 because most dry storage systems do not use this material-environment combination. Nevertheless, the applicant's evaluation is consistent with the available information regarding the corrosion mechanisms of aluminum alloys (ASM International 2000; Revie 2000), which indicates that general corrosion, pitting corrosion, crevice corrosion, galvanic corrosion are credible in an air-outdoor environment. In addition, the available information on aluminum alloys indicates that microbiologically influenced corrosion is not credible in an air-outdoor environment because of the lack of a suitable environment for the sustained microbial activity necessary for microbiologically influenced corrosion to occur. Therefore, the staff found that the applicant's assessment of corrosion related aging mechanisms and aging effects for aluminum alloys was acceptable.

The applicant provided an analysis showing that creep of the aluminum alloys was not expected based on the maximum temperature alloy type and the applied loads on the aluminum alloy components. The staff reviewed the applicant's analysis and determined that the applicant accurately considered the operating conditions for the aluminum components where the onset of creep of the aluminum alloys could occur. The staff determined that the applicant's assessment of creep for the aluminum alloys was consistent with the evaluation in NUREG-2214, Section 3.2.3.5. Therefore, the staff found that the applicant's assessment of creep aging mechanisms and aging effects for aluminum alloys was acceptable.

The applicant provided an analysis for thermal aging of the aluminum alloy basket materials that include precipitation-hardened 6061-T6 or 6061-T651 aluminum. The applicant cited the evaluation in NUREG-2214, Section 3.2.3.7, which stated that when alloy 6061-T6 is held at 392 °F its yield strength drops from approximately 18 ksi at 10,000 hours (1.14 years) to approximately 11.5 ksi at 100,000 hours (11.4 years). The applicant stated that because of this sensitivity to exposure time, ASME B&PV Code, Section II, requires that time-dependent properties be used for exposures above 350 degrees F (177 degrees C) for this alloy. Table 3-3 of the renewal application shows that the maximum temperature for the basket is 339 degrees F (171 degrees C), which is lower than the 350 degrees F (177 degrees C) threshold in ASME B&PV Code, Section II. Therefore, the applicant determined that thermal aging of the aluminum basket is not an aging effect that must be managed. Nevertheless, the applicant provided a supplemental evaluation in Appendix 3B of the renewal application for the TN-32 cask basket during a tip-over event. The staff found that the applicant's supplemental evaluation in Appendix 3B is consistent with the ASME B&PV Code Section II, Part D, temperature limits for aluminum alloys and the evaluation in NUREG-2214, Section 3.2.3.7. Therefore, the staff found that the applicant's assessment of thermal aging for aluminum alloy basket materials was acceptable. The staff's review of the applicant's supplemental evaluation of the basket for a tip-over event is included in SER Section 3.3.4.

Nickel Alloys

The aging mechanisms and aging effects for nickel alloys included in renewal application Section 3.4.3.4 are shown in SER Table 3.3-6. The staff reviewed the operational environments and potential aging mechanisms provided by the applicant using the information in NUREG-2214, Section 3.2.4. The applicant's evaluations for nickel alloy corrosion mechanisms, fatigue, radiation embrittlement, stress relaxation, and wear for the nickel alloy materials were not consistent with the evaluation in NUREG-2214, Section 3.2.4, because NUREG-2214 only evaluated the aging mechanisms for nickel alloys in an air-outdoor environment. The applicant stated that the nickel alloy metallic seal components are only exposed to a helium environment.

The evaluation of fatigue in NUREG-2214, Section 3.2.4.5, indicates that fatigue is a credible aging mechanism for nickel alloy materials in components that are subjected to repeated cyclic loads including cyclic loads as a result of thermal effects. The applicant stated that the nickel alloy metallic seals are crushed during installation and the thermal cycling of the liner will not result in fatigue or affect the ability of the aluminum jacket to fulfill the confinement function. The staff finds this justification for excluding fatigue acceptable because the TN-32 Dry Storage Cask seal is not subjected to cyclic loading in normal storage operations.

The evaluation of wear in NUREG-2214, Section 3.2.4, states that the only credible aging mechanism for nickel alloys in an air-outdoor environment is wear. NUREG-2214, Section 3.2.4.8, indicates that wear is a credible aging mechanism for nickel alloy materials in components that are subjected to repeated motion such as transfer operations. The applicant indicated in renewal application Section 3.4.3.4.7 that rolling contact wear results from the repeated mechanical stressing of the surface of a body rolling on another body. The applicant stated that wear is not a credible aging mechanism because there are no moving components while the TN-32 Dry Storage Casks are in storage. The staff finds this justification for excluding wear acceptable because the TN-32 Dry Storage Cask has no moving components in normal storage operations.

The staff determined that the applicant's assessment of aging effects and aging mechanisms for nickel alloy materials was acceptable because the applicant followed the guidance in NUREG-1927. The staff noted that NUREG-2214, Section 3.2.4 indicates that nickel alloys are not susceptible to stress relaxation or radiation embrittlement. While NUREG-2214 only assesses stress relaxation and radiation embrittlement for an air-outdoor environment, the evaluation in NUREG-2214 can be applied to helium environments because these aging mechanisms are dependent on temperature and radiation exposure and are not dependent on the chemical composition of the environment. Therefore, the staff determined that the applicant's evaluation was acceptable. The staff noted that while helium environments were not evaluated in NUREG-2214, nickel alloys have sufficient corrosion resistance such that corrosion mechanisms are not credible in air-outdoor environments. Because helium environments inside the dry storage cask do not contain moisture or contaminants that would promote corrosion, the staff determined that the applicant's evaluation was acceptable, meaning corrosion is not a credible aging mechanism.

Polymer Materials

The aging mechanisms and aging effects for polymer materials included in renewal application Section 3.4.3.5 are shown in SER Table 3.3-7. The staff reviewed the operational environments and potential aging mechanisms provided by the applicant using the information in NUREG-2214, Section 3.3.1. The applicant's evaluations for thermal aging and radiation embrittlement

were acceptable because these assessments were consistent with the evaluations in NUREG-2214, Sections 3.3.1.2 and 3.3.1.3, respectively. The following paragraph provides additional information on the boron depletion of the polymer neutron shielding materials.

The applicant provided a calculation for the boron-10 depletion of the neutron shield that considered the boron-10 density. Using the generic analysis for the depletion of boron-10 from the stainless steel neutron poison material in NUREG-2214, Section 3.4.1.1, the applicant stated that boron depletion was negligible for the PEO. The applicant stated that thermal aging and radiation embrittlement of the polymer material in a fully encased environment are credible aging effects for the PEO. The staff noted that the analysis for the borated stainless steel in NUREG-2214, Section 3.4.1.1, may not be applicable to the borated polymer as the polypropylene and polyester from the polymer shield would slow down neutrons more than stainless steel and have a larger absorption/depletion of boron. However, the staff found that conclusions about the borated polymer can be drawn from the applicant's analysis that provide confidence that boron depletion within the polymer material is minimal for the following reasons. The applicant performed an analysis for the borated aluminum within the basket with very conservative assumptions, which are discussed in Section 3.5.1 of this SER. This analysis demonstrates that the boron loss is minimal and independent of the material the boron is within (i.e. only based on the number of boron atoms and does not account for the aluminum). Additionally, the analysis for borated aluminum and steel represent neutron flux inside the basket. The borated polymer resin would get a lower neutron flux because it is outside of the basket. Performing this demonstration is consistent with the evaluation in NUREG-2214, Section 3.3.1.1, and conservative with respect to the analysis provided in NUREG-2214, Section 3.4.1.1, because of the concentration of boron in the TN-32 shielding material is on the higher end of the range used. Based on the above considerations, the staff determined that the applicant's analysis for boron depletion is acceptable for demonstrating that the boron depletion is negligible for the PEO.

Borated Aluminum Materials

The aging mechanisms and aging effects for borated aluminum materials included in renewal application Section 3.4.3.6 are shown in SER Table 3.3-8. The staff reviewed the operational environments and potential aging mechanisms provided by the applicant using the information in NUREG-2214, Section 3.4.2. The applicant stated that general corrosion and galvanic corrosion of the borated aluminum alloys are not credible in an inert environment. The staff determined that the applicant's analyses for these corrosion mechanisms in inert environments was acceptable because the assessment was consistent with the evaluation including in NUREG-2214, Sections 3.4.2.1 and 3.4.2.2. The applicant provided an assessment for creep, thermal aging, and radiation embrittlement to support the conclusion that these aging mechanisms are not credible for the borated aluminum alloys. The staff determined that the applicant's assessment was acceptable because the assessments were consistent with the evaluations included in NUREG-2214, Sections 3.4.2.5, 3.4.2.6, and 3.4.2.7, respectively.

For the depletion of boron, the applicant referenced the analysis included in TN-32 UFSAR Section 6.3.2 that showed boron-10 depletion of the borated aluminum alloys is negligible over a period of 1,000 years and is therefore, negligible during the PEO. The applicant determined that the analysis in UFSAR Section 6.3.2 met the criteria for a TLAA and therefore, the applicant included this analysis as a TLAA in CoC No 1021 renewal application Appendix 3A. The staff's review of the TLAA for boron-10 depletion is included in SER Section 3.5.1.

Concrete

The aging mechanisms and aging effects for concrete included in renewal application Section 3.4.3.7 are shown in SER Table 3.3-9. The staff reviewed the operational environments and potential aging mechanisms provided by the applicant using the information in NUREG-2214, Section 3.5.1. The applicant stated that creep, shrinkage, radiation damage, fatigue, and dehydration at high temperatures are not credible air-outdoor or groundwater/soil environments. The applicant stated that freeze-thaw, reaction with aggregates, aggressive chemical attack, corrosion of reinforcing steel, leaching of calcium hydroxide and salt scaling are credible aging mechanisms for air-outdoor or groundwater/soil environments. The staff determined that the assessments by the applicant were acceptable because they are consistent with the evaluation in NUREG-2214, Section 3.5.1. The applicant stated that differential settlement and microbiological degradation are credible in groundwater/soil environments but not credible in air-outdoor environments. The staff determined that the assessments by the applicant were acceptable because they are consistent with the evaluation in NUREG-2214, Section 3.5.1, which states that differential settlement and microbiological degradation are potential aging mechanisms and have aging effects on concrete in groundwater/soil environments but not in air-outdoor environments.

The staff noted that the analysis of concrete aging effects included in NUREG-2214 was based on concrete having only a structural function. Concrete aging effects such as cracks and loss of material can affect the concrete ITS structural function. Heat transfer is dependent on materials properties and material interfaces and discontinuities. Concrete aging effects that result in a loss of material or cracks are discontinuities that could affect heat transfer. The staff determined that the aging effects for concrete that result in a loss of material or the formation of cracks could affect the heat transfer by creating discontinuities in the concrete structure. Therefore, the staff determined that the evaluation provided in NUREG-2214, Section 3.5.1, developed for a structural function may be applied to concrete having a thermal function.

The applicant indicated that delayed ettringite formation (DEF) is considered credible in air-outdoor or groundwater/soil environments. The staff noted that while the assessment of delayed ettringite formation by the applicant is different from NUREG-2214, Section 3.5.1.13, which states that the conditions necessary for the occurrence of DEF are excessive temperatures during concrete placement and curing, the presence of internal sulfates, and a moist environment. As noted in NUREG-2214, Section 3.5.1.13, the American Concrete Institute (ACI) guidelines during concrete placement and curing can effectively limit the concrete temperature to below 70 degrees C (158 degrees F), therefore preventing the development of DEF. As such, NUREG-2214 states that DEF is not a credible aging mechanism in any environment. While the applicant's assessment differs from NUREG-2214, the staff determined that the applicant's assessment is conservative, and therefore acceptable.

The applicant provided an assessment for concrete hardening and determined that hardening was not a credible aging mechanism, as no appreciable hardening is expected during the PEO. The staff noted that some degree of concrete hardening with time is expected. As such, NUREG-2214 does not consider concrete hardening as an aging mechanism. The staff reviewed the applicant assessment which was based on the data in Table 2.13 of NUREG/CR-6424 (NRC, 1996b). Based on a review of the available data, the applicant stated that concrete hardening is not expected in the PEO. The staff determined that the applicant's assessment of hardening was acceptable based on the data provided to support the analysis that concrete hardening beyond 20 years is not a credible aging mechanism.

