VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

July 10, 2017

U. S. Nuclear Regulatory Commission
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Director, Division of Spent Fuel Management
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License No. SNM-2507

VIRGINIA ELECTRIC AND POWER COMPANY
OLD DOMINION ELECTRIC COOPERATIVE
NORTH ANNA POWER STATION
INDEPENDENT SPENT FUEL STORAGE INSTALLATION (ISFSI)
LICENSE RENEWAL APPLICATION: RESPONSE TO
SECOND REQUEST FOR ADDITIONAL INFORMATION (CAC NO. L25121)

On May 25, 2016, Virginia Electric and Power Company (Dominion Energy Virginia or the Company) on behalf of itself and Old Dominion Electric Cooperative (ODEC) submitted an application for renewal of the North Anna Power Station (NAPS) site-specific Independent Spent Fuel Storage Installation (ISFSI) license SNM-2507 (Agency Documents Access and Management System (ADAMS) Accession No. ML16153A140). The Nuclear Regulatory Commission (NRC) acknowledged acceptance of the license renewal application on July 21, 2016 (ADAMS Accession No. ML16207A104).

On November 23, 2016, Dominion Energy Virginia received from the NRC a Request for Additional Information (RAI) (ADAMS Accession No. ML16330A715) related to the application for renewal of the NAPS site-specific ISFSI license. Dominion Energy Virginia provided a response to the November 23, 2016 RAI on January 20, 2017 (ADAMS Accession No. ML17025A128).

On May 22, 2017, Dominion Energy Virginia received from the NRC a second RAI (ADAMS Accession No. ML17116A131) related to the application for renewal of the NAPS site-specific ISFSI license that contained four questions.

As requested in the second RAI, a public meeting was held between the NRC and Dominion Energy Virginia on June 14, 2017 to discuss the proposed response to the second RAI. During the public meeting, Dominion Energy Virginia personnel discussed the general approach for the proposed response to each of the four questions in the second RAI. The NRC staff then commented on each proposed response and provided additional clarifications in understanding the intended scope of the question.

NMSS24
NMSS26
NMSS

Attachment 1 provides the Dominion Energy Virginia responses to three of the four questions in the second RAI. Based on additional clarifications from the June 14, 2017 public meeting, the response to the fourth question (designated as RAI 3-15) will be provided no later than August 18, 2017.

Additionally, as requested in the cover letter associated with the second RAI, the Aging Management Programs and the NAPS ISFSI Safety Analysis Report Supplement (as revised through the first and second RAIs) are provided in the following Enclosures:

- Enclosure 1: marked-up version of the revised Aging Management Programs (AMPs)
- Enclosure 2: clean version of the revised AMPs with changes to the AMPs since the May 25, 2016 submittal annotated by a revision bar in the right margin.
- Enclosure 3: marked-up version of the revised NAPS ISFSI Safety Analysis Report Supplement
- Enclosure 4: clean version of the revised NAPS ISFSI Safety Analysis Report Supplement with changes to the AMPs since the May 25, 2016 submittal annotated by a revision bar in the right margin.

If you have any questions or require additional information, please contact Ms. Diane E. Aitken at (804) 273-2694.

Sincerely,

Mark D. Sartain
Vice President – Nuclear Engineering and Fleet Support

COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by Mark D. Sartain, who is Vice President – Nuclear Engineering and Fleet Support, of Virginia Electric and Power Company. He has affirmed before me that he is duly authorized to execute and file the foregoing document in behalf of that Company, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 10TH day of July, 2017.

My Commission Expires: 5-31-18.

Vicki L. Hull
NOTARY PUBLIC
Commonwealth of Virginia
Reg. # 140542
My Commission Expires May 31, 2018

Notary Public

Commitments made in this letter:

1. Perform annual neutron radiation surveys around the entire perimeter of reinforced concrete pad No.1.

Attachment 1: NAPS ISFSI License Renewal Second RAI Response

Enclosure 1: Marked-up Version - Revised Aging Management Programs
Enclosure 2: Clean Version - Revised Aging Management Programs
Enclosure 3: Marked-up Version – Revised NAPS ISFSI Safety Analysis Report Supplement
Enclosure 4: Clean Version – Revised NAPS ISFSI Safety Analysis Report Supplement

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Attachment 1

NAPS ISFSI License Renewal Second RAI Response

North Anna Power Station ISFSI
Virginia Electric and Power Company

RAI 3-4 Follow-up

Revise the table of aging effects in Appendix C of the renewal application to include cracking as an aging effect of polymer neutron shields under radiation and heat or provide justification for not including this aging effect in the table.

