SAFETY EVALUATION REPORT

FOR

LICENSE RENEWAL

PRAIRIE ISLAND NUCLEAR GENERATING PLANT
INDEPENDENT SPENT FUEL
STORAGE INSTALLATION

DOCKET NO. 72-10

LICENSE NO. SNM-2506

Office of Nuclear Material Safety and Safeguards
United States Nuclear Regulatory Commission
December, 2015

CONTENTS

TABLES

INTRODUCTION

By letter dated October 20, 2011, as supplemented February 29, 2012; April 26, 2012; July 26, 2013; July 31, 2014; September 3, 2014; and October 12, 2015, Northern States Power Company–Minnesota (NSPM) (thereafter the licensee), submitted an application to the U.S. Nuclear Regulatory Commission (NRC) for renewal of the operating license for the independent spent fuel storage installation (ISFSI) at the Prairie Island Nuclear Generating Plant (PINGP), Special Nuclear Material License No. SNM-2506, for a period of 40 years beyond the current license. The licensee submitted the license renewal application (LRA) in accordance with the regulatory requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) 72.42, "Duration of License; Renewal." Pursuant to 10 CFR 72.42(c), this application constitutes a timely renewal. In its LRA, the licensee documents the technical bases for renewal of the license and commitments to actions for managing potential aging effects on the structures, systems, and components (SSCs) of the ISFSI to ensure that these SSCs will maintain their intended functions during the period of extended operation.

The PINGP site encompasses about 578 acres and is located within the city limits of Red Wing in Goodhue County, Minnesota (NSPM, 2011a). NSPM owns and operates two nuclear generating units, Units 1 and 2, on the PINGP site. The ISFSI is located outside of the protected area of Units 1 and 2 (i.e., the area encompassed by a physical barrier and to which access is controlled), but within the PINGP controlled area, consistent with the definition of 10 CFR 72.3 (i.e., the area outside the protected area of Units 1 and 2 but within the site boundary of PINGP) (NSPM; 2011b, 2010b).

The PINGP ISFSI employs two dry spent fuel storage cask designs, the TN-40 and TN-40HT. Both metal-based casks are designed and manufactured by Transnuclear Inc. (AREVA Group). Each cask can hold up to 40 pressurized water reactor (PWR) fuel assemblies with burnup limits up to 45 gigawatt-days per metric ton of uranium (GWd/MTU) for the TN-40 and up to 60 GWd/MTU for the TN-40HT cask (NSPM, 2010a). The casks must be decontaminated to the surface contamination limits per the requirements of the cask design technical specifications (T.S. 3.2.1) before they can be moved onto the ISFSI. The ISFSI can hold up to 48 casks when fully loaded.

In the LRA, the licensee presented general information about the ISFSI design, a scoping evaluation to determine the SSCs within the scope of renewal and subject to an aging management review (AMR). For each in-scope SSC, the licensee proposed either a time-limited aging analysis (TLAA) or aging management program (AMP) to ensure that the SSC will maintain its intended functions during the period of extended operation.

The NRC staff reviewed the licensee's technical bases for safe operation of the ISFSI for an additional 40 years beyond the term of the current operating license. This safety evaluation report (SER) summarizes the results of the staff's review for compliance with 10 CFR 72.42, "Duration of License, Renewal." In its review of the LRA and development of the SER, the staff followed the guidance provided in NUREG–1927, "Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance," dated March 2011 (NRC, 2011).

This SER is organized into four sections: Section 1 provides the staff's review of the general information of the ISFSI. Sections 2 and 3 document the staff's evaluation of the application and issues considered during the review of the application. Section 4 provides the staff conclusions of this review.

Appendix A of this SER includes the AMPs, as submitted and revised by the licensee through the review process. Appendix B is a bibliography of the references in support of the staff's review and technical determinations.

1 GENERAL INFORMATION

1.1 Specific License Holder Information

Pursuant to Title 10 of the *Code of Federal Regulations*, Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste," the U.S. Nuclear Regulatory Commission (NRC) issued an operating license for the independent spent fuel storage installation (ISFSI) at Prairie Island Nuclear Generating Plant (PINGP), Special Nuclear Material (SNM) License No. SNM-2506, for 20 years, which expired on October 31, 2013. The current NRC license for the PINGP ISFSI is in timely renewal per the regulation found in 10 CFR 72.42(b). The design bases of the ISFSI provides for the construction and operation of 48 vertical dry storage casks (DSCs), which PINGP is building incrementally to meet storage requirements.

The ISFSI was originally licensed with the TN-40 vertical dry storage system (NRC, 1993). The TN-40HT vertical dry storage system was added through amendment of the ISFSI license (NRC, 2010a). The principal components of the PINGP ISFSI are two seismically qualified concrete pads (NRC, 1993) that provide for two parallel rows with 12 casks per row on each pad, and the earthen berm. The concrete pads have been categorized as "Important to Safety" (see Section 2.1.1 of this SER). The seismic design criteria for the ISFSI are identical to the criteria for Safe Shutdown Earthquake (SSE) of PINGP, with peak accelerations of 0.12g horizontal and 0.08g vertical (NRC, 1993). The TN-40 and TN-40HT cask body is comprised of a stainless steel inner shell and inner bottom plate, as well as a carbon steel outer shell, outer bottom plate, lid, and associated welds. The confinement boundary components (Northern States Power Company-Minnesota (NSPM) (NSPM, 2011b)) are:

- inner shell and bottom inner plate
- lid assembly outer plate, closure bolts and inner metal seal
- shell flange
- vent port cover plate, bolts, and seals
- drain port cover plate, bolts and seals

The inner shell and bottom inner plate are made of stainless steel and are surrounded by a carbon steel gamma shield. Radial neutron shielding is provided by borated polyester resin enclosed in aluminum boxes, which are attached to the exterior of the cask gamma shield. Axial neutron shielding for the top of the cask is provided by a disc of polypropylene encased in carbon steel and bolted to the cask lid. Each cask contains 40 pressurized water reactor (PWR) spent fuel assemblies (SFAs).

The PINGP ISFSI is surrounded by an earthen berm, which provides shielding to the public from direct radiation emitted from the casks. The casks are decontaminated to the surface contamination limits per the requirements of the cask design technical specifications before they can be moved on to the ISFSI (NSPM, 2010a).

1.2 Specific Financial Information

NSPM stated in the license renewal application (LRA) that it will remain financially qualified to carry out the operation and decommissioning of the ISFSI during the period of the renewed material license as required by 10 CFR 72.22(e).

The staff reviewed the NSPM's financial statement. Based on its review, the staff finds that the licensee has complied with the requirements of 10 CFR 50.75(b) and (c) with respect to providing decommissioning funding assurance for the requirements of 10 CFR 72.30(c) with respect to providing decommissioning funding assurance for the PINGP ISFSI license renewal period.

1.3 Specific Environmental Review

Regulations in 10 CFR 72.34, "Environment Report," require that each application for an ISFSI or monitored retrievable storage (MRS) license under this part must be accompanied by an Environmental Report that meets the requirements of subpart A of Part 51 of this chapter. In November 2013, the staff developed a draft environment assessment (EA) report (NRC, 2013) for the PINGP ISFSI license renewal. The staff issued the final EA in June 2015 (NRC, 2015).

1.4 Specific Safety Review

The objective of this safety review is to determine whether there is reasonable assurance that the ISFSI continues to meet the requirements of 10 CFR Part 72 during the period of extended operation. Pursuant to 10 CFR 72.42(a), an application for ISFSI license renewal must include the following: (i) time limited aging analyses (TLAAs) that demonstrate SSCs important to safety (ITS) will continue to perform their intended function for the requested period of extended operation and (ii) a description of the aging management program (AMP) for management of issues associated with aging that could adversely affect SSC ITS. The licensee stated that it followed the guidance in NUREG-1927 to perform a scoping evaluation and aging management review to identify all SSCs within the scope of the license renewal and pertinent aging mechanisms and effects, respectively. The licensee developed AMPs and TLAAs to assure that the identified SSCs within the scope of renewal will continue to perform their intended function during the period of extended operation. This review documents the staff's evaluation of the licensee's scoping analysis, aging management review, and supporting AMPs and TLAAs.

1.5 Application Content

The licensee's license renewal application, as supplemented with responses to requests for supplemental information (RSIs) (NSPM, 2012a) and requests for additional information (RAIs), (NSPM, 2013) contains the following information:

- general information
- scoping evaluation
- aging management review
- time-limited aging analyses
- aging management programs, and a
- safety analysis report supplement and changes.

In particular, the Safety Analysis Report Supplement and Changes provide changes and additions to the safety analysis report (SAR) as furnished by the licensee in order to document the results of the aging management review, time-limited aging analyses and aging management programs.

1.6 Interim Staff Guidance

The staff, industry, and other interested stakeholders gain experience and develop lessons learned with each operating ISFSI and renewed license. The documented lessons learned addresses issues related to the licensing goals for maintaining safety, improving effectiveness and efficiency, reducing regulatory burden, and increasing public confidence. The staff develops interim staff guidance (ISG) to clarify or to address issues not discussed NUREG-1927 (NRC, 2011). These ISGs are to be used by the staff, industry, and other interested stakeholders until incorporated into staff guidance documents such as regulatory guides and standard review plans. Table 1-1 lists the ISGs relevant to ISFSI license renewal.

1.7 Safety Review Evaluation Findings

The staff reviewed the descriptions of the ISFSI and dry cask storage system (DCSS) presented in Chapter 1 of the LRA and supplemental documentation and finds that there is sufficient detail to support the staff's review of the application with respect to the requirements of 10 CFR Part 72. The staff also reviewed the information provided by the application, representation, and responses to the staff's RAIs. The staff performed its review following the guidance provided in NUREG–1927, "Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance" (NRC, 2011). Based on its review, the staff determined that the licensee has provided sufficient information with adequate details to support the license renewal application with the follow findings:

F1.1 The information presented in the renewal application satisfies the requirements of 10 CFR 72.2, "Scope"; 72.22, "Contents of Application: General and Financial Information"; 72.34, "Environmental Report"; and 72.42, "Duration of License; Renewal."

F1.2 A tabulation of all supporting information and docketed material incorporated by reference has been provided in accordance with 10 CFR 72.42.

Table 1-1. Existing Interim Staff Guidance Relevant to ISFSI License Renewal	
Interim Staff Guidance Number	**Interim Staff Guidance Title**
SFST-ISG-1, Rev. 2	Damaged Fuel
SFST-ISG-2, Rev. 1	Fuel Retrievability
SFST-ISG-3	Post Accident Recovery and Compliance with 10 CFR 72.122(l)
SFST-ISG-4	Revision 1 Cask Closure Weld Inspections
SFST-ISG-5	Revision 1 Confinement Evaluation
SFST-ISG-9, Rev. 1	Storage of Components Associated with Fuel Assemblies
SFST-ISG-10, Rev. 1	Alternatives to the ASME Code
SFST-ISG-11, Rev. 3	Cladding Considerations for the Transportation and Storage of Spent Fuel
SFST-ISG-12, Rev. 1	Buckling of Irradiated Fuel Under Bottom End Drop Conditions
SFST-ISG-13	Real Individual
SFST-ISG-14	Supplemental Shielding
SFST-ISG-15	Materials Evaluation
SFST-ISG-16	Emergency Planning
SFST-ISG-17	Interim Storage of Greater Than Class C Waste
SFST-ISG-20	Transportation Package Design Changes Authorized Under 10 CFR Part 71 Without Prior NRC Approval
SFST-ISG-21	Use of Computational Modeling Software
SFST-ISG-22	Potential Rod Splitting Due to Exposure to an Oxidizing Atmosphere During Short-Term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel
SFST-ISG-24	Use of a Demonstration Program as a Surveillance Tool for Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years
SFST-ISG-25	Pressure Test and Helium Leakage Test of the Confinement Boundary for Spent Fuel Storage Canister

2 SCOPING EVALUATION

Title 10 of the *Codes of Federal Regulations* (10 CFR) 72.24, "Contents of Application: Technical Information," defines the required content to be included in a license application. Furthermore, 10 CFR 72.42 (a) requires each license renewal application (LRA) to include time-limited aging analyses (TLAAs) that demonstrate structures, systems, and components (SSCs) important to safety (ITS) will continue to perform their intended function for the requested period of extended operation; and a description of aging management programs (AMPs) for management of issues associated with aging that could adversely affect SSCs ITS. In addition, 10 CFR 72.122(I) requires that storage systems be designed to allow ready retrieval of spent fuel, high-level radioactive waste and reactor-related Greater Than Class C Waste (GTCC) for further processing or disposal.

A scoping evaluation is necessary to identify the SSCs requiring an aging management review (AMR). The objective of this scoping evaluation is to identify those SSCs meeting the following criteria:

1. SSCs are classified as important to safety (ITS), as they are relied on to do one of the following functions:

    i. Maintain the conditions required by the regulations, 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.

    These SSCs ensure that important safety functions are met for (1) confinement, (2) radiation shielding, (3) sub-criticality control, (4) heat-removal capability, (5) structural integrity, and (6) retrievability.

2. They are classified as not important to safety but, according to the design bases, their failure could prevent fulfillment of a function that is important to safety.

Consistent, with the guidance in NUREG-1927, the licensee provided the following information pertaining to the scoping evaluation:

- a description of the scoping process and methodology for the inclusion of SSCs in the renewal scope.

- a list of the SSCs (and appropriate subcomponents) that are identified as within the scope of renewal and subject to an AMR, including their intended function, and safety classification or basis for inclusion in the renewal scope.

- a list of sources of information used.

- a discussion needed to clarify the process, SSC designations, or sources of information used.

The staff reviewed the scoping process and the scoping results provided in the LRA (NSPM, 2011a). The following section discusses the staff's review and review findings on the licensee's scoping evaluation.

2.1 Scoping and Screening Methodology

LRA Section 2.0, "Scoping Evaluations," describes the methodology for identifying those SSCs of the Prairie Island Nuclear Generating Plant (PINGP) Independent Spent Fuel Storage Installation (ISFSI) that are within the scope of license renewal and those SSCs that are subject to an AMR.

The licensee followed the guidance contained in Section 2, "Scoping Evaluation," of NUREG–1927 (NRC, 2011) for the "Scoping methodology" provided in the Prairie Island ISFSI LRA (NSPM, 2011a). The licensee's scoping methodology considered the design basis of the ISFSI, which identified SSCs and their safety functions. The licensee identified the following documents that provide the technical basis for the Prairie Island ISFSI LRA and scoping evaluation:

- Prairie Island ISFSI safety analysis report (SAR) (NSPM, 2011b)
- Prairie Island ISFSI safety evaluation report (SER) (NRC, 1993)
- Prairie Island ISFSI SERs associated with subsequent license amendments
- Prairie Island updated safety analysis report (PINGP USAR) (NSPM, 2010b)
- Materials License No. SNM-2506 (NRC, 1993)
- technical specifications (NSPM, 2010a), and
- docketed licensing correspondence.

The Prairie Island ISFSI SAR (NSPM, 2011b) provided two types of safety classifications for SSCs of the TN-40 and TN-40HT storage cask designs, respectively. The design bases of the ISFSI and the TN-40 design (Section 4.5, SAR) defines SSCs as either "Safety Related" or "Non-Safety Related" for Prairie Island ISFSI SSCs of TN-40 design (NSPM, 2011b). The design bases of the ISFSI and the TN-40HT design (Section A4.5, SAR) defines SSCs as either: "Important to Safety" or "Not Important to Safety." Because NUREG–1927 (NRC, 2011) only classifies SSCs as either "Important to Safety" or "Not Important to Safety," the licensee used the following expanded scoping criteria in its LRA (NSPM, 2011a):

- Criterion 1: The SSC is classified as important to safety (*or safety related*) as it is relied on to do one of the following:
  - Maintain the conditions required by the regulations, license, or certificate of compliance (CoC) to store spent fuel safely
  - Prevent damage to the spent fuel during handling and storage

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

- Criterion 2: The SSC is classified as not ITS (or non-safety related) but, according to the licensing basis, its failure could prevent fulfillment of a function that is ITS, or its failure as a support SSC could prevent fulfillment of a function that is ITS.

The staff reviewed the scoping and screening methodology of Northern States Power Company Minnesota (NSPM) to determine whether the results meet the requirements of 10 CFR 72.24, "Contents of Application: Technical Information"; 72.42, "Duration of License; Renewal"; 72.120, "General Considerations"; and 72.122, "Overall Requirements." The following sections document the staff's review and evaluation of the licensee's scoping analyses.

2.1.1 Scoping Process

The licensee identified the ISFSI SSCs within the scope of renewal subject to an AMR. In order to accomplish this scoping evaluation, the licensee reviewed the Prairie Island ISFSI SAR (NSPM, 2011b), which discusses the quality standards for SSCs considered safety-related and ITS. The licensee reviewed design bases information and used it to identify those SSCs with safety functions meeting either Scoping Criterion 1 or two of the LRA, as discussed above in Section 2 of this SER. The classification of the ISFSI SSCs, including the TN-40 design, is provided in Table 4.5-1 of the Prairie Island ISFSI SAR (NSPM, 2011b) and presented in Table 2.1-1. The ISFSI SAR classifies SSCs in three broad categories: 1) safety related, 2) augmented quality, and 3) commercial material standard quality. The SAR defines safety related as any SSC that prevents or mitigates the consequences of postulated nuclear accidents that could cause undue risk to the health and safety of the public. The SAR further defines augmented classification as a procurement classification for items or services that do not perform a safety-related function, but are subject to special licensee requirements or U.S. Nuclear Regulatory Commission (NRC) regulatory requirements. The SAR clarifies that 10 CFR Part 50 Appendix B and 10 CFR Part 21 requirements do not apply to items and services purchased as augmented quality. The SAR further defines commercial material (CM) standard quality as a procurement quality classification for items or services which do not have a safety related function and are not subject to special licensee requirements or NRC imposed regulatory requirements. For items classified as augmented quality or commercial material (standard quality), these items are designed in accordance with the design rules identified in Section 4.2 of the SAR (NSPM, 2011b).

The classification of TN-40HT major components is provided in Table A4.5-1 of Prairie Island ISFSI SAR (NSPM, 2011b) and presented in Table 2.1-2. This classification of TN-40HT SSCs was made in accordance with NUREG/CR-6407 (NRC 1996).

The licensee further reviewed the Prairie Island ISFSI SER (NRC, 1993) that summarized the results of the NRC staff safety review of the original licensing of the Prairie Island ISFSI and the SERs associated with subsequent license amendments of the PINGP ISFSI (NSPM, 2011b). The licensee used the reviews of the design-bases documents, its scoping criteria, and the Figure 2-1 Flowchart of Scoping Evaluation contained in NUREG–1927 (NRC, 2011) to identify SSCs and their subcomponents that are within scope of the license renewal.

The staff reviewed the licensee's scoping process, including a description of the scoping methodology, supporting design-bases information, and the discussion needed to clarify the scoping process. The staff determined that the information provided is consistent with the guidance in NUREG-1927, and therefore finds the licensee's scoping process acceptable.

Table 2.1-1. Classification of Structures, Systems, and Components*		
Safety Related	**Augmented Quality**	**Commercial Material (Standard Quality)**
Containment Vessel*: Cask Body Shell Cask Body Bottom Lid Lid Bolts Basket Assembly Trunnions Concrete Pads: Concrete Reinforcing Steel	Lid Gaskets Lid Penetration Covers, Bolts, Gaskets Vent and drain port Covers, Bolts, Gaskets Neutron Shield Body Shielding Lid Shielding Security System	Protective Cover Overpressure System Transport Vehicle ISFSI Buildings Electrical Power: Lighting Receptacles
* For the purposes of this review, the term containment and confinement are used interchangeably. NSPM. "Prairie Island Independent Spent Fuel Storage Installation Safety Analysis Report." Table 4.5-1. Revision 14. Materials License No. SNM-2506. Agencywide Documents and Access Management System (ADAMS) No. ML113040131. Minneapolis, MN: Northern States Power Company–Minnesota. September 2011.		

Table 2.1-2. Classification of TN-40HT Major Components*	
Important to Safety	**Not Important to Safety**
Containment vessel including lid, flange, inner containment shell & bottom containment plate	Pressure monitoring system, & overpressure cover
Lid bolts	Protective cover, bolts, & seal
Lid vent and drain covers, & bolts	Paint on exterior of cask
Basket assembly including fuel compartments, poison plates, & structural plates	
Trunnions	
Basket rails	
Lid, vent & drain seals	
Radial neutron shield	
Cask body shield shell	
Cask body bottom	
Lid shield plate	
Top neutron shield including bolts	
Outer shell	
*NSPM. "Prairie Island Independent Spent Fuel Storage Installation Safety Analysis Report." Table A4.5-1. Revision 14. Materials License No. SNM-2506. ADAMS No. ML113040131. Minneapolis, MN: Northern States Power Company–Minnesota. September 2011.	

2.1.2 Structures, Systems, and Components within Scope of License Renewal Review

Based on the scoping process discussed earlier in Section 2.1.1, the licensee identified four main SSCs of the ISFSI to be within the scope of license renewal, which are tabulated in the Prairie Island ISFSI LRA (NSPM, 2011a, Table 2.4-1). The Prairie Island ISFSI LRA also identified SSCs that are not within scope of renewal and are not subject to an AMR. The SSCs within and not within the scope of license renewal are presented in Table 2.1-3. The SSCs identified in Table 2.1-3 to be within scope include:

- dry storage casks
- spent fuel assemblies
- reinforced concrete pads
- earthen berm

Table 2.1-3. Structures, Systems, and Components Within and Not Within Scope of License Renewal*			
Structures, Systems and Components	**Criterion 1**	**Criterion 2**	**In-Scope**
Dry Storage Cask	Y	N/A	Y
Spent Fuel Assemblies	Y	N/A	Y
Reinforced Concrete Pads	Y	N/A	Y
Earthen Berm	N	Y	Y
ISFSI Pressure Monitoring System	N	N	N
Lighting	N	N	N
Security Fence and Gates	N	N	N
Transport and Supporting Equipment	N	N	N
*NSPM. "Prairie Island Independent Spent Fuel Storage Installation Application for Renewed ISFSI Site-Specific License." Materials License No. SNM-2506. Table 2.4-1. ADAMS No. ML113040123. Minneapolis, MN: Northern States Power Company–Minnesota. October 2011.			

The licensee stated that these SSCs meet scoping Criterion 1 or 2 and subject to an AMR (NSPM, 2011a). The casks, spent fuel assemblies, and reinforced concrete pads were identified as SSCs within the scope of renewal based upon Criterion 1. Although Tables 4.5-1 and A4.5-1 of Prairie Island ISFSI SAR (NSPM, 2011b) did not include the earthen berm, Prairie Island ISFSI SAR, Section A7A.7.1 (NSPM, 2011b) takes credit for the presence of the earthen berm for shielding purposes and its failure could prevent fulfillment of a function that is ITS. Because of this credit of the earthen berm for shielding, the licensee (NSPM, 2013) included the earthen berm within scope of the license renewal based upon Criterion 2, not ITS (or nonsafety related).

For the SSCs identified to be within the scope of renewal (Table 2.1-3), the licensee further identified and described the subcomponents that support the SSC safety functions and therefore subject to an AMR (NSPM 2011a, Tables 2.4-2, 2.4-3, and 2.4-4). The licensee provided a description of these subcomponents in the Prairie Island ISFSI LRA (NSPM 2011a, Section 2.3) based on the information available in the design-bases documents. These SSC subcomponents within scope of the license renewal are tabulated in Tables 2.1-4, 2.1-5 and 2.1-6.

The staff reviewed the licensee's identification of the SSCs and subcomponents that are within the scope of license renewal, intended SSC safety functions, and safety classification or basis for inclusion in the license renewal scope. The staff confirmed the licensee's determination by reviewing the safety classification for the TN-40 design provided in Section 4.5 and Table 4.5-1 of the ISFSI SAR (NSPM, 2011b). The staff further confirmed the licensee's determination by reviewing the safety classification for the TN-40HT design provided in Section A4.5 and Table A4.5-1 of the Prairie Island ISFSI SAR (NSPM, 2011b). The staff's review of the subcomponents is predicated on the understanding that subcomponents may degrade under different modes or variable rates. This consideration is important since the performance of the subcomponents could impact the performance of in-scope SSCs during the period of extended operation. The staff notes that the licensee identified the earthen berm as a SSC within the scope of license renewal, although it was not classified as safety-related or ITS in the ISFSI SAR (NSPM, 2011b). Based on its review, the staff finds the licensee's scoping analysis results acceptable because the scoping evaluation is consistent with NUREG-1927 and appropriately classifies the subcomponents within the scope of license renewal.

Table 2.1-4. Subcomponents of Structures, Systems, and Components Within Scope of the License Renewal*		
Dry Storage Casks	**Spent Fuel Assembly**	**Structures**
Shell	Fuel Cladding	Reinforced Concrete Pads
Lid	Fuel Cladding End Plug	Earthen Berm
Inner Containment	Guide Tube	—
Bottom	Grid Assembly, Mid Fuel Assembly	—
Bottom Inner Containment	Grid Assembly, Top & Bottom	—
Upper Trunnion	Bottom Nozzle	—
Lower Trunnion	Upper Nozzle	—
Shield Plate	—	—
Outer Shell	—	—
Top Neutron Shield	—	—
Top Neutron Shield Enclosure	—	—
Top Neutron Shield Bolts	—	—
Radial Neutron Shield	—	—
Radial Neutron Shield Box	—	—
Lid Bolts	—	—
Lid Seal (O-ring)	—	—
Vent Port Covers	—	—
Drain Port Covers	—	—
Drain and Vent Port Cover Bolts	—	—
Drain and Vent Port Cover Seats (O-ring)	—	—
Basket Rails	—	—
Fuel Compartment	—	—
Aluminum Plate	—	—
Poison Plate	—	—
Containment Flange	—	—
*NSPM. "Prairie Island Independent Spent Fuel Storage Installation Application for Renewed ISFSI Site-Specific License." Materials License No. SNM-2506. Tables 2.4-2, 2.4-3, 2.4-4. ADAMS No. ML113040123. Minneapolis, MN: Northern States Power Company–Minnesota. October 2011.		

Table 2.1-5. Subcomponents of Structures, Systems, and Components Classified by the Licensee as Important to Safety*		
Dry Storage Casks	**Spent Fuel Assembly**	**Structure**
Shell	Fuel Cladding	Reinforced Concrete Pads
Lid	Fuel Cladding End Plug	—
Inner Containment	Guide Tube	—
Bottom	Grid Assembly, Mid Fuel Assembly	—
Bottom Inner Containment	Grid Assembly, Top & Bottom	—
Upper Trunnion	Bottom Nozzle	—
Lower Trunnion	Upper Nozzle	—
Shield Plate	—	—
Outer Shell	—	—
Top Neutron Shield	—	—
Top Neutron Shield Enclosure	—	—
Top Neutron Shield Bolts	—	—
Radial Neutron Shield	—	—
Radial Neutron Shield Box	—	—
Lid Bolts	—	—
Lid Seal (O-ring)	—	—
Vent Port Covers	—	—
Drain Port Covers	—	—
Drain and Vent Port Cover Bolts	—	—
Drain and Vent Port Cover Seals (O-ring)	—	—
Basket Rails	—	—
Fuel Compartment	—	—
Aluminum Plate	—	—
Poison Plate	—	—
Containment Flange	—	—
*NSPM. "Prairie Island Independent Spent Fuel Storage Installation Application for Renewed ISFSI Site-Specific License." Materials License No. SNM-2506. Tables 2.4-2, 2.4-3, 2.4-4. ADAMS No. ML113040123. Minneapolis, Minnesota: Northern States Power Company–MN. October 2011.		

Table 2.1-6. Subcomponents of Structures, Systems, and Components Classified by the Licensee as Not Important To Safety but Their Failure Would Affect the Important To Safety Structures, Systems, and Components to Perform Their Intended Functions		
Dry Storage Casks	**Spent Fuel Assembly**	**Structure**
None	None	Earthen Berm

2.1.3 Structures, Systems, and Components NOT Within Scope of License Renewal Review

The licensee identified SSCs and SSC subcomponents that do not support intended functions and therefore not subject to an AMR (Tables 2.4-1, 2.4-2, and 2.4-3, NSPM, 2011a). Table 2.1-7 provides a summary of these SSCs and SSC subcomponents. This table includes the cask pressure monitoring system, ISFSI lighting, security fence and gates, and transporter and supporting equipment. The licensee stated that lighting, security fence and gates, and the transporter and supporting equipment do not meet either of the scoping criteria and are not subject to an AMR. Sections 4.5.4 and A4.5.4 of Prairie Island ISFSI SAR (NSPM, 2011b) states that neither the protective weather cover and overpressure systems of TN-40 and TN-40HT casks nor the pressure monitoring system serve any safety function. The Prairie Island ISFSI SAR (NSPM, 2011b, Section A7A.8.6) presented an analysis to show that dose acceptance criteria would be satisfied even if the pressure-monitoring system was not functioning properly. The analyses presented also demonstrated that in a particular case of a latent seal failure and removal of the pressure monitoring system due to an accident, there would be time to recover from the condition prior to exceeding the applicable dose acceptance criteria. Furthermore, the licensee indicated that an AMR would not be required because the instrumentation in the pressure monitoring system is an active component, i.e. is not passive or long-lived, but is subject to a change in configuration or replacement based on a qualified life/specified time period. The licensee then described operations and maintenance procedures associated with the pressure monitoring system (NSPM, 2012b). These included twice daily verification of no alarms on the overpressure monitoring panel and that the interseal pressure for each cask is above its setpoint, recording of the interseal pressure twice a week, annual calibration of the pressure monitoring system which includes steps to check the transmitter, valve manifold, and fittings, verification that the interseal pressures for all casks are within 4 psi of each other, and replacing the pressure monitoring circuitry cards every 10 years.

The licensee identified the subcomponents of dry storage casks and spent fuel assemblies, respectively, that are not within scope of the license renewal review (Tables 2.4-2 and 2.4-3, NSPM, 2011a). The subcomponents in these tables are consistent with those presented in the design bases, Prairie Island ISFSI SAR (NSPM, 2011b) Tables 4.5-1 and A4.5-1.

The staff reviewed the licensee's identification of SSCs and subcomponents that are not within the scope of renewal review and basis for exclusion from the renewal scope. The staff finds that the lighting, security fence and gates, and transfer and supporting equipment are not within the scope of the license renewal review because they do not meet either of the scoping criteria. The staff considered the information described and, based on the guidance presented in NUREG-1927, determined that the licensee's scoping of the pressure monitoring system as not-in-scope is acceptable. The staff's basis for this determination is that, according to the design bases, the pressure monitoring system does not have a direct safety function and its failure would not prevent any SSC ITS from fulfilling its function. Based on its review, the staff finds the licensee's scoping analysis results acceptable because the scoping analysis is consistent with NUREG-1927 guidance and appropriately classifies the subcomponents not within the scope of license renewal.

Table 2.1-7. Subcomponents of Structures, Systems, and Components Identified by the Licensee as Not Within the Scope of the License Renewal Review*			
Dry Storage Casks	**Spent Fuel Assembly**	**Structures**	**Other Structures, Systems, and Components**
Protective Cover	Fuel Assembly Insert	None	Independent Spent Fuel Storage Installation Pressure Monitoring System
Protective Cover Bolt	Fuel Pallet	—	Lighting
Protective Cover Seal (O-ring)	Fuel Rod Spring	—	Security Fence and Gates
Overpressure Port Cover	—	—	Transporter and Supporting Equipment
Overpressure Port Cover Seal (O-ring)	—	—	—
Overpressure Tank, Isolation Valves and Tubing	—	—	—
Vent and Drain Quick Disconnects	—	—	—
Overpressure Port Cover Bolts	—	—	—
Lid Alignment Pins	—		—
*NSPM. "Prairie Island Independent Spent Fuel Storage Installation Application for Renewed ISFSI Site-Specific License." Materials License No. SNM-2506. Tables 2.4-1, 2.4-2, 2.4-3. ADAMS No. ML113040123. Minneapolis, MN: Northern States Power Company–Minnesota. October 2011.			