Spent Fuel Assembly Cladding Materials

The aging mechanisms and aging effects for spent fuel assemblies included in renewal application Section 3.4.3.8 are shown in SER Table 3.3-10. The staff reviewed the operational environments and potential aging mechanisms provided by the applicant using the information in NUREG-2214, Section 3.6.1. The applicant stated that there are no credible aging mechanisms for the spent fuel stored in an inert helium environment. Based on this evaluation, the applicant concluded that no aging management activities are required for the spent fuel assembly cladding material stored in the TN-32 Dry Storage Cask. The staff reviewed the AMR of the spent fuel assemblies provided by the applicant in the renewal application, Table 3-8. The staff noted that per NUREG-2214, Section 3.6.1, hydride reorientation and thermal creep are only considered credible for high burnup fuel with an average burnup > 45 gigawatt-day per metric ton uranium (Gwd/MTU). Because the TN-32 Dry Storage Cask TS limit the TN-32 Dry Storage Cask to a maximum average burnup of ≤ 45 Gwd/MTU, these aging mechanisms are not credible for fuel loaded into TN-32 Dry Storage Casks. Based on this, the staff determined that the applicant's assessment that no aging management activities are required for the spent fuel assemblies stored in the TN-32 Dry Storage Cask system was consistent with the evaluation in NUREG-2214, Section 3.6.1. Therefore, the staff found that the applicant's assessment of aging effects and aging mechanisms for spent fuel assembly cladding materials was acceptable and no aging management is required in the PEO.

The applicant referenced the analysis in TN-32 UFSAR Section 3.5.1, which indicates that the maximum fuel cladding temperature of the hottest fuel rod in the cask shall not exceed the temperature limit calculated in accordance with PNL-6189 (Levy et al., 1987) in order to prevent cladding creep. The applicant determined that the analysis in UFSAR Section 3.5.1 met the criteria for a TLAA and therefore, the applicant included this analysis as a TLAA in CoC No 1021 renewal application Appendix 3A. The staff's review of the TLAA for the maximum fuel cladding temperature is included in SER Section 3.5.2.

Spent Fuel Assembly Hardware Materials

The aging mechanisms and aging effects for spent fuel assembly hardware materials included in renewal application Section 3.4.3.9 are shown in SER Table 3.3-11. The staff reviewed the operational environments and potential aging mechanisms provided by the applicant using the information in NUREG-2214, Section 3.6.2. The applicant stated that there are no credible aging mechanisms for the spent fuel assembly hardware which are stored with the fuel assemblies in an inert helium environment. The staff determined that the applicant assessment is consistent with NUREG-2214, Section 3.6.2, which states that there are no credible aging mechanisms for spent fuel assembly hardware in a helium environment. Therefore, the staff found that the applicant's assessment of aging effects and aging mechanisms for spent fuel assembly hardware materials was acceptable and no aging management is required in the PEO.

Soil

The aging mechanisms and aging effects for soil material included in renewal application Section 3.4.3.10 are shown in SER Table 3.3-12. The applicant used information included in EPRI-1015078, to assess the potential aging mechanism for the soil berm. The applicant stated that credible aging mechanisms include wind erosion, surface flow of soil materials, settlement, frost action, and desiccation. The applicant stated that rain impact, subsurface flow of soil material, wave action, and sedimentation are not credible aging mechanisms. The staff

reviewed the applicant's assessment, the information included in EPRI-1015078; NUREG-0800, Section 2.5.4; and NRC RG 1.127, Revision 2, "Criteria and Design Features for Inspection of Water Control Structures Associated with Nuclear Power Plants" (ADAMS Accession No ML15107A412) (NRC 2016b), Section C5.b, "Onsite Inspection Program." The staff also reviewed the aging management of the berm at the Prairie Island Nuclear Generating Plant ISFSI and the staff's evaluation of the AMP in the Prairie Island Nuclear Generating Plant ISFSI SER (ADAMS Accession No. ML15285A007). The staff determined that the applicant's assessments of soil aging mechanisms are consistent with industry guidance in EPRI-1015078, RG 1.127, Revision 2, Section C.5.b, and the previous evaluation used to support the Prairie Island ISFSI renewal. Therefore, the staff found that the applicant's assessment of aging effects and aging mechanisms for soil material was acceptable and aging management is necessary for the wind erosion, surface flow of soil materials, settlement, frost action, and desiccation aging mechanisms.

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

Aging Mechanism	Aging Effect	CoC 1021 Renewal Application Section 3.4.3.1		Consistent with NUREG-2214 Section 3.2.1
		Credible Environments ¹	Non-Credible Environments ¹	
General corrosion	Loss of material	OD, E-C	HE, FE	Yes
Pitting and crevice corrosion	Loss of material	OD, E-C	HE, FE	Yes
Galvanic corrosion	Loss of material	OD	E-C, HE, FE	Yes
Microbiologically influenced corrosion	Loss of material	E-C	OD, HE, FE	Yes
Stress Corrosion Cracking and hydrogen embrittlement	Cracking	none	OD, E-C, HE, FE	Yes
Creep	Change in dimensions	none	OD, E-C, HE, FE	Yes
Fatigue	Cracking	none	OD, E-C, HE, FE	N/A ²
Thermal aging	Loss of fracture toughness and loss of ductility	none	OD, E-C, HE, FE	Yes
Radiation embrittlement	Loss of fracture toughness and loss of ductility	none	OD, E-C, HE, FE	Yes
Stress relaxation	Change in dimensions	OD	E-C, HE, FE	No ³
Wear	Loss of material	none	OD, E-C, HE, FE	Yes ⁴

¹ The applicant stated in CoC No. 1021 renewal application Section 3.4.3.1 that the relevant operational environments for carbon steel materials include Air-Outdoor (OD), Embedded-in-concrete (E-C), Helium (HE) and Fully Encased (FE).

² Not evaluated in NUREG-2214. NUREG-2214, Section 3.2.1.7, states that the applicant should evaluate the design-bases documents to determine whether the renewal application adequately addresses the implications of extending the operating period to 60 years. The applicant stated that the design basis for the TN-32 system did not include a fatigue analyses for the TN-32 Dry Storage Cask system components.

³ 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 operate at a temperature too low for stress relaxation in OD environments. The applicant stated in CoC No. 1021 renewal application Section 3.4.3.1.10 that the temperatures of the bolts may be sufficient for stress relaxation.

⁴ NUREG-2214, Section 3.2.1.11, states that wear is a credible aging mechanism for moving components such as doors used on transfer casks. The applicant stated in CoC No. 1021 renewal application Section 3.4.3.1.11 that rolling contact wear results from the repeated mechanical stressing of the surface of a body rolling on another body. The applicant also stated that because there are no moving components while TN-32 Dry Storage Casks are in storage, wear is not a credible aging mechanism for the TN-32 Dry Storage Casks.

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

Aging Mechanism	Aging Effect	CoC 1021 Renewal Application Section 3.4.3.2		Consistent with NUREG-2214 Section 3.2.2
		Credible Environments ¹	Non-Credible Environments ¹	
General corrosion	Loss of material	none	OD, HE, FE	Yes
Pitting and crevice corrosion	Loss of material	OD	HE, FE	Yes
Galvanic corrosion	Loss of material	OD	HE, FE	Yes ²
Microbiologically influenced corrosion	Loss of material	none	OD, HE, FE	Yes
Stress Corrosion Cracking (SSC)	Cracking	none	OD, HE, FE	No ³
Creep	Change in dimensions	none	OD, HE, FE	Yes
Fatigue	Cracking	none	OD, HE, FE	Yes
Thermal aging	Loss of fracture toughness and loss of ductility	none	OD, HE, FE	No ⁴
Radiation embrittlement	Loss of fracture toughness and loss of ductility	none	OD, HE, FE	Yes
Stress relaxation	Change in dimensions	none	OD, HE, FE	Yes
Wear	Loss of material	none	OD, HE, FE	No ⁵

¹ The applicant stated in CoC No. 1021 renewal application Section 3.4.3.2 that the relevant operational environments for stainless steel materials include Air-Outdoor (OD), Helium (HE) and Fully Encased (FE).

² Galvanic corrosion is considered credible for stainless steel in an OD environment in contact with a graphite lubricant. This is not analyzed, however, because the UFSAR does not identify graphite as an approved lubricant.

³ The applicant stated that the stainless steel exposed to an OD environment is not welded and therefore does not have stress required for SCC.

⁴ The applicant stated in CoC No. 1021 renewal application Section 3.4.3.2.8 that because the peak temperatures for welded stainless steel components exposed to air-outdoor, helium, and fully encased environments are below the temperature required for the phase changes associated with thermal aging and embrittlement of welded stainless steels, thermal aging is not considered credible for these subcomponents. In addition, the applicant stated that austenitic stainless steels that are not welded are not susceptible to thermal aging and embrittlement over the range of operating temperatures for these components in the TN-32 Dry Storage Casks.

⁵ NUREG-2214, Section 3.2.2.11, and Table 4-6 states that wear is a credible aging mechanism for transfer cask components such as rails that are subjected to repeated transfer operations. The applicant stated in CoC No. 1021 renewal application Section 3.4.3.2.11 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 TN-32 Dry Storage Cask system there are no bodies rolling on another body while the TN-32 Dry Storage Casks are in storage.

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

Aging Mechanism	Aging Effect	CoC 1021 Renewal Application Section 3.4.3.3		Consistent with NUREG-2214 Section 3.2.3
		Credible Environments ¹	Non-Credible Environments ¹	
General corrosion	Loss of material	OD	HE, FE	No ²
Pitting and crevice corrosion	Loss of material	OD	HE, FE	No ²
Galvanic corrosion	Loss of material	OD	HE, FE	No ²
Microbiologically influenced corrosion	Loss of material	none	OD, FE, HE	No ³
Creep	Change in dimensions	none	OD, FE, HE	Yes ⁴
Fatigue	Cracking	none	OD, FE, HE	Yes
Thermal aging	Loss of fracture toughness and loss of ductility	none	OD, FE, HE	Yes ⁵
Radiation embrittlement	Loss of fracture toughness and loss of ductility	none	OD, FE, HE	Yes

- ¹ The applicant stated in CoC No. 1021 renewal application Section 3.4.3.3 that the relevant operational environments for aluminum materials were limited to Air-Outdoor (OD), Helium (HE) and Fully Encased (FE).
- ² The applicant stated that general corrosion, pitting corrosion, crevice corrosion, and galvanic corrosion are considered credible in an OD environment. NUREG-2214, Section 3.2.3, did not consider OD environments for the evaluation of possible aging mechanisms and effects for aluminum.
- ³ The applicant stated that microbiologically influenced corrosion is not credible in OD environments. NUREG-2214, Section 3.2.3.4, did not consider OD environments for the evaluation of microbiologically influenced corrosion as a possible aging mechanisms and effects for aluminum.
- ⁴ The applicant provided an analysis to show that the highest temperatures of the aluminum components were below the temperature value where creep would be expected to occur.
- ⁵ NUREG-2214, Section 3.2.3.7, states that precipitation-hardened aluminum alloys such as 6061-T6 will have reduced strength after prolonged exposure to temperatures above 350 degrees F (177 degrees C). The applicant stated in CoC No. 1021 renewal application Section 3.4.3.3.7 that Type 6061 subcomponents do not exceed 339 degrees F (171 degrees C) and are therefore are not subjected to thermal aging.

Table 3.3-6. Summary of the aging mechanisms and aging effects for nickel alloys

Aging Mechanism	Aging Effect	CoC 1021 Renewal Application Section 3.4.3.4		Consistent with NUREG-2214 Section 3.2.4
		Credible Environments ¹	Non-Credible Environments ¹	
General corrosion	Loss of material	none	HE	No ^{2,3}
Pitting and crevice corrosion	Loss of material	none	HE	No ^{2,3}
Microbiologically influenced corrosion	Loss of material	none	HE	No ^{2,3}
Stress Corrosion Cracking	Cracking	none	HE	No ^{2,3}
Fatigue	Cracking	none	HE	No ^{2,4}
Radiation embrittlement	Loss of fracture toughness and loss of ductility	none	HE	No ^{2,5}
Stress relaxation	Change in dimensions	Not Assessed	Not Assessed	No ^{2,6}
Wear	Loss of material	none	HE	No ^{2,7}

¹ The applicant stated in CoC No. 1021 renewal application Section 3.4.3.4 that the only nickel alloy component is the liner of the metallic O-ring which is exposed to a Helium (HE) environment.

² NUREG-2214, Section 3.2.4, did not consider HE environments for the evaluation of possible aging mechanisms and effects for nickel alloys.

³ The applicant stated that general corrosion, pitting corrosion, crevice corrosion, microbiologically influenced corrosion, and stress corrosion cracking are not credible in HE environments. NUREG-2214, Section 3.2.4, only considered OD environments and concluded these corrosion mechanisms were not credible. Because these mechanisms are not credible in an OD environment, the applicant's assessment that these corrosion mechanisms are not credible for the less aggressive HE environment is valid.

⁴ The applicant stated that fatigue in an HE environment is not credible because the nickel alloy components are not subjected to cyclic loading.

⁵ The applicant stated that radiation embrittlement in a HE environment would not affect the function of the seal.

⁶ The applicant stated that the function of the seal nickel alloy liner and spring is to maintain the shape of the seal prior to installation.

⁷ The applicant stated that wear of the nickel alloy seal liner in a HE environment is not credible because there is no sliding or motion that would lead to wear.