In the November 23, 2016, RAI 3-4, the NRC staff requested Dominion to justify why effects due to thermal and radiation exposure (e.g., cracking) were not included as aging effects of the neutron shields in the TN-32 cask. In its response to this RAI, the applicant states:

> License renewal application Table AMR Results-1, "Transnuclear TN-32 Dry Storage Cask," identifies the aging effect of loss of material due to radiolytic decomposition and thermal degradation for the Top Neutron Shield and Radial Neutron Shield. The loss of material aging effect was identified based on loss of hydrogen and changes in polymer properties that result from exposure to heat and radiation. Prolonged loss of material can result in cracking and potentially streaming of radiation from the TN-32 cask. As described in Section A2.1, Elements 3, 4, and 5, loss of material from the polymer shielding is managed by the TN-32 Dry Storage Cask Aging Management Program.

Although these statements recognize loss of material can result in cracking, the table of aging effects does not explicitly address crack development and the potential for formation of neutron streaming paths as a potential aging effect of the neutron shields. The aging management review results and aging management programs (AMPs) should be clear to support the licensee's development of the implementation procedures and NRC's oversight of aging management activities. The staff also notes that the effective management of cracking and neutron streaming paths likely requires unique monitoring activities that may not be similar to those that manage general loss of material because neutron streaming may create hot spots for dose rate that make the neutron shield lose its intended function.

This information is required for the staff to determine compliance with 10 CFR 72.42(a), 10 CFR 72.104, 10 CFR 72.106, and 10 CFR 20.1301(a) and (b).

Response

The TN-32 Dry Storage Cask Aging Management Program and the North Anna ISFSI Safety Analysis Report (SAR) Supplement will be revised to include cracking as an aging effect for the top neutron shield and radial neutron shield subcomponents. These revisions are reflected in updates to the Appendix A: Aging Management Programs (Enclosures 1 and 2) and Appendix C: ISFSI SAR Supplement (Enclosures 3 and 4).

As previously described in the January 20, 2017 response to RAI 3-4, loss of material can ultimately lead to cracking in the polymer shielding materials utilized in the TN-32 dry storage casks. Therefore, the aging effects of loss of material and cracking for the polymer shielding are managed by the radiation monitoring activities of the TN-32 Dry Storage Cask Aging Management Program, as revised in the response to RAI 3-11 and provided in Enclosures 1 and 2.

RAI 3-5 Follow-up

Pertaining to AREVA calculation 503065-0500, "Neutron Fluence, Gamma Exposure and Dose Rate Calculation for North Anna Power Station TLAA Phase 2," Rev. 0:

1. Explain how the neutron flux at the mid-plane of the cask, $1.75x10^6$ n/s/cm^2, was calculated, and if it is based on the total source (32 fuel assemblies) in the cask.
2. Clarify whether 6.38 MeV was used as a cut-off for inclusion of neutrons in the flux calculation, and if so, justify this threshold.

In the November 23, 2016, RAI 3-5, the NRC staff requested Dominion to discuss how the buildup of flammable gas generated in the radial neutron shield is managed in the period of extended operation. In the February 28, 2017, submittal, Dominion provided AREVA Calculation No. 503065-0500, Rev. 0 to support its response to the RAI. It is not clear how neutron flux (as shown in Table 11-15 of AREVA Calculation No. 503065-0500) was determined and whether the cut-off energy 6.38 MeV was used in determining the neutron flux (page 13 of AREVA Calculation No. 503065-0500).

This information is required for the staff to determine compliance with 10 CFR 72.120(d).

Response

The neutron flux at locations on the TN-32 centerline was calculated using the mesh tally from the Monte Carlo N-Particle Transport Code analysis. The neutron flux at the mid-plane of the TN-32 cask is the maximum neutron flux on the cask centerline (1.75E+6 n/s/cm^2, from Table 11-15 of AREVA Calculation No. 503065-0500). The neutron flux at the mid-plane of the TN-32 cask is based on contributions from all 32 fuel assemblies.