2.2 Evaluation Findings

The staff reviewed the Prairie Island Nuclear Generation Plant ISFSI License Renewal Application and supplemental information as identified in the responses to the staff's observations, requests for supplemental information, and requests for additional information. The staff performed its review following the guidance provided in NUREG–1927, "Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance" (NRC, 2011) and the applicable Interim Staff Guidance (ISGs) identified in Table 1-1. The staff also used the information provided in NUREG/CR–6407, "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety" (NRC, 1996) for system and component classification in its review of the licensee's scoping analyses. Based on its review of this information, representations, and supplements (NSPM, 2010a,b; 2011a,b; 2012a,b; 2013, 2014) the staff finds the licensee's scoping and screening methodology to be acceptable. The licensed design of the ISFSI, including ITS and Not ITS SSCs, remains in effect during the period of extended operation. The staff further concludes:

F2.1 The licensee has identified all SSCs ITS and SSCs whose failure could prevent a SSC from performing its function per the requirements of 10 CFR 72.3, 10 CFR 72.24, 10 CFR 72.42, 10 CFR 72.120, 10 CFR 72.122(l), 10 CFR 72.126(a), and 10 CFR 72.128(a).

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

3 AGING MANAGEMENT REVIEW

3.1 Review Objective

The objective of the staff's review of the aging management review (AMR) is to determine if the licensee has adequately performed a review of applicable materials, environment, aging mechanisms and effects and identified adequate aging management activities for structures, systems, and components (SSCs) within the scope of renewal.

3.2 AMR Process

The licensee's AMR identified the aging mechanisms and aging effects applicable to each SSC based on its material of construction and service environment. For each aging mechanism and effect, the licensee further identified either a time-limited aging analysis (TLAA) or an aging management program (AMP) to ensure the intended function of the SSC would be maintained during the period of extended operation.

The staff reviewed the licensee's AMR process, including a description of the review process, the design basis information, and the discussion needed to clarify the AMR. Based on its review, the staff determined that the licensee's AMR process acceptable because it is consistent with NUREG 1927 and adequate for identifying pertinent aging effects for the SSCs within the scope of renewal.

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

Based on its AMR, the licensee identified the aging mechanisms and aging effects of applicable SSCs with respect to the materials that they are constructed from and the service environment in which they reside. Tables 3-1, 3-2, and 3-3 provide the results of the licensee's AMR and the AMPs it plans to apply to manage the aging effects of the identified SSCs during the period of extended operation. The data listed in Tables 3-1, 3-2, and 3-3 reflect information in the application as supplemented by the responses to requests for additional information (RAI).

3.3.1 Cask Body/Subcomponents

The licensee identified and characterized the following subcomponents ("DSC-#" term is for cross-reference with Table 3-1), materials, and environment combinations for the TN-40 and TN-40HT casks in LRA Section 2.3.1 as safety-related or ITS and within the scope of renewal:

- inner shell and bottom (DSC-1 through DSC-3, DSC-8, DSC-9)
- inner containment and bottom inner containment (DSC-6, DSC-7, DSC-10, DSC-11)
- lid (DSC-4, DSC-5)
- lid bolts and seals (DSC-31 through DSC-33)
- upper and lower trunnion (DSC-12, DSC-13)
- gamma shield plate (DSC-14, DSC-15)
- outer shell (DSC-16, DSC-17)
- top and radial neutron shield (DSC-18 through DSC-21, DSC-25 through DSC-28)
- top neutron shield enclosure and bolts (DSC-22 through DSC-24)
- aluminum radial neutron shield box (DSC-29, DSC-30)
- drain and vent port covers (DSC-34 through DSC-37)

- drain and vent port cover bolts and seals (DSC-38 through DSC-40)
- basket rails (DSC-41)
- fuel compartment (DSC-42)
- aluminum plates and poison plates (DSC-43 through DSC-45)
- containment flange (DSC-46 through DSC-49)

Table 3-1. Aging Management Review Results—Dry Storage Cask							
Item ID No.	**Component Name**	**In Scope Classification Criterions 1 or 2**	**Materials**	**Environment[1, 2, 3, 4]**	**Aging Effect/Mechanism**	**AMR SER Section**	**AMP SER Section**
DSC-1	Shell	1	Carbon Steel	(I) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-2	Shell	1	Carbon Steel	(E) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-3	Shell	1	Carbon Steel	(E) Atmosphere/Weather	Loss of material due to general, crevice, and pitting corrosion	3.3.1	3.5.1.1
DSC-4	Lid	1	Carbon Steel	(I) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-5	Lid	1	Carbon Steel	(E) Atmosphere/Weather	Loss of material due to general, crevice, pitting, and galvanic corrosion	3.3.1	3.5.1.1
DSC-6	Inner Containment	1	Nickel-Based Alloys	(I) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-7	Inner Containment	1	Nickel-Based Alloys	(E) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-8	Bottom	1	Carbon Steel	(I) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-9	Bottom	1	Carbon Steel	(E) Atmosphere/Weather	Loss of material due to general, crevice, and pitting corrosion	3.3.1	3.5.1.1
DSC-10	Bottom Inner Containment	1	Nickel-Based Alloys	(I) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-11	Bottom Inner Containment	1	Nickel-Based Alloys	(E) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-12	Upper Trunnion	1	Carbon Steel	(E) Atmosphere/Weather	Loss of material due to general, crevice, and pitting corrosion	3.3.1	3.5.1.1
DSC-13	Lower Trunnion	1	Carbon Steel	(E) Atmosphere/Weather	Loss of material due to general, crevice, and pitting corrosion	3.3.1	3.5.1.1
DSC-14	Shield Plate	1	Carbon Steel	(I) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-15	Shield Plate	1	Carbon Steel	(E) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-16	Outer Shell	1	Carbon Steel	(I) Air/Gas	None/NA	3.3.1	3.5.1.1

Table 3-1. Aging Management Review Results—Dry Storage Cask (continued)							
Item ID No.	**Component Name**	**In Scope Classification Criterions 1 or 2**	**Materials**	**Environment[1, 2, 3, 4]**	**Aging Effect/Mechanism**	**AMR SER Section**	**AMP SER Section**
DSC-17	Outer Shell	1	Carbon Steel	(E) Atmosphere/Weather	Loss of material due to general, crevice, and pitting corrosion	3.3.1	3.5.1.1
DSC-18	Top Neutron Shield	1	Polypropylene	(E) Air/Gas/Heat/Neutron and Gamma Radiation[5]	Cracking due to material property changes resulting from heat and radiation exposure	3.3.4	3.5.1.2
DSC-19	Top Neutron Shield	1	Polypropylene	(E) Air/Gas/Heat/Neutron and Gamma Radiation[5]	Embrittlement due to property changes resulting from heat and radiation exposure	3.3.4	3.5.1.2
DSC-20	Top Neutron Shield	1	Polypropylene	(E) Air/Gas/Heat/Neutron and Gamma Radiation[5]	Loss of elasticity due to property changes resulting from heat and radiation exposure	3.3.4	3.5.1.2
DSC-21	Top Neutron Shield	1	Polypropylene	(E) Air/Gas/Heat/Neutron and Gamma Radiation[5]	Radiolytic decomposition due to radiation exposure	3.3.4	3.5.1.2
DSC-22	Top Neutron Shield Enclosure	1	Carbon Steel	(I) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-23	Top Neutron Shield Enclosure	1	Carbon Steel	(E) Atmosphere/Weather	Loss of material due to general, crevice, and pitting corrosion	3.3.1	3.5.1.1
DSC-24	Top Neutron Shield Bolts	1	Carbon Steel	(E) Atmosphere/Weather	Loss of material due to general, crevice, and pitting corrosion	3.3.1	3.5.1.1
DSC-25	Radial Neutron Shield	1	Borated Polyester	(E) Air/Gas/Heat/Neutron and Gamma Radiation[5]	Cracking due to material property changes resulting from heat and radiation exposure	3.3.4	3.5.1.2

Table 3-1. Aging Management Review Results—Dry Storage Cask (continued)							
Item ID No.	**Component Name**	**In Scope Classification Criterions 1 or 2**	**Materials**	**Environment[1, 2, 3, 4]**	**Aging Effect/Mechanism**	**AMR SER Section**	**AMP SER Section**
DSC-26	Radial Neutron Shield	1	Borated Polyester	(E) Air/Gas/Heat/Neutron and Gamma Radiation[5]	Embrittlement due to property changes resulting from heat and radiation exposure	3.3.4	3.5.1.2
DSC-27	Radial Neutron Shield	1	Borated Polyester	(E) Air/Gas/Heat/Neutron and Gamma Radiation[5]	Loss of elasticity due to property changes resulting from heat and radiation exposure	3.3.4	3.5.1.2
DSC-28	Radial Neutron Shield	1	Borated Polyester	(E) Air/Gas/Heat/Neutron and Gamma Radiation[5]	Radiolytic decomposition due to radiation exposure	3.3.4	3.5.1.2
DSC-29	Radial Neutron Shield Box	1	Aluminum	(I) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-30	Radial Neutron Shield Box	1	Aluminum	(E) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-31	Lid Bolts	1	Carbon Steel	(E) Atmosphere/Weather	Loss of material due to general, crevice, pitting, and galvanic corrosion	3.3.2	3.5.1.1
DSC-32	Lid Seal (O-ring)	1	Aluminum	(I) Air/Gas	None/NA	3.3.3	3.5.1.1
DSC-33	Lid Seal (O-ring)	1	Aluminum	(E) Atmosphere/Weather (outer)	Loss of material due to crevice, pitting, and galvanic corrosion	3.3.3	3.5.1.1
DSC-34	Vent Port Covers	1	Stainless Steel	(I) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-35	Vent Port Covers	1	Stainless Steel	(E) Atmosphere/Weather	Loss of material due to crevice and pitting corrosion	3.3.1	3.5.1.1

Table 3-1. Aging Management Review Results—Dry Storage Cask (continued)							
Item ID No.	**Component Name**	**In Scope Classification Criterions 1 or 2**	**Materials**	**Environment[1, 2, 3, 4]**	**Aging Effect/Mechanism**	**AMR SER Section**	**AMP SER Section**
DSC-36	Drain Port Covers	1	Stainless Steel	(I) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-37	Drain Port Covers	1	Stainless Steel	(E) Atmosphere/Weather	Loss of material due to crevice and pitting corrosion	3.3.1	3.5.1.1
DSC-38	Drain and Vent Port Cover Bolts	1	Carbon Steel	(E) Atmosphere/Weather	Loss of material due to general, crevice, pitting, and galvanic corrosion	3.3.2	3.5.1.1
DSC-39	Drain and Vent Port Covert Seals (O-ring)	1	Aluminum	(I) Air/Gas	None/NA	3.3.3	3.5.1.1
DSC-40	Drain and Vent Port Covert Seals (O-ring)	1	Aluminum	(E) Atmosphere/Weather	Loss of material due to crevice, pitting, and galvanic corrosion	3.3.3	3.5.1.1
DSC-41	Basket Rails	1	Aluminum	(E) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-42	Fuel Compartment	1	Stainless Steel	(E) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-43	Aluminum Plate	1	Aluminum	(I) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-44	Aluminum Plate	1	Aluminum	(E) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-45	Poisson Plate	1	Borated Compounds	(E) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-46	Containment Flange	1	Carbon Steel	(I) Air/Gas	None/NA	3.3.1	3.5.1.1
DSC-47	Containment Flange	1	Carbon Steel	(E) Air/Gas	None/NA	3.3.1	3.5.1.1

Table 3-1. Aging Management Review Results—Dry Storage Cask (continued)							
Item ID No.	**Component Name**	**In Scope Classification Criterions 1 or 2**	**Materials**	**Environment[1, 2, 3, 4]**	**Aging Effect/Mechanism**	**AMR SER Section**	**AMP SER Section**
DSC-48	Containment Flange	1	Carbon Steel	(E) Atmosphere/Weather	Loss of material due to general, crevice, pitting, and galvanic corrosion	3.3.1	3.5.1.1
DSC-49[6]	Containment Flange	1	Stainless Steel	(E) Atmosphere/Weather	Loss of material due to crevice and pitting corrosion	3.3.1	3.5.1.1

[1]Some of the subcomponents may be exposed to both (I) internal and (E) external environments.

[2]The licensee stated that the (I) Air/Gas environment refers to the initial helium fill gas and trace amounts of other gases, such as Nitrogen, Oxygen, Argon, and fission product gases.

[3]The licensee stated that the (E) Air/Gas environment includes potential off-gases of the enclosed neutron shields.
[4]The licensee stated that the (E) Atmosphere/Weather environment refers to an outdoor environment including humidity, precipitation, ultraviolet radiation, ozone, and wind. The air temperature was stated to range from -35 °F to 100 °F.

[5]The staff has modified the environment of the top and radial neutron shield to include heat, and neutron and gamma radiation, per responses included in the supplemented LRA (NSPM, 2014).

[6]DSC-49 refers to an overlay of subcomponent DSC-48.

Table 3-2. Aging Management Review Results—Spent Fuel Assembly							
Item ID No.	Component Name	In Scope Classification Criterions 1 or 2	Materials	Environment[1]	Aging Effect/Mechanism	AMR SER Section	AMP SER Section
SFA-1	Fuel Cladding	1	Zirconium-Based Alloys	(I) Air/Gas	None/NA	3.3.5	3.5.2
SFA-2	Fuel Cladding	1	Zirconium-Based Alloys	(E) Air/Gas	None/NA	3.3.5	3.5.2
SFA-3	Fuel Cladding End Plug	1	Zirconium-Based Alloys	(E) Air/Gas	None/NA	3.3.5	3.5.2
SFA-4	Guide Tube	1	Zirconium-Based Alloys	(I) Air/Gas	None/NA	3.3.5	3.5.2
SFA-5	Guide Tube	1	Zirconium-Based Alloys	(E) Air/Gas	None/NA	3.3.5	3.5.2
SFA-6	Grid Assembly, Mid Fuel Assembly	1	Zirconium-Based Alloys	(E) Air/Gas	None/NA	3.3.5	3.5.2
SFA-7	Grid Assembly, Top & Bottom	1	Nickel-Based Alloys	(E) Air/Gas	None/NA	3.3.5	3.5.2
SFA-8	Bottom Nozzle	1	Stainless Steel	(E) Air/Gas	None/NA	3.3.5	3.5.2
SFA-9	Upper Nozzle	1	Stainless Steel	(E) Air/Gas	None/NA	3.3.5	3.5.2

[1]Section 3.3.5.1 provides the licensee's definition of the environments of the spent fuel assemblies.

Table 3-3. Aging Management Review Results—Concrete Pads and Earthen Berm							
Item ID No.	Component Name	In Scope Classification Criterions 1 or 2	Materials	Environment[1, 2]	Aging Effect/Mechanism	AMR SER Section	AMP SER Section
STR-1	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Atmosphere/Weather	Change in material properties due to leaching of $Ca(OH)_2$	3.3.6	3.5.1.3
STR-2	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Atmosphere/Weather	Cracking due to freeze-thaw	3.3.6	3.5.1.3
STR-3	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Atmosphere/Weather	Loss of material due to freeze-thaw	3.3.6	3.5.1.3
STR-4	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Atmosphere/Weather	Cracking due to reaction with aggregates	3.3.6	3.5.1.3
STR-5	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Atmosphere/Weather	Loss of strength due to reaction with aggregates[4]	3.3.6	3.5.1.3
STR-6	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Atmosphere/Weather	Cracking due to chemical attack[3]	3.3.6	3.5.1.3
STR-7	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Atmosphere/Weather	Loss of material due to chemical attack[3]	3.3.6	3.5.1.3
STR-8	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Atmosphere/Weather	Cracking due to corrosion of embedded steel[3]	3.3.6	3.5.1.3
STR-9	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Atmosphere/Weather	Loss of material due to corrosion of embedded steel[3]	3.3.6	3.5.1.3
STR-10	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Atmosphere/Weather	Loss of bond due to corrosion of embedded steel[3]	3.3.6	3.5.1.3
STR-11	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Soil (Buried)	Change in material properties due to leaching of $Ca(OH)_2$	3.3.6	3.5.1.3
STR-12	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Soil (Buried)	Cracking due to reaction with aggregates	3.3.6	3.5.1.3
STR-13	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Soil (Buried)	Loss of strength due to reaction with aggregates[4]	3.3.6	3.5.1.3

Table 3-3. Aging Management Review Results—Concrete Pads and Earthen Berm (continued)							
Item ID No.	**Component Name**	**In Scope Classification Criterions 1 or 2**	**Materials**	**Environment[1, 2]**	**Aging Effect/Mechanism**	**AMR SER Section**	**AMP SER Section**
STR-14	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Soil (Buried)	Cracking due to settlement	3.3.6	3.5.1.3
STR-15	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Soil (Buried)	Cracking due to chemical attack[3]	3.3.6	3.5.1.3
STR-16	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Soil (Buried)	Loss of material due to chemical attack[3]	3.3.6	3.5.1.3
STR-17	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Soil (Buried)	Cracking due to corrosion of embedded steel[3]	3.3.6	3.5.1.3
STR-18	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Soil (Buried)	Loss of material due to corrosion of embedded steel[3]	3.3.6	3.5.1.3
STR-19	Reinforced Concrete Pads	1	Reinforced Concrete	(E) Soil (Buried)	Loss of bond due to corrosion of embedded steel[3]	3.3.6	3.5.1.3
STR-20	Earthen Berm	2	Soil	(E) Atmosphere/Weather	Change in material properties due to desiccation	3.3.7	3.5.1.4
STR-21	Earthen Berm	2	Soil	(E) Atmosphere/Weather	Loss of form due to settlement	3.3.7	3.5.1.4
STR-22	Earthen Berm	2	Soil	(E) Atmosphere/Weather	Loss of form due to frost action	3.3.7	3.5.1.4
STR-23	Earthen Berm	2	Soil	(E) Atmosphere/Weather	Loss of material due to erosion (wind/rain impact)	3.3.7	3.5.1.4

[1]The licensee stated that the (E) Atmosphere/Weather environment refers to an outdoor environment including humidity, precipitation, ultraviolet radiation, ozone, and wind. The air temperature was stated to range from −35 °F to 100 °F.

[2]The licensee stated that (E) Soil (Buried) environment as the below-grade section of the concrete.

[3]The licensee excluded the applicability of chemical attack of the concrete and corrosion of the steel rebar as possible aging mechanisms, for both above-grade and below-grade environments. However, the licensee stated that it would include groundwater chemistry monitoring as a mitigation program to prevent aging effects due to aggressive chemical environments for the ISFSI pads.

[4]The licensee stated that loss of strength due to reaction with aggregates will be monitored through evidence of cracking.

The licensee summarized the AMR results for the cask subcomponents in LRA Table 3.2-1. The staff's evaluation of the AMR results for the cask body and associated subcomponents is provided in this section. The reviews of the AMR results for the closure bolts, cask seals, and neutron shield subcomponents are documented in Sections 3.3.2, 3.3.3, and 3.3.4 of this SER, respectively.

3.3.1.1 **Materials and Environments**

The licensee identified the materials of construction for individual cask subcomponents that were subject to AMR in LRA Table 3.2-1 (NSPM, 2011a). The staff reviewed the ISFSI design bases and confirmed that the licensee adequately identified the materials of construction of the cask body and associated subcomponents.

The licensee described the environments experienced by the cask body and associated subcomponents as either external or internal environments. The licensee noted the climatological data in Figure 2.3-1A of the PINGP USAR (NSPM, 2010b), which states that the external environment of the casks is bounded by the air temperature range of −37 to 38 °C [−35 to 100 °F]. The licensee defined the external environment of the casks as the outdoor atmosphere and weather environment that includes humidity, precipitation, ultraviolet radiation, ozone, and wind conditions. In LRA Table 3.2-1 (NSPM, 2011a), the external air and gas environment is stated to include the potential off gases from the enclosed neutron shields.

The internal environment of the casks refers to the air and gas environment. The casks were filled with helium gas and sealed during loading operations. The licensee assumed the internal air and gas environment to be the original helium fill gas and trace amounts of other gases, such as nitrogen, oxygen, argon, and fission product gases. The licensee stated that the maximum internal pressure and average gas temperature for the TN-40HT casks were 1.2×10^5 Pa [17.5 psig] and 235 °C [456 °F], respectively. The licensee further stated that these values bound those for the TN-40 casks. The gas temperature and corresponding pressure would decrease over time. The licensee also stated that the fast neutron fluence inside a TN-40HT cask is on the order of 10^{14} n/cm^2 after 25 years of storage, which is below the neutron embrittlement threshold value of 10^{17} n/cm^2.

The staff reviewed the licensee's description of the environments for the cask body and associated subcomponents. The staff reviewed Figures 2.3-1A, B, C in Section 2.3 of the PINGP USAR (NSPM, 2010b) and Figure 2.3 of the PINGP ISFSI SAR (NSPM, 2011b), which confirmed that the licensee adequately defined the climatic characteristics of the site region. The staff also reviewed the Prairie Island ISFSI SAR (NSPM, 2011b) and confirmed the values reported for the internal cask pressure and temperature (Section A3.3.2.2.6, Tables 3.2-3 and A3.2-2), as well as the value for the neutron fluence (Section A4.2.3.5). Based on its review, the staff finds the licensee's identification of the environments for the cask body and associated subcomponents acceptable.

3.3.1.2 **Aging Mechanisms/Effects on the Cask Body/Subcomponents during the Period of Extended Storage**

The licensee identified loss of material due to various corrosion mechanisms as the aging effects of the cask body and associated subcomponents exposed to outdoor atmosphere and weather environment.

The NRC requested that the licensee define the term “measureable loss of material” used in the LRA (NSPM, 2011a, Appendix A). The staff accepts the licensee’s clarifying definition of this term to mean that inspectors do not observe any depth to the corrosion and corrosion product stains. Based on its review of the revised operating experience element provided in the supplemented LRA (NSPM, 2014a, Enclosure 2, Attachment B), the staff confirmed that the licensee revised this definition to correctly reflect the observations from the lead cask examinations.

The aging effects/mechanisms identified include the following:

1. loss of material due to crevice corrosion for external aluminum, carbon steel, or stainless steel surfaces of the casks.

2. loss of material due to galvanic corrosion for external carbon steel or aluminum surfaces of the casks in contact with stainless steel.

3. loss of material due to general corrosion for external carbon steel surfaces of the casks.

4. loss of material due to pitting corrosion for external aluminum, carbon steel, or stainless steel surfaces of the casks.

The licensee stated that no aging mechanisms or effects were identified for the cask body and associated subcomponents exposed to the internal air/gas environments. The staff reviewed the design bases for the TN-40 and TN-40HT casks provided in Tables 3.4-1 and A3.4-1 of the Prairie Island ISFSI SAR (NSPM, 2011b). Section A.4.2.3.6 of Prairie Island ISFSI SAR (NSPM, 2011b) states that the interior of the cask is exposed to an inert helium environment, which does not support the occurrence of chemical or galvanic reactions because moisture or oxygen must be present for corrosion to occur. The cask is thoroughly dried before storage by a vacuum drying process. It is then sealed and backfilled with helium. The staff agrees that the drying requirements for moisture removal and helium backfill mitigate aging mechanisms or effects for the cask body cavity. Both storage cask designs (TN-40, TN-40HT) include a double metal seal with interspace leakage monitoring for lid closure, which ensure this inert atmosphere will be maintained for the period of extended operation.

The staff reviewed the licensee’s identification of aging mechanisms and effects for the cask body and associated subcomponents. Based on its review of the credible aging effects listed in NUREG–1801, “Generic Aging Lessons Learned (GALL) Report” (NRC, 2010b) and the operating experience provided in Section 2.0 of Appendix A to the LRA Revision 1 (NSPM, 2014a, Enclosure 2, Attachment B), the staff determined that the licensee performed a comprehensive AMR for the material and environment combinations. The staff finds the licensee’s identification of aging effects for the cask body and associated subcomponents acceptable.

3.3.1.3 **Evaluation of Proposed Aging Management Activities**

The licensee credited the ISFSI Inspection and Monitoring Program (NSPM, 2014a, Enclosure 2, Attachment B) to manage the identified aging effects for the cask body and associated subcomponents during the extended period of operation. The staff reviewed the license renewal application and references therein, including design bases and operating experience reports. Based on its review of the information provided in the LRA, responses to the staff’s

RAIs, and NUREG–1801, "Generic Aging Lessons Learned (GALL) Report" (NRC, 2010b), the staff concluded that an AMP is an acceptable means of ensuring that the identified aging effects will not result in a loss of intended function.

3.3.2 Closure Bolts

The licensee identified two types of closure bolts, the lid bolts (DSC-31) and the drain and vent port cover bolts (DSC-38). The licensee stated that the closure bolts secure the lid, and that the drain and vent port covers are bolted to the lid. The closure lid is secured to the cask body with bolts to ensure that the intended functions of confinement and structural integrity are maintained.

3.3.2.1 **Materials and Environments**

The licensee identified the material of construction for the closure bolts as carbon steel. The licensee described the environment experienced by the closure bolts as the outdoor atmosphere and weather environment that includes humidity, precipitation, ultraviolet radiation, ozone, and wind conditions.

The staff reviewed the licensee's description of material and environment for the closure bolts. The staff reviewed the ISFSI design bases and confirmed that the licensee adequately identified the material of construction of the cask bolts. The staff reviewed the pertinent sections of the PINGP USAR (NSPM, 2010b) and Prairie Island ISFSI SAR (NSPM, 2011b) and confirmed that the licensee has adequately identified the material of construction and the service environment for the closure bolts. Based on its review, the staff finds the licensee's identification of material and environment for the closure bolts acceptable.

3.3.2.2 **Aging Mechanisms/Effects on the Closure Bolts**

The licensee identified that the closure bolts exposed to outdoor atmosphere and weather environment are subject to loss of material due to general, crevice, pitting, or galvanic corrosion. The licensee further stated that these aging effects may lead to loss of the intended function of the closure bolts during the period of extended operation.

The staff reviewed the licensee's identification of aging effects for the closure bolts. Based on its review of the credible aging effects listed in NUREG–1801 (NRC, 2010b) and the operating experience provided in Section 2.0 of Appendix A to the LRA Revision 1(NSPM, 2014a, Enclosure 2, Attachment B), the staff determined that the licensee performed a comprehensive AMR for the material and environment combinations. The staff finds the licensee's identification of aging effects for the closure bolts acceptable.

3.3.2.3 **Evaluation of Proposed Aging Management Activities**

The licensee credited the ISFSI Inspection and Monitoring Program (NSPM, 2014a, Enclosure 2, Attachment B) to manage the loss of material aging effects due to general, crevice, pitting, and galvanic corrosion for the closure bolts during the renewal license period. The staff reviewed the license renewal application and references therein, including design bases and operating experience reports. Based on its review of the information provided in the LRA, responses to the staff's RAIs, and NUREG–1801, "Generic Aging Lessons Learned (GALL)

Report” (NRC, 2010b), the staff concluded that an AMP is an acceptable means of ensuring that the identified aging effects will not result in a loss of intended function.

3.3.3 Cask Seals

The licensee stated that there are three access ports in the cask lid equipped with Helicoflex metallic O-ring seals. The vent and drain port covers have two O-ring seals (DSC-39, DSC-40), while the overpressure port cover has one O-ring seal (DSC-32, DSC-33). The licensee also stated that the metallic O-ring seals possess long-term stability and high corrosion resistance to ensure tight and permanent containment.

3.3.3.1 **Materials and Environments**

The licensee identified the material of construction for the metallic O-ring seals of the cask lid as aluminum. The licensee differentiated the environments experienced by the cask seals as either external or internal environments. The licensee stated that the external environment of the cask seals is the outdoor atmosphere and weather environment, which were defined to include humidity, precipitation, ultraviolet radiation, ozone, and wind conditions. The licensee also stated that the internal air and gas environment of the cask seals is assumed to be the original helium fill gas and trace amounts of other gases, such as nitrogen, oxygen, argon, and fission product gases.

The staff reviewed the licensee’s description of material and environments for the cask seals. The staff reviewed the ISFSI design bases and confirmed that the licensee adequately identified the materials of construction of the cask seals. The staff reviewed the pertinent sections of the PINGP USAR (NSPM, 2010b) and Prairie Island ISFSI SAR (NSPM, 2011b) and confirmed that the licensee adequately identified the material of construction and the service environments for the cask seals. Based on its review, the staff finds the licensee’s identification of material and environments for the cask seals acceptable.

3.3.3.2 **Aging Mechanisms/Effects on the Cask Seals**

The licensee identified that the cask seals are exposed to outdoor atmosphere and weather environments, and are subject to loss of material due to crevice, pitting, or galvanic corrosion. The licensee further stated that these aging effects may lead to loss of the intended function of the cask seals during the period of extended operation.

The licensee stated that no aging mechanisms and effects were identified for the cask seals exposed to the air/gas environments.

The staff reviewed the licensee’s identification of aging effects for the cask seals. Based on its review of the credible aging effects listed in NUREG–1801 (NRC, 2010b) and the operating experience provided in Section 2.0 of Appendix A to the LRA Revision 1 (NSPM, 2014a, Enclosure 2, Attachment B), the staff determined that the licensee performed a comprehensive AMR for the material and environment combinations. The staff finds the licensee’s identification of aging effects for the cask seals acceptable.

3.3.3.3 **Evaluation of Proposed Aging Management Activities**

The licensee credited the ISFSI Inspection and Monitoring Program (NSPM, 2014a, Enclosure 2, Attachment B) to manage the loss of material due to crevice, pitting, and galvanic corrosion for the cask seals during the renewal license period. Based on its review of the information provided in the LRA, responses to the staff's RAIs, and NUREG–1801, "Generic Aging Lessons Learned (GALL) Report" (NRC, 2010b), the staff concluded that an AMP is an acceptable means of ensuring that the identified aging effects will not result in a loss of intended function.

3.3.4 Neutron Shield

Both TN-40 and TN-40HT casks use polymer-based neutron shields to reduce neutron radiation to assure that the ISFSI continues to meet the dose limits prescribed by 10 CFR 72.104, "Criteria for Radioactive Materials in Effluents and Direct Radiation from an ISFSI or MRS," and the exposure control requirements of 10 CFR 72.126 (a), as well as design basis radiation protection features that the licensee credited in Section A7.3 of the PINGP ISFSI SAR (NSPM, 2011b).

3.3.4.1 **Materials and Environments**

Both TN-40 and TN-40HT have a top neutron shield and a radial neutron shield. The top neutron shield is a polypropylene disk encased in a carbon steel enclosure. The radial neutron shield uses borated polyester resin cast into slender aluminum tubes.

The licensee performed an AMR on the neutron shields and identified the applicable materials and service environments. Table 3-1 of this safety evaluation report (SER) documents the licensee's final AMR results with a detailed breakdown into subcomponents. These subcomponents included in Table 3-1 (with item ID in parenthesis) are the top neutron shield (DSC-18 through DSC-21), the top neutron shield enclosure (DSC-22, DSC-23), top neutron shield bolts (DSC-24), radial neutron shield (DSC-25 through DSC-28), and radial neutron shield box (DSC-29, DSC-30).

The neutron shield is exposed to both high-energy radiation and heat that is generated by the spent fuel. The heat is primarily from the decay heat of the radioactive materials within the fuel. In addition, the licensee identified that the various subcomponents of the neutron shields are also exposed to the external air/gas environments. The licensee stated that the air/gas environment, defined as "(E) Air/Gas," in Table 3-1, was assumed to be the original helium fill gas and potential off-gases from the enclosed neutron shields.

The staff reviewed the design of the TN-40 and TN-40HT casks and the AMR results for the materials and service environment of the neutron shields (PINGP ISFSI SAR Sections 4.2.3.1, 7A.1, A1.3.2, A4.2.3.1, A7.3; Tables 1.3-2, 7A-1, A7A.1-1, 7A-1; NSPM, 2011b). Based on its review, the staff finds that the licensee has adequately identified the materials and the service environments of the neutron shields and hence the results are acceptable.