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

Aging Mechanism	Aging Effect	CoC 1021 Renewal Application Section 3.4.3.5		Consistent with NUREG-2214 Section 3.3.1
		Credible Environments ¹	Non-Credible Environments ¹	
Boron Depletion	Loss of shielding	none	FE	Yes ²
Thermal aging	Loss of fracture toughness and loss of ductility	FE	Not applicable	Yes
Radiation embrittlement	Cracking	FE	Not applicable	Yes

¹ The applicant stated in CoC No. 1021 renewal application Section 3.4.3.5 that the relevant operational environment for polymer materials is limited to Fully Encased (FE).

² The applicant provided an analysis to show that boron depletion was negligible over a 60-year period.

Table 3.3-8. Summary of the aging mechanisms and aging effects for Borated Aluminum Material

Aging Mechanism	Aging Effect	CoC 1021 Renewal Application Section 3.4.3.6		Consistent with NUREG-2214 Section 3.4.2
		Credible Environments ¹	Non-Credible Environments ¹	
General corrosion	Loss of Material	none	HE	Yes
Galvanic corrosion	Loss of Material	none	HE	Yes
Boron depletion	Reduction of neutron-absorbing capacity	none	HE	Yes ^{2,3}
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 The applicant stated in CoC No. 1021 renewal application Section 3.4.3.6 that the relevant operational environment for borated aluminum is limited to Helium (HE).

² The applicant provided an analysis in CoC No. 1021 renewal application Section 3.4.3.6 to show that boron depletion was negligible over a 60-year period.

³ 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 was addressed in a TLAA in CoC No. 1021 renewal application Appendix 3A.

Table 3.3-9. Summary of the aging mechanisms and aging effects for concrete

Aging Mechanism	Aging Effect	CoC 1021 Renewal Application Section 3.4.3.7		Consistent with NUREG-2214 Section 3.5.1
		Credible Environments ¹	Non-Credible Environments ¹	
Freeze-thaw	Cracking and loss of material	OD, GW	Not applicable	Yes
Creep	Cracking	none	OD, GW	Yes
Reaction with aggregates	Cracking, loss of strength, loss of material, and increase in porosity and permeability	OD, GW	Not applicable	Yes
Differential settlement	Cracking and loss of form	GW	OD	Yes
Aggressive chemical attack	Cracking, loss of strength, loss of material, increase in porosity and permeability, and reduction in concrete pH	OD, GW	Not applicable	Yes
Corrosion of reinforcing steel	Cracking and loss of material	OD, GW	Not applicable	Yes
Shrinkage	Cracking	none	OD, GW	Yes
Leaching of calcium hydroxide	Loss of strength, increase in porosity and permeability, and reduction in concrete pH	OD, GW	Not applicable	Yes
Radiation damage	Cracking and loss of strength	none	OD, GW	Yes
Fatigue	Cracking	none	OD, GW	Yes
Dehydration at high temperature	Cracking and loss of strength	none	OD, GW	Yes
Microbiological degradation	Loss of material and increase in porosity and permeability	GW	OD	Yes
Delayed ettringite formation	Cracking and loss of material	OD, GW	See Note 2	No ²
Salt scaling	Loss of material	OD, GW	Not applicable	Yes
Hardening	Increased hardness and strength	none	OD, GW	No ³

¹ The applicant stated in CoC No. 1021 renewal application Section 3.5.3.6 that the relevant operational environments for concrete includes Air-Outdoor (OD) and Groundwater/soil (GW).

² NUREG-2214, Section 3.5.1.13, states that American Concrete Institute (ACI) design and construction codes are sufficient to preclude delayed ettringite formation. The applicant indicated in CoC No. 1021 renewal application Section 3.4.3.7.13 that delayed ettringite formation is considered credible for the storage pad in OD and GW environments unless ruled out by the general licensee by an ISFSI-specific evaluation.

³ NUREG-2214, Section 3.5.1, did not assess hardening of the concrete. The applicant provided an assessment for the hardening of concrete in CoC No. 1021 renewal application Section 3.4.3.7.15.

Table 3.3-10. Summary of the aging mechanisms and aging effects for spent fuel assembly cladding materials

Aging Mechanism	Aging Effect	CoC 1021 Renewal Application Section 3.4.3.8		Consistent with NUREG-2214 Section 3.6.1
		Credible Environments ¹	Non-Credible Environments ¹	
Hydride-induced embrittlement	Loss of ductility	none	HE (low burnup fuel with zirconium alloy cladding)	Yes ²
Delayed hydride cracking	Cracking	none	HE	Yes
Thermal creep	Change in dimensions	none	HE (low burnup fuel with zirconium alloy cladding)	Yes ²
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 The applicant stated in CoC No. 1021 renewal application Section 3.4.3.8 that the relevant operational environment for zirconium alloy spent fuel assembly cladding materials is limited to Helium (HE).

² The applicant clarified that per the Technical Specifications, Section 2.1, fuel approved for storage in the TN-32 Dry Storage Cask is limited to a burnup of 45 GWd/MTU.

Table 3.3-11. Summary of the aging mechanisms and aging effects for spent fuel assembly hardware materials

Aging Mechanism	Aging Effect	CoC 1021 Renewal Application Section 3.4.3.9		Consistent with NUREG-2214 Section 3.6.2
		Credible Environments ¹	Non-Credible 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 The applicant stated in CoC No. 1021 renewal application Section 3.4.3.9 that the relevant operational environment for spent fuel assembly hardware materials is limited to Helium (HE).

Table 3.3-12. Summary of the aging mechanisms and aging effects for soil materials

Aging Mechanism	Aging Effect	CoC 1021 Renewal Application Section 3.4.3.10		Consistent with EPRI-1015078 ²
		Credible Environments ¹	Non-Credible Environments ¹	
Wind erosion	Loss of material	OD	Not applicable	Yes
Rain impact	Loss of material	none	OD	Yes
Surface flow	Loss of material	OD	Not applicable	Yes
Subsurface flow	Loss of material	none	OD	Yes
Wave action	Loss of material	none	OD	Yes
Settlement	Cracking and change in dimensions	OD	Not applicable	Yes
Frost action	Change in dimensions	OD	Not applicable	Yes
Sedimentation	Loss of material	none	OD	Yes
Desiccation	Change in properties and loss of material	OD	Not applicable	Yes

¹ The applicant stated in CoC No. 1021 renewal application Section 3.4.3.10 that the relevant operational environment for soil materials is limited to Air-Outdoor (OD).

² NUREG-2214 does not address aging of soil structures. The applicant referred to Electric Power Research Institute (EPRI) 1015078, "Plant Support Engineering: Aging Effects for Structures and Structural Components (Structural Tools)," December 2007, to assess aging mechanisms for an earthen berm.

SER Tables 3.3-13 through 3.3-15 show only the aging mechanisms and aging effects for the TN-32 Dry Storage Cask, storage pad, and the optional earthen berm, respectively, with the material group-environment combinations that the applicant determined to be credible and which require an AMP to address the aging effect(s). SER Tables 3.3-13 and 3.3-14 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 3.3-15 identifies whether the applicant's evaluation of aging management activities for each credible aging effect for the earthen berm is consistent with the generic technical bases and conclusions discussed in EPRI-1015078.

The aging mechanisms and effects that require aging management applicable to the TN-32 Dry Storage Cask subcomponents are shown in SER Table 3.3-13. The staff reviewed the AMR provided by the applicant for the TN-32 Dry Storage Cask subcomponents in the renewal application, Tables 3-5 and 3-6. The staff determined that the applicant's evaluation of necessary aging management activities was consistent with the results of the AMR and the identification of the credible aging mechanisms and effects for the TN-32 Dry Storage Cask subcomponents. The staff determined that the applicant's assessment was consistent with the evaluation in NUREG-2214. Therefore, the staff found that the applicant's necessary aging management activities were acceptable.

The aging mechanisms and effects that require aging management applicable to the storage pad for the TN-32 Dry Storage Casks are shown in SER Table 3.3-14. The staff reviewed the AMR provided by the applicant for the TN-32 Dry Storage Cask storage pad in the renewal application, Table 3-7. The staff determined that the applicant's evaluation of necessary aging management activities was consistent with the results of the AMR and the identification of the credible of aging mechanisms and effects for the storage pad. The staff determined that the applicant's assessment either (1) consistent with the evaluation in NUREG-2214 or (2) was conservative with respect to the evaluation in NUREG-2214. Therefore, the staff found that the applicant's necessary aging management activities were acceptable.

The aging mechanisms and effects that require aging management applicable to the optional earthen berm are shown in SER Table 3.3-15. The staff reviewed the AMR provided by the applicant in the renewal application, Table 3-9. In response to a request for additional information (RAI) (ADAMS Accession No. ML21036A237) the applicant stated that the effects of vegetation and roots would be beneficial for reducing wind driven surface water runoff erosion and desiccation. The applicant also stated that the effects of burrowing animals would be treated as an operational event that would be detected in normal maintenance activities. The staff determined that the applicant's evaluation of necessary aging management activities was consistent with the results of the AMR and the identification of the credible of aging mechanisms and effects for the optional earthen berm. The staff determined that the applicant's assessment is consistent with the technical bases and conclusions discussed in EPRI-1015078. Therefore, the staff found that the applicant's necessary aging management activities were acceptable.

Table 3.3-13. Aging mechanisms and effects that require aging management—TN-32 Dry Storage Cask

Material Group	Environment	Aging Mechanism	Aging Effect	Subcomponent¹	Aging Management Program	Consistent with NUREG-2214 Table 4-11
Steel	Air-Outdoor	General Corrosion	Loss of Material	All components exposed to an air-outdoor environment	TN-32 AMP	Yes
Steel	Air-Outdoor	Pitting/Crevice Corrosion	Loss of Material	All components exposed to an air-outdoor environment	TN-32 AMP	Yes
Steel	Air-Outdoor	Galvanic Corrosion	Loss of Material	Lid, protective cover, top neutron shield, lid bolts, vent and drain cover bolts, overpressure port cover bolts, flange	TN-32 AMP	Yes
Steel	Air-Outdoor	Stress Relaxation	Loss of Preload	Lid bolts, vent and drain cover bolts, overpressure port cover bolts	TN-32 AMP	No ²
Stainless Steel	Air-Outdoor	Pitting/Crevice Corrosion	Loss of Material	All components exposed to an air-outdoor environment	TN-32 AMP	No ³
Stainless Steel	Air-Outdoor	Galvanic Corrosion	Loss of Material	Protective cover bolts, top neutron shield bolts, vent and drain cover bolts, overpressure port cover bolts, Helicoil inserts	TN-32 AMP	Yes
Aluminum	Air-Outdoor	General Corrosion	Loss of Material	All components exposed to an air-outdoor environment	TN-32 AMP	No ⁴
Aluminum	Air-Outdoor	Pitting/Crevice Corrosion	Loss of Material	All components exposed to an air-outdoor environment	TN-32 AMP	No ⁴
Aluminum	Air-Outdoor	Galvanic Corrosion	Loss of Material	All components exposed to an air-outdoor environment	TN-32 AMP	No ⁴
Polymer	Fully Encased	Thermal Aging	Loss of fracture toughness and loss of ductility	Top neutron shield	TN-32 AMP	Yes
Polymer	Fully Encased	Radiation Embrittlement	Cracking	Top neutron shield	TN-32 AMP	Yes

Table 3.3-13. Aging mechanisms and effects that require aging management—TN-32 Dry Storage Cask

Material Group	Environment	Aging Mechanism	Aging Effect	Subcomponent¹	Aging Management Program	Consistent with NUREG-2214 Table 4-11
Borated Polymer	Fully Encased	Thermal Aging	Loss of fracture toughness and loss of ductility	Radial neutron shield	TN-32 AMP	Yes
Borated Polymer	Fully Encased	Radiation Embrittlement	Cracking	Radial neutron shield	TN-32 AMP	Yes

¹ The applicant included a complete list of TN-32 subcomponent parts in CoC No. 1021 renewal application Table 3-5.

² 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 and operated at a temperature too low for stress relaxation in OD environments. The applicant stated in CoC No. 1021 renewal application Section 3.4.3.1.10 that the temperatures of the bolts may be sufficient for stress relaxation.

³ Not considered as a credible aging effect requiring an aging management activity in NUREG-2214.

⁴ This material/environment combination was not evaluated in NUREG-2214. The basis for finding the applicant's submitted acceptable for this material/environment combination is discussed above.