6.38 MeV was not used as a cut-off point for inclusion of neutrons in AREVA Calculation No. 500365-0500. The statement in Section 8.1 of the calculation referring to 6.38 MeV was included in the original calculation only to define the approximate percentage of neutrons with energy levels greater than 6.38 MeV.

RAI 3-11 Follow-up

Justify that the proposed TN-32 Dry Storage Cask AMP as described in the applicant's response to RAI 3-11 is capable of detecting degradation of the neutron shields. Specifically, justify that the annual neutron survey at one location for each dry storage cask is sufficient to detect degradation of the neutron shields or revise the TN-32 Dry Storage Cask AMP and Appendix C of the renewal application to include an approach that can more fully characterize shielding performance around the entire cask perimeter.

In the November 23, 2016, RAI 3-11, the NRC staff requested the applicant to provide justification for its proposed use of the thermoluminescent dosimeter (TLD) measurements at the ISFSI perimeter fence as a means to detect neutron shield degradation, including localized degradation (e.g., shrinkage, cracking) of the individual casks. Dominion provided additional information in its January 20, 2017, response and proposed revising the TN-32 Dry Storage Cask AMP to include performance of an annual neutron radiation survey of each TN-32 cask. Dominion also committed to use TLDs with an additional chip to improve detection of neutrons in the intermediate and fast energy spectrum.

In its response to RAI 3-11, the applicant states that "A neutron survey will be performed annually at one location for each TN-32 dry storage cask." The applicant further indicates that the neutron survey will be conducted at approximately six feet from the surface of the cask.

However, it is not clear if the neutron detector to be used has the appropriate sensitivity to detect local neutron streaming from cracks in the neutron shields. Also, it is not clear whether measurement at a single location and measurement at the proposed distance from the cask is sufficient to detect neutron shield degradation that may occur at any location around the neutron shields.

In addition, based on the NAPS ISFSI Safety Analysis Report (SAR), the spacing between casks by design is about 16 feet center-to-center. Since the cask outer diameter is about 8.5 feet, the distance from the center line between two casks to the cask outer surface is 3.75 feet. If the detector is placed 6 feet away from one cask, the detector will be only 1.5 feet away from the neighboring cask. Considering the movement of the casks resulting from the August 23, 2011, Central Virginia earthquake, the distances between some casks are even smaller. As such, it is not clear to the staff how much the measured neutron radiation will be affected by the neighboring casks. The applicant needs to explain how the neutron radiation survey is to be performed with justification that the measured data are valid for the cask it intends to monitor. Based on the cask design, it appears that neutron radiation measurements around the cask are needed to assure detection of neutron shield degradation as part of the AMP.

This information is required to determine compliance with 10 CFR 72.42(a), 10 CFR 72.104, 10 CFR 72.106, and 10 CFR 20.1301(a) and (b).

Response

As described in Section 2.3.5.2 of the TN-32 Dry Storage Cask Topical Safety Analysis Report, the intended function of the neutron shielding material in the TN-32 dry storage casks is to limit radiation exposure at the controlled area (site) boundary and in the vicinity of the TN-32 dry storage casks. The neutron shielding material ensures that neutron radiation dose to the public and occupational workers remains within acceptable limits.

The TN-32 dry storage cask is equipped with a top and radial neutron shield to moderate neutrons originating in the stored fuel. Additionally, the radial neutron shield is impregnated with boron to further reduce neutron dose at the dry storage cask perimeter by absorption of neutrons. The neutron shielding of the TN-32 dry storage casks stored on reinforced concrete pad No. 1 are identical in design and construction. The neutron source term; however, is unique for each cask since it is a function of fuel enrichment, fuel burnup, and fuel storage time. Loss of material and cracking of the neutron shield would result in an upward shift in neutron energy and a subsequent increase in neutron flux.

The radiation monitoring activities summarized below provides reasonable assurance that a shift in neutron energy would be detected in a timely manner to limit radiation exposure and protect members of the public, as well as occupational workers during the period of extended operation.

<u>RADIATION MONITORING AT THE ISFSI PERIMETER FENCE (TLD)</u>

The current licensing basis requires that radiation monitoring of the ISFSI be accomplished using TLDs located at the ISFSI perimeter fence. Quarterly, neutron and gamma radiation doses are obtained from the perimeter fence TLDs and trended. An informal review of the quarterly ISFSI perimeter fence TLD neutron and gamma readings recorded over a 10-year period has been performed and no unusual trend in neutron radiation or unexpected radiation values were identified that warranted further action.