3.3.4.2 **Aging Mechanisms/Effects on the Neutron Shield**

The licensee identified the following aging effects/mechanisms that could lead to a loss of design function of the neutron shield:

1. cracking due to material property changes resulting from heat and radiation exposure

2. embrittlement due to property changes resulting from heat and radiation
3. loss of elasticity due to property changes resulting from heat and radiation exposure
4. radiolytic decomposition due to exposure to radiation

The licensee identified embrittlement, loss of elasticity, cracking, and radiolytic decomposition as possible aging effects of the polymer materials that could impede the neutron shield from fulfilling its design basis function due to the following three mechanisms:

1. loss of neutron moderation capability because of material thinning as a result of radiolytic decomposition of the polymer material.

2. loss of neutron moderation capability because of the streaming paths formed by the cracks.

3. loss of boron-10 (B-10) due to material redistribution as a result of polymer material shrinking or to a lesser degree, loss of B-10 due to depletion.

The net results of these aging effects are an increase in the number of neutrons coming out of the cask surface and an increase in neutron energy (i.e., an upward shifting of the neutron spectrum).

Based on literature review, research results, and operating experience (NRC, 2010b; Liu, et al., 2013; McManus and Chamis, 1996; Fu, et al., 1988; Cota, et al., 2007), when exposed to high-energy radiations and heat, polymer materials will degrade and the major aging effects of such degradations include loss of materials due to shrinkage and development of cracks. Loss of B-10 due to depletion caused by $^{10}B(n, \alpha)$ reactions is plausible but has a much less significant aging effect because the amount of ^{10}B loaded in the neutron shield is much more than is needed for the purposes of cask shielding. The licensee identified that exposure of the polymer-based neutron shield to the air/gas environments has no aging effects.

The licensee also identified loss of material due to corrosion on the carbon steel top neutron shield enclosure and bolts exposed to outdoor atmospheric and weather conditions. The licensee identified that the aluminum radial neutron shield boxes, holding the borated polyester neutron shield, have no aging effects while exposed to the air/gas environments. The staff's review of the AMR results on the carbon steel neutron shield enclosure and bolts are documented in Sections 3.3.1 and 3.3.2 of this SER, respectively.

The staff reviewed the licensee's AMR process and results on the neutron shield. Based on its review and the referenced publications, the staff determined that the licensee has adequately identified the aging mechanisms and aging effects that may result in loss of the intended safety functions of the neutron shields and hence the licensee's AMR results are acceptable.

3.3.4.3 **Evaluation of Proposed Aging Management Activities**

The licensee credited the ISFSI Inspection and Monitoring Activities Program (NSPM, 2014a, Enclosure 2, Attachment B) to manage the aging effects of the neutron shields. This program has a component in each element of the AMP for monitoring the performance of the neutron shields to assure that the neutron shield will maintain its intended function during the period of extended operation.

The staff reviewed the AMR process and the AMR results for the neutron shields. Based on its review of the information and representation from the licensee and publicly available technical publications (NRC, 2010b; Liu, et al., 2013; McManus and Chamis, 1996; Fu, et al., 1988; Cota, et al., 2007), the staff finds that the licensee has adequately identified the materials, environment, aging mechanisms and aging effects. Based on its review, the staff determined that the AMR performed by the licensee is correct and acceptable.

3.3.5 Spent Fuel Assemblies

The licensee stated that each cask at the ISFSI contains 40 pressurized water reactor (PWR) spent fuel assemblies, which, at the time of loading, had a maximum heat generation limit of less than 0.675 kilowatt per assembly for fuel stored in a TN-40 cask, and 0.800 kilowatts per assembly for fuel stored in a TN-40HT cask. The maximum average burnup is 45 gigawatt-days per metric ton uranium (GWd/MTU) for fuel stored in a TN-40 cask and 60 GWd/MTU for fuel stored in a TN-40HT cask.

The licensee identified the following subcomponents of the spent fuel assemblies for both the TN-40 and TN-40HT casks as within the scope of renewal:

1. fuel cladding and end plugs (SFA-1 through SFA-3)
2. guide tubes (SFA-4 and SFA-5)
3. grid assemblies (middle) (SFA-6)
4. grid assemblies (top, bottom) (SFA-7)
5. bottom nozzle (SFA-8)
6. upper nozzle (SFA-9)

The staff reviewed the accuracy of the description with the ISFSI design bases in the Prairie Island ISFSI SAR (Sections 3.1.1, A3.1-1, Tables 3.1-1, A3.1-3, 7.2-1, A7.2-1, A7.2-2, A7.2-5; NSPM, 2011b). Based on its review, the staff concludes that the description of the spent fuel assemblies is adequate.

3.3.5.1 **Materials and Environments**

External Air/Gas Environment

The licensee identified the external environment that the spent fuel assemblies are exposed to as being the same internal environment of the cask. More specifically, the licensee stated that in addition to the helium within the cask, trace amounts of other gases such as nitrogen, oxygen, argon and fission product gases may be present. The licensee further stated that these gases have collectively been grouped in the “(E) Air/Gas” environment used in Table 3-2.

The licensee recognized that residual boric acid may coat the surfaces of the spent fuel assemblies (SFAs) since they were exposed to a borated water environment in the spent fuel pool prior to storage. However, the licensee stated that any boric acid residue remaining on the SFAs will have no deleterious effects/mechanisms due to the absence of water and the materials of construction for the SFAs.

The licensee also stated that following initial cask loading, the maximum fuel cladding temperature was calculated to be 339 °C [642 °F] for fuel in a TN-40 cask and 360 °C [680 °F] for fuel in a TN-40HT cask. Fuel cladding temperature will then decrease over time while in storage. Staff recognizes that decay heat decreases as fuel's radioactivity decreases over time.

Internal Air/Gas Environment

The licensee identified the fuel cladding and guide tubes as the only two fuel assembly subcomponents to have internal environments. The licensee stated that the fuel rods were initially pressurized with helium during manufacturing. The licensee further clarified that the fuel rod internal environment, defined as "(I) Air/Gas" in Table 3-2, was assumed to be a combination of the original helium fill gas and fission products produced during reactor operation.

The licensee provided additional details on the materials of construction and service environments for the following subcomponents:

1. Fuel Cladding and End Plugs (SFA-1 through SFA-3)

The licensee stated that the fuel cladding and end-plugs are made of zirconium-based alloys. The licensee further identified the environment as either internal (SFA-1) or external (SFA-2, SFA-3). The NRC staff considers the end plugs as an integral part of the fuel assembly and not part of the fuel rod, as defined in Section 2.3.2 of the LRA.

2. Guide Tubes (SFA-4 and SFA-5)

The licensee identified the materials of construction of the guide tubes as zirconium-based alloys. The licensee further identified the guide tubes as being open on the end and having the same internal (SFA-4) and external (SFA-5) environment.

3. Grid Assemblies (Middle, Top and Bottom) (SFA-6 and SFA-7)

The licensee identified the mid and the top/bottom grid assemblies, which are attached to the guide tubes, as made of zirconium-based alloys or nickel-based alloys, respectively. The licensee further identified the environment of the grid assemblies to be external, as defined above.

4. Bottom Nozzle (SFA-8)

The licensee identified the bottom nozzle as made of stainless steel. The licensee further identified the environment of the bottom nozzle to be external, as defined above.

5. Upper Nozzle (SFA-9)

The licensee identified the upper nozzle as made of stainless steel. The licensee further identified the environment of the bottom nozzle to be external, as defined above.

The staff reviewed the accuracy of the materials of construction and service environments of the spent fuel assemblies with the ISFSI design bases in the Prairie Island ISFSI SAR (Sections 3.1.1, A3.1-1, Tables 3.1-1, A3.1-3, 7.2-1, A7.2-1, A7.2-2, A7.2-5; NSPM, 2011b). . The Technical Specifications 3.1.1, "Cask Cavity Vacuum Drying," and 3.1.2, "Cask Helium Backfill Pressure," for the loading of both the TN-40 and TN-40HT (NSPM, 2010a) require that the fuel be dried consistent to the specifications of NUREG–1567, “Standard Review Plan for Spent Fuel Dry Storage Facilities” (the cask cavity is dry by maintaining a cavity absolute pressure less than or equal to 10 mbar for a 30 minute period with the cask isolated from the vacuum pump) and backfilled with an atmosphere of inert gas. Based on its review, the staff concludes that the licensee adequately identified the materials of construction and service environment of the spent fuel assemblies.

3.3.5.2 **Aging Mechanisms/Effects on the Spent Fuel Assemblies**

The licensee stated that spent fuel assemblies with burnups of less than 45 GWd/MTU are not impacted by radial hydride formation, per guidance in Interim Staff Guidance (ISG)-11, Revision 3, “Cladding Considerations for the Transportation and Storage of Spent Fuel” (NRC, 2003). The licensee further stated that results of the Dry Cask Storage Characterization Project in Idaho support the conclusion that the condition of the spent fuel assemblies will not degrade under extended storage. The maximum assembly average burnup for a spent fuel assembly stored in a TN-40 cask is 45 GWd/MTU, as specified in the ISFSI Technical Specifications Functional and Operating Limit 2.2 (NSPM, 2010a). Thus, the licensee stated that spent fuel assemblies in the TN-40 casks are not impacted by radial hydride formation.

The licensee also determined that for SFAs with burnups greater than 45 GWd/MTU, the likelihood of this degradation mechanism occurring is minimized by limiting peak cladding temperature to less than 400 °C [752 °F]. The maximum assembly average burnup for a SFA stored in a TN-40HT cask is 60 GWd/MTU, as specified in the ISFSI Technical Specification Functional and Operating Limit 2.3 (NSPM, 2010a). Table A3.3-3 of the ISFSI SAR (NSPM, 2011b) shows that the maximum calculated cladding temperature for storage conditions for SFAs to be stored in a TN-40HT cask is 360 °C [680 °F]. This value is below the 400 °C [752 °F] limit, as defined in ISG-11, Revision 3. As a result, the licensee recognized that ISG-11, Revision 3 is considered to adequately bound conditions associated with the higher burnup limit of 60 GWd/MTU for the TN-40HT casks. Thus, the licensee further concluded that spent fuel assemblies in the TN-40HT casks are not impacted by radial hydride formation.

Based on the above assessment, the licensee determined there are no aging effects/mechanisms that require management for spent fuel assemblies stored in the inert environment in a cask.

The staff reviewed the identified aging mechanisms and effects for the spent fuel assemblies. The degradation of spent fuel assemblies is discussed in ISG-11, Rev. 3, references therein, as well as Gruss et.al. (KA Gruss, et., al, 2010) and Peehs (M Peehs, IAEA, 1998). The staff has identified creep as the predominant degradation mechanism for spent fuel assemblies in the discussion section of ISG-11 Rev. 3. The staff reviewed these and other relevant literature, including lessons learned from NUREG/CR 6745, “Dry Cask Storage Characterization Project—Phase 1; CASTOR V/21 Cask Opening and Examination,” (Bare et al., 2001), and NUREG/CR 6831, “Examination of Spent PWR Fuel Rods after 15 Years in Dry Storage,” (Einziger et al., 2003). The research in the later NUREG reports demonstrated that low burnup fuel cladding and other cask internals had no deleterious effects after 15 years of storage. This research confirmed the basis for ISG-11, Rev. 3 as to creep deformation. ISG-11 provides limits for temperature and stresses in the cladding (NRC 2003). These research results suggested that degradation of low burnup fuel cladding should not occur during the first renewal period, provided that the design-basis internal environment has been maintained. Based on its review, the staff agrees that no aging effects or mechanisms require management for low burnup fuel

(<45 GWd/MTU). The staff has stated in ISG-24 (2014) that there is no evidence to suggest that HBU fuel cannot similarly be stored safely and then retrieved for time periods beyond 20 years, but the supporting experimental data is not extensive. Therefore, confirmatory data or a commitment to obtain data on HBU fuel and taking appropriate steps in an aging management plan (AMP) will provide further information that will be useful in evaluating the safe handling of individual assemblies of HBU fuel for extended durations. Based on its review of the references listed above, information presented in the LRA, the responses to RAIs and the inclusion of an Aging Management Program for confirmation of the licensee's conclusion that no aging effects/mechanisms require management for the spent fuel assemblies, the staff determined the licensee's AMR results to be adequate.

3.3.5.3 **Evaluation of Proposed Aging Management Activities**

Per 10 CFR 72.122 (l), storage systems must be designed for ready retrieval of the spent fuel. The NRC staff has indicated in ISG-2 Revision 1 that "a fuel assembly is "ready retrievable" if it remains structurally sound (i.e., no gross degradation) and could be handled by normal means (i.e., does not pose operational safety problems during removal)." The NRC staff further indicated in ISG-11 Revision 3 that if the maximum fuel temperature was maintained below 400 °C [752 °F] and the fuel was stored in a dry inert atmosphere that the staff expects that the fuel would stay structurally sound during normal and off-normal operations. Unless the fuel assemblies are canned or handled by other appropriate means, they must maintain structural soundness in order to meet the regulations and maintain the configuration analyzed in the approved design bases.

The Technical Specifications 3.1.1, "Cask Cavity Vacuum Drying," and 3.1.2, "Cask Helium Backfill Pressure," for the loading of both the TN-40 and TN-40HT (NSPM, 2010a) require that the fuel be dried consistent to the specifications of NUREG–1567, "Standard Review Plan for Spent Fuel Dry Storage Facilities" (the cask cavity is dry by maintaining a cavity absolute pressure less than or equal to 10 mbar for a 30 minute period with the cask isolated from the vacuum pump) and backfilled with an atmosphere of inert gas. Per ISG-11 Revision 3, the NRC staff indicated that these conditions ensure that cladding creep, which is considered the potential mechanism of gross degradation of the fuel, will not occur during storage.

The PINGP ISFSI may store only low burnup fuel (burnup ≤ 45 GWd/MTU) in the TN-40 system and both high (burnup > 45 GWd/MTU) and low burnup fuel in the TN-40HT system. Per ISG-24, the NRC staff indicated that the low and high burnup fuel terms are of convenience and do not indicate that fuel properties undergo a significant changes as burnup is increased from 44 to 45 GWd/MTU. Based on data obtained through fuel testing in Idaho where low burnup fuel was stored for 15 years in a dry inert atmosphere and showed no signs of degradation, the NRC staff determined that degradation of the fuel will not occur during storage periods up to 100 years. Therefore, the staff finds that no TLAA or AMP is necessary to store the low burnup fuel for up to a total of 60 years as requested.

In addition to the storage of low burnup fuel, PINGP began storing high burnup fuel in April 2013. Some differences exist between low and high burnup fuel, which include: (i) additional cladding oxidation which causes higher hydrogen content in high burnup Zircaloy-4 and Zirlo cladding and (ii) higher cladding stress due to potentially greater fission gas release. NRC staff established ISG-11 Revision 3 with models that extrapolate the expected performance of low and high burnup fuel during storage. Creep is the primary degradation mechanism during storage, as established in ISG-11 Rev. 3. Therefore, creep models were used to extrapolate the HBU fuel rod behavior to extended storage times to give reasonable assurance of acceptable performance. In order to maintain reasonable assurance that creep will not result in aging effects leading to an unanalyzed condition of the fuel, an aging management program may be proposed to ensure compliance with 10 CFR 72.42. An AMP conforming to the guidance in ISG-24 may be used to perform periodic surveillance checks to confirm that the creep model extrapolations in ISG-11 Rev. 3 remain conservative and maintain acceptable fuel performance during the period of extended operation. Therefore, PINGP identified a confirmation method through a surrogate high burnup fuel surveillance program in conformance to ISG-24, as identified in Section 3.0 of Appendix A to the LRA Revision 1 (NSPM, 2014a, Enclosure 2, Attachment B) and entitled "High Burnup Fuel Monitoring Program". This surveillance program will be used to confirm that the high burnup fuel performance continues as expected and support the conclusions drawn in ISG-11 Rev. 3 before moving into the period of extended operation beyond the initial 20-year period. Thus, the NRC staff has issued a license condition (see License Condition No. 26) to ensure the licensee provides the results of this confirmatory evaluation related to HBU fuel performance, as described in the "High Burnup Fuel Monitoring Program".

3.3.6 Concrete Pads

The ISFSI has two seismically qualified concrete pads (STR-1 through STR-19), each supporting two parallel rows of 12 casks per row. The intended safety function of the concrete pads is to provide structural support and a uniform level surface for the casks. Each pad is 36 inches thick and designed to a nominal compressive strength of 3,000 psi at 28 days. The licensee identified the pads as safety-related and within the scope of renewal.

The staff reviewed the accuracy of the description with the ISFSI design bases referenced in the Prairie Island ISFSI SAR (NSPM, 2011b, Section 4.2.1). Based on its review, the staff concludes that the description of the pad is correct and acceptable.

3.3.6.1 **Materials and Environments**

The licensee identified the concrete pads as made of steel reinforced concrete. The licensee noted the climatological data in Figure 2.3-1 of the PINGP USAR (NSPM, 2010b), which states that the external environment of the pads is bounded by the air temperature range of −37 to 38 °C [−35 to 100 °F]. The licensee further identified the service environment of the above-grade section of the concrete pad to be "Atmosphere/Weather," which was defined to include humidity, precipitation, ultraviolet radiation, ozone, and wind. The licensee also specified the below-grade (buried) section of the concrete is being exposed to soil.

The staff reviewed and confirmed that the initial license design bases states that the pads were designed and constructed in accordance with ACI 318-89 (ACI, 1989), including criteria set therein for the detailing and fabrication of the reinforcing steel. More specifically, the design bases states that all reinforcing steel meet the specifications per ASTM A615. The staff reviewed Figures 2.3-1A, B, C in Section 2.3 of the PINGP USAR (NSPM, 2010b) and Figure 2.3 of the PINGP ISFSI SAR (NSPM, 2011b) and confirmed that the licensee has adequately provided the climatic characteristics of the site region. The staff concludes that the licensee adequately identified the materials of construction and service environment of the concrete pads.

3.3.6.2 **Aging Mechanisms/Effects on the Concrete Pad**

The licensee identified the following aging effects/mechanisms that could lead to a loss of design safety function of the concrete pads:

1. Change in material properties due to leaching of calcium hydroxide (above-grade/below-grade)

2. Cracking or loss of material due to freeze-thaw degradation (above-grade)

3. Cracking or loss of strength due to reaction with aggregates (above-grade/below-grade)

4. Cracking due to settlement (below-grade).

The licensee defined the aging effect ‘change in material properties’ of the concrete to include increased porosity and permeability, reduction in strength and reduction in pH. The licensee further stated that loss of strength due to reaction with aggregates will be monitored through evidence of cracking. The licensee excluded the applicability of chemical attack of the concrete and corrosion of the steel rebar as possible aging mechanisms, for both above-grade and below-grade environments. However, the licensee stated that it would include a groundwater chemistry program to ensure the absence of aggressive chemical environments for the ISFSI pads.

The staff reviewed the ISFSI design bases, applicable industry-wide operating experience and guidance provided in consensus codes and standards [ACI 349.3R (ACI, 2002), ACI 201.1R and ASCE 11-99 (ASCE, 2000)]. The staff has determined that the aging mechanisms of chemical attack of the concrete and corrosion of the steel rebar are applicable to the concrete pads. However, the staff has determined that the licensee’s inclusion of a groundwater chemistry program in the AMP will serve to ensure that an aggressive chemical environment will be identified and appropriate action will be taken before there is a loss of intended function. Based on its review, the staff finds the licensee’s identification of aging mechanisms and effects for the concrete pads acceptable.

3.3.6.3 **Evaluation of Proposed Aging Management Activities**

The licensee credited the ISFSI Inspection and Monitoring Program (NSPM, 2014a, Enclosure 2, Attachment B) to manage the identified aging effects or mechanisms for the concrete pads. The licensee further stated in the application that no calculations or analyses that have all attributes of a TLAA were identified for the concrete pads. The staff reviewed the license renewal application and references therein, including design bases and operating experience reports, and concluded that an AMP is an acceptable means for ensuring that the identified aging effects will not lead to a loss of intended function.

3.3.7 Earthen Berm

The ISFSI is surrounded by a 17 feet (ft) high earthen berm (STR-20 through STR-23), except for the ISFSI access road opening. The licensee stated that the earthen berm has a slope of one horizontal to one vertical. The design safety function of the earthen berm is to provide radiation shielding for the public. The licensee identified the earthen berm as within the scope of the license renewal.

The staff reviewed the accuracy of the description with the ISFSI design bases referenced in the Prairie Island ISFSI SAR (NSPM, 2010b, Section 2.5.5). Based on its review, the staff concludes that the description of the earthen berm is correct and acceptable.

3.3.7.1 **Materials and Environments**

The licensee identified the earthen berm as made of geo-fabric reinforced earth fill material. The licensee further identified the service environment as "Atmosphere/Weather," which was defined to include humidity, precipitation, ultraviolet radiation, ozone, and wind.

The staff reviewed the accuracy of the materials of construction and service environment of the earthen berm with the ISFSI design bases referenced in the Prairie Island ISFSI SAR (NSPM, 2011b, Section 2.5.5). The staff reviewed Figures 2.3-1A,B,C in Section 2.3 of the PINGP USAR (NSPM, 2010b) and confirmed that the licensee has adequately provided the climatic characteristics of the site region. Based on its review, the staff concludes that the licensee adequately identified the materials of construction and service environment of the earthen berm.

3.3.7.2 **Aging Mechanisms/Effects on the Earthen Berm**

The licensee identified the following aging effects/mechanisms that could compromise the design safety function of the earthen berm

1. Change in material properties due to desiccation
2. Loss of form due to settlement and frost action
3. Loss of material due to erosion

In the supplemental LRA amendment (NSPM, 2014a, Enclosure 2) , the licensee provided further clarification on the aging effect "change in material properties" due to desiccation and included "surface erosion" as a visible sign of change in material properties due to desiccation that could be detected by visual inspection.

The staff reviewed the identified aging mechanisms and effects for the earthen berm. The staff determined the aging management review (AMR) to be comprehensive and complete based on the ISFSI design bases and Inspection and Monitoring Program [NSPM (2011a), Sections A2.0, A2.3.2, and A2.10.2]. Based on its review, the staff finds the licensee's identification of aging mechanisms and effects for the earthen berm acceptable.

3.3.7.3 **Evaluation of Proposed Aging Management Activities**

The licensee credited the ISFSI Inspection and Monitoring Program (NSPM, 2014a, Enclosure 2, Attachment B) to manage the identified aging effects or mechanisms for the earthen berm. The licensee further stated in the LRA that no calculations or analyses that have all attributes of a TLAA were identified for the earthen berm. The staff reviewed the license renewal application and references therein and concluded that an AMP is an acceptable means for ensuring that the identified aging effects will not lead to a loss of intended function.

3.3.8 Evaluation Findings

The staff reviewed the AMR for the PINGP ISFSI to verify that the application adequately identified the materials, environments, and aging effects of the in-scope SSCs. Based on its review of the LRA, the licensee's responses to the staff's requests for supplemental information (RSIs) and observations, and RAIs, the staff finds:

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

F3.2 The licensee's AMR process is comprehensive in identifying all pertinent aging mechanisms and effects applicable to the SSCs within the scope of renewal and has provided a summary of the information in the renewal application and SAR supplement.

3.4 Time-Limited Aging Analysis Evaluation

TLAAs are calculations or analyses used to demonstrate that in-scope SSCs will maintain their intended design function throughout an explicitly stated period of extended operation (e.g., 40 years). These calculations or analyses may be used to assess fatigue life (number of cycles to predicted failure), or time-limited life (operating timeframe until expected loss of intended function).

Pursuant to 10 CFR 72.3, "Definitions," TLAAs must meet all six of the following criteria:

1. Involve SSCs important to safety (ITS) within the scope of the license or certificate renewal, as delineated in Subpart F of 10 CFR Part 72, "General Design Criteria," or within the scope of the spent fuel storage certificate renewal, as delineated in Subpart L of 10 CFR Part 72, "Approval of Spent Fuel Storage Casks," respectively.

2. Consider the effects of aging.

3. Involve time-limited assumptions defined by the current operating term, for example 40 year.

4. Were determined to be relevant by the licensee or certificate holder in making a safety determination.

5. Involve conclusions or provide the basis of conclusions related to the capability of SSCs to perform their intended safety functions.

6. Are contained or incorporated by reference in the design bases.

The licensee identified only three TLAAs, the following two of them meeting all six criteria per 10 CFR 72.3:

- Basket Aluminum Components for Long Term Storage Deadweight
- Neutron Damage of the Cask Metallic Components

The licensee also identified additional calculations and analyses on a third TLAA topic, flammable gas generation in polymer neutron shields, that were not contained or incorporated by reference in the design bases. These calculations and analyses were reviewed to disposition aging on SSCs within the scope of renewal, and justify their exclusion from an Aging Management Program.

- Flammable Gas Generation in Polymer Neutron Shields

The staff reviewed the licensee's TLAAs. Based on its review of the design bases, the staff concludes that the licensee correctly identified TLAAs and the results are acceptable for demonstrating that the associated components will be able to maintain their intended function during the period of extended operation. The following three sections provide the staff's review of the above three TLAAs performed by the licensee.

3.4.1 Basket Aluminum Components for Long-Term Storage Deadweight

The licensee evaluated the basket's aluminum components (Aluminum Plates, Table 2.1-5) for long-term storage loading (i.e., deadweight). The compressive stresses, due to deadweight, were compared to allowable stress values, which would limit the amount of creep in the aluminum components to within acceptable levels. The licensee estimated the design allowable stress based upon the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME, 1998, Section II, Part D, Appendix 1).

The licensee documented the evaluation of basket aluminum components for long-term storage deadweight in the Prairie Island ISFSI SAR (NSPM, 2011b, Section A4B.1.5.6). The SAR identifies that the maximum compressive stress in the aluminum inserts was conservatively calculated because it assumed that the entire length of the basket was self-supported at the bottom without taking credit of the bolts. Based on its calculation the licensee determined that the maximum stress of the aluminum components is 15.68 psi. The SAR compared this maximum stress value to an allowable stress limit of 758 psi calculated at 243°C [470°F]. This represents the stress in 1100 Aluminum to produce a strain of 0.01 in 550,000 hours. This is longer than the 60-year period of operation and shows that the calculated maximum stress of 15.68 psi is much lower than the allowable of 758 psi.

The licensee stated that the TLAA confirmed that the original evaluation of the aluminum basket components for long-term storage deadweight was projected through the end of the period of extended operation. The licensee further concluded that the TLAA demonstrated that creep would not prevent the aluminum components from performing their intended functions during the period of extended operation.

Staff reviewed the thermal analysis of the TN-40HT cask in the Prairie Island ISFSI SAR (NSPM, 2011b), which bounds the TN-40 cask because the latter has a much lower decay heat load limit. The analysis showed that the maximum temperature of the basket aluminum rails would not exceed 237°C [459 °F]. This temperature is below that assumed for the allowable stress value, i.e., 243°C [470°F] in the TLAA. The staff reviewed the licensee's TLAA, assumptions, and creep calculations and determined that the TLAAs and associated results are valid. Therefore, the staff finds the licensee's TLAA for the cask basket aluminum components acceptable.

3.4.2 Neutron Damage of the Cask Metallic Components

The licensee identified the effect of neutron damage of cask metallic components for the TN-40HT casks as a TLAA in the LRA (NSPM, 2011a, Appendix B). In order to assess the TLAA for this effect, the licensee calculated a projected value for the integrated fast neutron flux at the end of 60 years. For the calculation, the integrated fast neutron flux inside a TN-40HT cask was assumed to be on the order of 10^{14} n/cm^2 over the period of 25 years based upon the assessment documented in the Prairie Island ISFSI SAR (NSPM, 2011b, Section A4.2.3.5). The licensee concluded that the integrated fast neutron flux was less than the NRC (1988) threshold value of 10^{17} n/cm^2 for neutron damage and extrapolation of the data available down to the10^{14} n/cm^2 range confirmed there would be virtually no neutron damage to any of the TN-40HT cask metallic components after 25 years. For the TLAA, the integrated neutron flux value of 10^{14} n/cm^2 after 25 years was used to calculate the value for the integrated fast neutron flux at the end of 60 years (35/25 = 1.4) by a linear extrapolation, resulting in a total of 2.4×10^{14} n/cm^2 after 60 years ($10^{14} \times (1+1.4) = 2.4 \times 10^{14}$). The licensee stated that since this value is less than the threshold limit of 10^{17} n/cm^2 for neutron embrittlement, and concluded that there would be virtually no neutron embrittlement to any of the TN-40HT cask for the period of extended operation. Further, the licensee concluded that the TLAA demonstrates that neutron damage is so small that it will not prevent the metallic components of the TN-40HT casks from performing their intended functions during the period of extended operation.

The staff verified the total estimated neutron flux value provided by the licensee for the integrated fast neutron flux at 25 years in the Prairie Island ISFSI SAR (NSPM, 2011b, Section A4.2.3.5) and the projected value for integrated fast neutron flux at 60 years and determined these estimates to be conservative. The staff also identifies that the TN-40HT calculation bounds the TN-40 casks because the fuel in the TN-40HT contain much higher neutron sources than the fuel within the TN-40 casks. Based on its review, the staff finds the licensee's TLAA evaluation for neutron damage of the cask metallic components acceptable.

3.4.3 Flammable Gas Generation in Polymer Neutron Shields

The licensee identified that flammable gas may be generated in the neutron shield due to radiolytic decomposition of the polymer, which is the base material of the neutron shield. The applicant performed a TLAA in its response to the second round RAI (NSPM, 2014a, Enclosure 5) to demonstrate that the accumulative gases generated in the neutron shield will be negligible over 60 years.

The licensee recognized in its response to the RAI that the amount of flammable gas that could be generated is dependent on the following factors:

a) The radiolytic G-value (molecules of flammable gas per 100 eV of radiation energy absorbed)

b) The amount of energy absorbed in the resins (both the polypropylene top shield and the polyester radial shield) due to gamma and neutron radiation during 60 years of storage

c) The mass of resins within the enclosures

The licensee used the SAS2H module of the SCALE 5.0 computer suite to calculate the neutron and gamma source terms that are necessary for the energy deposition model. The licensee calculated the flammable gases generated based on the energy deposited in the neutron shield using the MCNP computer code. The licensee then converted the energy deposited in the neutron shield by using the methodology and the G-value described in NUREG/CR-6673, "Hydrogen Generation in TRU Waste Transportation Packages." Solubility values from a Sandia National Laboratory report (San Marchi, 2008) were also used to demonstrate that the hydrogen would remain dissolved within the resin, such that there would be no free release of hydrogen from the resin and no significant buildup of flammable gas from radiolysis during the 60-year period. The calculation determined that there could be 4.25E-2 moles of flammable gases generated in the top polypropylene resin and 4.29E-1 moles in the side polyester resin. A copy of the calculation was provided as part of the licensee's response to the second round RAI (NSPM, 2014a, Enclosure 5).

The staff verified the total estimated neutron and gamma source input used in the MCNP model as well as the projected energy deposited over 60 years and determined these estimates to be conservative and acceptable. The staff also identifies that the TN-40HT calculation bounds the calculation used for the TN-40 casks because the fuel in the TN-40HT casks contain much higher neutron and gamma sources than those of the TN-40 casks. Based on its review, the staff finds the licensee's TLAA evaluation for flammable generation in the neutron shield acceptable because the TLAA demonstrates that there is a reasonable assurance that the flammable gases generated over 60 years (proposed period of extended operation) would not be significant in regard to safety.

3.4.4 Evaluation Findings

The staff reviewed the TLAAs presented in the LRA (NSPM, 2011a) against the regulatory requirements of 10 CFR 72.42, "Duration of License; Renewal." The staff verified that the TLAAs assumptions, calculations, and analyses were adequate and bounded the environments and aging mechanisms for the pertinent SSCs. Based on its review of the information and representations, the staff finds:

F3.3 The licensee identified all aging mechanisms and effects pertinent to SSCs within the scope of renewal that involve TLAAs. The methods and values of the input parameters for the licensee's TLAAs are adequate. Therefore, the licensee's TLAAs provide reasonable assurance that the SSCs will maintain their intended function(s) for the period of extended operation, require no further aging management activities, and meet the requirements in 10 CFR 72.42(a)(1)..