Table 3.3-14. Aging mechanisms and effects that require aging management—ISFSI Storage pad

Material Group	Environment	Aging Mechanism	Aging Effect	Subcomponent ¹	Aging Management Program	Consistent with NUREG-2214 Table 4-24
Steel	Embedded in concrete	General corrosion	Loss of material	ISFSI Storage pad	Storage pad AMP	Yes
Steel	Embedded in concrete	Pitting and crevice corrosion	Loss of material	ISFSI Storage pad	Storage pad AMP	Yes
Steel	Embedded in concrete	Microbiologically influenced corrosion	Loss of material	ISFSI Storage pad	Storage pad AMP	Yes
Concrete	Air-Outdoor	Freeze-thaw	Cracking, Loss of material	ISFSI Storage pad	Storage pad AMP	Yes
Concrete	Air-Outdoor	Reaction with aggregates	Cracking, Loss of strength	ISFSI Storage pad	Storage pad AMP	Yes
Concrete	Air-Outdoor	Aggressive chemical attack	Cracking, Loss of strength Loss of material Reduction in concrete pH	ISFSI Storage pad	Storage pad AMP	Yes
Concrete	Air-Outdoor	Corrosion of reinforcing steel	Loss of concrete/steel bond Loss of material, Cracking, Loss of strength	ISFSI Storage pad	Storage pad AMP	Yes
Concrete	Air-Outdoor	Leaching of calcium hydroxide	Loss of strength, Increase in porosity and permeability, Reduction in concrete pH	ISFSI Storage pad	Storage pad AMP	Yes
Concrete	Air-Outdoor	Delayed ettringite formation	Loss of material, Loss of strength, Cracking	ISFSI Storage pad	Storage pad AMP	No ²
Concrete	Air-Outdoor	Salt scaling	Loss of material	ISFSI Storage pad	Storage pad AMP	Yes
Concrete	Groundwater/ soil	Freeze-thaw	Cracking, Loss of material	ISFSI Storage pad	Storage pad AMP	Yes

Table 3.3-14. Aging mechanisms and effects that require aging management—ISFSI Storage pad

Material Group	Environment	Aging Mechanism	Aging Effect	Subcomponent ¹	Aging Management Program	Consistent with NUREG-2214 Table 4-24
Concrete	Groundwater/ soil	Reaction with aggregates	Cracking, Loss of strength	ISFSI Storage pad	Storage pad AMP	Yes
Concrete	Groundwater/ soil	Differential settlement	Cracking	ISFSI Storage pad	Storage pad AMP	Yes
Concrete	Groundwater/ soil	Aggressive chemical attack	Cracking, Loss of strength Loss of material Reduction in concrete pH	ISFSI Storage pad	Storage pad AMP	Yes
Concrete	Groundwater/ soil	Corrosion of reinforcing steel	Loss of concrete/steel bond Loss of material, Cracking, Loss of strength	ISFSI Storage pad	Storage pad AMP	Yes
Concrete	Groundwater/ soil	Leaching of calcium hydroxide	Loss of strength, Increase in porosity and permeability, Reduction in concrete pH	ISFSI Storage pad	Storage pad AMP	Yes
Concrete	Groundwater/ soil	Microbiological degradation	Loss of strength Loss of material Increase in porosity and permeability, Reduction in concrete pH	ISFSI Storage pad	Storage pad AMP	Yes
Concrete	Groundwater/ soil	Delayed ettringite formation	Loss of material, Loss of strength, Cracking	ISFSI Storage pad	Storage pad AMP	No ²
Concrete	Groundwater/ soil	Salt scaling	Loss of material	ISFSI Storage pad	Storage pad AMP	Yes

¹ The applicant provided the materials information for the subcomponent parts in CoC No. 1021 renewal application Table 3-7.

² NUREG-2214, Section 3.5.1.13, states that ACI design and construction codes are sufficient to preclude delayed ettringite formation. The applicant indicated in CoC No. 1021 renewal application Section 3.4.3.7.13 that delayed ettringite formation is considered credible for the storage pad in OD and GW environments unless ruled out by the general licensee by an ISFSI-specific evaluation.

Table 3.3-15. Aging mechanisms and effects that require aging management—Earthen Berm

Material Group	Environment	Aging Mechanism	Aging Effect	Subcomponent	Aging Management Program	Consistent with EPRI-1015078¹
Soil	Air-Outdoor	Wind Erosion	Loss of material	Earthen Berm	Berm AMP	Yes
Soil	Air-Outdoor	Surface Flow	Loss of material, Loss of form	Earthen Berm	Berm AMP	Yes
Soil	Air-Outdoor	Settlement	Loss of form	Earthen Berm	Berm AMP	Yes
Soil	Air-Outdoor	Frost Action	Loss of form	Earthen Berm	Berm AMP	Yes
Soil	Air-Outdoor	Desiccation	Change in properties	Earthen Berm	Berm AMP	Yes
¹ The applicant referred to Electric Power Research Institute (EPRI) 1015078, "Plant Support Engineering: Aging Effects for Structures and Structural Components (Structural Tools)," December 2007, to assess aging mechanisms for an earthen berm.						

3.3.4 Supplemental Evaluation

The applicant assessed the thermal aging of the aluminum basket plates in the TN-32 Dry Storage Cask in Appendix 3B of the renewal application to assess the effect on structural integrity of the plates. This analysis was included as a supplemental evaluation because the TN-32 UFSAR did not include this analysis in the original design basis for the TN-32 Dry Storage Cask.

The applicant stated that for the TN-32 Dry Storage Cask, the structural effectiveness of the aluminum basket plates is only credited for the tip-over accident conditions. The applicant referenced a supplemental evaluation of a TN-32 Dry Storage Cask which addressed the effects of thermal aging of the aluminum basket plates during a tip-over accident (Virginia Electric and Power Company, 2017). This evaluation was originally performed in response to an RAI for the renewal of Special Nuclear Material license number SNM-2507 and previously approved by the staff. The applicant reviewed the referenced evaluation and concluded that it was applicable and comprehensive in addressing the thermal aging of aluminum basket plates for the CoC No. 1021 renewal.

The referenced evaluation included a tip-over analysis of a TN-32 Dry Storage Cask which considered the structural analysis of the aluminum basket plates. The analysis considered previous work on the thermal aging of Al 6061-T6 showing that after exposure to elevated temperatures for extended periods the aluminum's yield and tensile strength decrease until they reach the properties of the fully annealed alloy, 6061-O (Farrell, 1995). To account for the effects of annealing and temperature, the applicant's structural analysis for the basket materials was conducted using temperature dependent material properties of aluminum 6061-O (Kaufman, 1999) with lower bound values for the yield and tensile strength at the maximum temperature for the aluminum alloy basket plates in the PEO (i.e., the maximum temperature of the basket plates after 20 years of storage). The evaluation showed that maximum stress intensities in the thermally aged aluminum plates remain below applicable limits defined in the TN-32 UFSAR for the tip-over analysis. The applicant concluded that this referenced evaluation sufficiently demonstrated that the TN-32 Dry Storage Cask maintains structural integrity while considering the effects of thermal aging of the aluminum basket plates.

The staff reviewed the applicant's assessment of thermal aging of the aluminum basket plates in Appendix 3B of the renewal application and the supplemental evaluation (Virginia Electric and Power Company, 2017) incorporated by reference. Since the referenced evaluation was performed on a TN-32 Dry Storage Cask system using the same materials, the NRC staff finds the referenced evaluation is applicable to all TN-32 Dry Storage Cask variants. The staff reviewed the structural analysis of the TN-32 basket in the TN-32 UFSAR and determined that the tip-over accident conditions are the bounding accident conditions for the aluminum basket. Based on the staff's review of the material properties and stress analysis of the aluminum basket in the referenced evaluation, the staff finds the applicant sufficiently addressed the potential for thermal aging of the aluminum components and demonstrated the structural functions of the aluminum components are not adversely affected. The staff finds the applicant's assessment of thermal aging of the aluminum basket plates in the TN-32 system to be consistent with evaluation in NUREG-2214, Section 3.2.3.7, and is therefore acceptable.

3.4 Evaluation Findings

The staff reviewed the AMR provided in the renewal application and supplemental documentation to verify it identified the materials, environments, and aging effects of the in-scope SSCs. The staff performed its review following the guidance provided in NUREG-1927, and consistent with the evaluation in NUREG-2214. Based on its review of the renewal application, 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 the renewal, and the applicant provided appropriate descriptions of the materials and operating environments for those SSCs within the scope of the renewal in the renewal application.

- 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 the renewal, and the applicant provided an acceptable summary of the AMR results in the renewal application.

3.5 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 safety function throughout an explicitly stated period of operation. Under 10 CFR 72.3, "Definition," TLAAs are the calculations/analyses that meet all six of the following criteria:

1. involve structures, systems, and components ITS 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.

Based on its review, the applicant identified the following analyses as meeting all six TLA criteria:

- Boron depletion in the borated aluminum plates
- Establishment of fuel cladding temperature limits
- Ensure cavity pressure remains above one atmosphere on the coldest day at the end of the storage period

The staff used the guidance in NUREG-1927, Section 3.5, to review the applicant's updated TLAAs and supplemental analyses. The staff also used the AMR tables in NUREG-2214, Chapter 4, that identify aging management approaches including AMPs, TLAAs, or supplemental analyses for credible aging effects that could challenge the capability of each of the SSCs and their subcomponents to fulfill its important-to-safety function(s) in the 20- to 60-year PEO.

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

3.5.1 Boron Depletion in the in the borated aluminum plates

The applicant stated that the TN-32 UFSAR, Section 6.3.2, evaluated the potential for boron-10 depletion in the poison plates of the basket. The evaluation used a calculated neutron scalar flux of 8.41×10^5 n/cm²-s at the center of the basket and was based on a period of 1,000 years. This analysis uses cross section data for thermal neutrons as boron-10 has the highest absorption for thermal neutrons, making this a conservative assumption. The applicant's

analysis also makes the conservative assumption that the neutron fluence is constant, rather than decreasing over time. The evaluation determined that the fraction of the original boron-10 that would be depleted is negligible. The applicant stated that because the existing analysis assumes 1,000 years of service, the evaluation remains valid and demonstrates that the boron poison plates will continue to perform their intended function through the end of the PEO.

The staff reviewed the applicant's analysis for boron depletion of the poison plates by comparing the applicant's analysis to the generic evaluation included in Section 3.4.2.4 of NUREG-2214. This comparison supports the conclusion 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 TN-32 Dry Storage Cask. The staff noted that the applicant's evaluation used calculated neutron scalar flux that is toward the upper end of the range typical for dry cask storage (NRC 2011). This is a conservative assumption and shows that even if TN-32 has a neutron flux on the higher end of what is typical, the analysis shows negligible boron depletion of the poison plates for a period of 1,000 years. The staff determined that the applicant's assessment was acceptable because the applicant's evaluation is consistent with the evaluation provided in NUREG-2214, Section 3.4.2.4. Therefore, the applicant's calculation for negligible boron depletion covers the PEO.

3.5.2 Establishment of fuel cladding temperature limits

The applicant stated that per TN-32 UFSAR Section 3.5.1, the maximum fuel cladding temperature of the hottest fuel rod in the cask shall not exceed the temperature limit calculated in accordance with PNL-6189 (Levy et al., 1987). The applicant stated that the temperature limit was established to prevent cladding creep. The applicant stated that the methodology in PNL-6189 is based on a storage period of 40 years. The applicant calculated this limit to be 631 degrees F (333 degrees C) for 7-year cooled fuel and 622 degrees F (328 degrees C) for 10-year cooled fuel. The applicant noted that the thermal analyses in TN-32 UFSAR Section 4 selected the more conservative value of 622 degrees F (328 degrees C) for the fuel cladding temperature limit.

The applicant stated that the PNL-6189 methodology predates the current accepted limit for low burnup fuel in ISG-11, Revision 3. The applicant noted that because the TN-32 TS limit the Zircaloy clad fuel to an average burnup of 45 Gwd/MTU, the fuel stored in the TN-32 Dry Storage Cask is not considered to be high burnup fuel. The applicant concluded that since (1) the fuel cladding temperature limits applied to the fuel stored in the TN-32 Dry Storage Cask are lower than the current accepted limit identified in ISG-11, and (2) the temperature of the fuel assemblies will continue to decrease with time, the maximum fuel cladding temperature calculations remain valid for the PEO and demonstrate that the cladding will continue to perform its intended safety function through the end of the PEO.

The staff reviewed the methodology, assumptions, and conclusions for temperature limits for the spent fuel cladding in the TN-32 Dry Storage Cask. As noted in NUREG-2214, Section 3.6.1 and 3.6.2, there are no aging effects that are considered credible for spent fuel cladding or spent fuel assembly hardware for assemblies with average burnups that do not exceed 45 Gwd/MTU. The staff noted that the applicant's analysis is in agreement with the analysis provided in NUREG-2214. Further, the methodology used by the applicant for the maximum fuel assembly temperature based on PNL-6189 is conservative with respect to ISG-11, Rev 3. The staff determined that the applicant's analysis for temperature limits for the spent fuel cladding materials are bounded by the technical basis in NUREG-2214, and are therefore acceptable.