The TLDs currently utilized at the ISFSI perimeter fence are capable of detecting neutrons with energies ranging between thermal and 6 MeVs. As neutron energy increases, the response of these TLDs decreases significantly. As indicated in the original response to RAI-3-11 dated January 20, 2017, an additional chip, such as a CR

39 polycarbonate chip, or equivalent, will be installed to improve the detection of neutrons in the intermediate and fast neutron energy spectrums. The CR 39 chip has a relatively flat response to neutron energies in the range of 200 keV to 6 MeV. It should be noted that over 98% of the neutrons originating in the stored fuel (prior to moderation) of the TN-32 dry storage casks are at energy levels below 6.38 MeV. Therefore, the additional chip, in combination with the TLDs currently in use at North Anna, will assure detection of neutron dose resulting from thermal, intermediate, and fast neutrons at the ISFSI perimeter fence.

ANNUAL NEUTRON RADIATION SURVEYS

In addition to the installation of an additional chip, such as a CR 39 polycarbonate chip, or equivalent, the radiation monitoring activities of the TN-32 Dry Storage Cask Aging Management Program will be further enhanced by the performance of annual neutron radiation surveys around the entire perimeter of reinforced concrete pad No.1. These annual neutron radiation surveys are in lieu of the annual neutron surveys at one location for each TN-32 dry storage cask committed to in the original response to RAI-3-11 dated January 20, 2017.

Annually, neutron radiation surveys will be performed to measure and record the neutron radiation levels at thirty-two locations around the cask array. Neutron measurements will be recorded at fifteen locations along the long axis of the reinforced concrete pad No. 1 on both the east and west sides at points centrally located between every two adjacent casks, extending past the last cask on each end. The dose rate readings will be measured and recorded at a distance of approximately one foot outward from the edge of reinforced concrete pad No. 1. One additional measurement will be recorded along the short axis at a point centrally located between the two casks at each end of reinforced concrete pad No. 1.

The annual frequency for neutron radiation surveys is justified given that TLDs, capable of detecting the neutron energies emitted by the TN-32 dry storage casks, continuously monitor doses to the public and dose rate readings are measured and recorded quarterly. Occupational workers are protected by the Radiological Work Control Program, as described below.

Neutron dose rate readings will be taken at an approximate elevation corresponding to the maximum neutron flux. An elevation corresponding to the maximum neutron flux is the most likely location for radial neutron shield degradation to occur, and therefore serves as a leading indicator for axial and radial locations not specifically monitored during the annual neutron surveys. The TN-32 dry storage cask elevation corresponding to the maximum neutron flux will be specified in a station procedure.

A tissue equivalent proportional counter, such as the REM 500 neutron survey meter, will be used to measure the neutron dose rate at the thirty-two survey points. The REM 500 neutron survey meter is a sealed spherical tissue equivalent proportional counter that has a relatively linear dose rate response to neutron energies in the range of 70 keV to 20 MeV. For the annual neutron surveys, the REM 500 survey meter will be operated in accordance with the manufacturer's recommendations and station procedures, with sufficient count time to ensure the statistical accuracy of the measurements.

Neutron energies at various distances from a TN-32 dry storage cask have previously been evaluated by Dominion using bubble dosimeters. The results revealed that nearly 100% of the neutrons at the cask surface have energies greater than 100 keV, while approximately 70% of the neutrons at a distance of ten feet have energies greater than 100 keV. Since 98% of the neutrons in a TN-32 dry storage cask have energies less than 6.38 MeV, as previously stated, the REM 500 neutron survey meter is capable of detecting neutrons emitted from a TN-32 dry storage cask. Dominion has previously used the REM 500 neutron survey meter to measure the neutron dose rates from a TN-32 dry storage cask with, and without, the top neutron shield in place during cask loading operations. The dose rate measurements were recorded at a distance of approximately six feet above the top of the cask. The dose rate measurement results are provided below:

TN-32 Dry Storage Cask Dose Rates with REM 500

Location	mrem/hr (shield in place)	mrem/hr (shield removed)
Center of Cask Lid	0.3388	19.56
Above Lid Penetration B	0.75	10.4
Edge of Lid Bolt No. 10	1.771	10.01

The above results confirm the ability of the REM 500 neutron survey meter to detect the shift in neutron energies that would result from loss of material and cracking of the shielding material, thus assuring detection of neutron shield degradation.