3.5 Aging Management Program

Pursuant to 10 CFR 72.42(a)(2), the licensee must provide a description of AMPs for management of issues associated with aging that could adversely affect SSCs that are ITS. The licensee provided two AMPs in Appendix A to LRA Revision (NSPM, 2014a, Enclosure 2, Attachment B). The AMPs provided in the LRA Revision reflect information in the application as supplemented by the responses to the staff's RAIs.

- ISFSI Inspection and Monitoring Program
- High Burnup Fuel Monitoring Program

As specified in License Condition No. 19., the AMPs summarized in Appendix C, Rev. 1, in the Supplement to the License Renewal Application will be incorporated into the SAR required by 10 CFR 72.70(a) after issuance of the license. Changes are incorporated into the SAR pursuant to 10 CFR 72.48. Consistent with 10 CFR 72.48, modifications that would require a change to the terms, conditions, or specifications incorporated in the license may not be altered through the 10 CFR 72.48 change process. Because staff considers some of the information and activities in the AMPs summarized in Appendix C, Rev. 1 to be necessary to make the requisite safety findings for reasonable assurance, some conditions have been added to the license in this regard. (See License Conditions No. 21-26). These license conditions were added because the staff has relied on this specific information in the AMPs to obtain reasonable assurance that the SSCs within the scope of the pertinent AMPs will maintain their intended function through the period of extended operation. The staff has provided a description of the specific license conditions in the SER sections addressing those specific AMP details. (See Sections 3.5.1.1, 3.5.1.2, 3.5.1.3, 3.5.1.4, 3.5.2, and 3.5.3).

3.5.1 ISFSI Inspection and Monitoring Program

The licensee proposed a general AMP, "ISFSI Inspection and Monitoring Program," in Appendix A to the LRA Revision 1 (NSPM, 2014a, Enclosure 2, Attachment B). The AMP detailed the activities to be performed to ensure the following in-scope SSCs will maintain their intended design safety functions per 10 CFR 72.42(a)(2). The sections hereafter detail the staff's review of the adequacy of this AMP to address the identified aging mechanisms and effects of the following in-scope SSCs and subcomponents:

- In-scope SSCs
  - Dry Storage (In-service) Casks
  - Reinforced Concrete Pads
  - Earthen Berm
- In-scope Subcomponent of the Dry Storage (In-service) Casks
  - Polymer Neutron Shield

3.5.1.1 **Dry Storage (In-service) Casks**

The ISFSI Inspection and Monitoring Program includes periodic inspection activities to manage the aging effects of the dry storage casks. The licensee identified "Dry Storage Casks" as an SSC within scope of the license renewal in Table 2.4-1 of the LRA. The licensee also used the term "In-service Casks" in the ISFSI Inspection and Monitoring Program AMP in Appendix A to the LRA Revision1 (NSPM, 2014a, Enclosure 2, Attachment B). For the purposes of the staff review, the terms "Dry Storage Casks" and "In-service Casks" are considered equivalent. For clarity, the staff expects the licensee to adopt a single term for the incorporation into the next revised SAR. The staff reviewed the AMP against the criteria provided in Section 3.6.1 of NUREG–1927 (NRC, 2011). The staff's evaluation of each of the program elements is as follows:

1. Scope of the Program

The licensee defined the scope of the program to include visual inspections to monitor the conditions and performance of the casks. The licensee references applicable aging mechanisms and effects in Table A2.1-1 of the Appendix A to the LRA Revision 1 (NSPM, 2014a, Enclosure 2, Attachment B) that are within the scope of this AMP. The aging effect managed by this program for the dry storage (in-service) casks is loss of material due to various corrosion mechanisms. The scope of the visual inspections includes:

- Visual inspection of the exterior of the dry storage (in-service) casks.
- Monitoring of the inter-seal pressure of the dry storage (in-service) casks.
- Visual inspection of a dry storage (in-service) cask bottom prior to the end of the initial license period.
- Visual inspection under a dry storage (in-service) cask protective cover prior to the end of the initial license period.
- Visual inspection of the cask bottom in the event that a dry storage (in-service) cask is lifted in preparation for movement.
- Visual inspection under the protective cover of a dry storage (in-service) cask in the event the cover is removed for maintenance.
- Visual inspection of the bottom and the protective cover of the lead cask at least every 20 years.

The staff reviewed the licensee's Scope of the Program and determined that the licensee has correctly identified the aging mechanisms and effects of the dry storage (in-service) casks to be managed by the activities in the program.

2. Preventive Actions

The licensee defined the visual inspection of the dry storage (in-service) casks as a condition-monitoring program, which does not require any preventive actions. The staff finds the definition of this program element acceptable.

3. Parameters Monitored or Inspected

The licensee stated that the dry storage (in-service) casks are visually inspected to ensure that the intended function of the casks is maintained during the period of extended operation. The licensee stated that the casks are visually inspected for signs of corrosion, damage, and/or debris accumulation on the cask exterior surfaces. The lead cask inspections were performed in June 2011 to look for signs of deterioration in the inaccessible areas of the cask bottom and underneath the protective cover. The licensee stated that loss of material due to corrosion is the applicable aging effect. The licensee also stated that the pressure of the inter-seal helium gas is monitored to verify the integrity of the seals of the cask lid and that the intended function of the casks is not compromised.

The staff reviewed the licensee's activities involving the Parameters Monitored or Inspected for the visual inspections of the casks and inter-seal pressure monitoring. Pursuant to 10 CFR 72.158, "Control of Special Processes," the licensee shall establish measures to ensure that special processes, including nondestructive testing (such as visual inspections described in this AMP), are controlled and accomplished by qualified personnel using qualified procedures (with identified parameters to be inspected or monitored, as defined in this AMP element) in accordance with applicable codes, standards, specifications, criteria, and other special requirements. The licensee will be relying upon the use of applicable industry codes and standards for the visual inspection, which is a type of nondestructive testing method. Therefore, the staff reviewed the licensee's description of the visual inspections with the expectation that the licensee's choice and use of applicable codes and standards will continue to satisfy the requirements of 10 CFR 72.158 and the existing approved Quality Assurance Program.

The staff reviewed the information contained in the LRA and subsequent RAI responses, including results from the lead system inspection and other past ISFSI monitoring activities. However, results from inspection activities to assess age-related degradation of dry storage systems are presently limited, thus the LRA contained only limited operating experience. The staff, therefore, reviewed the licensee's AMP to determine if the licensee was able to demonstrate with reasonable assurance that the dry storage (in-service) cask subcomponents would continue to perform their intended function through the renewal period. The licensee identified specific parameters to be monitored or inspected in the AMP in order to demonstrate that these subcomponents will be adequately inspected to prevent a loss of intended function through the renewal period.

The staff determined that the specific parameters to be monitored or inspected in the AMP are appropriate based upon the technical references pertinent to age related degradation of cask materials in similar environments, including reactor renewal guidance provided in NUREG-1801 (NRC, 2010b). Therefore, with the inclusion of the specific parameters to be monitored or inspected in the AMP, the staff concludes that signs of deterioration will be adequately detected and appropriately addressed before degradation reaches a level where the cask subcomponent would be challenged in performing its intended function.

Because the staff relied upon the specific parameters to be monitored or inspected in the AMP in reaching its reasonable assurance finding, the staff has added a specific license condition to prevent changes to these AMP criteria absent a license amendment. (See License Condition No. 23).

The staff finds that the activities involving the Parameters Monitored or Inspected provide reasonable assurance for managing the aging mechanisms and effects, and ensuring the intended function of the dry storage (in-service) casks will be maintained during the period of extended operation.

4. Detection of Aging Effects

The licensee stated that quarterly visual inspections of the physical condition of the exterior surfaces of all casks provide a means to detect degradation of these casks due to potential loss of material and ensure that the intended functions are not compromised. The licensee also stated that visual inspections of both the cask bottom and the area underneath the cask protective cover by inspections of opportunity and, as a minimum, at 20-year intervals for the lead cask, provide a means to detect degradation due to potential loss of material and ensure that the intended functions are not compromised.

The licensee stated that pressure monitoring of all casks is performed as a continuous process and checked daily for alarms. This provides a means to detect metallic O-ring seal degradation due to potential loss of material and ensure that the intended function is not compromised.

The staff reviewed the activities involving the licensee's Detection of Aging Effects and determined that quarterly visual inspections of the casks and continuous inter-seal pressure monitoring as part of the maintenance and surveillance activities provide acceptable means to effectively detect the aging effects of loss of material so that the dry storage (in-service) casks will maintain their intended functions for the period of extended operation. Pursuant to 10 CFR 72.158, "Control of Special Processes," the licensee shall establish measures to ensure that special processes, including nondestructive testing (such as visual inspections described in this AMP), are controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements. The licensee will be relying upon the use of applicable industry codes and standards for the visual inspection, which is a type of nondestructive testing method. Therefore, the staff reviewed the licensee's description of the visual inspections with the expectation that the licensee's choice and use of applicable codes and standards will continue to satisfy the requirements of 10 CFR 72.158 and the existing approved Quality Assurance Program.

The staff reviewed the information contained in the LRA, and subsequent RAI responses, including results from the lead system inspection and other past ISFSI monitoring activities. However, results from inspection activities to assess age-related degradation of dry storage systems are presently limited, thus the LRA contained only limited operating experience. The staff, therefore, reviewed the licensee's AMP to determine if the licensee was able to demonstrate with reasonable assurance that the dry storage (in-service) cask subcomponents would continue to perform their intended function through the renewal period. The licensee identified specific inspection intervals and areas of inspection coverage in the AMP in order to demonstrate that these subcomponents will be adequately inspected to prevent a loss of intended function through the renewal period.

The staff determined that the specific inspection intervals and areas of inspection coverage in the AMP are appropriate based upon the technical references pertinent to age related degradation of cask materials in similar environments, including reactor renewal guidance provided in NUREG-1801 (NRC, 2010b). Therefore, with the inclusion of the specific inspection intervals and areas of inspection coverage in the AMP, the staff concludes that signs of deterioration will be adequately detected and appropriately addressed before degradation reaches a level where the cask subcomponent would be challenged in performing its intended function.

Because the staff relied upon the specific inspection intervals and areas of inspection coverage in the AMP in reaching its reasonable assurance finding, the staff has added a specific license condition to prevent changes to these AMP criteria absent a license amendment. (See License Condition No. 23).

The staff finds that the Detection of Aging Effects contains an adequate detection method, inspection or monitoring frequency and sample size to ensure timely detection of aging effects. Therefore, the information described in this AMP element provide reasonable assurance that aging mechanisms and effects identified in the AMR of the dry storage (in-service) casks will be managed during the period of extended operation.

5. Monitoring and Trending

The licensee stated that quarterly visual inspections will be performed to determine the potential existence of loss of material for the cask exterior surfaces and accumulation of debris. The licensee stated that pressure monitoring of each cask to detect potential loss of material is provided as a continuous process and checked daily for alarms. The licensee also stated that the AMP requires monitoring the condition of SSCs using current and historical operating experience along with industry operating experience to detect, evaluate, and trend degraded conditions. More specifically, the licensee clarified that when degraded conditions are detected and associated corrective actions are completed, the SSCs will continue to be monitored against performance goals.

The licensee further stated in the supplemented LRA (NSPM, 2014a, Enclosure 2) that the ISFSI Inspection and Monitoring Program, as a subset of the PINGP Structures Monitoring Program, requires that the program coordinator evaluate the results of the inspections for adverse trends including an evaluation of whether the frequency of the inspections should be increased. More specifically, the periodic structures inspection procedure contains requirements to generate an inspection report that includes a section on historical information and trends. The licensee noted that this section is to contain relevant maintenance information on the structure collected while preparing for the inspection. At a minimum, the section will identify the status of Work Requests and Actions Requests issues during the previous inspection of the structure. The section will also include a discussion of the significance of past and present inspection findings. In particular, the licensee stated that this section addresses whether the findings represent an adverse trend or random deficiency indicative of normal structural aging.

The staff reviewed the Monitoring and Trending Element of this AMP and determined that the licensee's monitoring and trending methods provide an acceptable means to effectively predict the extent of the aging effects of loss of material and timely corrective actions. The staff finds that the Monitoring and Trending provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the dry storage (in-service) casks.

6. Acceptance Criteria

The licensee stated that the program includes acceptance criteria to evaluate the extent of a degraded condition and the need for corrective action before the loss of intended function. The licensee stated that the acceptance criteria for visual inspections of the casks are the absence of any of the aging effects (i.e., no observable indications of corrosion). The licensee also stated that if the inspector observes any indication of corrosion, the condition would be entered into its Corrective Action Program. The licensee stated that the acceptance criterion for inter-seal pressure monitoring is the absence of an alarmed condition, and the alarm setpoint is higher than the inter-seal pressure specified in the Prairie Island ISFSI Technical Specification 3.1.5 (NSPM, 2010a).

The staff reviewed the licensee's Acceptance Criteria and determined that the acceptance criteria is acceptable because the licensee specified that corrective actions will be taken if any indication of loss of material due to any corrosion mechanisms is detected by the inspector or an alarmed condition exists.

The staff reviewed the information contained in the LRA, and subsequent RAI responses, including results from the lead system inspection and other past ISFSI monitoring activities. However, results from inspection activities to assess age-related degradation of dry storage systems are presently limited, thus the LRA contained only limited operating experience. The staff, therefore, reviewed the licensee's AMP to determine if the licensee was able to demonstrate with reasonable assurance that the dry storage (in-service) cask subcomponents would continue to perform their intended function through the renewal period. The licensee identified specific acceptance criteria in the AMP in order to demonstrate that these subcomponents will be adequately inspected to prevent a loss of intended function through the renewal period.

The staff determined that the specific acceptance criteria in the AMP are appropriate based upon the technical references pertinent to age related degradation of cask materials in similar environments, including reactor renewal guidance provided in NUREG-1801 (NRC, 2010b). Therefore, with the inclusion of the specific acceptance criteria in the AMP, the staff concludes that signs of deterioration will be adequately detected and appropriately addressed before degradation reaches a level where the cask subcomponent would be challenged in performing its intended function.

Because the staff relied upon the specific acceptance criteria in the AMP in reaching its reasonable assurance finding, the staff has added a specific license condition to prevent changes to these AMP criteria absent a license amendment. (See License Condition No. 23).

The staff finds that the Acceptance Criteria provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the dry storage (in-service) casks.

7. Corrective Actions

The licensee stated that its Corrective Actions Program requirements are established in accordance with the requirements of 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants" and NSPM Quality Assurance Topical Report. The licensee stated that a single Corrective Action Program is applied regardless of the safety classification of the structure or component.

The licensee further stated that the Corrective Action Program procedures require the initiation of an Action Request for actual or potential problems including failures, malfunctions, discrepancies, deviations, defective material and equipment, nonconformances, and administrative control discrepancies, to ensure that conditions adverse to quality, operability, functionality, and reportability issues are promptly identified, evaluated if necessary, and corrected as appropriate. Guidance on establishing priority and timely resolution of issues is contained within the Corrective Action Program procedure. All corrective actions for deviating conditions that are adverse to quality are performed in accordance with the requirements of the Quality Assurance Program that complies with the requirements of 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants." Any resultant maintenance, repair/replacement activities, or special handling requirements are performed in accordance with approved procedures.

The licensee noted that corrective actions provide reasonable assurance that deficiencies adverse to quality are either promptly corrected or evaluated to be acceptable. For evaluations that do not result in repair or replacement, engineering analysis is used to provide reasonable assurance that the intended function is maintained consistent with the design basis. If any deviating condition is assessed to be significantly adverse to quality, the cause of the condition is determined and an action plan is developed to preclude recurrence. Corrective actions identify recurring discrepancies and initiate additional corrective actions including root cause analysis to preclude recurrence. The licensee stated that degraded conditions identified by the AMP inspections will be entered into the Corrective Action Program. Actions required to resolve inspection findings will be tracked to completion and trended within the Corrective Action Program.

The licensee further noted in the supplemented LRA (NSPM, 2014a, Enclosure 2) that the Corrective Action Program also contains provisions to:

- Determine if the condition is reportable to the NRC (e.g., results in the loss of intended function).
- Perform equipment evaluations, apparent cause evaluations, and root cause evaluations.
- Perform functionality assessments.
- Address the extent of condition.
- Determine actions to prevent recurrence.
- Identify operating experience actions.
- Trend conditions.

The licensee further noted that it is through evaluations conducted as part of the Corrective Action Program that the determination would be made if an AMP, Monitoring Program, or inspection procedure would be revised.

The staff reviewed the details of the Corrective Action Program as part of the existing PINGP Quality Assurance Program. Per the requirements of 10 CFR 72.172, "Corrective Action," the staff expectation is that if an unanalyzed degraded condition is identified by the AMP inspections, the licensee will enter the finding into the Corrective Action Program and resolve the finding. The staff finds that the licensee's correction action program per the quality assurance requirements in 10 CFR Part 50, Appendix B, provides reasonable assurance that corrective actions will be adequate for managing the aging mechanisms and effects identified in the AMR of the dry storage (in-service) casks.

8. Confirmation Process

The licensee stated that the confirmation process is part of the NSPM Corrective Action Program to ensure that the corrective actions taken are adequate and appropriate, have been completed, and are effective. The licensee further stated that the focus of the confirmation process is on the follow-up actions that must be taken to verify effective implementation of corrective actions. More specifically, the measure of effectiveness is in terms of correcting the adverse condition and precluding repetition of significant conditions adverse to quality. The licensee clarified that the Corrective Action Program procedures include provisions for timely evaluation of adverse conditions and implementation of any corrective actions required, including root cause evaluations and prevention of recurrence where appropriate. More specifically, these procedures provide for tracking, coordinating, monitoring, reviewing, verifying, validating, and approving corrective actions, to ensure effective corrective actions are taken.

The licensee further stated the Corrective Action Program is monitored for potentially adverse trends. More specifically, the existence of an adverse trend due to recurring or repetitive adverse conditions will result in the initiation of an Action Request. The licensee confirmed that the AMP will also uncover unsatisfactory conditions resulting from ineffective corrective action.

The staff reviewed the details provided for the licensee's Confirmation Process, as part of the existing Quality Assurance Program, to ensure that appropriate corrective actions are completed and are effective. The staff finds that the licensee's Corrective Action Program per the quality assurance requirements in 10 CFR Part 50, Appendix B, provides reasonable assurance that the Confirmation Process is adequate for managing the aging mechanisms and effects identified in the AMR of the dry storage (in-service) casks.

9. Administrative Controls

The licensee stated that the NSPM's Quality Assurance Program, associated formal review and approval processes, and administrative controls applicable to the AMP are implemented in accordance with the requirements of the NSPM Quality Assurance Topical Report and 10 CFR Part 50, Appendix B. The licensee further stated that the administrative controls that govern aging management activities at PINGP are established in accordance with the PINGP Administrative Control Program and associated Fleet Procedures.

The staff reviewed the details provided for the licensee's Administrative Controls, as part of the existing Quality Assurance Program, to ensure that the administrative controls will be adequate to provide a formal review and approval process. The staff concludes that the NSPM Quality Assurance Program, per the quality assurance requirements in 10 CFR Part 50, Appendix B, provides reasonable assurance that the Administrative Controls are adequate for managing the aging mechanisms and effects identified in the AMR of the dry storage (in-service) casks.

10. Operating Experience

The licensee stated that a review of ISFSI operating history provided evidence that any potential aging effects were identified, evaluated, and managed effectively, assuring that structures and components remained capable of performing their intended functions. The licensee concluded that the dry storage (in-service) casks will continue to perform their intended functions during the period of extended operation.

The licensee stated that the visual inspections of the dry storage (in-service) casks to date, including lead cask inspections, identified only minor cases of coating degradation which were corrected by touching-up of the existing coating material, and there was no observable loss of material on the base metal under the degraded coating. The licensee provided an assessment of potential impacts on the shield plate's intended functions assuming loss of 2.54-cm [1-in] thickness after 100 years due to a postulated bounding corrosion rate of 0.254 mm/year [10 mils/year] on the cask bottom. The licensee cited three sources of literature data to support the bounding corrosion rate of 0.254 mm/year [10 mils/year]. The licensee stated that the bottom shield plates of the TN-40 and TN-40HT casks are still able to perform their intended functions with an assumed loss of 2.54 cm [1 in] of material. The licensee also stated that an inspection frequency of at least one inspection every 20 years for the bottom shield plate is sufficient to ensure that detection of the loss of material aging effect occurs before there is a loss of the shield plate's intended function.

The licensee discussed operating experience at the Surry ISFSI involving five TN-32 casks, a system dry cask design to the TN-40 and TN-40HT [TN, 2001]. This Surry ISFSI operating experience identified corrosion of the lid bolts and the outer metallic lid seals resulting from external water intrusion. The licensee stated that the root cause of the corrosion was leaking due to improper installation of the Conax connector seals for the electrical connector in the cask protective cover. The licensee further identified the issue as a design and installation issue and not age-related and not subject to this AMP.

The licensee identified additional operating experience, also referenced in the 2001 TN Bulletin. This operating experience referred to five casks at the Surry ISFSI and one cask in the North Anna ISFSI that did not retain the original torque value at initial cask placement on the concrete pads. Lid bolts could be removed by hand on two of these casks. The licensee stated that in all cases there was no evidence that the lid metallic O-rings lost their seal due to the reduced torque. Further evaluation by TN confirmed that the lid seals would remain compressed and containment maintained. TN did not identify areas in the design of the bolted flange/seal that would cause the bolt preload to decrease with time. The licensee stated that a change in the bolt torquing sequence methodology should be implemented to mitigate against the possibility of thermal expansion causing this bolting issue. TN further recommended that lubricant should be applied to the bolts and special attention be paid to the calibration of the bolt torquing equipment. The licensee stated that these recommendations were incorporated in the applicable existing PINGP maintenance procedures.

The licensee further stated that recent operating experience at the Peach Bottom ISFSI identified corrosion of the lid bolts and outer-metallic seals due to loss of bolt-preload stress. The operating experience evaluation report (QF-0447, Revision 0, 2011) identified that the corrosion was caused by leakage of moisture past the protective cover. The report further stated that the corrective actions included replacing the cover seal, improving the bolt torquing process, and resealing the protective cover. The report identified thermal transients for the cask, such as during cask draining, as the root cause for the bolt loosening. As such, the operating experience has not demonstrated the loss of bolting preload as an age-related mechanism, hence, not subject to the license renewal review.

The licensee stated that the dry storage (in-service) cask inter-seal helium pressures has revealed no issues with the seals or age related issues with the pressure monitoring system. The licensee also stated that there have been instances during extreme cold weather conditions when a low-pressure alarm was received requiring the pressure monitoring system to be recharged and the fittings tightened. However, these event-driven issues were identified as a function of extreme temperature conditions and not age-related. The licensee further stated that trending of periodic radiation surveys results shows no evidence that the shielding is degrading.

The staff reviewed the licensee's Operating Experience and found the licensee's evaluation of relevant operating experience demonstrates that the program will effectively manage aging effects of the dry storage (in-service) casks during the period of extended operation. The staff further confirmed that the loss of bolting preload identified by the licensee is not an age-related degradation mechanism, and hence not subject to the aging management review of the cask. The staff also determined the assessment of potential impacts of corrosion on the shield plate's intended functions acceptable because the bottom shield plate will maintain its intended functions during the license renewal period. The staff finds that the Operating Experience stated and referenced in the LRA provides reasonable assurance that this AMP will be adequate for managing the aging mechanisms and effects identified in the AMR of the dry storage (in-service) casks.

3.5.1.2 **Cask Polymer Neutron Shield**

Both TN-40 and TN-40HT casks use polymer-based neutron shields to reduce neutron radiation coming from the spent fuel in the casks. One way to manage the aging effects of the neutron shields is to monitor the performance of the neutron shields and take corrective actions when the dose rate outside of the cask exceeds the established acceptance criteria. The licensee created a general AMP, "ISFSI Inspection and Monitoring Program" and credits this for ensuring that both the design basis "Radiation Protection Design Features," as described in Section A7.3 of the PINGP USAR (NSPM, 2010b) and ALARA (as low as is reasonably achievable) considerations remain valid during the period of extended operation. The staff reviewed the AMP against the criteria provided in NUREG–1927 (NRC, 2011, Section 3.6.1). The staff's evaluation of each of the program elements is as follows:

1. Scope of Program

The licensee defined the scope of the program as monitoring the performance of the neutron shield to assure that the ISFSI meets the dose requirements of 10 CFR 72.104 during the period of extended operation. The licensee also credits this program for ensuring that the design basis "Radiation Protection Design Features," as described in Section A7.3 of the PINGP USAR (NSPM, 2010b) and ALARA considerations, which was designed based on the physical conditions of the initial neutron shield, remain valid during the period of extended operation. The scope of the general AMP includes in its line item 3, radiation monitoring and associated surveillance activities of the dry storage (in-service) cask.

The neutron shield achieves its designed safety function (i.e., reducing neutron radiations from the casks) by (i) reducing the neutron energy through moderation by hydrogen and carbon atoms in the polymer and (ii) absorbing neutrons that have been slowed down by the boron in the shield. As such, monitoring of the dose rates outside of the cask can be a way to monitor the performance of the neutron shields.

The staff reviewed the definition of the scope of this program and finds that the licensee accurately defined the scope of the program. The components to be managed are clearly defined and the scope element is acceptable.

2. Preventive Actions

The licensee determined that this is a condition-monitoring program and no preventive actions are required. The staff determined that this element is adequately defined and hence acceptable.

3. Parameters Monitored or Inspected

The licensee identified the measured neutron dose rate as the parameters to be monitored. The licensee demonstrated that it is adequate to use quarterly neutron dose rate measurements as a means to detect loss of intended functions of the neutron shield.

The licensee has been performing and has committed to continuing to perform neutron dose rate measurements on a quarterly basis for each cask. The licensee stated that the dose rate measurements will use neutron detectors that are capable of detecting increase in cask surface neutron intensity and shift of neutron spectrum.

The staff reviewed the entire AMP and finds that the neutron dose rate can be used as a means to detect loss of the intended function of the neutron shield because the intended function of the neutron shield is to reduce neutron radiation so that the radiation exposure requirements of 10 CFR 72.104(a) and 72.126 are met. The dose rate is the essential parameter to monitor. Based on this basic physics principle, the staff finds that neutron dose rate is a direct and effective means to monitor the neutron shield performance.

Based on its review, the staff determined that the measurement equipment, personnel qualification, and actual measurements should be inspected to ensure the measured data are suitable and reliable for this purpose.

4. Detection of Aging Effects

The base material of the neutron shield is polyester that is made primarily of oxygen, carbon, hydrogen, and aluminum. Boron is added in the polymer to absorb neutrons that have been slowed down to lower energies and zinc is added to retard fire damage.

Based on research results and operating experience (NRC, 2010b; Chopra, et al., 2013; McManus and Chamis, 1996; Fu, et al., 1988; Cota, et al., 2007), when exposed to high-energy radiations and heat, polymer materials will degrade to shrink and further develop cracks. These aging effects will hinder the neutron shield to fulfill its design basis function with three mechanisms:

(1) Loss of neutron moderation capability because of thinning.

(2) Loss of neutron moderation capability because of the streaming paths formed due to cracks.

(3) Loss of neutron absorption capability because of B-10 redistribution or to a lesser degree, loss of B-10 due to depletion.

The net results of these aging effects are increase in number of neutrons coming out of the cask surface and increase in neutron energy (i.e., upward shifting of neutron spectrum). The licensee identified that an upshift of the neutron spectrum and increase in neutron flux are indicators of loss of the intended functions of the neutron shield.

In the definition of the AMP, the licensee stated that it relies on the (1) monitoring intervals and (2) monitoring method and technique as specified in the of the AMP, “ISFSI Inspection and Monitoring Program,” to demonstrate that the polymer neutron shields will be adequately monitored to prevent a loss of intended function through the period of extended operation. The staff reviewed the licensee's specific aging management activities in this AMP to determine with reasonable assurance that the polymer neutron shields would continue to perform their intended function through the renewal period. The staff also reviewed information from technical reports pertinent to polymer materials age related degradation, commercial power reactor renewal guidance, NUREG-1801 (NRC, 2010b), and other peer-reviewed technical references (Johson, et al., 2009; Jordan, et al, 2005). Based on its review, the staff concludes with reasonable assurance that the licensee will be able to detect aging effects of the polymer neutron shields and implement timely corrective actions before loss of intended function of the neutron shields through the period of extended operation with the following License Conditions:

(a) Within 90 days of the issuance of the renewed license, Northern States Power Company-Minnesota shall establish baseline values for dose rate trending analyses to be used in detecting any potential loss of intended function of the neutron shield.

(b) Thereafter, Northern States Power Company-Minnesota shall continue to perform dose rate surveys for each loaded cask at an interval not to exceed three months, as is consistent with the aging management program "ISFSI Inspection and Monitoring Program."

(c) Northern States Power Company-Minnesota shall compare the measured dose rate data with the established baseline values to detect any increase in neutron dose rates. Upon detecting any unexpected upward trend in the measured neutron dose rates, Northern States Power Company-Minnesota shall place the non-compliant cask into the licensee corrective actions program to evaluate the cause for loss of intended function and determine whether a similar problem could occur within other casks.

With the above conditions, the staff finds that the Detection of Aging Effects provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the polymer neutron shields. These conditions correspond to License Conditions No. 24(a), 24(b) and 24(c).

The staff reviewed this conclusion and finds the licensee has identified all the aging effects of the neutron shield. Based on its review, the staff finds that the licensee has adequately identified all major aging mechanisms and aging effects of the neutron shield. Therefore, the measurement of neutron dose rates outside the surface of each individual cask is an acceptable way for detecting aging of the polymer-based neutron shield.

5. Monitoring and Trending

The licensee stated that the measured neutron dose rate data will be trended and monitored to detect a loss of neutron shielding capacity. The licensee further stated that the AMP requires monitoring the condition of SSCs using current and historical operating experience along with industry operating experience to detect, evaluate, and trend degraded conditions. More specifically, the licensee clarified that when degraded conditions are detected and all associated corrective actions are complete, the SSCs will be monitored once again against performance goals.

The licensee further stated in the supplemented LRA (NSPM, 2014a, Enclosure 2) that the "ISFSI Inspection and Monitoring Program," as a subset of the PINGP Structures Monitoring Program, requires that the program coordinator evaluate the results of the inspections for adverse trends including an evaluation of whether the frequency of the inspections should be increased. More specifically, the periodic structures inspection procedure contains requirements to generate an inspection report that includes a section on historical information and trends. The licensee clarified that this section is to contain relevant maintenance information on the structure collected while preparing for the inspection. At a minimum, the section will identify the status of Work Requests and Actions Requests issues during the previous inspection of the structure. The section will also include a discussion of the significance of past and present inspection findings. In particular, the licensee stated that this section addresses whether the findings represent an adverse trend or random deficiency indicative of normal structural aging.

The staff reviewed the licensee's Monitoring and Trending and determined that the licensee's monitoring and trending methods provide an acceptable means to effectively predict the extent of the aging effects and timely corrective actions. The staff recognized that because the licensee is using dose rate rather than neutron fluence as the parameter to be monitored, any neutron spectrum shift to higher energy will also be detected in the dose rate measurements. The staff further recognized that the dose rate is an integrated measurement that accounts for both the number of neutrons reaching the detector and a dose rate conversion factor, which is a function of neutron energy. The staff finds that the Monitoring and Trending provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the polymer-based neutron shield.

6. Acceptance Criteria

The licensee will use the following criteria to determine if no loss of intended function has occurred:

- No unexpected upward trend in neutron radiation intensity.
- No apparent neutron spectrum shift.
- No change in the neutron axial radiation profile.
- Neutron radiation measurement locations must be comprehensive to ensure any neutron shield degradation is detected.
- Neutron detector(s) must be appropriate for detecting the neutrons at all energy levels.
- Neutron detector(s) must be calibrated following appropriate quality assurance program.

In the response to the second round RAI (NSPM, 2014a, Enclosure 2), the licensee recognized the difficulties in performing neutron dose rate measurements and committed to using neutron detectors that are appropriate for detecting neutron dose rate changes and personnel who are qualified for measurement, operation monitoring and trending analyses in their respective areas of specialty.