3.5.3 Ensure cavity pressure remains above one atmosphere on the coldest day at the end of the storage period

The applicant stated that TN-32 USFAR Section 2.2.5.3.3 contains a design criterion that one atmosphere of pressure must exist in the cavity (i.e., the cask interior) on the coldest day at the end of the PEO. As noted by the applicant, the purpose of pressurizing the cavity above atmospheric pressure is to prevent in-leakage of air. The applicant stated that preventing leakage of air into the TN-32 Dry Storage Cask is necessary to avoid corrosion of the pressure boundary components that could lead to a loss of material. The applicant stated that while the design of the overpressure monitoring system ensures there will be no out-leakage past the seals during normal operations, the cavity pressure decreases over time as the decay heat decreases. The applicant clarified that the end of life cavity pressure analysis assumes a cavity gas temperature corresponding to the end of the 20-year storage period and therefore, the end of life cavity pressure analysis must be revised or updated to demonstrate that the cavity pressure will be above one atmosphere at the end of the PEO, i.e., a total of 60 years.

The applicant provided an updated cavity pressure calculation that demonstrates that the cavity pressure of a TN-32 Dry Storage Cask remains above atmospheric pressure on the coldest day regardless of how long it has been in storage. The applicant's analysis was based on the ideal gas law which governs the change in cavity pressure as the temperature inside the cavity decreases. The applicant cited Section 7.2.2.1 of the TN-32 UFSAR for the initial gas temperature of 411 degrees F (211 degrees C) and TN-32 TS 3.1.2 for the cavity minimum allowed pressure of 2.10 atm (2,130 mbar). The applicant stated the minimum average daily ambient design temperature for the TN-32 Dry Storage Cask is -20 degrees F (-29 degrees C). Assuming that the helium gas temperature is the same as the ambient air temperature, the applicant determined that the minimum pressure in the cask would be 1.06 atm (1,074 mbar). In response to an RAI regarding the effect of cask leak rate on the cavity gas pressure the applicant indicated (ADAMS Accession No. ML21036A238) that UFSAR Section 2.3.2.1, Confinement Barriers and Systems, considered permeation through the confinement vessel negligible and leakage past the higher pressure of the monitoring system physically impossible. Therefore, the applicant concluded the decrease in cavity pressure during the storage period occurs only as a result of a reduction in the cavity gas temperature with time.

The NRC reviewed the applicant's original assessment in TN-32 USFAR Section 2.2.5.3.3 and the basis for the revised calculation. The TLAA provided by the applicant considers the decay heat of the fuel, time in service at the end of the PEO, and the minimum ambient operating temperature for the TN-32 Dry Storage Cask. The staff verified that Section 7.2.2.1 of the TN-32 UFSAR indicates that the average cavity gas temperature is 411 degrees F (211 degrees C) with 100 degrees F (38 degrees C) ambient air and maximum solar load. In addition, the staff verified that TN-32 TS 3.1.2 stipulates the cavity minimum allowed pressure of 2.10 atm (2,130 mbar). The staff confirmed that the minimum average daily ambient design temperature for the TN-32 Dry Storage Cask is -20 degrees F (-29 degrees C) as shown in Table 2.5-1 of the TN-32 USFAR. The staff noted that the assumption of the helium fill gas temperature as being the same as the minimum daily ambient temperature is conservative because the residual decay heat from the stored spent fuel will result in internal temperatures above that of the ambient external environment. The staff verified that the applicant's calculation was based on initial and assumed final helium gas temperatures, which resulted in a final pressure greater than one atm. The staff determined that the applicant's revised assessment was acceptable because the calculation shows that the TN-32 Dry Storage Cask design criteria is met for the PEO.

3.5.4 Evaluation Findings

The staff reviewed the renewal application and design-bases documentation to confirm that the applicant did not omit any TLAAs that were part of the approved design bases. The staff performed its review following the guidance provided in NUREG-1927 and NUREG-2214.

Based on its review of the renewal application, the staff finds the following:

- F3.3 The applicant appropriately evaluated all aging mechanisms and effects pertinent to SSCs within the scope of the renewal that had the potential to involve TLAAs. Therefore, the applicant's evaluation provides reasonable assurance that the SSCs will maintain their intended functions for the PEO, require no further aging management activities, and meet the requirements in 10 CFR 72.240(c)(2).

3.6 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 renewal application:

- (1) TN-32 AMP
- (2) Storage pad AMP
- (3) Earthen berm AMP

The staff used the guidance in NUREG-1927, Section 3.6, to review the applicant's AMPs. In particular, the staff used the guidance in NUREG-1927, Section 3.6.1, which provides detailed review instructions for the ten elements of an AMP to meet the regulatory requirements of 10 CFR 72.240(c)(3). The staff also used the information in NUREG-2214, Chapter 6, Example Aging Management Programs, that contains example AMPs that an applicant may use to address the credible aging effects identified in the AMR tables. The staff used the information in NUREG-2214, Sections 6.6, Reinforced Concrete Structures, and the example AMP for concrete structures in NUREG-2214, Table 6-3, to inform the review of the applicant's AMP for the reinforced concrete storage pad. The staff used the information in NUREG-2214, Section 6.7, Monitoring of Metallic Surfaces, and Section 6.8, Bolted Cask Seal Leakage Monitoring, along with the example AMP for monitoring of metallic surfaces in NUREG-2214, Table 6-4, and the example AMP for bolted cask seal leakage monitoring in NUREG-2214, Table 6-5, to inform the review of the applicant's AMP for the TN-32 Dry Storage Cask.

In addition, the staff reviewed the applicant's AMR for the optional earthen berm using the information included in EPRI-1015078 cited by the applicant. The staff also reviewed the information in (1) NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 2.5.4 "Stability of Subsurface Materials and Foundations" (ADAMS Accession No. ML13311B744) (NRC 2014), (2) NRC RG 1.127, Revision 2, "Criteria and Design Features for Inspection of Water Control Structures Associated with Nuclear Power Plants" (ADAMS Accession No. ML15107A412), Section C.5.b., "Onsite Inspection Program," (3) the aging management of the berm at the Prairie Island Nuclear Generating Plant ISFSI (ADAMS Accession No. ML15285A007), and (4) the staff evaluation of the TN-40 Dry Storage Cask AMP in the Prairie Island Nuclear Generating Plant ISFSI SER (ADAMS Accession No. ML15336A230). The staff used the information in EPRI-1015078 and NUREG-0800, Section 2.5.4, for additional insight into aging mechanisms and effects for earthen structures. The staff used the information in NRC RG 1.127, Section C.5.b, for information on the inspection of earthen embankment structures for the detection of aging effects.

The staff compared the content of the AMPs provided by the applicant to the results of the AMR. The staff determined that the AMPs provided by the applicant are consistent with the results of the AMR for SSCs within the scope of the renewal and address credible aging effects that were not dispositioned with TLAAs or supplemental analyses. The staff conducted the safety review of the proposed AMPs in the renewal application per the guidance in NUREG-1927, and, when applicable, to the generically acceptable example AMPs in NUREG-2214. The staff's review of the AMPs provided by the applicant in the renewal application along with the changes to the AMPs in response to RAIs (ADAMS Accession No. ML20316A030, ML21036A237 and ML21076A040) is provided in the following subsections.

3.6.1 TN-32 AMP

The staff conducted the safety review of the proposed AMPs in the renewal application per the guidance in NUREG-1927, Section 3.6.1, specific to each AMP element. In addition, the staff used the generically acceptable example AMPs in NUREG-2214, Table 6-4, for the visual inspection of the TN-32 Dry Storage Cask external surfaces and Table 6-5 for the review of the pressure monitoring system.

Scope of program: The applicant stated that the program calls for general licensees to visually inspect and monitor the condition of the TN-32 subcomponents listed in the renewal application, Table 4-1. The applicant stated that the renewal application Section 4.3 identifies the materials aging effects to be managed as follows:

- Steel
 - Loss of material due to general, pitting, crevice, and galvanic corrosion
 - Loss of preload due to stress relaxation of bolts
- Stainless Steel
 - Loss of material due to pitting, crevice, and galvanic corrosion
- Polymers
 - Shrinkage/cracking due to thermal aging and radiation embrittlement
- Aluminum
 - Loss of material due to general, pitting, crevice, and galvanic corrosion

The staff reviewed the applicant's description of the scope of program for the TN-32 AMP and determined that the description follows the guidance in NUREG-1927, Section 3.6.1.1. The staff verified that the scope of program identifies the specific SSCs and subcomponents covered by the AMP, the intended function to be maintained, and identifies the specific materials, environments, and aging mechanisms and effects to be managed. The staff determined that the scope of program for the TN-32 AMP covers the all of the potential aging mechanisms and effects identified in the AMR for the subcomponents of the TN-32 Dry Storage Cask that are within the scope of renewal review. Therefore, the staff determined that the applicant's description for the scope of program AMP element was acceptable.

Preventive actions: The applicant stated that the TN-32 AMP is a condition-monitoring program that does not include preventive actions.

The staff determined that the applicant's description of the preventive actions AMP element follows the guidance in NUREG-1927, Section 3.6.1.2, which states that some condition or performance monitoring programs do not rely on preventive actions and thus this information need not be provided. Therefore, the staff determined that the applicant's description for the preventive actions AMP element was acceptable.

Parameters monitored or inspected: The applicant stated that the TN-32 AMP consists of interseal pressure monitoring, radiation monitoring, and visual inspections of the subcomponents within the scope of the TN-32 AMP for the aging mechanisms and effects identified in the renewal application, Table 4-1. The applicant stated that monitoring of the interseal pressure of the TN-32 Dry Storage Cask is used to verify the integrity of the TN-32 Dry Storage Cask seals. The applicant stated that gamma and neutron radiation monitoring will be conducted to ensure that there is no loss of the shielding intended safety function. The

applicant stated that visual inspections will be performed on the TN-32 Dry Storage Cask looking for loss of material for steel and stainless steel subcomponents.

The staff reviewed the applicant's description of the parameters monitored and inspected for the TN-32 AMP and determined that the description was acceptable because program element identifies the specific parameters that will be monitored or inspected to identify degradation before a loss of intended function, meaning the program element follows the guidance in NUREG-1927, Section 3.6.1.3. Therefore, the staff determined that the applicant's description of the parameters monitored on inspected AMP element was acceptable.

Detection of aging effects: The applicant stated that the interseal pressure is monitored by measuring the pressure in the overpressure system. Monitoring of the overpressure system, which controls the interseal pressure, is used to determine if the TN-32 Dry Storage Cask seals continue to function as designed. A decrease in pressure is an indication that one of the seals in TN-32 Dry Storage Cask is allowing helium gas to leak past the seal. The TN-32 AMP uses the same equipment, methods, and frequency used to comply with TN-32 TS 3.1.5, "Cask Interseal Pressure." In addition, the applicant stated that the TS Surveillance Requirement (SR) 3.1.5.1 requires verification that the cask interseal helium pressure is above 3.2 atm absolute every seven days.

The applicant stated that the detection of gamma and neutron radiation is accomplished by placing thermoluminescent dosimeters (TLDs) at the ISFSI perimeter fence and conducting surveys of neutron radiation around the perimeter of the storage pad. The applicant stated that TLDs for monitoring neutron radiation shall be capable of detecting low, intermediate, and high energy neutrons. This can be accomplished with a Columbia Resin (CR) 39 chip or equivalent dosimetry equipment. The placement of the TLDs depends on the characteristics of each site and justification of the placement of the TLDs must be documented in a site's program documentation. The applicant stated that the TLD readings are obtained quarterly and the neutron surveys will be performed annually. Increases in dose rates are attributable to deterioration of the gamma and neutron shielding because radiation from spent fuel decreases over time. Thus, the results from these monitoring activities provide a means to detect deterioration of the TN-32 Dry Storage Cask gamma and neutron shielding due to loss of material, shrinkage, or cracking before the limits in 10 CFR 20.1301 and 10 CFR 72.104 are exceeded. This is because radiation from spent fuel decreases over time and an increase is detected, it would likely be from degradation to the shielding.

The applicant stated that visual inspection, referenced under the "Parameters monitored or inspected," AMP element (either direct or remote) will be performed on the surfaces of in-scope subcomponents in the normally accessible and non-accessible areas. The applicant stated that accessible surfaces of all TN-32 Dry Storage Casks will be visually inspected on an annual basis. In addition, the applicant stated that a scheduled visual inspection of normally non-accessible areas of a lead TN-32 Dry Storage Cask will be performed within two years prior to 20 years of the first loaded TN-32 Dry Storage Cask being placed in storage, or no later than eighteen months after the effective date of the CoC renewal, whichever is later. The applicant stated that the initial inspection will serve as a baseline and subsequent inspections would occur on a frequency of every 20 ± 1 years thereafter.

The applicant stated that visual inspections are looking for loss of material indicated by corrosion or rust stains on steel or stainless steel surfaces and rust stains on the concrete pad. The applicant clarified that removal of bolts for the annual inspection of the accessible surfaces is not required. The applicant stated that ASME non-destructive examination (NDE)

qualifications are not required to perform the visual inspections of accessible areas; however, the inspectors of accessible areas shall be trained/qualified per the licensees' specific procedures. For the visual examinations of the normally non-accessible areas, the applicant stated that the personnel performing the inspection shall be qualified and certified in accordance with ASME Section XI, IWA-2300.