The staff reviewed the information presented in the LRA describing the licensee's AMP to determine if the licensee was able to demonstrate, with reasonable assurance, that the polymer neutron shields would continue to perform their intended function through the renewal period. The licensee identified the specific acceptance criteria in the AMP in order to demonstrate that the polymer neutron shields will be adequately monitored to prevent a loss of intended function through the renewal period.

The staff also considered information from technical references pertinent to age related degradation of polymer materials, including reactor renewal guidance provided in NUREG-1801(NRC, 2010b), applicable industry practice on neutron dose rate detection, NRC reports, and other technical references. Based upon its review, the staff concludes that, with the specific acceptance criteria in the AMP, the licensee has demonstrated with reasonable assurance that the polymer neutron shields will maintain their intended function through the renewal period. The staff has determined that the specific acceptance criteria in the AMP are appropriate based upon the technical references pertinent to age related degradation of the materials of construction in similar environments. With the inclusion of the specific acceptance criteria in the AMP, the staff concludes that aging-related degradation of the neutron shields will be detected in a timely manner and corrective actions will be implemented before the neutron shields lose their intended function.

Based on these findings, the staff finds that the Acceptance Criteria provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the polymer neutron shields.

7. Corrective Actions

The licensee stated that immediate corrective actions would be taken if the acceptance criteria are not met. The licensee further clarified that these actions may include use of additional temporary shielding to limit the direct neutron radiations or sky shine to the side boundary. The licensee stated that a permanent solution will be taken after the root cause is determined.

The licensee stated that its Corrective Action Program requirements are established in accordance with the requirements of 10 CFR Part 50, Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants” and NSPM Quality Assurance Topical Report. The licensee stated that a single Corrective Action Program is applied regardless of the safety classification of the structure or component.

The licensee further stated that the Corrective Action Program procedures require the initiation of an Action Request for actual or potential problems including failures, malfunctions, discrepancies, deviations, defective material and equipment, nonconformances, and administrative control discrepancies, to ensure that conditions adverse to quality, operability, functionality, and reportability issues are promptly identified, evaluated if necessary, and corrected as appropriate. Guidance on establishing priority and timely resolution of issues is contained within the Corrective Action Program procedure. All corrective actions for deviating conditions that are adverse to quality are performed in accordance with the requirements of the Quality Assurance Program which complies with the requirements of 10 CFR Part 50, Appendix B. Any resultant maintenance, repair/replacement activities, or special handling requirements are performed in accordance with approved procedures.

The licensee clarified that corrective actions provide reasonable assurance that deficiencies adverse to quality are either promptly corrected or evaluated to be acceptable. For evaluations that do not result in repair or replacement, engineering analysis is used to provide reasonable assurance that the intended function is maintained consistent with the design basis. If the deviating condition is assessed to be significantly adverse to quality, the cause of the condition is determined and an action plan is developed to preclude recurrence. Corrective actions identify recurring discrepancies and initiate additional corrective actions including root cause analysis to preclude recurrence. The licensee stated that degraded conditions identified by the AMP inspections will be entered into the Corrective Action Program. Actions required to resolve inspection findings will be tracked to completion and trended within the Corrective Action Program.

The licensee further clarified in the supplemented LRA (NSPM, 2014a, Enclosure 2) that the Corrective Action Program also contains provisions to:

- Determine if the condition is reportable to the NRC (e.g., results in the loss of intended function).
- Perform equipment evaluations, apparent cause evaluations, and root cause evaluations.
- Perform functionality assessments.
- Address the extent of condition.
- Determine actions to prevent recurrence.
- Identify operating experience actions.
- Trend conditions.

The licensee further clarified that it is through evaluations conducted as part of the Corrective Action Program that the determination would be made if an AMP, Monitoring Program, or inspection procedure would be revised.

The staff reviewed the licensee's commitments and finds them acceptable. Based on these statements, the staff considers that a timely action to reduce neutron radiations exceeding the acceptance criteria is practical and executable. The staff further considers that a permanent corrective action will be sufficient to assure that the dose limits of 10 CFR 72.104 and 10 CFR 72.126 are satisfied.

The staff further reviewed the details provided for the Corrective Action Program as part of the existing PINGP Quality Assurance Program. Per the requirements of 10 CFR 72.172, the staff expects that if an unanalyzed degraded condition is identified by the AMP inspections, the licensee will enter the finding into the Corrective Action Program and resolve the finding. The staff finds that the licensee's corrective action program per the quality assurance requirements in 10 CFR Part 50, Appendix B provides reasonable assurance that corrective actions will be adequate for managing the aging mechanisms and effects identified in the AMR of the polymer-based neutron shield.

The licensee stated in the AMP that corrective actions will be taken if potential loss of neutron shielding function. The staff reviewed the information contained in the LRA and the licensee's AMP to determine if the licensee's corrective actions are able to demonstrate with reasonable assurance that the polymer neutron shields would continue to perform their intended function through the period of extended operation.

As part of this review, the staff considered information from technical references pertinent to age related degradation of materials, including NUREG-1801 (NRC, 2010b) reactor renewal guidance, NRC reports, and other technical references. Based on its review, the staff concludes that, with the specific corrective actions in the AMP, the licensee has demonstrated with reasonable assurance that the polymer neutron shields will maintain their intended function through the renewal period. The staff further determined that these specific corrective actions in the AMP are appropriate for managing age related degradation of the polymer shields with the following condition:

> Northern States Power Company-Minnesota shall compare the measured dose rate with the established baseline value to detect increase in dose rate. Upon detecting any unexpected upward trend in the measured neutron dose rates, Northern States Power Company-Minnesota shall place the non-compliant cask into corrective actions program to rectify the lost intended function. The licensee shall perform a root-cause analysis to determine the cause of the problem and whether the similar problem could occur on other casks.

With the above condition, the staff finds that the Detection of Aging Effects provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the polymer neutron shields. The above condition is necessary to assure timely detection of neutron shield degradation and prompt corrective actions to ensure that the regulatory requirements of 10 CFR 72.104 and 72.106 are met. This condition corresponds to License Condition No. 24(c).

8. Confirmation Process

The licensee credits its continuing monitoring of the dose rates at each cask as a means for confirmation of the effectiveness of the corrective actions. If further dose rate measurements show that new dose rates are higher than expected, further corrective actions, including use of additional neutron shield and root-cause analysis of the failed corrective actions, will be taken.

The staff reviewed the licensee proposed confirmation process and determined it acceptable. Measuring the dose rates or neutron fluence are the only means for confirmation of meeting the 10 CFR 72.104 and 10 CFR 72.126 dose limits.

9. Administrative Controls

The licensee will use the existing plant Quality Assurance Program consistent with the requirements of Appendix B of 10 CFR Part 50 to control the quality of the AMP. Since these programs have been reviewed and approved by the staff in the initial licensing process, the staff has a reasonable assurance that the site Quality Assurance Program remains acceptable and the staff therefore did not perform further review of this part.

10. Operating Experience

The licensee discussed in general terms regarding site-specific and industry-wide operating experience. The licensee provided in its response to the staff's RAIs, historical gamma and neutron dose rate measurement data. From these data, there is no obvious increase in dose rate. Based on these results, the staff finds that there is no indication of loss of safety function of the neutron shield in the history of the PINGP ISFSI.

The staff reviewed the neutron shield AMP with respect to the 10 elements as outlined in NUREG–1927 (NRC, 2011). The staff reviewed the method and the technical bases for the neutron shield monitoring program. Based on its review, the staff determined that the technical bases of this AMP are valid and the procedures implemented are reliable and accurate. On the bases of these assessments, the staff determined that the neutron shield monitoring AMP is adequate for managing the identified aging effects on the polymer-based neutron shield that is used in the TN-40 and TN-40 HT casks at the PINGP ISFSI.

3.5.1.3 **Concrete Pads**

The ISFSI Inspection and Monitoring Program details the activities to manage the aging mechanisms and effects of the reinforced concrete pads. The staff reviewed the AMP against the criteria provided in NUREG–1927 (NRC, 2011, Section 3.6.1). The staff's evaluation of each of the program elements is as follows:

1. Scope of the Program

The licensee defined the scope of the program to include visual inspection of the concrete pads and monitoring of groundwater chemistry. The licensee references applicable aging mechanisms and effects in Table A2.1-1 of the Appendix A to the LRA Revision 1 (NSPM, 2014a, Enclosure 2, Attachment B) that are within the scope of this AMP. The aging effects of the concrete pads managed by this program include:

- Change in material properties due to leaching of calcium hydroxide (above-grade/below-grade).
- Cracking or loss of material due to freeze-thaw degradation (above-grade).
- Cracking due to reaction with aggregates (above-grade/below-grade).
- Cracking due to settlement (below-grade).

The staff reviewed the licensee's activities involving the Scope of the Program and determined that the licensee has identified the aging mechanisms and effects of concrete pads to be managed by the program. The staff finds that the activities involving the Scope of the Program provide reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the concrete pads.

2. Preventive Actions

The licensee defined the visual inspection of the concrete pads as a condition monitoring program, which does not require any preventive actions. The licensee further defined the groundwater chemistry monitoring as a mitigation program to prevent aging effects from exposure to an aggressive chemical environment.

The staff finds that the condition monitoring and mitigation programs provide reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the concrete pads.

3. Parameters Monitored or Inspected

The licensee stated that the parameters to be monitored and inspected during the visual inspection of the concrete pads are consistent with those in industry codes and standards, including ACI 349.3R, “Evaluation of Existing Nuclear Safety-Related Concrete Structures” (ACI, 2002). The aging effects that are monitored for the concrete pads are change in materials properties, cracking, and loss of material. The licensee further noted that the aging management for change in materials properties (increased in porosity and permeability, reduced strength, lower pH) will be accomplished by managing the aging mechanism (i.e., by inspecting for evidence of leaching and deposits of calcium products).

The licensee stated that monitoring of the groundwater chemistry for chloride, sulfate and pH will be used to verify that the concrete pads are not exposed to an aggressive chemical environment. The licensee stated that this AMP will ensure that parameters inspected focus on conditions identified during industry and plant specific operating experience reviews.

The staff reviewed the licensee’s Parameters Monitored or Inspected for the visual inspections of the concrete pads and monitoring of the groundwater chemistry. Pursuant to Control of Special Processes in 10 CFR 72.158, the licensee shall establish measures to ensure that special processes, including nondestructive testing (such as visual inspections described in this AMP), are controlled and accomplished by qualified personnel using qualified procedures (with identified parameters to be inspected or monitored, as defined in this AMP element) in accordance with applicable codes, standards, specifications, criteria, and other special requirements. The licensee will be relying upon the use of applicable industry codes and standards for the visual inspection, which is a type of nondestructive testing method. Therefore, the staff reviewed the licensee’s description of the visual inspections with the expectation that the licensee’s choice and use of applicable codes and standards will continue to satisfy the requirements of 10 CFR 72.158 and the existing approved Quality Assurance Program. The staff finds that the Parameters Monitored or Inspected provides reasonable assurance for managing the aging mechanisms and effects, and ensuring the intended function of the concrete pads will be maintained during the period of extended operation.

4. Detection of Aging Effects

The detection of aging effects relies on visual inspection of the concrete pads. The licensee stated that accessible areas will be inspected at intervals not to exceed 5 years. The licensee further stated that opportunistic inspections will be used for inaccessible areas (e.g., inspection of the area underneath a cask if the cask is moved, or inspections of below-grade portions of the pad if excavated, exposed or modified for any reason).

The licensee stated that monitoring of groundwater chemistry will include sampling of well water and river water every 6 months. The licensee further stated in the supplemented LRA (NSPM, 2014a, Enclosure 2, Attachment B) that water samples are obtained from the vicinity of the PINGP site. The samples will be characterized for chloride, sulfate, and pH to periodically confirm that the concrete pads are not exposed to an aggressive chemical environment.

The staff reviewed the licensee’s Detection of Aging Effects and determined that inspection methods and frequencies for the concrete pads provide acceptable means to effectively detect the aging mechanisms and effects so that the concrete pads will maintain their intended functions for the period of extended operation. Pursuant to 10 CFR 72.158, “Control of Special Processes” the licensee shall establish measures to ensure that special processes, including nondestructive testing (such as visual inspections described in this AMP), are controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements. The licensee is relying upon the use of applicable industry consensus guides and standards for the visual inspection, which is a type of nondestructive testing method. Therefore, the staff reviewed the licensee's description of the visual inspections with the expectation that the licensee's choice and use of applicable guides and standards will continue to satisfy the requirements of 10 CFR 72.158 and the existing approved Quality Assurance Program.

The staff reviewed the information contained in the LRA, and subsequent RAI responses, including results from the lead system inspection and other past ISFSI monitoring activities. However, results from inspection activities to assess age-related degradation of dry storage systems are presently limited, thus the LRA contained only limited operating experience. The staff, therefore, reviewed the licensee's AMP to determine if the licensee was able to demonstrate with reasonable assurance that the concrete pads would continue to perform their intended function through the renewal period. The licensee identified specific inspection intervals and areas of inspection coverage in the AMP in order to demonstrate that the concrete pads will be adequately inspected to prevent a loss of intended function through the renewal period.

The staff determined that the specific inspection intervals and areas of inspection coverage in the AMP are appropriate based upon the technical references pertinent to age related degradation of concrete in similar environments, including American Concrete Institute guides (ACI) 349.3R-02 (ACI, 2002), ACI 201.1R-08 (ACI, 2008), American National Standards Institute/American Society of Civil Engineers guidelines (ANSI/ASCE) 11-99 (ASCE, 2000), and reactor renewal guidance provided in NUREG-1801 (NRC, 2010b). Therefore, with the inclusion of the specific inspection intervals and areas of inspection coverage in the AMP, the staff concludes that signs of deterioration will be adequately detected and appropriately addressed before degradation reaches a level where the concrete pads would be challenged in performing its intended function.

Because the staff relied upon the specific inspection intervals and areas of inspection coverage in the AMP in reaching its reasonable assurance finding, the staff has added a specific license condition to prevent changes to these AMP criteria absent a license amendment. (See License Condition No. 22).

The staff finds that the Detection of Aging Effects provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the concrete pads.

5. Monitoring and Trending

The licensee stated that the AMP requires monitoring the condition of SSCs using current and historical operating experience along with industry operating experience to detect, evaluate, and trend degraded conditions. More specifically, the licensee clarified that when degraded conditions are detected and all associated corrective actions are complete, the SSCs will be monitored once again against performance goals.

The licensee further stated in the supplemented LRA (NSPM, 2014a, Enclosure 2) that the ISFSI Inspection and Monitoring Program, as a subset of the PINGP Structures Monitoring Program, requires that the program coordinator evaluates the results of the inspections for adverse trends including an evaluation of whether the frequency of the inspections should be increased. More specifically, the periodic structures inspection procedure contains requirements to generate an inspection report that includes a section on historical information and trends. The licensee noted that this section is to contain relevant maintenance information on the structure collected while preparing for the inspection. At a minimum, the section will identify the status of Work Requests and Actions Requests issues during the previous inspection of the structure. The section will also include a discussion of the significance of past and present inspection findings. In particular, the licensee stated that this section addresses whether the findings represent an adverse trend or random deficiency indicative of normal structural aging.

The staff reviewed the licensee's Monitoring and Trending and determined that the licensee's monitoring and trending methods provide an acceptable means to effectively predict the extent of the aging effects and timely corrective actions. The staff finds that the Monitoring and Trending provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the concrete pads.

6. Acceptance Criteria

The licensee stated the acceptance criteria for all visual inspections of the concrete pads are consistent with, or more restrictive than, those contained in Section 5.2.1 of ACI 349.3R-02 (ACI, 2002) (i.e., the second-tier criteria). The licensee clarified in the supplemented LRA (NSPM, 2014a, Enclosure 2) that some of the specific criteria would lead to an Action Request for cracks, calcium streaks and deposits, surface scaling, spalling, rust stains and failure of old concrete patched. The licensee further clarified that exceeding the parameters in such specific acceptance criteria would require entering the condition into the Corrective Action Program and evaluating if the condition is acceptable or if repair is required. The licensee also stated that the acceptance criteria for the groundwater chemistry monitoring are concentrations of chlorides less than or equal to 500 ppm, sulfates less than or equal to 1,500 ppm, and pH greater than or equal to 5.5.

The staff reviewed the acceptance criteria in the consensus standard ACI 349.3R (ACI, 2002) and determined that the second-tier criteria was adequate for determining a loss of intended function in the concrete pads. The staff notes that the groundwater chemistry monitoring criteria was also found to be commensurate with ASME B&PV Code Section XI, Subsection IWL (ASME, 2013).

The staff reviewed the information contained in the LRA, and subsequent RAI responses, including results from the lead system inspection and other past ISFSI monitoring activities. However, results from inspection activities to assess age-related degradation of dry storage systems are presently limited, thus the LRA contained only limited operating experience. The staff, therefore, reviewed the licensee's AMP to determine if the licensee was able to demonstrate with reasonable assurance that the concrete pads would continue to perform their intended function through the renewal period. The licensee identified specific acceptance criteria in the AMP in order to demonstrate that the concrete pads will be adequately inspected to prevent a loss of intended function through the renewal period.

The staff determined that the specific acceptance criteria in the AMP are appropriate based upon the technical references pertinent to age related degradation of concrete in similar environments, including American Concrete Institute guides (ACI) 349.3R-02 (ACI, 2002), ACI 201.1R-08 (ACI, 2008), American National Standards Institute/American Society of Civil Engineers guidelines (ANSI/ASCE) 11-99 (ASCE, 2000), and reactor renewal guidance provided in NUREG-1801 (NRC, 2010b). Therefore, with the inclusion of the specific acceptance criteria in the AMP, the staff concludes that signs of deterioration will be adequately detected and appropriately addressed before degradation reaches a level where the concrete pads would be challenged in performing its intended function.

Because the staff relied upon the specific acceptance criteria in the AMP in reaching its reasonable assurance finding, the staff has added a specific license condition to prevent changes to these AMP criteria absent a license amendment. (See License Condition No. 22).

The staff finds that the Acceptance Criteria provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the concrete pads.

7. Corrective Actions

The licensee stated that its Corrective Actions Program requirements are established in accordance with the requirements of 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants" and NSPM Quality Assurance Topical Report. The licensee stated that a single Corrective Action Program is applied regardless of the safety classification of the structure or component.

The licensee further stated that the Corrective Action Program procedures require the initiation of an Action Request for actual or potential problems including failures, malfunctions, discrepancies, deviations, defective material and equipment, nonconformances, and administrative control discrepancies, to ensure that conditions adverse to quality, operability, functionality, and reportability issues are promptly identified, evaluated if necessary, and corrected as appropriate. Guidance on establishing priority and timely resolution of issues is contained within the Corrective Action Program procedure. All corrective actions for deviating conditions that are adverse to quality are performed in accordance with the requirements of the Quality Assurance Program, which complies with the requirements of 10 CFR Part 50, Appendix B. Any resultant maintenance, repair/replacement activities, or special handling requirements are performed in accordance with approved procedures.

The licensee noted that corrective actions provide reasonable assurance that deficiencies adverse to quality are either promptly corrected or evaluated to be acceptable. For evaluations that do not result in repair or replacement, engineering analysis is used to provide reasonable assurance that the intended function is maintained consistent with the design basis. If the deviating condition is assessed to be significantly adverse to quality, the cause of the condition is determined and an action plan is developed to preclude recurrence. Corrective actions identify recurring discrepancies and initiate additional corrective actions including root cause analysis to preclude recurrence. The licensee stated that degraded conditions identified by the AMP inspections will be entered into the Corrective Action Program. Actions required to resolve inspection findings will be tracked to completion and trended within the Corrective Action Program.

The licensee further clarified in the supplemented LRA (NSPM, 2014a, Enclosure 2) that Corrective Action also contains provisions to

- Determine if the condition is reportable to the NRC (e.g., results in the loss of intended function).

- Perform equipment evaluations, apparent cause evaluations, and root cause evaluations.

- Perform functionality assessments.

- Address the extent of condition.

- Determine actions to prevent recurrence.

- Identify operating experience actions.

- Trend conditions.

The licensee further clarified that it is through evaluations conducted as part of the Corrective Action Program that the determination would be made if an AMP, Monitoring Program, or inspection procedure would be revised.

The staff reviewed the details provided for the Corrective Action Program as part of the existing PINGP Quality Assurance Program. Per the requirements of 10 CFR 72.172, the staff expects that if an unanalyzed degraded condition is identified by the AMP inspections, the licensee will enter the finding into the Corrective Action Program and resolve the finding. The staff finds that the licensee's correction action program per the quality assurance requirements in 10 CFR Part 50, Appendix B provides reasonable assurance that corrective actions will be adequate for managing the aging mechanisms and effects identified in the AMR of the concrete pads

8. Confirmation Process

The licensee stated that the confirmation process is part of the NSPM Corrective Action Program to ensure that the corrective actions taken are adequate and appropriate, have been completed, and are effective. The licensee further stated that the focus of the confirmation process is on the follow-up actions that must be taken to verify effective implementation of corrective actions. More specifically, the measure of effectiveness is in terms of correcting the adverse condition and precluding repetition of significant conditions adverse to quality. The licensee clarified that the Corrective Action Program procedures include provisions for timely evaluation of adverse conditions and implementation of any corrective actions required, including root cause evaluations and prevention of recurrence where appropriate. More specifically, these procedures provide for tracking, coordinating, monitoring, reviewing, verifying, validating, and approving corrective actions, to ensure effective corrective actions are taken.

The licensee further stated the Corrective Action Program is monitored for potentially adverse trends. More specifically, the existence of an adverse trend due to recurring or repetitive adverse conditions will result in the initiation of an Action Request. The licensee confirmed that the AMP will also uncover unsatisfactory conditions resulting from ineffective corrective action.

The staff reviewed the details provided for the licensee's Confirmation Process, as part of the existing Quality Assurance Program, to ensure that appropriate corrective actions are completed and are effective. The staff finds that the licensee's Corrective Action Program per the quality assurance requirements in 10 CFR Part 50, Appendix B provides reasonable assurance that the Confirmation Process is adequate for managing the aging mechanisms and effects identified in the AMR of the concrete pads.

9. Administrative Controls

The licensee stated that the NSPM Quality Assurance Program, associated formal review and approval processes, and administrative controls applicable to the AMP are implemented in accordance with the requirements of the NSPM Quality Assurance Topical Report and 10 CFR Part 50, Appendix B. The licensee further stated that the administrative controls that govern aging management activities at PINGP are established in accordance with the PINGP Administrative Control Program and associated Fleet Procedures.

The staff reviewed the details provided for the licensee's Administrative Controls, as part of the existing Quality Assurance Program, to ensure that the administrative controls will be adequate to provide a formal review and approval process. The staff concludes that the NSPM Quality Assurance Program, per the quality assurance requirements in 10 CFR Part 50, Appendix B, provides reasonable assurance that the Administrative Controls are adequate for managing the aging mechanisms and effects identified in the AMR of the concrete pads.

10. Operating Experience

The licensee stated that visual inspections of the concrete pads were performed during the initial license period in accordance with existing PINGP procedures. The licensee further performed a review of ISFSI operating history during the initial license period. More specifically, the licensee provided a summary of the last two inspection reports including ISFSI structures.

During a quarterly inspection report in the third quarter of 2001, the licensee stated that shallow surface spalls were identified around the base plates of three of the monitor stands adjacent to the casks. The licensee further stated that the Corrective Action Program evaluation determined these spalls acceptable, with a recommendation for inspections at a seven-year interval. The inspection also revealed four shrinkage cracks on the floor slab of the Equipment Storage Building (not within the scope of renewal). The licensee found the condition acceptable with a recommendation for periodic inspections every seven years.

The last inspection report from the second quarter of 2008 identified that the licensee initiated a work request to excavate the spalled concrete as identified in the above referenced inspection of 2001. The licensee patched the excavated areas to prevent further degradation in these areas. The licensee stated that significant holes were also found along the foundation of the Alarm Monitoring Building (not within scope of renewal). The licensee corrected these deficiencies by filling these holes and compacting the affected soil.

As a result of the operating experience issues in the 2001 and 2008 inspections, the licensee decreased the inspection frequency interval from seven years to five years. The licensee further stated that there have not been any Licensee Event Reports associated with the Prairie Island ISFSI. Moreover, the licensee stated that no age-related degradation issues or findings for the concrete pads were identified after reviewing the ISFSI Corrective Action Program database.

The licensee conducted a review of precedent ISFSI license renewal applications to evaluate any relevant operating experience, including Calvert Cliffs Nuclear Power Plant, H. B. Robinson

Steam Electric Station, and Surry Power Station. The licensee did not identify any specific operating experience related to concrete structures from the conclusions of this review.

The licensee also performed a lead cask inspections, per NUREG–1927 (NRC, 2011, Appendix E). Inspection of the concrete under the lifted casks did not exhibit visual signs of degradation.

The staff reviewed the licensee's Operating Experience and found no operating experience to indicate that the program would not be effective in managing the aging effects of the concrete pads during the period of extended operation. The staff finds that the operating experience stated and referenced in the LRA provides reasonable assurance that this AMP will be adequate for managing the aging mechanisms and effects identified in the AMR of the concrete pads.

3.5.1.4 **Earthen Berm**

The ISFSI Inspection and Monitoring Program details the activities to manage the aging mechanisms and effects of the earthen berm. The staff reviewed the AMP against the criteria provided in NUREG–1927 (NRC, 2011, Section 3.6.1). The staff's evaluation of each of the program elements is as follows:

1. Scope of Program

The licensee defined the scope of the program to include visual inspection of the conditions and performance of the earthen berm. The licensee referenced applicable aging mechanisms and effects in Table A2.1-1 of the Appendix A to the LRA Revision 1 (NSPM, 2014a, Enclosure 2, Attachment B) that are within the scope of this AMP. The aging effects managed by this program for the earthen berm include:

- change in material properties due to desiccation.
- loss of form due to settlement and frost action.
- loss of material due to erosion.

The staff reviewed the licensee's Scope of Program and determined that the licensee has identified the aging mechanisms and effects of earthen berm to be managed by the program. The staff finds the Scope of Program provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the earthen berm.

2. Preventive Actions

The licensee defined the visual inspection of the earthen berm as a condition monitoring program, which does not require any preventive actions.

The staff finds that the condition monitoring program provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the earthen berm.

3. Parameters Monitored or Inspected

The licensee stated that the parameters to be monitored and inspected during the visual inspection of the earthen berm are consistent with those in industry codes and standards. The aging effects that are monitored for the earthen berm are change in material properties, loss of form, and loss of material.

The licensee stated that this AMP will ensure that parameters inspected focus on conditions identified during industry and plant specific operating experience reviews.

The staff reviewed the licensee's Parameters Monitored or Inspected for the visual inspections of the earthen berm. Pursuant to 10 CFR 72.158, "Control of Special Processes," the licensee shall establish measures to ensure that special processes, including nondestructive testing (such as visual inspections described in this AMP), are controlled and accomplished by qualified personnel using qualified procedures (with identified parameters to be inspected or monitored, as defined in this AMP element) in accordance with applicable codes, standards, specifications, criteria, and other special requirements. Therefore, the staff reviewed the licensee's description of the visual inspections (a nondestructive testing method) with the expectation that the licensee's choice and use of applicable codes and standards will continue to satisfy the requirements of 10 CFR 72.158 and the existing approved Quality Assurance Program.

The staff reviewed the information contained in the LRA, and subsequent RAI responses, including results from ISFSI monitoring activities during the initial license period. The staff further reviewed the licensee's AMP to determine if the licensee was able to demonstrate with reasonable assurance that the earthen berm would continue to perform its intended function through the renewal period. The licensee identified specific parameters monitored or inspected in the AMP in order to demonstrate that the earthen berm will be adequately inspected to prevent a loss of intended function through the renewal period.

The staff determined that the specific parameters monitored or inspected in the AMP are appropriate based upon the technical references pertinent to age related degradation of soil in similar environments. Therefore, with the inclusion of the specific parameters monitored or inspected in the AMP, the staff concludes that signs of deterioration will be adequately detected and appropriately addressed before degradation reaches a level where the earthen berm would be challenged in performing its intended function.

Because the staff relied upon the specific parameters monitored or inspected in the AMP in reaching its reasonable assurance finding, the staff has added a specific license condition to prevent changes to these AMP criteria absent a license amendment. (See License Condition No. 25).

The staff finds that the Parameters Monitored or Inspected provides reasonable assurance for managing the aging mechanisms and effects, and ensuring the intended function of the earthen berm will be maintained during the period of extended operation.

4. Detection of Aging Effects

The detection of aging effects relies on visual inspection of the earthen berm. The licensee stated that the earthen berm will be inspected at least once every five years.

The staff reviewed the licensee's Detection of Aging Effects and determined that inspection methods and frequencies for the earthen berm provide acceptable means to effectively detect the aging mechanisms and effects so that the concrete pads will maintain their intended functions for the period of extended operation. Pursuant to 10 CFR 72.158, "Control of Special

Processes," the licensee shall establish measures to ensure that special processes, including nondestructive testing (such as visual inspections described in this AMP), are controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements. Therefore, the staff reviewed the licensee's description of the visual inspections (a type of nondestructive testing method) with the expectation that the licensee's choice and use of applicable codes and standards will continue to satisfy the requirements of 10 CFR 72.158 and the existing approved Quality Assurance Program.

The staff reviewed the information contained in the LRA, and subsequent RAI responses, including results from ISFSI monitoring activities during the initial license period. The staff further reviewed the licensee's AMP to determine if the licensee was able to demonstrate with reasonable assurance that the earthen berm would continue to perform its intended function throughout the renewal period. The licensee identified specific inspection intervals in the AMP in order to demonstrate that the earthen berm will be adequately inspected to prevent a loss of intended function throughout the renewal period.

The staff determined that the specific inspection intervals in the AMP are appropriate based upon the technical references pertinent to age related degradation of soil in similar environments. Therefore, with the inclusion of the specific inspection intervals in the AMP, the staff concludes that signs of deterioration will be adequately detected and appropriately addressed before degradation reaches a level where the earthen berm would be challenged in performing its intended function.

Because the staff relied upon the specific inspection intervals in the AMP in reaching its reasonable assurance finding, the staff has added a specific license condition to prevent changes to these AMP criteria absent a license amendment. (See License Condition No. 25).

The staff finds that the Detection of Aging Effects provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the earthen berm.

5. Monitoring and Trending

The licensee stated that the AMP requires monitoring the condition of SSCs using current and historical operating experience along with industry operating experience to detect, evaluate, and trend degraded conditions. More specifically, the licensee clarified that when degraded conditions are detected and all associated corrective actions are complete, the SSCs will be monitored once again against performance goals.

The licensee further stated in the supplemented LRA (NSPM, 2014a, Enclosure 2) that the ISFSI Inspection and Monitoring Program, as a subset of the PINGP Structures Monitoring Program, requires that the program coordinator evaluate the results of the inspections for adverse trends including an evaluation of whether the frequency of the inspections should be increased. More specifically, the periodic structures inspection procedure contains requirements to generate an inspection report that includes a section on historical information and trends. The licensee clarified that this section is to contain relevant maintenance information on the structure collected while preparing for the inspection. At a minimum, the section will identify the status of Work Requests and Actions Requests issues during the previous inspection of the structure. The section will also include a discussion of the significance of past and present inspection findings. In particular, the licensee stated that this section addresses whether the findings represent an adverse trend or random deficiency indicative of normal structural aging.

The staff reviewed the licensee's Monitoring and Trending and determined that the licensee's monitoring and trending methods provide an acceptable means to effectively predict the extent of the aging effects and timely corrective actions. The staff finds that the Monitoring and Trending provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the earthen berm.

6. Acceptance Criteria

The licensee stated that the acceptance criteria for all visual inspections of the earthen berm are the absence of any aging effects listed in Table A2.1-1 of the Appendix A to the LRA Revision 1 (NSPM, 2014a, Enclosure 2, Attachment B). More specifically, the licensee stated that the inspector will look for indications of:

- Slope instability (indication of loss of form aging effect): The licensee stated that the inspection procedure calls for the inspector to look for indications of sand boils, seepage, slippage of the embankment toe, and dropping of the embankment crown due to more than surface erosion.