The staff reviewed the applicant's detection of aging effects for the TN-32 AMP and determined that the description was acceptable because the program element identifies the inspection method, samples size, timing of inspections, and inspection frequency necessary to identify degradation before a loss of intended function.

The staff found that the detection of aging effects using interseal pressure monitoring was acceptable because the TN-32 AMP utilizes the same equipment, methods, and frequency used to comply with TN-32 TS 3.1.5. The staff noted that the TN-32 Dry Storage Cask design uses an inner and outer seal with the interseal region at a higher pressure than either the cask interior or the external environment. By monitoring the pressure in the interseal region using the overpressure system, any leak of either the inner or the outer seal would be readily detected. The staff noted that the pressure monitoring systems on bolted lid spent fuel storage systems have detected seal leakage as a result of seal corrosion prior to a loss of intended function.

The staff found that the radiation monitoring was capable of detecting any degradation to the gamma and neutron shield based on TLDs constantly monitoring the area, annual inspections, and annual radiation surveys. The TLDs are in place to confirm compliance with limits in 10 CFR 20.1301 and 10 CFR 72.104 and increases in radiation beyond these limits would be detected. TLDs may not be able to detect localized failure of a single cask as they detect an average dose rate at a distance. Localized degradation that would result in a hot spot near an individual cask would affect workers near the area of degradation and would be detected when surveys are performed to obtain a radiation work permit before workers entered the area as stated in the March 17, 2021 supplement (ADAMS Accession No. ML21076A040). Any areas that have unexpectedly high radiation would be entered into the corrective action program as a matter of standard radiation protection practices. The annual visual inspections additionally ensure that degradation to the gamma shielding would be detected because corrosion of the steel cask would be readily identified by the visual inspection and annual neutron surveys ensure that degradation to the neutron shielding would be detected. These additional factors provide assurance that any shielding degradation resulting in streaming paths not seen by the TLDs would be detected.

The staff found that the stated visual inspections looking for loss of material indicated by corrosion or rust stains on steel or stainless steel surfaces and rust stains on the concrete pad are acceptable because corrosion of the carbon steel and stainless steel components will produce corrosion products that are readily apparent. In addition, the staff determined that the personnel requirements, which stipulate that the annual inspection be performed by staff trained by the general licensee, and the inspection of the normally non-accessible areas, which the applicant's requirements mandate be performed by ASME qualified personnel, are sufficient for the detection of aging effects to prevent a loss of intended function. The staff determined that the 20 year inspection interval for the normally non-accessible components of the TN-32 Dry Storage Cask was acceptable because the cask design provides protection of these subcomponents and the OE review did not identify aging-related issues that would require more frequent inspection intervals.

The staff determined that the applicant's description for the detection of aging effects AMP element follows the guidance in NUREG-1927, Section 3.6.1.4, and identifies how the potential aging effects for the TN-32 Dry Storage Cask will be detected by the inspection and monitoring methods specified in the AMP. Therefore, the staff determined that the applicant's description of the detection of aging effects AMP element was acceptable.

Monitoring and trending: The applicant stated that general licensees perform the inspections and monitoring activities in the TN-32 AMP periodically to identify areas of degradation and that conditions that do not meet the acceptance criteria are entered into the general licensees' corrective action program. The applicant stated that visual inspections consider the cumulative OE from previous inspections and assessments in order to monitor the progression of aging effects over time. The applicant stated that general licensees will compare the data taken from inspections and monitoring activities to past site data taken as well as to industry OE, including data gathered by the Institute of Nuclear Power Operations (INPO) Aging Management INPO Database (AMID), as discussed in Nuclear Energy Institute (NEI) 14-03 (NEI 2016).

The staff reviewed the applicant's description of the monitoring and trending element of the TN-32 AMP and determined that the applicant's description follows the guidance in NUREG-1927, Section 3.6.1.5. Specifically, the applicant's description for the AMP element includes a baseline inspection established at the beginning of the PEO and the applicant described how the data will be collected and evaluated against the results of past inspection data. The staff found the frequency of the radiation monitoring and trending reasonable and acceptable based on the requirement that there be multiple modes of detection with acceptance criteria to identify aging effects. These include, as described above in this and the preceding sections, annual visual inspections, annual neutron monitoring, continuous monitoring by the TLDs, and the necessary radiation surveys as needed to support radiation work permits. Therefore, the staff determined that the applicant's description of the detection of aging effects AMP element was acceptable.

Acceptance criteria: The applicant stated that the acceptance criterion for interseal pressure monitoring is the limit specified in TN-32 Dry Storage Cask TS 3.1.5—i.e., it must be at least 3.2 atm absolute. The applicant stated that the acceptance criteria for radiation monitoring is the absence of an annual increasing trend in neutron or gamma quarterly TLD readings at the ISFSI perimeter fence and absence of an annual increasing trend in the neutron surveys at the storage pad perimeter. The applicant stated that the acceptance criteria for the visual inspections are no observed corrosion, no rust stains on steel or stainless steel surfaces, and no rust stains on the concrete pad. In addition, the applicant stated that if any of the above acceptance criteria are not met, further evaluation is required through the general licensees' corrective action program.

The staff reviewed the description and determined that the applicant's description of the acceptance criteria AMP element follows the guidance in NUREG-1927, Section 3.6.1.6. The staff determined that the acceptance criterion for interseal pressure monitoring is acceptable because it is based on the limit specified in TN-32 Dry Storage Cask TS 3.1.5, which assures that the original design basis is maintained throughout the PEO. The staff determined that the applicant's acceptance criteria for gamma and neutron radiation monitoring were acceptable because the TN-32 AMP specifies measurement and monitoring of gamma and neutron radiation trends. An increasing trend might indicate degradation of the shielding, as the radiation source should decay over time. Therefore, the staff found that the acceptance criteria for gamma and neutron radiation monitoring were appropriate. The staff determined that the applicant's acceptance criteria for visual inspection of corrosion—which specifies no observed

corrosion, no rust stains on steel or stainless steel surfaces, and no rust stains on the concrete pad—were acceptable because corrosion products are readily observed in visual inspection and the observed presence of corrosion products indicates corrosion that could result in a loss of material. The staff verified the applicant stated that any inspection or monitoring result that does not meet the acceptance criteria would be entered into the general licensees' corrective action program for further evaluation. Therefore, the NRC staff found the applicant's description of the acceptance criteria AMP element to be acceptable.

Corrective actions: The applicant stated that under the AMP, general licensees implement quality assurance (QA) procedures; review and approval processes; and administrative controls according to the requirements of 10 CFR Part 50, Appendix B. This ensures that general licensees promptly identify and correct conditions adverse to quality. These procedures include root cause determination and prevention of recurrence. The applicant stated that general licensees either correct deficiencies (i.e., inspection results that do not meet acceptance criteria) or evaluate the cask to be acceptable for continued service through engineering analysis. This engineering analysis provides reasonable assurance that the intended safety function is maintained consistent with current licensing basis conditions. In addition, the applicant stated that the extent of condition investigation per the general licensees' corrective action program may cause additional inspections through use of a different method, increased inspection frequency, and/or expanded inspection sample size.

The staff reviewed the applicant's description of the corrective action element for the TN-32 AMP and verified that the corrective actions for the TN-32 Dry Storage Cask AMP state 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. Based on this, the staff determined that the corrective actions followed the guidance in NUREG-1927, 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. Therefore, the staff finds the applicant's description of the corrective actions AMP element to be acceptable.

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

The staff reviewed the applicant's description of the confirmation process element for the TN-32 AMP and determined that the description follows the guidance in NUREG-1927, Section 3.6.1.8, which states that the confirmation process AMP element is intended to verify that preventive actions are adequate and that appropriate corrective actions have been completed and are effective. The staff verified that the confirmation process for the TN-32 AMP includes provisions to verify that appropriate corrective actions have been completed and are effective and relies on the general licensees' QA programs approved under 10 CFR Part 50, Appendix B, which contains provisions to preclude repetition of significant conditions adverse to quality. Therefore, the staff determined that the applicant's description of the confirmation process AMP element was acceptable.

Administrative controls: The applicant stated that the administrative controls under the CoC holder's or general licensees' QA procedures and corrective action program provide a formal review and approval process. The applicant stated that the administrative controls are

implemented in accordance with the requirements of 10 CFR Part 50, Appendix B, and will continue for the PEO. The applicant stated that general 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 OE, research, monitoring, or inspection is reportable to the NRC.

The staff reviewed the applicant's description of the administrative controls element for the TN-32 AMP using the guidance in NUREG-1927, Section 3.6.1.9. The staff confirmed that the applicant's description of the administrative controls under the CoC holder's or general licensees' QA procedures and corrective action program provide a formal review and approval process for the TN-32 AMP. The staff determined that the applicant's description states that the administrative controls are in accordance with the general licensee QA program approved under 10 CFR Part 50, Appendix B, and will continue for the PEO. Therefore, the staff determined that the applicant's description of the administrative controls AMP element was acceptable.

Operating experience: The applicant stated that renewal application Appendix 3C documents the review of various sources of OE relevant to the TN-32 Dry Storage Cask and includes the results of inspections of the TN-32 and TN-40 Dry Storage Casks in service. The applicant stated that the TN-32 AMP will be updated, as necessary, to incorporate new information on degradation due to aging effects identified from plant-specific inspection findings, related industry OE, and related industry research. The applicant noted that future plant-specific and industry aging management and aging-related OE are captured through the general licensees' review processes. The ongoing review of both plant-specific and industry OE will continue through the PEO to ensure that this AMP continues to be effective in managing the identified aging effects.

The staff reviewed the applicant's description of the operating experience AMP element for the TN-32 AMP and determined that the description follows the guidance in NUREG-1927, Section 3.6.1.10. Specifically, the staff determined that the applicant's description identified the relevant sources of OE listed in NUREG-1927, Section 3.6.1.10. The staff determined that the applicant assessed current OE and included provisions to capture future plant-specific and industry aging management and aging-related OE through the OE review process. Therefore, the staff determined that the applicant's description of the operating experience AMP element was acceptable.

The staff review verified that each element of the TN-32 AMP contained the provisions necessary so that the AMP will be effective for identifying degradation of the TN-32 Dry Storage Casks and implementing corrective actions before a loss of intended function. The staff determined that the AMP for the TN-32 Dry Storage Casks is consistent with the guidance provided in NUREG-1927, Section 3.6.1. Thus, the staff determined that the AMP for the TN-32 Dry Storage Casks in the renewal application was acceptable for managing the aging effects as a result of credible aging mechanisms.

3.6.2 Storage pad AMP

This subsection documents the staff review of the storage pad AMP. The staff used the review guidance in NUREG-1927, Section 3.6.1, specific to each AMP element. In addition, the staff

used the generically acceptable example AMPs in NUREG-2214, Table 6-3, for the review of the reinforced concrete structures.

Scope of program: The applicant stated that the program calls for general licensees to visually inspect the surfaces of the storage pad subcomponents listed in the renewal application, Table 4-2. The applicant stated that renewal application Section 4.4 identifies the materials aging effects to be managed, as follows:

- Steel
 - Loss of material due to general corrosion, pitting corrosion, and crevice corrosion
- Concrete
 - Loss of material due to freeze-thaw, aggressive chemical attack, corrosion of reinforcing steel, delayed ettringite formation, salt scaling, and microbiological degradation
 - Cracking due to freeze-thaw, reaction with aggregates, differential settlement, aggressive chemical attack, corrosion of reinforcing steel, and delayed ettringite formation
 - Loss of strength due to reaction with aggregates, aggressive chemical attack, corrosion of reinforcing steel, leaching of calcium hydroxide, delayed ettringite formation, and microbiological degradation
 - Reduction of concrete pH due to aggressive chemical attack, leaching of calcium hydroxide, and microbiological degradation
 - Loss of concrete/steel bond due to corrosion of reinforcing steel
 - Increase in porosity and permeability due to leaching of calcium hydroxide and microbiological degradation

The staff reviewed the applicant's description of the scope of program for the storage pad AMP and determined that the description was acceptable because the program element follows the guidance in NUREG-1927, Section 3.6.1.1, and is consistent with the example AMP in NUREG-2214, Table 6-3. The staff verified that the scope of program identifies the specific SSCs and subcomponents covered by the AMP, the intended function to be maintained, and identifies the specific materials, environments, and aging mechanisms and effects to be managed. The staff determined that the scope of the program for the Storage pad AMP covers the all of the potential aging mechanisms and effects identified in the AMR for the subcomponents of the storage pad for the TN-32 Dry Storage Cask that are within the scope of renewal. Therefore, the staff determined that the applicant's description for the scope of program AMP element was acceptable.

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

The staff determined that the applicant's explanation is acceptable because, as noted in NUREG-1927, Section 3.6.1.2, some condition or performance monitoring programs do not rely on preventive actions and thus this information need not be provided. Therefore, the staff determined that the applicant's description for the preventive actions AMP element was acceptable.