- Settlement (indication of loss of form aging effect): The licensee stated that the inspection procedure relies upon the training and qualification of the inspectors (i.e., civil or structural degree and one or more years of structural inspection experience) to make the determination if settlement has occurred.

- Surface erosion (indication of loss of material and change in material properties aging effects): The licensee stated that the inspection procedure calls for the inspector to look for indications of rutting, raveling, loss of riprap, and other irregularities which over time have the potential to change embankment height and slope.

The licensee further stated in the supplemented LRA (NSPM, 2014a) that a wide range of conditions may be observed during inspections of the berm, which are appropriately addressed in the inspection procedure, consistent with other earthen structures included in the Structures Monitoring Program for the PINGP site.

The staff reviewed the licensee's Acceptance Criteria in the supplemented LRA and Appendix A to the LRA Revision 1 (NSPM, 2014a, Enclosure 2, Attachment B), and determined that the criteria were adequate for determining a loss of intended function in the earthen berm. The staff finds that the Acceptance Criteria provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the earthen berm.

7. Corrective Actions

The licensee stated that its Corrective Action Program requirements are established in accordance with the requirements of 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants" and NSPM Quality Assurance Topical Report. The licensee stated that a single Corrective Action Program is applied regardless of the safety classification of the structure or component.

The licensee further stated that the Corrective Action Program procedures require the initiation of an Action Request for actual or potential problems including failures, malfunctions, discrepancies, deviations, defective material and equipment, nonconformances, and administrative control discrepancies, to ensure that conditions adverse to quality, operability, functionality, and reportability issues are promptly identified, evaluated if necessary, and corrected as appropriate. Guidance on establishing priority and timely resolution of issues is contained within the Corrective Action Program procedure. All corrective actions for deviating conditions that are adverse to quality are performed in accordance with the requirements of the Quality Assurance Program, which complies with the requirements of 10 CFR Part 50, Appendix B. Any resultant maintenance, repair/replacement activities, or special handling requirements are performed in accordance with approved procedures.

The licensee clarified that corrective actions provide reasonable assurance that deficiencies adverse to quality are either promptly corrected or evaluated to be acceptable. For evaluations that do not result in repair or replacement, engineering analysis is used to provide reasonable assurance that the intended function is maintained consistent with the design basis. If the deviating condition is assessed to be significantly adverse to quality, the cause of the condition is determined and an action plan is developed to preclude recurrence. Corrective actions identify recurring discrepancies and initiate additional corrective actions including root cause analysis to preclude recurrence. The licensee stated that degraded conditions identified by the AMP inspections will be entered into the Corrective Action Program. Actions required to resolve inspection findings will be tracked to completion and trended within the Corrective Action Program.

The licensee further clarified in the supplemented LRA (NSPM, 2014a, Enclosure 2) that Corrective Action also contains provisions to:

- Determine if the condition is reportable to the NRC (e.g., results in the loss of intended function).
- Perform equipment evaluations, apparent cause evaluations, and root cause evaluations.
- Perform functionality assessments.
- Address the extent of condition.
- Determine actions to prevent recurrence.
- Identify operating experience actions.
- Trend conditions.

The licensee further clarified that it is through evaluations conducted as part of the Corrective Action Program that the determination would be made if an AMP, Monitoring Program, or inspection procedure would be revised.

The staff reviewed the details provided for the Corrective Action Program as part of the existing PINGP Quality Assurance Program. Per the requirements of 10 CFR 72.172, the staff expects that if an unanalyzed degraded condition is identified by the AMP inspections, the licensee will enter the finding into the Corrective Action Program and resolve the finding. The staff finds that the licensee's correction action program per the quality assurance requirements in 10 CFR Part 50, Appendix B provides reasonable assurance that corrective actions will be adequate for managing the aging mechanisms and effects identified in the AMR of the earthen berm.

8. Confirmation Process

The licensee stated that the confirmation process is part of the NSPM Corrective Action Program to ensure that the corrective actions taken are adequate and appropriate, have been completed, and are effective. The licensee further stated that the focus of the confirmation process is on the follow-up actions that must be taken to verify effective implementation of corrective actions. More specifically, the measure of effectiveness is in terms of correcting the adverse condition and precluding repetition of significant conditions adverse to quality. The licensee clarified that the Corrective Action Program procedures include provisions for timely evaluation of adverse conditions and implementation of any corrective actions required, including root cause evaluations and prevention of recurrence where appropriate. More specifically, these procedures provide for tracking, coordinating, monitoring, reviewing, verifying, validating, and approving corrective actions, to ensure effective corrective actions are taken.

The licensee further stated the Corrective Action Program is monitored for potentially adverse trends. More specifically, the existence of an adverse trend due to recurring or repetitive adverse conditions will result in the initiation of an Action Request. The licensee confirmed that the AMP will also uncover unsatisfactory conditions resulting from ineffective corrective action.

The staff reviewed the details provided for the licensee's Confirmation Process, as part of the existing Quality Assurance Program, to ensure that appropriate corrective actions are completed and are effective. The staff finds that the licensee's Corrective Action Program per the quality assurance requirements in 10 CFR Part 50, Appendix B, provides reasonable assurance that the Confirmation Process is adequate for managing the aging mechanisms and effects identified in the AMR of the earthen berm.

9. Administrative Controls

The licensee stated that the NSPM Quality Assurance Program, associated formal review and approval processes, and administrative controls applicable to the AMP are implemented in accordance with the requirements of the NSPM Quality Assurance Topical Report and 10 CFR Part 50, Appendix B. The licensee further stated that the administrative controls that govern aging management activities at PINGP are established in accordance with the PINGP Administrative Control Program and associated Fleet Procedures.

The staff reviewed the details provided for the licensee's Administrative Controls, as part of the existing Quality Assurance Program, to ensure that the administrative controls will be adequate to provide a formal review and approval process. The staff concludes that the NSPM Quality Assurance Program, per the quality assurance requirements in 10 CFR Part 50, Appendix B, provides reasonable assurance that the Administrative Controls are adequate for managing the aging mechanisms and effects identified in the AMR of the earthen berm.

10. Operating Experience

The licensee stated that visual inspections of the earthen berm were performed during the initial license period in accordance with existing PINGP procedures. The licensee further performed a review of ISFSI operating history during the initial license period. More specifically, the licensee provided a summary of the last two inspection reports including ISFSI structures.

The licensee stated no anomalies have been identified for the earthen berm.

The staff reviewed the licensee's Operating Experience and found no operating experience to indicate that the program would not be effective in managing the aging effects of the earthen berm during the period of extended operation. The staff finds that the operating experience stated and referenced in the LRA provides reasonable assurance that this AMP will be adequate for managing the aging mechanisms and effects identified in the AMR of the earthen berm.

3.5.2 High Burnup Fuel Monitoring Program

The licensee stated that the ISFSI provides for long-term dry fuel interim storage for high burnup spent fuel assemblies (i.e., fuel assemblies with discharge burnups between 45 and 60 GWd/MTU). The licensee's AMR of the high burnup spent fuel assemblies (SFAs) in a dry inert environment did not identify any aging effects/mechanisms that could lead to reconfiguration of the HBU fuel, i.e. an unalyzed condition in the safety analysis report that compromises an intended function. However, the licensee recognized that there had been relatively little operating experience, to date, with dry storage of high burnup fuel. Therefore, the licensee provided an AMP in Section 3.0 of Appendix A to the LRA Revision 1 (NSPM, 2014a, Enclosure 2, Attachment B), entitled "High Burnup Fuel Monitoring Program." The purpose of the High Burnup Fuel Monitoring Program is to confirm the expected performance of the high burnup fuel assemblies during the period of extended operations.

The licensee's AMP was submitted in conformance to ISG-24, which identifies an acceptable confirmation method through a surrogate high burnup fuel surveillance program. The AMP is based on the U.S. Department of Energy (DOE) funded high burnup fuel dry storage cask demonstration program (EPRI, 2014) or other high burnup fuel surveillance demonstrations that meet the criteria of ISG-24. ISG-24 entitled "The Use of a Demonstration Program as a Surveillance Tool for Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years" provides the acceptance criteria for the surveillance demonstration. NRC staff also developed ISG-11 Revision 3 with models that extrapolate the expected performance of low and high burnup fuel during storage. The licensee's AMP relies on a surrogate surveillance program to confirm that the high burnup fuel performance continues as expected and supports the conclusions drawn in ISG-11 Revision 3 before moving into the period of extended operation beyond the initial 20-year period. The staff recognizes that this is a similar approach to that used to provide reasonable assurance for low burnup fuel performance (EPRI, 2002, 2014; Einziger, et al., 2003a & b; Bare, et al., 2001).

1. Scope of Program

The licensee defined the scope of the program to include high burnup spent fuel assemblies with discharge burnups between 45 and 60 GWd/MTU. The licensee stated that the initial fuel assemblies covered under this AMP were placed into dry storage in a TN-40HT cask on April 4, 2013.

The licensee stated that the spent fuel cladding materials are either Zircaloy-4 or Zirlo™ stored in a dry helium environment. The licensee further stated that the aging effects would be determined for material/environment combinations per ISG-24 Revision 0 or the "High Burnup Dry Storage Cask Research and Development Project (HDRP)" (EPRI, 2014).

The licensee stated that the AMP relies upon the joint Department of Energy (DOE) and Electric Power Research Institute (EPRI) HDRP, or in case for some reason the results of the DOE demonstration are delayed, an alternative program meeting the guidance in ISG-24 as a surrogate program to monitor the condition of high burnup spent fuel assemblies in dry storage. The licensee further stated that the HDRP is a program designed to collect data from a spent nuclear fuel storage system containing high burnup fuel in a dry helium environment. More specifically, the program entails loading and storing a TN-32 bolted lid cask (the Research Project Cask) at Dominion Virginia Power's North Anna Power Station with intact high burnup spent nuclear fuel (with nominal burnups ranging between 53 GWd/MTU and 58 GWd/MTU). The fuel assemblies to be used in the HDRP include four different kinds of cladding (Zircaloy-4, low-tin Zircaloy-4, Zirlo™, and M5™). The licensee clarified that the HDRP cask is to be licensed to the temperature limits contained in ISG-11 Revision 3, and loaded such that the fuel cladding temperature is as close to the limit as practicable.

The staff used ISG-24 as review guidance for the Scope of the Program of the "High Burnup Fuel Monitoring Program". ISG-24 states that the technical review staff should ascertain that the following conditions are met if the demonstration is to be used by the applicant to support fuel assembly conditions for storage of HBF beyond 20 years and to be applicable to support a license or certificate application:

- That the maximum burn-up of the fuel in the application is less than the burn-up of the fuel in the demonstration. If the burn-up is higher than that in the demonstration, the applicant should provide evidence, based on characteristics of the fuel, derived either from reactor rod qualification testing or other separate effects tests, that the demonstration fuel is reasonably characteristic of the stored fuel and the added burn-up will not change the results determined by the demonstration. Similarly, if there is a different cladding type used, arguments based on comparison of composition and fabrication technique (e.g., stress-relieved and annealed, recrystallized, etc.) should justify the use of the demonstration results.
- The demonstration program fuel shall include at least two full fuel assemblies. The assemblies may be reconstituted.
- Data from the demonstration program must be indicative of a storage duration long enough to justify extrapolation to the total storage time requested but no less than 10 years if the data is to be used to support license extension from 20 – 40 years. As a minimum, the monitoring data from the demonstration must be available before the end of the current licensing period. If available, data from the examination of the rods should be cited in the applicant's analysis of the condition of the fuel.

The staff reviewed the description of the Scope of the Program, which is defined by the DOE-funded HDRP or alternative program meeting the criteria in ISG-24. The staff reviewed the Prairie Island ISFSI Technical Specification Functional and Operating Limit 2.3, which specifies that the maximum assembly average burnup for a spent fuel assembly stored in a TN-40HT cask is 60 GWd/MTU (NSPM, 2010a). The staff further reviewed the design bases (Table A3.1-1, "Prairie Island Fuel Assembly Design Characteristics", Prairie Island ISFSI SAR, NSPM, 2011b), which identifies Zircaloy-4 and Zirlo™ as cladding materials of the spent fuel. Per

NUREG-1927, the staff reviewed the specific SSCs and subcomponents covered in the “High Burnup Fuel Monitoring Program” and verified that the Scope of Program provides reasonable assurance that the licensee will be informed of any aging mechanisms and effects identified by the surrogate surveillance program.

The staff reviewed the final test plan of the DOE/EPRI HDRP (EPRI, 2014) and verified that the acceptance criteria identified in ISG-24 is met by the DOE/EPRI HDRP surrogate high burnup fuel surveillance program. The staff therefore finds that the Scope of the Program conforms to guidance in ISG-24, and therefore concludes that the surrogate surveillance program will serve as confirmation that fuel performs as expected per ISG-11 Revision 3, and can be readily retrieved.

2. Preventive Actions

The licensee stated that no preventive or mitigating attributes are associated with this AMP, except initial design limits placed during loading operations. More specifically, the licensee referenced technical specifications that ensure fuel is stored in an inert environment thus preventing cladding degradation due to oxidation. Technical Specification 3.1.1, “Cask Cavity Vacuum Drying,” (NSPM, 2010a) demonstrates that the cask cavity is dry by maintaining a cavity absolute pressure less than or equal to 10 mbar for a 30 minute period with the cask isolated from the vacuum pump. In addition, Technical Specification 3.1.2, “Cask Helium Backfill Pressure,” (NSPM, 2010a) requires that the cask is backfilled with helium and that the inert environment be established within 34 hours of commencing cask draining. The licensee clarified that this time requirement ensures that the peak cladding temperature remains below 400°C [752°F] (i.e., the temperature specified in ISG-11 Revision 3), thus mitigating degradation due to cladding creep.

The staff confirmed the loading requirements under Technical Specifications 3.1.1 and 3.1.2, and verified these meet the acceptance criteria in ISG-11, Revision 3. Per ISG-11 Revision 3, the staff expects acceptable fuel performance during the initial 20-year period of storage if the peak cladding temperature is below the limit in ISG-11, Revision 3 for normal conditions of storage and short-term loading operations [400 °C (752 °F)], limited thermal cycling has been used during loading operations, and the fuel is stored in a dry inert atmosphere.

The staff used ISG-24 as review guidance for the “High Burnup Fuel Monitoring Program”. ISG-24 states that a demonstration program provides an acceptable method for an applicant to demonstrate compliance with the cited regulations for storage of light water reactor fuels (LWR) for periods of greater than 20 years by:

- Confirming the expected fuel conditions, based on technical arguments made in ISG-11 (NRC 2003), after a substantial storage period that is sufficiently long (~ 10 years) to extrapolate the findings; and
- Confirming the cladding creep predictions that are the basis for the guidance recommendation for the maximum temperature in ISG-11 (NRC 2003) are not exceeded and that sufficient creep margin exists for the extended storage period.

The staff reviewed the licensee’s Preventive Actions and finds these meet the loading and drying requirements specified in ISG-11, Revision 3. The staff further finds that the Preventive Actions conform to guidance in ISG-24, and therefore concludes that the surrogate surveillance program will serve as confirmation that fuel performs as expected per ISG-11, Revision 3, and can be readily retrieved.

3. Parameters Monitored or Inspected

The licensee specifies that either the surveillance demonstration program as described in the HDRP or an alternative program will meet the guidance set forth in ISG-24.

The staff used ISG-24 as review guidance for the Parameters Monitored or Inspected of the "High Burnup Fuel Monitoring Program". ISG-24 states that the technical review staff should ascertain that the following conditions are met if the demonstration is to be used by the applicant to support fuel assembly conditions for storage of HBF beyond 20 years and to be applicable to support a license or certificate application:

- If the applicant uses direct observations of the rod behavior to imply the condition of the rods in its system, either a) the temperatures in the demonstration must bound the temperatures in the application, or b) if the applicant uses predictive tools that have been confirmed by the demonstration, then the temperatures of the rods in the application do not have to be bound by the temperature of the rods in the demonstration. The temperature models used in the application should either be benchmarked a) against the demonstration temperature data, or b) against actual measured rod temperature data in the same temperature range.
- If the applicant is using gas analysis or another gas detection method to establish the condition of the fuel, the interior of a demonstration canister or cask should be quantitatively monitored for, at a minimum, moisture, oxygen, and fission gas. The duration and frequency of the gas monitoring should be determined by analysis of the potential degradation. Gases should always be quantitatively monitored prior to opening of the canister. If the applicant claims that no galvanic degradation is feasible, then, if after drying, moisture is detected in the canister, moisture and hydrogen concentration should be monitored at a reasonable frequency to be determined by the applicant until the moisture disappears. Gas monitoring is not expected during movement of the canister. If the applicant is using the gas analysis to show no breaches would occur during transport, gas quantitative monitoring must be conducted before and after transport.
- Cask internal temperature monitoring should be conducted at a frequency that is suitable for determining the temperature profile over the duration of the demonstration.
- As practicable, some population of stored rods should be examined whenever the system is opened. These rods should be extracted from the fuel assembly to determine properties of the rods that affect degradation such as cladding creep, fission gas release, hydride reorientation, cladding oxidation, and cladding mechanical properties.

The staff reviewed the final test plan of the DOE/EPRI HDRP (EPRI, 2014) and verified that the Parameters Monitored and Inspected for the surrogate high burnup fuel surveillance program meet the acceptance criteria identified in ISG-24. Per ISG-24, these parameters should include temperature, gas composition, cask or canister condition, and physical properties of the stored high burnup fuel.

The DOE/EPRI HDRP final test plan (EPRI, 2014) states that, prior to loading the HDRP cask with high burnup assemblies, up to 25 fuel rods will be removed, prepared for shipment using normal, approved vacuum-drying procedures, and shipped to a national laboratory for detailed non-destructive and destructive examination. These ‘sister rods’ have very similar characteristics to those that will be stored in the HDRP cask and will be taken from either assemblies having similar operating histories (symmetric partners) to those that are selected for storage in the HDRP cask or actual fuel assemblies to be included in the HDRP cask. The detailed examination at the national laboratory will provide essential information on the physical state of the high burnup rods and the fuel contained in the rods prior to the loading, drying, and long-term dry storage process. Similar tests are to be performed at the end of the long-term storage period to identify any changes in the properties of the fuel rods during the dry storage period. Monitoring of the vent gases during the drying process will be performed to determine if any fuel rods fail during the loading process. For the first two weeks after the completion of the drying process, periodic gas samples will be taken to determine the amount of fission gas, water vapor, oxygen, and hydrogen gas, if present. The test plan states that the EPRI team will continue to investigate and evaluate methods for performing gas sampling during the storage period. If sampling methods can be licensed, funded, and deployed without creating undue risk to the project, it will be implemented.

The final test plan further states that presence of one or more of the above-listed gases would indicate defects of one or more SNF rods during the drying process, incomplete removal of water during the drying process, presence of oxygen, or radiolysis or other hydrogen generation activity due to any remaining water. Temperature data will be recorded no less frequently than hourly during the first two weeks to provide data during the thermal transient from spent fuel pool temperature to the peak assembly temperatures that will occur during the vacuum drying process, and then to the steady-state temperatures with the helium backfill gas for the initial storage period. Approximately two weeks after completion of the drying process, the cask will be moved to the ISFSI pad for long-term storage, during which periodic temperature measurements will be taken throughout the long-term storage process. If water vapor or Kr-85 gas is detected during drying, or the first two weeks after drying, it is anticipated that the license will allow the cask to be moved to the pad and the test would continue. This is because the presence of water vapor and Kr-85 in some of the dry storage systems could be typical if water or Kr-85 gas is found in the HDRP cask. At the end of the long-term storage process, which may be up to 10 years or longer, the cask will be returned from the ISFSI pad to the cask preparation area at North Anna and prepared for transportation to an off-site Fuel Examination Facility. At the Fuel Examination Facility, the cask will be reopened and the fuel visually examined for changes that occurred during drying and storage. Rods will be extracted from the high burnup assemblies and the same detailed non-destructive and destructive examinations will be performed as those performed on the sister rods extracted prior to loading into the Research Project Cask at the beginning of the test.

DOE/EPRI have planned to make the confirmation data from the demonstration program available via a website accessible to the public.

The staff reviewed the licensee’s Parameters Monitored or Inspected and concludes it is consistent with the guidance in ISG-24. Therefore, the staff finds it provides reasonable assurance that the licensee will be informed of any aging mechanisms and effects by the DOE-funded HDRP or alternative program meeting the criteria in ISG-24. The staff further finds that such surrogate surveillance program will serve as confirmation that fuel performs as expected per ISG-11 Revision 3, and can be readily retrieved.

4. Detection of Aging Effects

The licensee specifies that either the surveillance demonstration program as described in the HDRP or an alternative program will meet the guidance set forth in ISG-24.

The staff used ISG-24 as review guidance for the Detection of Aging Effects of the "High Burnup Fuel Monitoring Program". ISG-24 states that the technical review staff should ascertain that the following conditions are met if the demonstration is to be used by the applicant to support fuel assembly conditions for storage of HBF beyond 20 years and to be applicable to support a license or certificate application:

- If the applicant uses direct observations of the rod behavior to imply the condition of the rods in its system, either a) the temperatures in the demonstration must bound the temperatures in the application, or b) if the applicant uses predictive tools that have been confirmed by the demonstration, then the temperatures of the rods in the application do not have to be bound by the temperature of the rods in the demonstration. The temperature models used in the application should either be benchmarked a) against the demonstration temperature data, or b) against actual measured rod temperature data in the same temperature range.
- If the applicant is using gas analysis or another gas detection method to establish the condition of the fuel, the interior of a demonstration canister or cask should be quantitatively monitored for, at a minimum, moisture, oxygen, and fission gas. The duration and frequency of the gas monitoring should be determined by analysis of the potential degradation. Gases should always be quantitatively monitored prior to opening of the canister. If the applicant claims that no galvanic degradation is feasible, then, if after drying, moisture is detected in the canister, moisture and hydrogen concentration should be monitored at a reasonable frequency to be determined by the applicant until the moisture disappears. Gas monitoring is not expected during movement of the canister. If the applicant is using the gas analysis to show no breaches would occur during transport, gas quantitative monitoring must be conducted before and after transport.
- Cask internal temperature monitoring should be conducted at a frequency that is suitable for determining the temperature profile over the duration of the demonstration.
- As practicable, some population of stored rods should be examined whenever the system is opened. These rods should be extracted from the fuel assembly to determine properties of the rods that affect degradation such as cladding creep, fission gas release, hydride reorientation, cladding oxidation, and cladding mechanical properties.

The staff reviewed the final test plan of the DOE/EPRI HDRP (EPRI, 2014) and verified that the Detection of Aging Effects for the surrogate high burnup fuel surveillance program meet the acceptance criteria identified in ISG-24. Per NUREG-1927 (NRC, 2011), the Detection of Aging Effects should describe methods used for monitoring and inspection, frequency and timing of activities, sample sizes and data collection methods. The DOE/EPRI HDRP final test plan (EPRI, 2014) describes these attributes, as they pertain to activities for inspection and monitoring for temperature, gas composition, cask or canister condition, and physical properties of the stored high burnup fuel.

The DOE/EPRI HDRP (EPRI, 2014) final test plan states that, prior to loading the HDRP cask with high burnup assemblies, up to 25 fuel rods will be removed, prepared for shipment using normal, approved vacuum-drying procedures, and shipped to a national laboratory for detailed non-destructive and destructive examination. These ‘sister rods’ have very similar characteristics to those that will be stored in the HDRP cask and will be taken from either assemblies having similar operating histories (symmetric partners) to those that are selected for storage in the HDRP cask or actual fuel assemblies to be included in the HDRP cask. The detailed examination at the national laboratory will provide essential information on the physical state of the high burnup rods and the fuel contained in the rods prior to the loading, drying, and long-term dry storage process. Similar tests are to be performed at the end of the long-term storage period to identify any changes in the properties of the fuel rods during the dry storage period. Monitoring of the vent gases during the drying process will be performed to determine if any fuel rods fail during the loading process. For the first two weeks after the completion of the drying process, periodic gas samples will be taken to determine the amount of fission gas, water vapor, oxygen, and hydrogen gas, if present. The test plan states that the EPRI team will continue to investigate and evaluate methods for performing gas sampling during the storage period. If sampling methods can be licensed, funded, and deployed without creating undue risk to the project, it will be implemented.

The final test plan further states that presence of one or more of the above-listed gases would indicate defects of one or more SNF rods during the drying process, incomplete removal of water during the drying process, presence of oxygen, or radiolysis or other hydrogen generation activity due to any remaining water. Temperature data will be recorded no less frequently than hourly during the first two weeks to provide data during the thermal transient from spent fuel pool temperature to the peak assembly temperatures that will occur during the vacuum drying process, and then to the steady-state temperatures with the helium backfill gas for the initial storage period. Approximately two weeks after completion of the drying process, the cask will be moved to the ISFSI pad for long-term storage, during which periodic temperature measurements will be taken throughout the long-term storage process. If water vapor or Kr-85 gas is detected during drying, or the first two weeks after drying, it is anticipated that the license will allow the cask to be moved to the pad and the test would continue. This is because the presence of water vapor and Kr-85 in some of the dry storage systems could be typical if water or Kr-85 gas is found in the HDRP cask. At the end of the long-term storage process, which may be up to 10 years or longer, the cask will be returned from the ISFSI pad to the cask preparation area at North Anna and prepared for transportation to an off-site Fuel Examination Facility. At the Fuel Examination Facility, the cask will be reopened and the fuel visually examined for changes that occurred during drying and storage. Rods will be extracted from the high burnup assemblies and the same detailed non-destructive and destructive examinations will be performed as those performed on the sister rods extracted prior to loading into the Research Project Cask at the beginning of the test.

DOE/EPRI have planned to make the confirmation data from the demonstration program available via a website accessible to the public.

The staff reviewed the licensee’s Detection of Aging Effects and because it is consistent with the guidance in ISG-24 and NUREG-1927, the staff finds it provides reasonable assurance that the licensee will be informed of any aging mechanisms and effects by the DOE-funded HDRP or alternative program meeting the criteria in ISG-24. The staff further finds that such surrogate surveillance program will serve as confirmation that fuel performs as expected per ISG-11 Revision 3, and can be readily retrieved.

5. Monitoring and Trending

The licensee stated that, as information/data from the surrogate surveillance program becomes available, it will monitor, evaluate, and trend the information via its Operating Experience Program and/or the Corrective Action Program to determine what actions should be taken to manage fuel and cladding performance, if any.

The licensee stated it will use its Operating Experience Program and/or Corrective Action Program to determine what actions should be taken if it receives information/ data from other sources than the demonstration program on fuel performance.

The licensee further stated it will perform formal evaluations of the aggregate feedback from the HDRP and other sources of information at the specific points in time during the period of extended operation. These evaluations will each include an assessment of the continued performance of the high burnup fuel assemblies per the analyzed conditions in the safety analysis report. The licensee stated that these separate evaluations will occur by April 4, 2028, 2038 and 2048, respectively.

ISG-11, Revision 3 was developed to set storage conditions so that no gross ruptures would occur. Based on a significant amount of short term testing, including some on high burnup fuel it was determined that the relevant cladding degradation mechanism was cladding creep. Oxidation mechanisms were eliminated because the internal atmosphere was specified as dry and inert. The design of the fuel rod makes cladding creep a self–limiting mechanism. The limiting value depends on the maximum temperature of the fuel rod. To maintain the maximum creep below 1%, although higher amounts of creep can be tolerated without rod breach, a maximum temperature was recommended. If the maximum temperature is below that recommended in ISG-11 Rev 3 and the fuel is stored in a dry inert atmosphere, both of which are met in this application, the staff has reasonable assurance that no adverse fuel performance will occur. The staff finds that the schedule for the Monitoring and Trending provided in the AMP, which takes into account operating experience from the DOE/EPRI HDRP and fuels data obtained from other relevant sources, will reinforce this reasonable assurance as the high burnup fuel is stored for the additional 40 years.

The staff used ISG-24 as review guidance for the Detection of Aging Effects of the "High Burnup Fuel Monitoring Program". ISG-24 states that the technical review staff should ascertain that the following condition is met if the demonstration is to be used by the applicant to support fuel assembly conditions for storage of HBF beyond 20 years and to be applicable to support a license or certificate application:

- A learning AMP should be periodically re-evaluated given the current state of knowledge regarding the ability of HBF to meet the regulatory requirements while in dry cask storage. Licensing conditions should require updated AMPs to be submitted to the NRC whenever new data from the demonstration or other short-term tests or modeling results indicates potential degradation of the fuel or deviation from the fuel's expected behavior. Updates to AMPs will be subject to inspection.

The staff reviewed the licensee's Monitoring and Trending and because it is consistent with the guidance in ISG-24, the staff finds it provides reasonable assurance that the licensee will be informed of any aging mechanisms and effects by the DOE-funded HDRP or alternative program meeting the criteria in ISG-24. The staff further finds that the surrogate surveillance program will serve as confirmation that fuel performs as expected per ISG-11 Revision 3, and can be readily retrieved.

6. Acceptance Criteria

The licensee stated that the Acceptance Criteria are defined by the HDRP or alternative surveillance surrogate program meeting the criteria in ISG-24.

The licensee further clarified that if any of the following fuel performance criteria are exceeded in the HDRP or alternative program, a corrective action will be required:

- Cladding Creep—total creep strain extrapolated to the total approved storage duration based on the best fit to the data, accounting for initial condition uncertainty shall be less than 1 percent. The staff notes that, per the technical bases indentified in ISG-11, Revision 3, cladding failure could potentially occur at >2% creep strain so 1% is considered conservative

- Hydrogen—maximum hydrogen content of the cover gas over the approved storage period shall be extrapolated from the gas measurements to be less than 5 percent. The staff notes that this acceptance criteria ensures that flammability limits in the design bases are not exceeded.

- Drying—the moisture content in the cask, accounting for measurement uncertainty, shall indicate no greater than one liter of residual water after the drying process is complete. The staff notes that this requirement is necessary in order for creep to be the only relevant degradation mechanism, as identified in ISG-11, Revision 3.

- Fuel rod breach—fission gas analysis shall not indicate more than 1 percent of the fuel rod cladding breaches. The staff notes that this represents the maximum number of assumed failures during normal operation for the design-bases confinement evaluation.

The staff notes that the acceptance criteria defined by the licensee provides confirmation about the fuel conditions used for the development of ISG-11, Revision 3. It further provides confirmation that the design bases of the fuel is being maintained throughout the period of extended operation. The staff also notes that ISG-24 does not provide specific acceptance criteria for the performance of the fuel in the surrogate demonstration program. ISG-24 provides guidance to the staff on ascertaining if the demonstration is valid for supporting fuel assembly conditions for storage of HBF beyond 20 years and determining if it may be used to support a license or certificate application.

The staff reviewed the licensee's Acceptance Criteria and finds it provides reasonable assurance that the licensee will take corrective action if results of the DOE/EPRI HDRP or alternative program meeting the criteria in ISG-24 were to demonstrate that conditions in ISG-11, Revision 3 are not maintained. The staff further finds that the proposed corrective actions are adequate for ensuring that the design bases of the fuel is maintained throughout the period of extended operation. The staff therefore concludes that such surrogate surveillance program will serve as confirmation that fuel performs as expected per ISG-11 Revision 3, and can be readily retrieved.

7. Corrective Actions

The licensee stated that its Corrective Actions Program requirements are established in accordance with the requirements of 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants" and NSPM Quality Assurance Topical Report. The licensee further stated that a single Corrective Action Program is applied regardless of the safety classification of the structure or component.

The licensee clarified that, at each of the assessments detailed in AMP Section 5, the impact of the aggregate feedback will be assessed and actions taken when warranted. The licensee further clarified that these evaluations will address lessons learned and take appropriate corrective actions, including:

- Perform repairs or replacements.
- Modify this confirmatory program in a timely manner.
- Adjust age-related degradation monitoring and inspection programs (e.g., scope, frequency).
- Actions to prevent reoccurrence.
- An evaluation of the dry cask storage system (DCSS) to perform it's safety and retrievability functions.
- Evaluation of the effect of the corrective actions on this component to other safety components.