Parameters monitored or inspected: The applicant stated that the storage pad AMP consists of visual inspections to monitor for material degradation as identified in renewal application, Table

4-2. The applicant stated that accessible areas of the storage pad will undergo direct visual inspection, including the aboveground exposed surface of the storage pad. The applicant stated that the normally non-accessible areas of the storage pad include external surfaces of the storage pad under the TN-32 Dry Storage Casks and that the inaccessible areas of the storage pad include below-grade surfaces of the storage pad, and the components embedded in concrete. The applicant did not include inspection of the normally non-accessible concrete surface area under the TN-32 Dry Storage Casks or the inaccessible areas of the storage pad that is below-grade.

The staff reviewed the applicant's description of the parameters monitored and inspected for the storage pad AMP and determined that the applicant's description of the AMP element follows the guidance in NUREG-1927, Section 3.6.1.3. The staff determined that the applicant's description identifies the specific parameters that will be monitored or inspected to identify degradation before a loss of intended function. The staff determined that the applicant's AMP element description is also consistent with the example AMP in NUREG-2214, Table 6-3. Therefore, the staff determined that the applicant's description of the parameters monitored or inspected AMP element was acceptable.

Detection of aging effects: The applicant stated that under the AMP, general licensees are to conduct direct visual inspections utilizing ACI-349.3R, "Report on Evaluation and Repair of Existing Nuclear Safety-Related Concrete Structures", (ACI 2018) Section 3.6.1, "Visual inspection," for the above-grade portions of the concrete storage pad, allowing for detection of aging effects listed in renewal application, Table 4-2. In response to an RAI (ADAMS Accession No. ML20316A030), the applicant stated that the visual inspection of the storage pad shall be conducted by staff that meet the qualification requirements of ACI-349.3R, Chapter 7. The applicant stated that for storage pad concrete, under the AMP general licensees develop crack maps and document dimensions in photographic records by inclusion of a tape measure/crack gauge, a comparator, or both.

The applicant stated that general licensees assess potential degradation of the below-grade portion of the concrete pad by inspecting the aboveground, exposed surfaces of the storage pads for indications of aging and by reviewing the results of groundwater sampling at a minimum of three locations in the area of the ISFSI to ensure the below-grade portions are not exposed to an aggressive environment. The applicant stated that the approach is consistent with the Type 1 below-grade inaccessible areas in Section 6 of ACI 349.3R-2018 except the AMP does not explicitly call for inspections of opportunity if the below-grade concrete is exposed due to excavation for any reason. In response to an RAI (ADAMS Accession No. ML20316A030), the applicant stated that the inspection of opportunity was not included in the AMP because the likelihood of excavating adjacent to an existing ISFSI pad is so small that the potential aging management benefit does not warrant the additional procedural complexity required to ensure that the inspections of opportunity would be performed.

The applicant stated that the baseline AMP visual inspection and groundwater sampling is to be conducted at most two years prior to 20 years of the first loaded TN-32 Dry Storage Cask being placed in storage, or no later than eighteen months after the effective date of the CoC renewal, whichever is later. The applicant stated that subsequent inspections and groundwater sampling are to be conducted every 5 years \pm 1 year following the baseline inspection.

The staff reviewed the applicant's description for the detection of aging effects for the storage pad AMP element and determined that the AMP element description follows the guidance in NUREG-1927, Section 3.6.1.4. The applicant's description identifies the inspection method,

sample size, timing of inspections, and inspection frequency. The staff determined that the applicant described how the potential aging effects for the storage pad will be detected by the inspection and monitoring methods identified in this AMP. The staff also determined that the description for the detection of aging effects for the storage pad AMP element is consistent with the example AMP in NUREG-2214, Table 6-3, with the exception of the opportunistic inspection associated with excavations. The staff noted that the example AMP for reinforced concrete structures in NUREG-2214, Table 6-3, relies on the methodology included in ACI 349.3R including the inspection techniques, frequency of inspection, and personal qualification requirements. The staff determined that the inspection of the aboveground, accessible portions of the concrete pad combined with groundwater chemistry monitoring is sufficient to monitor for aging of the storage pad and identify degradation before a loss of intended function and, based on that, inspection of opportunity is not necessary to find the applicant's description of this AMP element acceptable. Therefore, the staff determined that the applicant's description of the detection of the aging effects AMP element was acceptable.

Monitoring and trending: The applicant stated that general licensees perform the inspections and monitoring activities in the storage pad AMP periodically to identify areas of degradation and to ensure that conditions that do not meet the acceptance criteria are entered into the general licensees' corrective action programs. The applicant stated that the monitoring and trending AMP element considers the cumulative OE from previous storage pad inspections and assessments in order to monitor and trend the progression of aging effects over time. The applicant stated that general licensees will monitor data from the inspections and ground water sampling. The applicant stated that the data obtained will be compared to past site data as well as to industry OE, including data gathered by the AMID as discussed in NEI 14-03.

The staff reviewed the applicant's description of the monitoring and trending element for the storage pad AMP and determined that the description follows the guidance in NUREG-1927, Section 3.6.1.5. The staff determined that the AMP element includes a baseline inspection established at the beginning of the PEO, describes how the inspection and monitoring data will be collected, and describes the evaluation of the results against the AMP acceptance criteria to ensure that the timing of the next scheduled inspection will occur before a loss of intended function. Therefore, the staff determined that the applicant's description of the parameters monitored or inspected AMP element was acceptable.

Acceptance criteria: The applicant listed the visual inspection acceptance criteria which are consistent with those in ACI 349.3R in renewal application Section 4.4.6. In response to an RAI (ADAMS Accession No. ML20316A030), the applicant stated that the justification for using the ACI 349.3R acceptance criteria was because ACI 349.3R is the recognized industry standard for managing aging effects of concrete. The applicant stated that the majority of the second-tier criteria in ACI 349.3R address conditions where the degradation results in the concrete material being replaced by discrete air pockets such as cracking or spalling. The applicant stated that since air has lower heat conductivity than the concrete material, the acceptance criteria in ACI 349.3R can be extended to be applicable for monitoring the concrete thermal function. The applicant noted that the magnitude of the acceptance criteria such as the size of cracks or spalling is very small compared to the surface area of the pad under the cask. Therefore, the applicant concluded that while the focus of ACI 349.3R may be the structural performance of the concrete, it can also be used to ensure that the thermal function is maintained. The applicant also included acceptance criteria for the groundwater chemistry-sampling program with specific criteria for pH, and the concentrations of chlorides and sulfates. In addition, the applicant stated that if any of the above acceptance criteria are not met, further evaluation is required through the general licensees' corrective action program.

The staff reviewed the applicant's description and determined that the acceptance criteria follow the guidance in NUREG 1927, Section 3.6.1.6, and are based on the ACI 349.3R code second-tier acceptance criteria for the inspection of concrete structures and included specific numerical values to ensure that the design bases are maintained. The staff determined that the applicant's description of the groundwater monitoring program is also consistent with the criteria in ACI 349.3R and ASME Code Section XI, Subsection IWL. In addition, the staff determined that the applicant's acceptance criteria for visual inspection and groundwater monitoring in the storage pad acceptance criteria AMP description are consistent with the example AMP in NUREG-2214, Table 6-3. Therefore, the NRC staff found the applicant's description of the acceptance criteria AMP element to be acceptable.

Corrective actions: The applicant stated that under the AMP, general licensees implement QA procedures; review and approval processes; and administrative controls according to the requirements of 10 CFR Part 50, Appendix B. This ensures that general licensees promptly identify and correct conditions adverse to quality. These procedures include root cause determination and prevention of recurrence. The applicant stated that general licensees either correct deficiencies or are evaluate the storage pad to be acceptable for continued service through engineering analysis. This engineering analysis provides reasonable assurance that the intended safety function is maintained consistent with current licensing basis conditions. In addition, the applicant stated that the extent of condition investigation per the general licensees' corrective action program may cause additional inspections through means of a different method, increased inspection frequency, and/or expanded inspection sample size.

The staff reviewed the applicant's description of the corrective action AMP element and determined that the description follows the guidance in NUREG-1927, Section 3.6.1.7. The staff verified that the corrective action descriptions for the Storage pad AMP state the measures to be taken when the acceptance criteria are not met and include root cause determination and prevention of recurrence of significant conditions adverse to quality. Based on this, the staff determined that the corrective action descriptions followed the guidance in NUREG-1927, which states that an applicant may reference the use of the corrective action program approved under 10 CFR Part 50, Appendix B. Therefore, the staff finds the applicant's description of the corrective actions AMP element to be acceptable.

Confirmation process: The applicant stated that under the AMP, the confirmation process will be commensurate with the general licensees' QA programs 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 licensees' QA programs approved under 10 CFR Part 50, Appendix B, also contain provisions to preclude repetition of significant conditions adverse to quality.

The staff reviewed the applicant's description of the confirmation process element for the storage pad AMP and determined that the description follows the guidance in NUREG-1927, Section 3.6.1.8, which states that the confirmation process AMP element is intended to verify that preventive actions are adequate and that appropriate corrective actions have been completed and are effective. The staff verified that the confirmation process for the storage pad AMP includes provisions to verify that appropriate corrective actions have been completed and are effective and that the AMP relies on the general licensees' QA programs approved under 10 CFR Part 50, Appendix B, which contains provisions to preclude repetition of significant conditions adverse to quality. Therefore, the staff determined that the applicant's description of the confirmation process AMP element was acceptable.

Administrative controls: The applicant stated that the administrative controls under the CoC holder's or general licensees' QA procedures and corrective action programs provide a formal review and approval process. The applicant stated that the CoC holder and general licensees implement the administrative controls in accordance with the requirements of 10 CFR Part 50, Appendix B, and will continue to do so for the PEO. The applicant stated that general licensees and the CoC holder use the 10 CFR Part 72 regulatory requirements to determine if a particular aging-related degradation condition or event identified via OE, research, monitoring, or inspection is reportable to the NRC.

The staff reviewed the applicant's description of the administrative controls element for the storage pad AMP and determined that the description follows the guidance in NUREG-1927, Section 3.6.1.9. The staff confirmed that the applicant's description of the administrative controls under the CoC holder's or general licensees' QA procedures and corrective action program provides a formal review and approval process for the storage pad AMP. The staff determined that the applicant's description states that the administrative controls are in accordance with the general licensees' QA program approved under 10 CFR Part 50, Appendix B, and will continue for the PEO. Therefore, the staff determined that the applicant's description of the administrative controls AMP element was acceptable.

Operating experience: The applicant described the results of inspections of TN-32 and TN-40 Dry Storage Casks and the storage pad at a specifically licensed ISFSI that have been in service for several years in renewal application, Appendix 3C. The storage pad inspections at the specifically licensed ISFSI did not identify storage pad aging effects. The applicant stated that the storage pad AMP will be updated, as necessary, to incorporate new information on degradation due to aging effects identified from plant-specific inspection findings, related industry OE, and related industry research. The applicant noted that future plant-specific and industry aging management and aging-related OE are captured through the general licensees' OE review process. The ongoing review of both plant-specific and industry OE will continue through the PEO to ensure that this AMP continues to be effective in managing the identified aging effects.

The staff reviewed the applicant's description of the operating experience AMP element for the storage pad AMP and determined that the description follows the guidance in NUREG-1927, Section 3.6.1.10. Specifically, the staff determined that the applicant's description identified the relevant sources of OE listed in NUREG-1927, Section 3.6.1.10. The staff determined that the applicant assessed current OE and included provisions to capture future plant-specific and industry aging management and aging-related OE through the OE review process. Therefore, the staff determined that the applicant's description of the operating experience AMP element was acceptable.

The staff review verified that each element of the storage pad AMP contained the provisions necessary so that the AMP will be effective for identifying degradation of the storage pads for the TN-32 Dry Storage Casks and implementing corrective actions before a loss of intended function. The staff determined that the AMP for the storage pad is consistent with the guidance provided in NUREG-1927, Section 3.6.1. Therefore, the staff determined that the AMP for the storage pad in the renewal application was acceptable for managing the aging effects as a result of credible aging mechanisms.

3.6.3 Earthen berm AMP

This subsection documents the staff review of the earthen berm AMP. The staff used the review guidance in NUREG-1927, Section 3.6.1, specific to each AMP element. This guidance describes an acceptable way for applicants to meet the relevant regulatory requirements.

Scope of program: The applicant stated that under the program, general licensees visually inspect the exterior surfaces of an earthen berm if the general licensee credits an earthen berm in meeting regulatory dose limits. The aging effects/mechanisms managed include:

- Loss of material due to wind erosion and surface flow
- Loss of form due to surface flow, settlement, and frost action
- Change in material properties due to desiccation

The staff reviewed the applicant's description of the scope of program for the earthen berm AMP and determined that the AMP element follows the guidance in NUREG-1927, Section 3.6.1.1. The staff verified that the scope of program identifies the specific SSCs and subcomponents covered by the AMP, the intended function to be maintained, and identifies the specific materials, environments, and aging mechanisms and effects to be managed. The staff determined that the scope of the program for the earthen berm AMP covers the all of the potential aging mechanisms and effects identified in the AMR for the subcomponents of the earthen berm that are within the scope of renewal review. Therefore, the staff determined that the applicant's description for the scope of program AMP element was acceptable.

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

The staff determined that the applicant's description follows the guidance in NUREG-1927, Section 3.6.1.2, which states that some condition or performance monitoring programs do not rely on preventive actions and thus this information need not be provided. Therefore, the staff determined that the applicant's description for the preventive actions AMP element was acceptable.

Parameters monitored or inspected: The applicant stated that the earthen berm AMP consists of periodic visual inspections of the berm's surface looking for signs of erosion, formation of gullies, settlement, or frost heaving. The applicant stated that the frequency of these inspections will ensure that the loss of material or change in the size/shape of the berm is detected prior to the loss of an intended safety function. In response to an RAI (ADAMS Accession No. ML20316A030), the applicant stated that data collected from visual inspections typically consists of inspector notes, potentially photos, and is typically attached to the work package or procedure controlling/documenting the inspection.

The staff reviewed the applicant's description of the parameters monitored and inspected for the earthen berm AMP and determined that the description of the AMP element follows the guidance in NUREG-1927, Section 3.6.1.3. The description identifies the specific parameters that will be monitored or inspected to identify degradation before a loss of intended function. In addition, the staff determined that the parameters monitored or inspected AMP element is consistent with the guidance in EPRI-1015078, Chapter 8, which identifies loss of material from wind and water runoff, loss of form as a result of settlement or frost action, and change in material properties as a result of desiccation as aging mechanisms to be managed for passive

and long-lived earthen structures. Therefore, the staff determined that the applicant's description of the parameters monitored on inspected AMP element were acceptable.

Detection of aging effects: The applicant stated that under the AMP, general licensees conduct direct visual inspections on all accessible surfaces of the earthen berm. The applicant also stated that a baseline AMP visual inspection is to be conducted no more than two years prior to 20 years of the first loaded TN-32 Dry Storage Cask being placed in storage, or no later than eighteen months after the effective date of the CoC renewal, whichever is later. In response to an RAI (ADAMS Accession No. ML20316A030), the applicant stated that the inspector will be looking for signs of erosion such as scours and gullies, settlement, and frost heaving, i.e., the acceptance criteria listed in Section 4.5.6 of the renewal application. Renewal application Section 3.4.3.10 describes the AMR of the soil material, indicating how the AMP acceptance criteria are tied to the various aging effects. Specifically, the renewal application describes the data to be collected, and how the data will be used to assess the aging effects described in renewal application Section 4.5.1 "Earthen Berm AMP – Scope of Program." Renewal application Sections 3.4.3.10.1 and 3.4.3.10.3 describe how wind can erode loose surface soil from an earthen structure, surface flow can cause soil surfaces to erode resulting in surface scour or gullies. Sections 3.4.3.10.6 and 3.4.3.10.7 describe the loss of form aging effect due to settlement and frost heaving, and Section 3.4.3.10.9 describes how desiccation coupled with surface flow or wind action may accelerate these effects of erosion. The applicant stated that subsequent inspections are to be conducted every 5 ± 1 years following the baseline inspection.

The staff reviewed the applicant's detection of aging effects for the earthen berm AMP and determined that the description was acceptable because the program element identifies the inspection method, samples size, timing of inspections, and inspection frequency. The staff determined that the specific inspection intervals in the AMP are appropriate based on information in NRC RG 1.127, which describes periodic inspections to be performed at least once every 5 years. The staff reviewed the applicant's detection of aging effects for the earthen berm and determined that the description was consistent with NUREG-1927, Section 3.6.1.4, and is acceptable because the program element identifies the inspection method, samples size, timing of inspections, and inspection frequency necessary to identify degradation before a loss of intended function.

Monitoring and trending: The applicant stated that general licensees perform the inspections and monitoring activities in the earthen berm AMP periodically in order to identify areas of degradation and that conditions that do not meet the acceptance criteria are entered into the general licensees' corrective action program. The applicant stated that the monitoring and trending AMP element considers the cumulative OE from previous earthen berm inspections and assessments in order to monitor and trend the progression of aging effects over time. In response to an RAI (ADAMS Accession No. ML20316A030), the applicant stated that per renewal application Sections 4.5.5 and 4.5.6 general licensees enter observations that do not meet the acceptance criteria into their corrective action program for further evaluation. The applicant stated that it is the general licensees' corrective action programs that perform the trending of any conditions that do not meet the acceptance criteria. In addition, the applicant stated that the acceptance criteria listed in Section 4.5.6 are very conservative in that any signs of erosion, scours, gullies, settlement, or frost heaving are to be entered into the general licensees' corrective action programs for further evaluation.

The staff determined that the applicant's description of the monitoring and trending AMP element follows the guidance in NUREG-1927, Section 3.6.1.5. The applicant's description for the AMP element includes a baseline inspection established at the beginning of the PEO and

the applicant described how the data will be collected and evaluated against the AMP acceptance criteria to ensure that the timing of the next scheduled inspection will occur before a loss of intended function and compared to the results of past inspection data for trending. The staff found the frequency of inspection was acceptable based on the guidance provided in NRC RG 1.127. Therefore, the staff determined that the applicant's description of the monitoring and trending AMP element was acceptable.

Acceptance criteria: The applicant stated that the acceptance criteria for the earthen berm AMP are the absence of (1) erosion; (2) scours or gullies from surface runoff; (3) settlement; and (4) frost heaving. In addition, the applicant stated that if any of the above acceptance criteria are not met, further evaluation is required through the general licensees' corrective action program.

The staff determined that the applicant's description of the acceptance criteria AMP element follows the guidance in NUREG 1927, Section 3.6.1.6. The applicant described the acceptance criteria for visual inspection of the berm. The acceptance criteria specify no observed erosion, scours, or gullies from surface runoff, settlement, or frost heaving. The staff determined that these aging effects are readily observed in visual inspection based on the inspection guidance provided in NRC RG 1.127, Section C.5.b. Therefore, the NRC staff found the applicant's description of the acceptance criteria AMP element to be acceptable.

Corrective actions: The applicant stated that under the AMP, general licensees implement QA procedures; review and approval processes; and administrative controls according to the requirements of 10 CFR Part 50, Appendix B. This ensures that general licensees promptly identify and correct conditions adverse to quality. These procedures include root cause determination and prevention of recurrence. The applicant stated that general licensees either correct deficiencies or evaluate the earthen berm to be acceptable for continued service through engineering analysis. This engineering analysis provides reasonable assurance that the intended safety function is maintained consistent with current licensing basis conditions. In addition, the applicant stated that the extent of condition investigation per the general licensees' corrective action program may cause additional inspections through use of a different method, increased inspection frequency, and/or expanded inspection sample size.

The staff reviewed the applicant's description of the corrective action element for the earthen berm AMP and determined that it follows the guidance in NUREG-1927, 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 actions for the earthen berm AMP state the measures to be taken when the acceptance criteria are not met including root cause determination and prevention of recurrence for significant conditions adverse to quality. Therefore, the staff finds the applicant's description of the corrective actions AMP element to be acceptable.

Confirmation process: The applicant stated that the confirmation process will be commensurate with the general licensees' QA programs 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 licensees' QA programs 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 earthen berm AMP and determined that the description follows the guidance in NUREG-1927, Section 3.6.1.8, which states that the confirmation process AMP element is intended to verify

that preventive actions are adequate and that appropriate corrective actions have been completed and are effective. The staff verified that the confirmation process for the earthen berm AMP includes provisions to verify that appropriate corrective actions have been completed and are effective and relies on the general licensees' QA program approved under 10 CFR Part 50, Appendix B, which contains provisions to preclude repetition of significant conditions adverse to quality. Therefore, the staff determined that the applicant's description of the confirmation process AMP element was acceptable.

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

The staff reviewed the applicant's description of the administrative controls element for the earthen berm AMP and determined that the description follows the guidance in NUREG-1927, Section 3.6.1.9. The staff confirmed that the applicant's description of the administrative controls under the CoC holder's or general licensees' QA procedures and corrective action program describes a formal review and approval process for the earthen berm AMP. The staff determined that the applicant's description states that the administrative controls are in accordance with the general licensee QA program approved under 10 CFR Part 50, Appendix B, and will continue for the PEO. Therefore, the staff determined that the applicant's description of the administrative controls AMP element was acceptable.

Operating experience: The applicant stated that Section 8.3.4 of EPRI-1015078 indicates that an operational history review was performed to review the generic communications related to earthen structures and the related aging effects. This operational history review found no correspondence that was directly related to aging of earthen structures. The applicant stated that the lack of reports reflects the high reliability of earthen structures and the lack of significant aging-related degradation. The applicant stated that the earthen berm AMP will be updated, as necessary, to incorporate new information on degradation due to aging effects identified from plant-specific inspection findings, related industry OE, and related industry research. The applicant noted that future plant-specific and industry aging management and aging-related OE are captured through the general licensees' OE review process. The ongoing review of both plant-specific and industry OE will continue through the PEO to ensure that this AMP continues to be effective in managing the identified aging effects.

The staff reviewed the applicant's description of the operating experience AMP element for the earthen berm AMP and determined that the description follows the guidance in NUREG-1927, Section 3.6.1.10. The staff determined that the applicant's description identified the relevant sources of OE listed in NUREG-1927, Section 3.6.1.10. The staff determined that the applicant assessed current OE and included provisions to capture future plant-specific and industry aging management and aging-related OE through the OE review process. Therefore, the staff determined that the applicant's description of the operating experience AMP element was acceptable.

The staff review verified that each element of the earthen berm AMP contained the provisions necessary so that the AMP will be effective for identifying degradation of the earthen berm and

implementing corrective actions before a loss of intended function. The staff determined that the AMP for the optional earthen berm is consistent with the guidance provided in NUREG-1927, Section 3.6.1. Therefore, the staff determined that the AMP for the optional earthen berm for the TN-32 Dry Storage Cask in the renewal application was acceptable for managing the aging effects as a result of credible aging mechanisms.

3.6.4 Changes to the Updated Final Safety Analysis Report

The applicant provided an appendix to the renewal application that included changes to the UFSAR. Appendix Table A-1 documents the changes to the UFSAR associated with the renewal and describes the basis for the changes. These changes included updated TLAAs and supporting analyses for the PEO. The applicant stated that a new Section 15, "Aging Management," will be added to the UFSAR that incorporates the approved AMPs including the TN-32 AMP, the storage pad AMP, and the optional earthen berm AMP.

The staff reviewed the changes to the UFSAR and determined that the changes are acceptable because the applicant has included updated TLAAs and supporting analyses for the PEO and the AMPs that will be incorporated into the UFSAR.

3.6.5 Evaluation Findings

The staff reviewed the AMPs in the CoC No. 1027 renewal application. The staff performed its review following the guidance provided in NUREG-1927, and the generic evaluations in 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 PEO, in accordance with 10 CFR 72.240(c)(3).

4 CONDITIONS TO ADDRESS RENEWAL

This section provides a consolidated list of the changes to the conditions resulting from the review of the renewal application, some which have been described throughout the previous sections of this SER. The basis of the changes is provided here 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 Amendment 1:**

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 renewal. The UFSAR shall reflect the changes and CoC holder commitments resulting from the review and approval of the renewal of the CoC. 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 Amendment 1:**

72.212 EVALUATIONS FOR RENEWED COC USE

Any general licensee that initiates spent fuel dry storage operations with the TN-32 dry storage cask system after the effective date of the CoC renewal and any general licensee operating a TN-32 dry storage cask 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 renewal of the CoC;

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 renewal of the CoC and the NRC Safety Evaluation Report related to the renewal of the CoC; 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 [13] 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 PEO. This includes potential use of the TN-32 dry storage cask system by general licensees 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 TN-32 dry storage cask system must evaluate it for use at their respective sites. This condition also makes it clear that general licensees that currently use a TN-32 dry storage cask 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 Amendment 1:

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 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.

4.2 Changes to Technical Specifications

1. Added the following section, "Aging Management Program," to the initial CoC (Amendment 0) and Amendment 1 as Section 5.2.4:

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 a TN-32 dry storage cask system 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 FSAR supplement. 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), among other things, requires that the safety analysis report accompanying the application contain TLAs demonstrating that the DSS SSCs will continue to perform their intended functions for the requested PEO and a description of the AMP for management of issues associated with aging that could adversely affect ITS SSCs .

The NRC staff reviewed the renewal application for the TN-32 Dry Storage Cask, in accordance with 10 CFR Part 72. The staff followed the guidance in NUREG-1927. Based on its review of the renewal application and the CoC conditions, the staff determined that renewal of CoC No. 1021 for the TN-32 Dry Storage Cask meets the requirements of 10 CFR 72.240.

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