The staff reviewed the details provided for the Corrective Action Program as part of the existing PINGP Quality Assurance Program. Per the requirements of 10 CFR 72.172, "Corrective Action," and consistent with the commitments in the tollgates table of the revised LRA, the staff expects that if any of the evaluations in this AMP (as defined in AMP element 5, "Monitoring and Trending") identifies a condition not analyzed in the approved design bases, the licensee will submit a License Amendment Request to the NRC with its proposed actions to address the issues indicated by the evaluation and to continue safe storage of high burnup fuel. The staff has issued License Condition No. 26 to ensure that the licensee complies with this expectation and the licensee's commitments in the tollgates table of the revised LRA. The staff finds that the licensee's correction action program per the quality assurance requirements in 10 CFR Part 50, Appendix B provides reasonable assurance that corrective actions will be adequate for managing any aging mechanisms and effects identified by the DOE-funded HDRP or alternative program meeting the criteria in ISG-24.

8. Confirmation Process

The licensee stated that the confirmation process is part of the NSPM Corrective Action Program to ensure that the corrective actions taken are adequate and appropriate, have been completed, and are effective. The licensee further stated that the focus of the confirmation process is on the follow-up actions that must be taken to verify effective implementation of corrective actions. More specifically, the measure of effectiveness is in terms of correcting the adverse condition and precluding repetition of significant conditions adverse to quality. The licensee clarified that the Corrective Action Program procedures include provisions for timely evaluation of adverse conditions and implementation of any corrective actions required, including root cause evaluations and prevention of recurrence where appropriate. More specifically, these procedures provide for tracking, coordinating, monitoring, reviewing, verifying, validating, and approving corrective actions, to ensure effective corrective actions are taken.

The staff reviewed the details provided for the licensee's confirmation process, as part of the existing Quality Assurance Program, to ensure that appropriate corrective actions are completed and are effective. The staff finds that the licensee's Correction Action Program per the quality assurance requirements in 10 CFR Part 50, Appendix B provides reasonable assurance that the confirmation process is adequate for managing any aging mechanisms and effects identified by the DOE-funded HDRP or alternative program meeting the criteria in ISG- 24.

9. Administrative Controls

The licensee stated that the NSPM Quality Assurance Program, associated formal review and approval processes, and administrative controls applicable to the AMP are implemented in accordance with the requirements of the NSPM Quality Assurance Topical Report and 10 CFR Part 50, Appendix B. The licensee further stated that the administrative controls that govern aging management activities at PINGP are established in accordance with the PINGP Administrative Control Program and associated Fleet Procedures.

The staff reviewed the details provided for the licensee's administrative controls, as part of the existing Quality Assurance Program, to ensure that the administrative controls will be adequate to provide a formal review and approval process. The staff concludes that the NSPM Quality Assurance Program, per the quality assurance requirements in 10 CFR Part 50, Appendix B, provides reasonable assurance that the administrative controls are adequate for managing any aging mechanisms and effects identified by the DOE-funded HDRP or alternative program meeting the criteria in ISG-24.

10. Operating Experience

The licensee stated that it intends to rely on the information from the HDRP with similar types of high burnup fuel. The licensee further stated that it will evaluate and take any additional data/research to assess fuel performance from both domestic and international sources that are relevant to the fuel in the NSPM casks.

The staff reviewed the licensee's "operating experience" program element and finds no operating experience to indicate that the surrogate surveillance program will not be effective in managing any aging mechanisms and effects identified by the DOE-funded HDRP or alternative program meeting the criteria in ISG-24.

3.5.3 Evaluation Findings

The staff reviewed the AMPs presented in the application against the regulatory requirements of 10 CFR 72.42, "Duration of License; Renewal." The staff verified that the AMPs are adequately identified and appropriate for managing the aging effects identified for the SSCs. The staff also verified that the methods and technical bases of these AMPs are acceptable.

The staff reviewed the information contained in the revised LRA, and subsequent RAI responses, including results from the lead system inspection and other past ISFSI monitoring activities. However, results from inspection activities to assess age-related degradation of dry storage systems are presently limited, thus the revised LRA contained only limited operating experience. The staff, therefore, reviewed the licensee's AMPs to determine if the licensee was able to demonstrate with reasonable assurance that the SSCs and subcomponents of SSCs would maintain their intended functions through the renewal period. The licensee identified specific SSC and SSC subcomponents, and specific aging mechanisms and effects to be managed by the AMPs in order to demonstrate that the SSC and SSC subcomponents would perform their intended function through the renewal period.

The staff determined that the SSC and SSC subcomponents are appropriately identified, and the identified aging effects/mechanisms are consistent with the technical references pertinent to age related degradation of materials, including reactor renewal guidance provided in NUREG-1801 (NRC, 2010b). Therefore, with the inclusion of the specific SSC and SSC subcomponents and aging effects/mechanisms in the AMPs, the staff concludes that signs of deterioration will be adequately detected and addressed before degradation reaches a level where the SSC or SSC subcomponent would be challenged in performing its intended function.

Because the staff is relying upon these specific SSC and SSC components and aging effects/mechanisms being within the scope of the AMPs in reaching its reasonable assurance finding, the staff has added a specific license condition to prevent removal of an SSC or SSC subcomponent or an aging effect/mechanism from the scope of the AMP absent a license amendment. (See License Condition No. 21).

Based on its review of the information and representation, the staff finds:

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

4 CONCLUSION

Pursuant to Title 10 of the *Code of Federal Regulations (*10 CFR) 72.42(a), the Commission may issue a renewed license if it finds that actions have been identified and have been or will be taken, such that there is reasonable assurance that the activities authorized by the renewed license will continue to be conducted in accordance with the design basis.

The staff of the U.S. Nuclear Regulatory Commission (NRC) (the staff) reviewed the license renewal application (LRA) for the independent spent fuel storage installation at the Prairie Island Nuclear Generating Plant, in accordance with NRC regulations 10 CFR 72.42(a). The staff followed the guidance provided in NUREG–1927, "Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance," interim staff guidance (ISG) as identified in Table 1-1. Based on its review of the LRA and the license conditions, the staff determines that the plant has met the requirements of 10 CFR 72.42(a).

APPENDIX A

AGING MANAGEMENT PROGRAM

TABLE of CONTENTS

LIST OF TABLES:

LIST OF FIGURES:

APPENDIX A: AGING MANAGEMENT PROGRAM

A1.0 Introduction

This appendix is a summary of the activities that manage the effects of aging for the Independent Spent fuel Storage Installation (ISFSI) components that have been identified as being subject to Aging Management Review (AMR). The Aging Management Program (AMP) credited for the management of those aging effects and mechanisms identified for the Prairie Island ISFSI is the ISFSI Inspection and Monitoring Activities Program. This program is a subset of the Prairie Island Nuclear Generating Plant (PINGP) Structures Monitoring Program.

The ISFSI Inspection and Monitoring Activities Program is discussed in Section A2.0. That section provides a description of the ISFSI Inspection and Monitoring Activities Program which includes an introduction, an evaluation in terms of the attributes or elements of an effective Aging Management Program, and a summary. The ten elements, which are part of the ISFSI Inspection and Monitoring Activities Program, are also described. The results of an evaluation of each PINGP program element as compared to each NUREG-1927, “Standard Review Plan for Renewal of Independent Spent Fuel Storage Installation Licenses and Dry Cask Storage System Certificates of Compliance” (Subsection 3.6, Aging Management Program) program element are provided to evidence consistency.

Section 3.0, Aging Management Reviews, provides tables that summarize the results of the AMRs. These tables identify the Aging Management Activity (AMA) credited for managing each aging effect and mechanism for each component or subcomponent listed in the AMR. The AMA manages the aging effects and mechanisms, or the relevant conditions that could lead to those aging effects and mechanisms, applicable to each structure or component and provides reasonable assurance that the integrity of the structure or component will be maintained under current licensing basis conditions during the period of extended operation.

The Aging Management Review of the high burnup fuel spent fuel assemblies in a dry inert environment did not identify any aging effects/mechanisms that could lead to a loss of intended function. However, it is recognized that there has been relatively little operating experience, to date, with dry storage of high burnup fuel. Reference A5.8 provides a listing of a significant amount of scientific analysis examining the long term performance of high burnup spent fuel. These analyses provide a sound foundation for the technical basis that long term storage of high burnup fuel, i.e., greater than 20 years, may be performed safely and in compliance with regulations. However, it is also recognized that scientific analysis is not a complete substitute for confirmatory operating experience. Therefore, Section A3, High Burnup Fuel Monitoring Program, describes a program to confirm that the high burnup fuel assemblies’ intended function(s) are maintained during the period of extended operations. Although the program is a confirmatory program, the description below uses each attribute of an effective AMP as described in NUREG-1927 to the extent possible.

A2.0 ISFSI Inspection and Monitoring Program

The Prairie Island ISFSI provides for long-term dry fuel interim storage for spent fuel assemblies until such time that the spent fuel assemblies may be shipped off-site for final disposition. The casks presently utilized at the Prairie Island ISFSI are the Transnuclear TN-40 and TN-40HT (both of which have a 40 fuel assembly capacity) and are designed for outdoor storage. Accordingly, the exterior materials are capable of withstanding the anticipated effects of "weathering" under normal conditions.

The purpose of the ISFSI Inspection and Monitoring Activities Program is to ensure that the structure's or component's intended function(s) is not degraded for the in-service casks, concrete pads or earthen berm.

A description of the ISFSI Aging Management Program is provided below using each attribute of an effective AMP as described in NUREG-1927 for the renewal of a site-specific Part 72 license.

A2.1 Scope of Program

A2.1.1 NUREG-1927 Program Element

NUREG-1927 Program Element 1, Scope of the Program, (Reference A5.1) states "The scope of the program should include the specific structures and components subject to an AMR."

A2.1.2 PINGP Program Element

The ISFSI Inspection and Monitoring Activities Program requires periodic inspection activities that monitor the condition of structures and components within the scope of License Renewal as the method used to manage aging effects.

The aging effects managed by this program are included in Table A2.1-1. The aging effects/mechanisms applicable to each structure and component are dependent upon their associated material/environment combinations, design, and installation. Those structures and components that have been grouped together for aging management review (e.g., Carbon Steel in Atmosphere/Weather) have been evaluated and based upon the materials of construction, design, installation, and environments, will have the same aging effects.

The scope of the ISFSI Inspection and Monitoring Activities Program includes:

1) Visual inspection of the exterior of the in-service casks,
2) Monitoring of the interseal pressure of the in-service casks,
3) Radiation monitoring and associated surveillance activities of the in-service casks,
4) Visual inspection of the concrete pads,
5) Visual inspection of the earthen berm,

6) Visual inspection of an in-service cask bottom prior to the end of the current ISFSI license period,
7) Visual inspection under an in-service cask protective cover (surfaces normally not visible or accessible with the cover in-place) prior to the end of the current ISFSI license period,
8) Visual inspection of the cask bottom in the event an in-service cask is lifted in preparation for movement (inspections of opportunity),
9) Visual inspection under the protective cover (surfaces normally not visible or accessible with the cover in-place) of an in-service cask in the event the cover is removed for maintenance (inspections of opportunity),
10) Visual inspection of the bottom and under the protective cover of the lead cask at least every 20-years, and
11) Monitoring of ground water chemistry.

A2.1.3 Comparison to NUREG-1927 Program Element

This PINGP program element is consistent with NUREG-1927, Element 1, Scope of the Program.

A2.2 Preventive Actions

A2.2.1 NUREG-1927 Program Element

NUREG-1927 Program Element 2, Preventive Actions, (Reference A5.1) states "Preventive actions should mitigate or prevent the applicable aging effects."

A2.2.2 PINGP Program Element

The ISFSI Inspection and Monitoring Activities Program consists of visual inspections, condition monitoring, and performance monitoring activities to detect degradation of structures and components before the loss of their intended function(s). No preventive or mitigating attributes are associated with these activities.

Aging effects of concrete due to aggressive chemicals were determined not to be applicable to the ISFSI concrete pads due to the lack of exposure to an aggressive chemical environment. To ensure this potential aging mechanism does not become applicable, monitoring of the ground water chemistry will be relied upon as a mitigation program to prevent aging effects from occurring.

A2.2.3 Comparison to NUREG-1927 Program Element

This PINGP program element is consistent with NUREG-1927, Element 2, Preventive Actions.

A2.3 Parameters Monitored or Inspected

A2.3.1 NUREG-1927 Program Element

NUREG-1927 Program Element 3, Parameters Monitored or Inspected, (Reference A5.1) states "Parameters monitored or inspected should be linked to the effects of aging on the intended functions of the particular structure and component."

A2.3.2 PINGP Program Element

The parameters monitored by the ISFSI Inspection and Monitoring Activities Program are consistent with those identified in industry codes and standards including Electric Power Research Institute (EPRI) Report 1002950, "Aging Effects for Structures and Structural Components (Structural Tools)," EPRI Report 1010639, "Non-Class 1 Mechanical Implementation Guideline and Mechanical Tools," EPRI Technical Report 1007933 "Aging Assessment Field Guide," and American Concrete Institute (ACI) report 349.3R, "Evaluation of Existing Nuclear Safety-Related Concrete Structures". The parameters included in the program ensure degraded conditions are identified and corrected by clearly defining degraded condition criteria and associated corrective action requirements to prevent the loss of intended function. Industry and plant specific operating experience (OE) are also reviewed to ensure that parameters inspected focus on conditions identified during these OE reviews. See Table A2.1-1 for a detailed list of aging effects and mechanisms for structures and components inspected or monitored as required by the ISFSI Inspection and Monitoring Activities Program.

The ISFSI Inspection and Monitoring Activities Program also contains provisions to inspect the concrete pads whenever inaccessible (buried) areas are excavated, exposed, or modified.

In-service casks inspections

The condition of the exterior of each in-service cask is inspected visually to ensure the intended functions of the cask exterior are not compromised. Visual inspections will look for signs of damage or deterioration of the cask exterior surfaces. Additionally, the inspections will identify debris accumulating on the cask exterior surfaces. Debris may create the potential for localized conditions to support the corrosion process. The aging effect that is monitored by these inspections is loss of material. The intended functions that are monitored for these subcomponents include:

- Provides heat transfer (HT)
- Maintains a pressure boundary (PB)
- Provides radiation shielding (SH)
- Provides structural/functional support (SS)

Interseal pressure monitoring

The pressure of the helium cover gas is monitored to verify the integrity of the seals of the in-service cask lid and that the intended function is not compromised. The aging effect that is monitored by these inspections is loss of material. The intended function that is monitored for this subcomponent is:

- Maintains a pressure boundary (PB)

<u>Radiation surveys</u>
Radiation surveys (gamma and neutron) as well as continuous monitoring via thermoluminescent dosimeters (TLD) at the ISFSI site boundary are used to verify that the radiation levels remain within the specified limits and that the shielding materials in the in-service casks are intact and are effectively performing their intended function. Degradation in the effectiveness of the shielding material would be detected by a corresponding increase in radiation levels. The aging effects that are monitored by this monitoring are the loss of the gamma shielding material and cracking of the neutron shielding material. The intended function that is monitored for this subcomponent is:

- Provides radiation shielding (SH)

<u>Concrete pad inspections</u>
A visual inspection of the accessible areas of the concrete pads is performed to determine that no deterioration has occurred and that the intended function is not compromised. The aging effects that are monitored by these inspections are change in material properties, cracking and loss of material. The intended function that is monitored for this subcomponent is:

- Provides structural/functional support (SS)

<u>Earthen berm inspections</u>
The earthen berm surrounding the ISFSI is visually inspected to determine that no deterioration has occurred and that the intended function is not compromised. The aging effects that are monitored by these inspections are change in material properties, loss of form and loss of material. The intended function that is monitored for this subcomponent is:

- Provides radiation shielding (SH)

<u>Lead cask inspections</u>
Additionally, a visual inspection of an in-service cask bottom (“lead cask”) was performed in June 2011, prior to the end of the current ISFSI license period. This visual inspection was performed to primarily ensure that there was no unanticipated degradation and the intended functions were not compromised. This inspection looked for signs of deterioration in the normally inaccessible area underneath the cask to determine the general condition of the cask bottom. This inspection was considered representative of the total population of the in-service casks based on the service period involved, material, and environment. The aging effect that was monitored by these inspections was loss of material.

A visual inspection under two in-service casks protective covers was also performed in June 2011, prior to the end of the current ISFSI license period. This visual inspection was primarily performed to ensure that there was no unanticipated degradation and the intended functions were not compromised. This inspection looked for signs of deterioration in the normally inaccessible area underneath the protective covers. This inspection was considered representative of the total population of the in-service casks based on the service period involved, materials, and environment. The aging effect that is monitored by these inspections was loss of material.

Ground Water Chemistry
Monitoring of ground water chemistry for Chloride, Sulfate, and pH is used to verify that the concrete pads are not being exposed to an aggressive chemical environment, thus preventing aging effects due to aggressive chemicals from occurring. The intended function monitored by this activity is:

- Provides structural/functional support (SS)

A2.3.3 Comparison to NUREG-1927 Program Element

This PINGP program element is consistent with NUREG-1927, Element 3, Parameters Monitored or Inspected.

A2.4 Detection of Aging Effects

A2.4.1 NUREG-1927 Program Element

NUREG-1927 Program Element 4, Detection of Aging Effects, (Reference A5.1) states “Detection of aging effects should occur before there is a loss of any structure and component intended function. This includes aspects such as method or technique (i.e., visual, volumetric, surface inspection), frequency, sample size, data collection, and timing of new or one-time inspections to ensure timely detection of aging effects.”

A2.4.2 PINGP Program Element

A condition examination is an acceptable method used to identify aging effects and is consistent with methods provided in industry codes and standards.

Additionally, the ISFSI Inspection and Monitoring Activities Program requires inspection personnel to be trained and technically qualified to perform these examinations. The personnel evaluating the structural examination results (concrete pads and earthen berm) are degreed engineers with one or more years of structural inspection experience. The personnel evaluating the cask examination results shall be qualified in accordance with PINGP site-specific requirements.

Quarterly visual inspections of the physical condition of the exterior surfaces of all in-service casks provide a means to detect degradation of these components due to potential loss of material and confirm that the intended functions are not compromised. The visual inspections of the casks will be performed with the unaided eye under general lighting conditions; mirrors, flashlights, and magnifiers may be used as an aid to visual inspections but are not required.

Pressure monitoring of all in-service casks is performed as a continuous process and checked daily for alarms. This provides a means to detect metallic O-ring seal degradation due to potential loss of material and confirm that the intended function is not compromised.

Radiation monitoring at the ISFSI boundary and quarterly radiation surveys (gamma and neutron) of the casks provide a means to detect shielding material degradation of the in-service casks and confirm that the intended function is not compromised.

Visual inspections of the accessible areas of the concrete pads every five years, and inspections of opportunity of inaccessible areas (e.g., if a cask is moved or excavation of a below grade portion), provide a means to detect degradation of these areas due to potential change in material properties, cracking, and loss of material. These inspections confirm that the intended function is not compromised.

Visual inspections of the earthen berm on a five-year frequency provide a means to detect degradation due to potential change in material properties, loss of form, and loss of material. These inspections confirm that the intended function is not compromised.

Visual inspections of the bottom of an in-service cask as an inspection of opportunity and, as a minimum, at 20-year intervals for the lead cask, provide a means to detect degradation of the bottom material due to potential loss of material and confirm that the intended functions are not compromised.

Visual inspections underneath the protective cover of an in-service cask as an inspection of opportunity and, as a minimum, at 20-year intervals for the lead cask, provide a means to detect degradation due to potential loss of material and confirm that the intended functions are not compromised.

Visual inspections of the ISFSI structures and components provide reasonable assurance that any degradation of the in-service casks, concrete pads, or earthen berm is identified and confirm that the structure or component intended function(s) is not compromised.

A review of plant-specific operating experience and industry operating experience for plants with similar materials and site conditions found that aging degradation occurs slowly over time and that an inspection frequency of once every five years was sufficient for the detection of aging effects before any loss of intended function for the concrete pads and earthen berm. This has also been confirmed by this same performance frequency of once every five years for those structures and components within the scope of the Maintenance Rule (10 CFR 50.65) such as the Reactor Containment Vessels, Shield Buildings, Auxiliary Buildings, etc. The ISFSI Inspection and Monitoring Activities Program contains provisions to accelerate the frequency of the examinations based on inspection results.

Monitoring of ground water chemistry is a mitigation activity and does not provide for detection of aging effects. Sampling well water and river water every six months for Chloride, Sulfate and pH provides a means to confirm that the concrete pads are not exposed to an aggressive chemical environment.

A2.4.3 Comparison to NUREG-1927 Program Element

This PINGP program element is consistent with NUREG-1927, Element 4, Detection of Aging Effect.

A2.5 Monitoring and Trending

A2.5.1 NUREG-1927 Program Element

NUREG-1927 Program Element 5, Monitoring and Trending, (Reference A5.1) states “Monitoring and trending should provide for prediction of the extent of the effects of aging and timely corrective or mitigative actions.”

A2.5.2 PINGP Program Element

The ISFSI Inspection and Monitoring Activities Program, as a subset of the PINGP Structures Monitoring Program, requires monitoring the condition of structures and components using current and historical operating experience along with industry operating experience to detect, evaluate, and trend degraded conditions. When degraded conditions are detected and all associated corrective actions are complete, the structures and components are again monitored against established performance goals. The program ensures the original design basis for the structures and components is maintained by effectively managing the applicable aging effects.

Periodic visual inspections determine the potential existence of loss of material for the in-service cask exterior surfaces and accumulation of debris. The inspection frequency is quarterly. Pressure monitoring of each in-service cask to detect potential loss of material is provided as a continuous process and checked daily for alarms. Radiation levels at the ISFSI site are continuously monitored and are evaluated and recorded quarterly to detect the potential for shielding material degradation. Surveys associated with facility entry and/or cask placement are performed as required and supplement the overall radiation monitoring program. The concrete pads are visually inspected at least once every five years for any evidence of change in material properties, cracking, or loss of material. The earthen berm is visually inspected at least once every five years for any evidence of change in material properties, loss of form, and loss of material. A visual inspection of an in-service cask bottom and a visual inspection of the area underneath an in-service cask protective cover were performed in June 2011. Subsequent inspections of normally inaccessible areas of the cask bottoms and area underneath the protective cover will be performed on an inspection of opportunity basis and, as a minimum, at 20-year intervals for the lead cask.

All observations regarding the material condition of the ISFSI are recorded in inspection procedures. The ISFSI Inspection and Monitoring Activities Program includes a process used to evaluate past and current conditions of structures and components and to determine whether they represent an adverse trend or random deficiency indicative of normal aging. If degradation exceeds or appears that it will exceed that expected of a properly maintained structure or component, a corrective action is generated requiring further engineering evaluation. All degraded conditions that result in a corrective action are trended in accordance with the Corrective Action Program.

A2.5.3 Comparison to NUREG-1927 Program Element

This PINGP program element is consistent with NUREG-1927, Element 5, Monitoring and Trending

A2.6 Acceptance Criteria

A2.6.1 NUREG-1927 Program Element

NUREG-1927 Program Element 6, Acceptance Criteria, (Reference A5.1) states "Acceptance criteria, against which the need for corrective action will be evaluated, should ensure that the particular structure and component intended functions are maintained under the existing licensing-basis design conditions during the period of extended operation."

A2.6.2 PINGP Program Element

The ISFSI Inspection and Monitoring Activities Program includes acceptance criteria for when the condition is to be entered into the Corrective Action Program before there is a loss of intended function. The acceptance criteria include sufficient detail to ensure timely detection of any degraded condition, followed by an evaluation in the Corrective Action Program to ensure that the particular structure or component intended function(s) is maintained under the existing licensing basis design conditions. Industry and plant-specific OE are also reviewed to ensure that the ISFSI Inspection and Monitoring Activities Program's acceptance criteria focus on conditions identified during these OE reviews.

The acceptance criteria for all visual inspections of an in-service cask are the absence of any of the aging effects listed in Table A2.1-1, i.e., no observable indications of corrosion.

The acceptance criterion for interseal pressure monitoring is the absence of an alarmed condition. The alarm setpoint is higher than the interseal pressure specified in the Prairie Island ISFSI Technical Specification 3.1.5.

The acceptance criterion for radiation dose monitoring of an in-service cask is the absence of an increasing trend.

The acceptance criteria for all visual inspections of the concrete pads are consistent with, or more restrictive than, those contained in Section 5.2.1 of ACI 349.3R (Reference A5.6), i.e., the second-tier criteria.

The acceptance criteria for all visual inspections of the earthen berm are the absence of any of the aging effects listed in Table A2.1-1.

The acceptance criteria for the ground water chemistry monitoring are Chloride ≤ 500 ppm, Sulfate ≤ 1500 ppm, and a pH ≥ 5.5.

The “Structures Monitoring Program,” which invokes the ISFSI Inspection and Monitoring Activities Program, includes a three tiered classification of inspection findings, namely, “Acceptable,” “Acceptable with Deficiencies,” and “Unacceptable.” An “Acceptable” condition is described as a structure or component capable of performing its intended function free of unexpected deficiencies or degradation. The “Acceptable with Deficiencies” condition is described as a structure or component considered capable of performing its intended function, but has accelerated degradation or unexpected deficiencies which, without special attention, could shorten its design life. An “Unacceptable” condition refers to a structure or component that has been damaged or degraded such that it may not be capable of performing its intended function.

A2.6.3 Comparison to NUREG-1927 Program Element

This PINGP program element is consistent with NUREG-1927, Element 6, Acceptance Criteria.

A2.7 Corrective Actions

A2.7.1 NUREG-1927 Program Element

NUREG-1927 Program Element 7, Corrective Actions, (Reference A5.1) states “Corrective actions, including root cause determination and prevention of recurrence, should be timely.”

A2.7.2 PINGP Program Element

Northern States Power Company – Minnesota (NSPM) has a single Corrective Action Program that is applied regardless of the safety classification of the structure or component. The Corrective Action Program requirements are established in accordance with the requirements of the NSPM Quality Assurance Topical Report and 10 CFR 50, Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.”

The Corrective Action Program procedures require the initiation of an Action Request for actual or potential problems including failures, malfunctions, discrepancies, deviations, defective material and equipment, nonconformances, and administrative control discrepancies, to ensure that conditions adverse to quality, operability, functionality, and reportability issues are promptly identified, evaluated if necessary, and corrected as appropriate. Guidance on establishing priority and timely resolution of issues is contained within the Corrective Action Program procedure.

All corrective actions for deviating conditions that are adverse to quality are performed in accordance with the requirements of the Quality Assurance Program which complies with the requirements of 10 CFR 50, Appendix B. Any resultant maintenance, repair/replacement activities, or special handling requirements are performed in accordance with approved procedures. Corrective actions provide reasonable assurance that deficiencies adverse to quality are either promptly corrected or are evaluated to be acceptable. Where evaluations are performed without repair or replacement, engineering analysis reasonably assures that the intended function is maintained consistent with the current licensing basis. If the deviating condition is assessed to be significantly adverse to quality, the cause of the condition is determined and an action plan is developed to preclude recurrence. Corrective actions identify recurring discrepancies and initiate additional corrective actions including root cause analysis to preclude recurrence.

Degraded conditions identified by the AMP inspections will be entered into the Corrective Action Program. Actions required to resolve inspection findings will be tracked to completion and trended within the Corrective Action Program.

A2.7.3 Comparison to NUREG-1927 Program Element

This PINGP program element is consistent with NUREG-1927, Element 7, Corrective Actions.

A2.8 Confirmation Process

A2.8.1 NUREG-1927 Program Element

NUREG-1927 Program Element 8, Confirmation Process, (Reference A5.1) states “The confirmation process should ensure that preventive actions are adequate and appropriate corrective actions have been completed and are effective.”

A2.8.2 PINGP Program Element

The confirmation process is part of the NSPM Corrective Action Program and ensures that the corrective actions taken are adequate and appropriate, have been completed, and are effective. The focus of the confirmation process is on the follow-up actions that must be taken to verify effective implementation of corrective actions. The measure of effectiveness is in terms of correcting the adverse condition and precluding repetition of significant conditions adverse to quality. Procedures include provisions for timely evaluation of adverse conditions and implementation of any corrective actions required, including root cause evaluations and prevention of recurrence where appropriate. These procedures provide for tracking, coordinating, monitoring, reviewing, verifying, validating, and approving corrective actions, to ensure effective corrective actions are taken.

The Corrective Action Program is also monitored for potentially adverse trends. The existence of an adverse trend due to recurring or repetitive adverse conditions will result in the initiation of an Action Request. The AMP or AMAs will also uncover unsatisfactory conditions resulting from ineffective corrective action.

A2.8.3 Comparison to NUREG-1927 Program Element

This PINGP program element is consistent with NUREG-1927, Element 8, Confirmation Process.

A2.9 Administrative Controls

A2.9.1 NUREG-1927 Program Element 9, Administrative Controls

NUREG-1927 Program Element 9, Administrative Controls, (Reference A5.1) states "Administrative controls should provide a formal review and approval process."

A2.9.2 PINGP Program Element

The NSPM Quality Assurance Program, associated formal review and approval processes, and administrative controls applicable to the AMP and Aging Management Activities, are implemented in accordance with the requirements of the NSPM Quality Assurance Topical Report and 10 CFR Part 50, Appendix B. The administrative controls that govern AMAs at PINGP are established in accordance with the PINGP Administrative Control Program and associated Fleet Procedures.

A2.9.3 Comparison to NUREG-1927 Program Element

This PINGP program element is consistent with NUREG-1927, Element 9, Administrative Controls.

A2.10 Operating Experience

A2.10.1 NUREG-1927 Program Element

NUREG-1927 Program Element 10, Operating Experience, (Reference A5.1) states "Operating experience involving the AMP, including past corrective actions resulting in program enhancements or additional programs, should provide objective evidence to support a determination that the effects of aging will be adequately managed so that the structure and component intended functions will be maintained during the period of extended operation."

A2.10.2 PINGP Program Element

The ISFSI Inspection and Monitoring Activities Program has been effective in maintaining plant structures and components. A review of ISFSI operating history provides evidence that any potential aging effects have been identified, evaluated, and managed effectively, ensuring that structures and components remain capable of performing their intended functions. It can be concluded that there is reasonable assurance that these structures and components will continue to perform their intended functions during the period of extended operation.

Routine Inspections

The Prairie Island ISFSI has been in operation since May of 1995. Visual inspections of the in-service casks, concrete pads, and earthen berm are performed in accordance with existing PINGP procedures. Inspections of the in-service casks to date have identified only minor cases of coating degradation which are corrected by touching-up of the existing coating material. There has been no evidence of loss of material under the degraded coating. No anomalies have been identified for the earthen berm. No anomalies of consequence have been identified for the concrete pads.

Lead Cask Inspections

Additional visual inspections of the normally inaccessible external surfaces of the in-service casks were evaluated for performance during a baseline inspection. The need and scope for these inspections were based on the above OE issues discussed below and the guidance in NUREG-1927 Appendix E – Component-Specific Aging Management (Reference A5.1). NUREG-1927 Appendix E states "A staff-accepted way to verify canister condition at an independent spent fuel storage installation is by remote visual inspection of one or more canisters ("lead canisters"). A lead canister is selected on the basis of longest time in service, or hottest thermal load, and/or other parameters that contribute to degradation" (Reference A5.1). Following this guidance, NSPM selected Cask TN-40 01 (Cask 01) as the lead cask because it had the longest in-service time of 16 years. The baseline inspection included inspection of the bottom of the cask (cask area in direct contact with the concrete pad) and underneath the protective cover. Due to industry OE concerning the area underneath the protective covers (water intrusion and bolt torque issues), this portion of the baseline inspection was expanded to include the inspection of a second in-service cask. As a result, Cask TN-40 13 (Cask 13) was also selected for inspection of the area underneath the protective cover.

The results of the cask bottom inspection revealed that approximately 25% of the protective coating on the bottom of Cask 01 exhibited loss of adhesion (peeling). In areas with loss of adhesion, the base metal did not exhibit any degradation that would affect the cask's intended function. The majority of the base metal was clean, however some corrosion and corrosion product stains were observed, mainly in areas where the epoxy coating itself was cracking. In those areas, the base metal did not have observable loss of material (no depth). Additionally, the concrete under the cask exhibited no visual signs of degradation. Therefore, the evaluation in the Corrective Action Program concluded that no corrective action was necessary.

With the protective cover removed, inspection of the area underneath the cover of Cask 01 was performed. During this inspection, no subcomponents within the scope of License Renewal exhibited any evidence of degradation. The observable area of the lid and lid bolt heads had no indication of corrosion. A coating of rust was found on the cask flange at the protective cover interface. This rust coating originated on the carbon steel protective cover, was deposited on the cask flange, and was easily removed. The removal of this coating revealed no degradation to the stainless steel overlay surface of the cask flange and no corrosion between the lid and flange in the main lid seal area. The neutron shield bolts were removed, inspected, and observed to have no indication of corrosion with the N-5000 lubricant still intact on the threads. The neutron shield protective coating exhibited no signs of corrosion.

The protective cover was found to have uniform corrosion on the flange sealing surface outside (external side) of the O-ring seal. There was minor corrosion around the protective cover bolt holes where the bolt heads had broken the epoxy coating due to friction upon installation. The underside of the protective cover dome had no signs of degradation. The protective cover O-ring seal remained in acceptable condition with the exterior coating on the protective cover exhibiting checking on approximately 15% to 20% of the surface area.

Inspection of the area underneath the protective cover of Cask 13 was also performed with the protective cover removed. During this inspection, no subcomponents within the scope of License Renewal exhibited any evidence of degradation. The observable area of the lid and lid bolt heads had no indication of corrosion. The stainless steel flange overlay had only small stains where rust from the protective cover was deposited. The stains were removed and there was no indication of corrosion on the observable area of the flange and no corrosion was observed between the lid and flange near the main lid seal area. The neutron shield bolts were removed and inspected with no indication of corrosion and also had the N-5000 lubricant still intact on the threads. The neutron shield had two rust stains on the protective coating directly below the access cover with one stain approximately six inches in diameter and the other approximately two inches in diameter. The protective cover was found to have corrosion on the interior. The corrosion appears to have started at the interior face of the access cover opening where the stainless steel overpressure system piping welded to the access plate made contact with the protective cover. The protective cover dome had evidence of corrosion in the area where it connected to the access plate. The access plate itself had corrosion on the entire interior surface excluding the area that was covered by the rubber gasket. However, none of these subcomponents exhibiting corrosion are within the scope of License Renewal.

The inspections performed for Cask 01 and Cask 13 with the protective covers removed were performed on those subcomponents not normally accessible and included the protective covers, access plates, neutron shields, neutron shield bolts, lid bolts, etc. Additionally, the torque values for the lid bolts were verified to address the industry OE discussed above. No degradation of any of the subcomponents within the scope of License Renewal were identified that would affect their intended function(s). Furthermore, the as-found lid bolt torque value met the original 1995 as-left torque value of 930 ft-lbs.

During the baseline inspections of Casks 01 and 13, the accessible areas of the casks were also inspected. The upper trunnions of Cask 01 exhibited some corrosion product stains on the top of the trunnion shaft. There was no indication of corrosion on all other areas inspected on Cask 01 and Cask 13.

A work order to repair the epoxy coating on Cask 01 upper trunnions, and additional cask coating surfaces was initiated. Based on the results of the above inspections, it was concluded that these structures and components remain capable of performing their intended functions throughout the period of extended operation.

Cask Interseal Pressure Monitoring

Trending of the in-service cask interseal helium pressures has revealed no issues with the seals or age related issues with the pressure monitoring system leak-tight integrity on any of the 29 in-service casks. However, there have been instances during extreme cold weather conditions when a low pressure alarm was received requiring the pressure monitoring system to be charged and the fittings tightened. These event-driven issues were a function of extreme temperature conditions and not age-related.

Radiation Surveys

NSPM performs periodic radiation surveys of the in-service casks. Trending of these surveys results shows no evidence that the shielding is degrading. Figure A2.10-1 provides the gamma dose rates at two meters from the three casks that have been in-service the longest. Figure A2.10-2 provides the neutron dose rates at two meters from the three casks that have been in-service the longest.

Corrective Action Program

A review of items in the Corrective Action Program and the "Structures Monitoring Program Quarterly Inspection Reports" was also performed. Minor maintenance items such as cleaning and painting of pull-box covers and transmitter base plates were identified for components which are not within the scope of License Renewal.

As previously discussed, inspections of the in-service casks identified minor cases of coating degradation. Touch-up of the coating material corrected this condition with no evidence of loss of material on the casks. There have been instances during extreme cold weather conditions, as previously discussed (last instance was January of 2010 with an ambient temperature of -20^{0}F), when a low pressure alarm was received on casks requiring the pressure monitoring system to be charged and the fittings tightened. These event-driven issues were a function of extreme temperature conditions and not age-related.

No other issues or findings were noted in the Corrective Action Program database relative to aging of the in-scope ISFSI structures and components.

Program Health Status Reports
The ISFSI Inspection and Monitoring Activities Program is a subset of the PINGP Structures Monitoring Program. A summary of the last two Structures Monitoring Program Inspection Reports that included ISFSI structures is provided below:

- Structures Monitoring Program, Quarterly Inspection Report Third Quarter 2001

  Shallow surface spalls were identified around the base plates of three of the monitor stands adjacent to the casks. These spalls were considered acceptable. It was recommended that monitoring be continued at the specified seven-year frequency.

Four shrinkage cracks were identified on the floor slab of the Equipment Storage Building (not within the scope of License Renewal). This condition was considered acceptable. It was recommended that monitoring be continued at the seven-year frequency. Abraded coatings and surface corrosion were also identified on the pull box frames, door frames and sills in addition to loose or missing nuts and washers at the building columns. A Work Request was initiated to correct these deficient conditions. Corrosion of the interseal pressure transmitter frames and supports, including pull box frames, pull box covers, ground clamps, and Environmental Monitor supports (not within the scope of License Renewal) was also identified. A Work Request was initiated to correct these deficient conditions.

- Structures Monitoring Program, Quarterly Inspection Report Second Quarter 2008

  A Work Request was initiated to excavate to sound material the spalled concrete identified in the 3Q01 inspection and then patch the area to prevent further degradation for the shallow surface spalls identified around the base plates of three of the monitor stands.

  Significant holes were found along the foundation of the Alarm Monitoring Building (not within the scope of License Renewal). A Work Request was initiated to correct these deficient conditions by filling these holes and compacting the affected soil.

  Although the inspections identified above noted minor issues that did not pose any challenges and were adequately monitored by existing PINGP procedures which required a seven-year inspection frequency, this frequency was subsequently changed to a five-year frequency in February of 2011. This change was performed to be consistent with the requirements of the Structures Monitoring Program and the Maintenance Rule and, as a result, increased the ISFSI inspection frequency from a seven year interval to a five year interval.

<u>System Health and Status Reports</u>
The actual status of the ISFSI is evaluated under the Prairie Island ISFSI System Monitoring and Reporting Tool, “Health and Status Report.” As of July 2011, overall ISFSI performance was “Green” based on no operability concerns, no open corrective work orders and no overdue preventive maintenance work orders. There have not been any Licensee Event Reports associated with the Prairie Island ISFSI.

No issues or findings were noted relative to the ISFSI structures and components.

<u>NRC Inspection Reports</u>

NRC inspection reports issued during the period of February 28, 2005 through April 29, 2010 were reviewed for the ISFSI site.

No issues or findings were noted relative to the ISFSI structures and components.

Industry OE
EPRI Report 1002882, "Dry Cask Storage Characterization Project - Final Report" (Reference A5.2), indicated the possibility of corrosion of the stainless steel fasteners for the rear breech plate which is located on the bottom of the CASTOR V/21 casks. Although NSPM does not utilize the CASTOR V/21 cask design, the concern was addressed as part of the baseline inspections discussed earlier in this section.

Virginia Electric and Power Company (Dominion) identified in the Surry ISFSI License Renewal Application (Reference A5.3) corrosion of their Transnuclear TN-32 lid bolts and outer metallic lid seals. Dominion stated that the corrosion of the lid bolts and outer metallic seal was the result of external water intrusion in the vicinity of the bolts and seal. It was determined that the Conax connector seal for the electrical connector in the cask protective cover was leaking due to improper installation of the connector. This degradation was a function of improper installation and not age-related. However, as a result of this experience, the vendor, Transnuclear (TN), issued an Information Bulletin (Reference A5.4) on these findings. The TN Information Bulletin informed all TN storage cask users of two issues that occurred at Dominion's Surry Power Station involving the TN-32 Storage Casks.

The first issue concerned the Helicoflex metallic seals utilized in the cask lid. Beginning in December 1999, five low-pressure alarms occurred over a six month period. These alarms were investigated and attributed to loose or leaking pressure switches. The installed Ashcroft pressure switches were replaced with Wasco pressure switches for both Surry and North Anna. Future TN casks use the new Wasco pressure switch. This issue was a design and installation issue and not age-related.

As a result of this issue, Dominion brought five casks back to the fuel pool area from the ISFSI for lid removal. The lid seals were removed and examined both visually and microscopically and revealed that the outer metallic seal contained small thru-wall holes caused by corrosion of the outer aluminum seal jacket. No corrosion was observed on the inner containment seal nor was any leakage detected past the inner seal; therefore, containment of the cask was never compromised. Corrosion was also observed on two of the five casks' lid edges where metallic spray and/or paint did not fully cover the surface. The casks showed evidence of water intrusion and/or high humidity inside the protective cover. In some cases, residue from standing/pooling water under the lid was observed. In the presence of water, the galvanic couple between aluminum and stainless steel is sufficient to cause corrosion. It had been concluded that theTN-32 design with aluminum metallic seals is sensitive to galvanic corrosion occurring if standing water or humid conditions near saturation are experienced under the protective cover.

The TN-32 casks at Surry were a unique design in terms of the protective cover and the overpressure (OP) system. The OP system utilized pressure switches attached directly to the OP tank with electrical wires emerging from the top of the protective cover through a Conax fitting. Water entered the protective cover through the Conax fitting at the apex of the dome, due to the Conax connectors not being properly installed on the casks. This issue was a design and installation issue and not age-related. A new protective cover and OP system was retrofitted to the existing casks consistent with other TN metal storage casks with tubing to the OP tank through a bolted and gasketed cover plate located on the protective cover (similar to the TN-40 and TN-40HT cask design). Thus, the potential leak path through the Conax connection at the top of the cover was eliminated.

TN stated that the Surry site location may have exacerbated the corrosion issue due to the brackish environment and the presence of chlorides in the water from precipitation or humidity which would accelerate a galvanic reaction. Although the Prairie Island ISFSI site is not located in an area that is exposed to a brackish environment, NSPM has conservatively included loss of material due to galvanic corrosion for aluminum as a potential aging mechanism in the ISFSI Atmosphere/Weather environment.

The second issue discussed in the TN bulletin was identified upon returning the Surry casks to the fuel pool area to remove the lid. It was discovered that some lid bolts on three casks did not have the original torque value applied prior to placement of the casks at the ISFSI. Lid bolts could be removed by hand on two casks. However, in all cases there was no evidence that the lid metallic O-rings lost their seal due to the reduced bolt torque. A majority of the hand-tight bolts were identified at locations that are tightened early in the “star” torquing sequence. Evaluations by TN confirmed that the lid seals would remain compressed and containment would be maintained.

Consensus was that a change in bolt torquing sequence methodology should be taken to mitigate the possibility of thermal expansion causing the bolting problems. TN stated that it was common practice for the final torque on the lid bolts to be applied after thermal equilibrium of the cask was obtained. This would translate into using an intermediate lid bolt torque value during the draining and vacuum drying operations. A minimum of two passes should be utilized in the star pattern and additional passes made as necessary until there is no further movement of the bolts. Additionally, lubricant should be applied to the bolts and special attention paid to the calibration of the bolt torquing equipment. TN recommended the use of Neolube or Loc-Tite N-5000 as the lubricant. Additional information on this subject may be found in the TN Information Bulletin.

Similar operating experience was identified with the TN-68 casks utilized at the Peach Bottom Atomic Power Station (Reference A5.5). This information was evaluated in NSPM’s review of the operating experience.

In response to the bolting issues, the vendor recommended a bolt torquing sequence methodology and application of Loc-Tite N-5000, as stated above.

These recommendations have been addressed at PINGP and are incorporated in the applicable existing PINGP maintenance procedures.

Precedent License Renewal Applications OE
A review of precedent ISFSI license renewal applications was performed to evaluate any relevant operating experience. ISFSIs included in this review were Calvert Cliffs Nuclear Power Plant, H. B. Robinson Steam Electric Station, and Surry Power Station. The results of these reviews concluded that the Prairie Island ISFSI Inspection and Monitoring Activities Program is effective in monitoring and detecting degradation and taking effective corrective actions as needed to preclude loss of intended function.

Conclusion
The OE, reviews, and monitoring described above confirm that any potential aging effects will be identified, evaluated, and managed effectively, ensuring that these structures and components remain capable of performing their intended functions.

A2.10.3 Comparison to NUREG-1927 Program Element

This PINGP program element is consistent with NUREG-1927, Element 10, Operating Experience.

A3.0 HIGH BURNUP FUEL MONITORING PROGRAM

The Prairie Island ISFSI provides for long-term dry fuel interim storage for high burnup spent fuel assemblies, i.e., fuel assemblies with discharge burnups greater than 45 GWD/MTU, until such time that the spent fuel assemblies may be shipped off-site for final disposition. The cask system presently utilized at the Prairie Island ISFSI for the storage of high burnup spent fuel is the Transnuclear TN-40HT which has a 40 fuel assembly capacity and is designed for outdoor storage.

The Aging Management Review of the high burnup fuel spent fuel assemblies in a dry inert environment did not identify any aging effects/mechanisms that could lead to a loss of intended function. However, it is recognized that there has been relatively little operating experience, to date, with dry storage of high burnup fuel. Reference A5.8 provides a listing of a significant amount of scientific analysis examining the long term performance of high burnup spent fuel. These analyses provide a sound foundation for the technical basis that long term storage of high burnup fuel, i.e., greater than 20 years, may be performed safely and in compliance with regulations. However, it is also recognized that scientific analysis is not a complete substitute for confirmatory operating experience. Therefore, the purpose of the High Burnup Fuel Monitoring Program is to confirm that the high burnup fuel assemblies' intended function(s) are maintained during the period of extended operations.

A description of the High Burnup Fuel Monitoring Program is provided below. Although the program is a confirmatory program, the description below uses each attribute of an effective AMP as described in NUREG-1927 for the renewal of a site-specific Part 72 license to the extent possible.

A3.1 AMP Element 1: Scope of the Program

Fuel Stored in a TN-40HT Cask is limited to an assembly average burnup of 60 GWd/MTU (note that the nominal burnup value is lower to account for uncertainties). The cladding materials for the Prairie Island high burnup fuel are Zircaloy-4 and Zirlo™, and the fuel is stored in a dry helium environment. High burnup fuel was first placed into dry storage in a TN-40 HT cask on April 4, 2013.

The High Burnup Fuel Monitoring Program relies upon the joint Electric Power Research Institute (EPRI) and Department of Energy (DOE) "High Burnup Dry Storage Cask Research and Development Project" (HDRP) (Reference A5.9) or an alternative program meeting the guidance in Interim Staff Guidance (ISG) 24, Reference A5.10, as a surrogate program to monitor the condition of high burnup spent fuel assemblies in dry storage.

The HDRP is a program designed to collect data from a spent nuclear fuel storage system containing high burnup fuel in a dry helium environment. The program entails loading and storing a TN-32 bolted lid cask (the Research Project Cask) at Dominion Virginia Power's North Anna Power Station with intact high burnup spent nuclear fuel (with nominal burnups ranging between 53 GWd/MTU and 58 GWd/MTU). The fuel assemblies to be used in the program include four different kinds of cladding (Zircaloy-4, low-tin Zircaloy-4, Zirlo™, and M5™). The Research Project Cask is to be licensed to the temperature limits contained in ISG-11, Reference A5.7, and loaded such that the fuel cladding temperature is as close to the limit as practicable. Aging effects will be determined for material/environment combinations per ISG-24 Rev. 0 or the "High Burnup Dry Storage Cask Research and Development Project" (HDRP).

A3.2 AMP Element 2: Preventive Actions

The High Burnup Fuel Monitoring Program consists of condition monitoring to confirm there is no degradation of a high burnup fuel assembly that would result in a loss of intended function(s). Other than the initial design limits placed on loading operations, no preventive or mitigating attributes are associated with these activities.

During the initial loading operations of the TN-40HT casks, the design and ISFSI Technical Specifications (TS) require that the fuel be stored in a dry inert environment. TS 3.1.1, "Cask Cavity Vacuum Drying," demonstrates that the cask cavity is dry by maintaining a cavity absolute pressure less than or equal to 10 mbar for a 30 minute period with the cask isolated from the vacuum pump. TS 3.1.2, "Cask Helium Backfill Pressure," requires that the cask then be backfilled with helium. These two TS requirements ensure that the high burnup fuel is stored in an inert environment thus preventing cladding degradation due to oxidation mechanisms. TS 3.1.2 also requires that the helium environment be established within 34 hours of commencing cask draining. This time requirement ensures that the peak cladding temperature remains below 752°F (i.e., the temperature specified in ISG-11), thus mitigating degradation due to cladding creep.

A3.3 AMP Element 3: Parameters Monitored/ Inspected

Either the surveillance demonstration program as described in the HDRP or an alternative program should meet the guidance of ISG-24, Rev. 0.

A3.4 AMP Element 4: Detection of Aging Effects

Either the surveillance demonstration program as described in the HDRP or an alternative program should meet the guidance of ISG-24, Rev. 0.

A3.5 AMP Element 5: Monitoring & Trending

As information/data from a fuel performance surveillance demonstration program becomes available, NSPM will monitor, evaluate, and trend the information via its Operating Experience Program and/or the Corrective Action Program to determine what actions should be taken to manage fuel and cladding performance, if any.

Similarly, NSPM will use its Operating Experience Program and/or Corrective Action Program to determine what actions should be taken if it receives information/ data from other sources than the demonstration program on fuel performance.

Formal evaluations of the aggregate feedback from the HDRP and other sources of information will be performed at the specific points in time during the period of extended operation delineated in the table below. These evaluations will include an assessment of the continued ability of the high burnup fuel assemblies to continue to perform their intended function(s) at each point.

Toll Gate	Year *	Assessment
1	2028	Evaluate information obtained from the HDRP loading and initial period of storage along with other available sources of information. If the HDRP NDE (i.e., cask gas sampling, temperature data) has not been obtained at this point and no other information is available then NSPM has to provide evidence to the NRC that no more than 1% of the HBF has failed.

Toll Gate	Year *	Assessment
2	**2038**	2.a - (i) Evaluate information obtained from the destructive (DE) and non-destructive (NDE) examination of the fuel placed into storage in the HDRP along with other available sources of information and provide the evaluation to the NRC with simultaneous copies to the Prairie Island Indian Community. (ii) If the aggregate of this information indicates that the high burnup fuel assemblies will not perform “intended function(s)” – as that term is used in NRC regulations – NSPM will submit a License Amendment Request to NRC with its proposed actions to address the issues indicated by the evaluation and to continue safe storage of high burnup fuel. (iii) If the aggregate of this information confirms the ability of the high burnup fuel assemblies to continue to perform intended function(s) for the remainder of the period of extended operations, subsequent assessments may be cancelled. 2.b If by January 1, 2033 it becomes evident that the HDRP DE of the fuel will not be completed in time to support the assessment required by Toll Gate 2.a, NSPM will submit a License Amendment Request to the NRC outlining its plans to obtain evidence to demonstrate that the fuel performance acceptance criteria 1-4 in element 6 continue to be met. This License Amendment Request will be submitted to the NRC for approval no later than December 31, 2033. The evaluation using this evidence will be completed by 2038.
3	2048	Evaluate any other new information.

* Assessments are due by April 4 of the year identified in the table

The above assessments are not, by definition, stopping points. No particular action, unless noted in this AMP, other than performing an assessment is required to continue cask operation. To proceed, an assessment of aggregated available operating experience (both domestic and international), including data from monitoring and inspection programs, NRC-generated communications, and other information will be performed. The evaluation will include an assessment of the ability of the high burnup fuel assemblies to continue to perform their intended function(s).

A3.6 AMP Element 6: Acceptance Criteria

- The HDRP or any other demonstration used to provide fuel performance data should meet the acceptance criteria guidance of ISG-24 Rev 0.
- If any of the following fuel performance criteria are exceeded in the HDRP or alternative program, a corrective action is required[1]:
    1. Cladding Creep: total creep strain extrapolated to the total approved storage duration based on the best fit to the data, accounting for initial condition uncertainty shall be less than 1%
    2. Hydrogen – maximum hydrogen content of the cover gas over the approved storage period shall be extrapolated from the gas measurements to be less than 5%
    3. Drying – The moisture content in the cask , accounting for measurement uncertainty, shall indicate no greater than one liter of residual water after the drying process is complete
    4. Fuel rod breach – fission gas analysis shall not indicate more than 1% of the fuel rod cladding breaches

A3.7 AMP Element 7: Corrective Actions

The NSPM Corrective Action Program commensurate with 10 CFR 50 Appendix B will be followed.

In addition, at each of the assessments in AMP Section 5, the impact of the aggregate feedback will be assessed and actions taken when warranted. These evaluations will address any lessons learned and take appropriate corrective actions, including:

- Perform repairs or replacements
- Modify this confirmatory program in a timely manner
- Adjust age-related degradation monitoring and inspection programs (e.g., scope, frequency)
- Actions to prevent reoccurrence
- An evaluation of the DCSS to perform it’s safety and retrievability functions

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[1] While it is not a fuel performance criteria, the spatial distribution and time history of the temperature must be known to evaluate the relationship between the performance of the rods in the HDRP and the HBF rod behavior expected in the TN-40HT cask.

- Evaluation of the effect of the corrective actions on this component to other safety components.

A3.8 AMP Element 8: Confirmation Process

The confirmation process is part of the NSPM Corrective Action Program and ensures that the corrective actions taken are adequate and appropriate, have been completed, and are effective. The focus of the confirmation process is on the follow-up actions that must be taken to verify effective implementation of corrective actions. The measure of effectiveness is in terms of correcting the adverse condition and precluding repetition of significant conditions adverse to quality. Procedures include provisions for timely evaluation of adverse conditions and implementation of any corrective actions required, including root cause evaluations and prevention of recurrence where appropriate. These procedures provide for tracking, coordinating, monitoring, reviewing, verifying, validating, and approving corrective actions, to ensure effective corrective actions are taken.

A3.9 AMP Element 9: Administrative Controls

The NSPM Quality Assurance Program, associated formal review and approval processes, and administrative controls applicable to this program and Aging Management Activities, are implemented in accordance with the requirements of the NSPM Quality Assurance Topical Report and 10 CFR Part 50, Appendix B. The administrative controls that govern AMAs at PINGP are established in accordance with the PINGP Administrative Control Program and associated Fleet Procedures.

A3.10 AMP Element 10: Operating Experience

Surrogate surveillance demonstration programs with storage conditions and fuel types similar to those in the dry storage system that satisfies the ISG-24 acceptance criteria are a viable method to obtain operating experience. NSPM intends to rely on the information from the HDRP with similar types of HBU fuel. The HDRP is viable as a surrogate surveillance program. Additional data/research to assess fuel performance from both domestic and international sources that are relevant to the fuel in the NSPM casks will also be used.

A4.0 Summary

The review of operating experience identified a number of incidents related to dry fuel storage. Although many of these were event-driven and most were not age-related, for those that did involve credible aging effects and mechanisms, evaluations were conducted to assess potential susceptibility. These evaluations indicated that the aging effects and mechanisms that were identified at the Prairie Island ISFSI are bounded by the Aging Management Reviews that were performed for those structures and components identified as within the scope of License Renewal.

Operating experience to date has not indicated any degradation that would affect the structures or component intended function(s). Inspections, monitoring, and surveillances continue to be conducted that would identify deficiencies. The Corrective Action Program is in place to track and correct deficiencies in a timely manner. Corrective actions have been effectively implemented when inspection and monitoring results have indicated degradation. Continued implementation of the ISFSI Inspection and Monitoring Activities Program and the High Burnup Fuel Monitoring Program provide reasonable assurance that the aging effects will be managed such that the intended functions will be maintained during the period of extended operation.

A5.0 References (Appendix A, Aging Management Program)

A5.1 NUREG-1927, *Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance*, March 2011.
A5.2 EPRI Report 1002882, *Dry Cask Storage Characterization Project, Final Report*, September 2002.
A5.3 Letter from D.A. Christian, Virginia Electric and Power Company to D.A. Cool (NRC), *Surry Independent Spent Fuel Storage Installation License Renewal Application*, dated April 29, 2002, ADAMS Accession Number ML021290068.
A5.4 Transnuclear Information Bulletin, April 2001.
A5.5 Letter from G. L. Stathes, Exelon Generation Company to Director Spent Fuel Project Office (NRC), *Submittal of Independent Spent Fuel Storage Installation (ISFSI) Cask Event Report*, dated December 01, 2010, ADAMS Accession Number ML110060275.
A5.6 American Concrete Institute, ACI 349.3R-96, *Evaluation of Existing Nuclear Safety-Related Concrete Structures*, January 1996.
A5.7 NRC Interim Staff Guidance 11, *Cladding Considerations for the Transportation and Storage of Spent Fuel*, Revision 3, November 17, 2003.
A5.8 Letter from R. McCullum (NEI) to M. Lombard (NRC), dated March 22, 2013, *Industry Analysis and Confirmatory Information Gathering Program to Support the Long-Term Storage of High Burnup Fuel (HBF)*, (ADAMS Accession No. ML13084A045).
A5.9 High Burnup Dry Storage Cask Research and Development Project Final Test Plan, February 27, 2014, DOE Contract No.: DE-NE-0000593.
A5.10 NRC Interim Staff Guidance 24, *The Use of a Demonstration Program as a Surveillance Tool for Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years*, Revision 0, July 11, 2014.

TABLE A2.1-1
Managed Aging Effects

Material	Environment	Aging Effect	Aging Mechanism
Aluminum	Atmosphere/Weather	Loss of Material	Crevice Corrosion
Aluminum	Atmosphere/Weather	Loss of Material	Galvanic Corrosion
Aluminum	Atmosphere/Weather	Loss of Material	Pitting Corrosion
Carbon Steel	Atmosphere/Weather	Loss of Material	Crevice Corrosion
Carbon Steel	Atmosphere/Weather	Loss of Material	Galvanic Corrosion
Carbon Steel	Atmosphere/Weather	Loss of Material	General Corrosion
Carbon Steel	Atmosphere/Weather	Loss of Material	Pitting Corrosion
Polypropylene	Air/Gas	Cracking	Material property changes from radiation exposure
Borated Polyester	Air/Gas	Cracking5	Material property changes from radiation exposure
Stainless steel	Atmosphere/Weather	Loss of Material	Crevice Corrosion
Stainless steel	Atmosphere/Weather	Loss of Material	Pitting Corrosion
Concrete	Atmosphere/Weather	Change in Material Properties	Leaching of $Ca(OH)_2$
Concrete	Atmosphere/Weather	Cracking	Freeze-Thaw
Concrete	Atmosphere/Weather	Cracking	Reaction with Aggregates
Concrete	Atmosphere/Weather	Loss of Material	Freeze-Thaw
Concrete	Soil	Change in Material Properties	Leaching of $Ca(OH)_2$
Concrete	Soil	Cracking	Reaction with Aggregates
Concrete	Soil	Cracking	Settlement
Earthen Structures	Atmosphere/Weather	Change in Material Properties	Desiccation
Earthen Structures	Atmosphere/Weather	Loss of Form	Settlement
Earthen Structures	Atmosphere/Weather	Loss of Form	Frost Action
Earthen Structures	Atmosphere/Weather	Loss of Material	Erosion (Wind/Rain Impact)

Figure A2.10-1
Two Meter Gamma Dose Rates

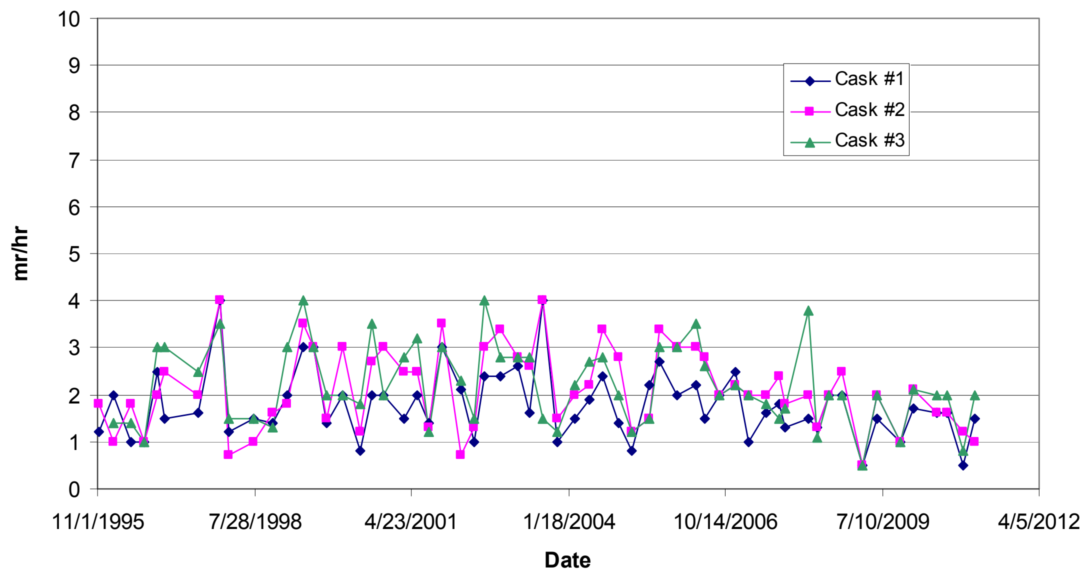
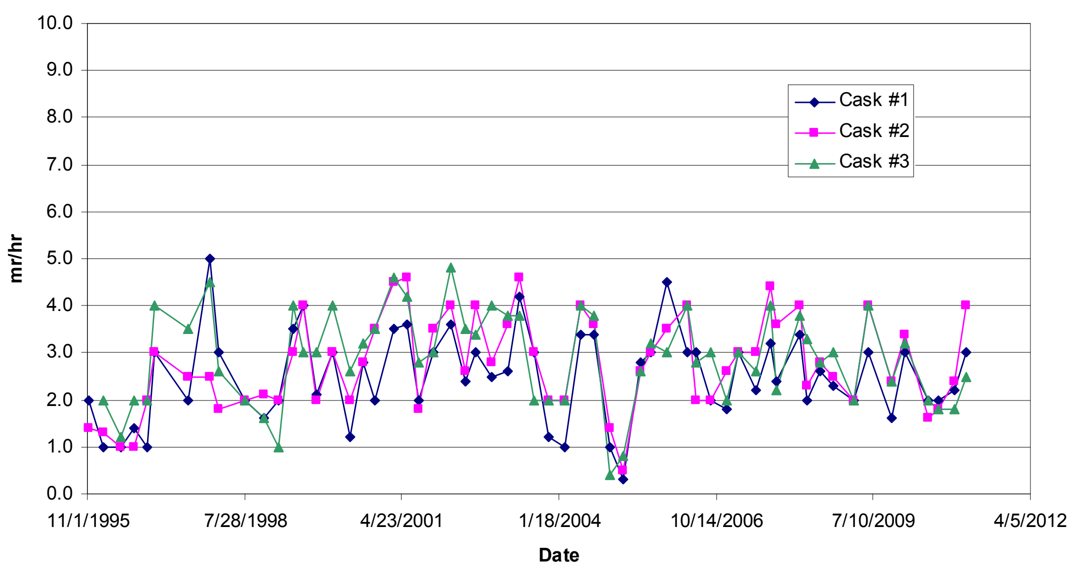


Figure A2.10-2
Two Meter Neutron Dose Rates



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