OCCUPATIONAL EXPOSURE CONTROLS

Personnel access to the ISFSI is restricted by a fence with locked gates. Station Security personnel monitor and control access to the ISFSI. The Dominion Radiological Work Control Program requires a Radiation Work Permit (RWP) be prepared for maintenance activities at the ISFSI. The RWP ensures occupational workers are protected when work is performed in radiological controlled areas. When a RWP is initiated, health physics technicians perform surveys to determine the general radiological conditions at the job site. This radiation survey provides an additional opportunity to detect any adverse conditions that may exist around the TN-32 dry storage cask(s). The RWP contains the survey results and any additional radiological information necessary to protect maintenance personnel, such as required protective clothing, respirator requirements, and dose and dose rate limits. The RWP also specifies the required dosimetry for entry into the ISFSI. All activities in the vicinity of the TN-32 dry storage casks require neutron and gamma dosimetry to be worn. Maintenance personnel are restricted from entering the ISFSI boundary until they have read and understand the contents of the RWP, and have been briefed by health physics personnel.

Prior to allowing maintenance on TN-32 dry storage cask(s) to commence, an additional detailed neutron and gamma survey is performed. For example, when a protective cover is removed, a detailed neutron and survey of the top of the dry storage cask is performed immediately after cover removal and prior to maintenance personnel accessing the top of the cask. In accordance with station procedures, personnel performing radiation surveys are required to be qualified health physics technicians. Portable instruments used during surveys are verified to be calibrated and operable prior to use.

DOSE RATE TRENDING

As indicated in the original response to RAI-3-11 dated January 20, 2017, procedures for annual trending of radiation values will be implemented prior to entering the period of extended operation. For the trending, engineering personnel will obtain the annual neutron radiation survey results and the four previous quarterly ISFSI perimeter fence TLD neutron and gamma dose values. The annual neutron dose rates recorded during the survey at reinforced concrete pad No. 1 and the quarterly neutron and gamma TLD readings will be plotted and trended. For each neutron survey location, a separate graph will be plotted. Neutron and gamma TLD readings will also be plotted on separate graphs, with each TLD location uniquely identified on each graph. Each graph will be updated annually so that trends can be easily observed on each graph over the 40-year period of extended operation. The trending evaluation will consider information pertaining to cask loading and movement to assist in evaluating trends in ISFSI dose rates.

Neutron radiation baseline values for each annual neutron radiation survey location and each ISFSI TLD location will be determined prior to entering the period of extended operation. Movement or placement of additional TN-32 dry storage casks at the ISFSI can influence baseline radiation values. Therefore, new baseline values will be established if a TN-32 dry storage cask is removed or if additional TN-32 dry storage casks are placed on reinforced concrete pad No.1, or if the TLD locations are changed.

CORRECTIVE ACTIONS

The annual neutron radiation survey is intended to provide an assessment of the general neutron radiation dose rates at reinforced concrete pad No. 1. As described in

NUREG-1927, Section 3.6.1.4, consistently measuring and trending of neutron dose rates at the same locations conforms to previously accepted aging management sampling practices.

In the event trending shows an unexplained increase in neutron dose rates, the condition will be entered into the Corrective Action Program. As part of the initial corrective actions, health physics personnel will be required to perform detailed cask surveys at multiple axial and radial locations to ascertain the source of increased radiation (i.e., which cask). Additional corrective actions could include increasing the number and frequency of cask surveys, use of temporary shielding, and/or returning the cask to the spent fuel pool to off-load the stored fuel and remove the cask from service. The associated corrective actions and lessons learned will be shared with the industry in the Aging Management INPO Database (AMID). As described in the TN-32 Dry Storage Cask Aging Management Program, the AMID database will also be reviewed periodically to ensure aging management of the neutron shields is consistent with the most recent industry practices.

CONCLUSION

The enhanced neutron detection capability of TLDs located at the ISFSI perimeter fence, supplemented with annual neutron surveys at reinforced concrete pad No. 1, provide reasonable assurance that neutron shield degradation as a result of loss of material and cracking of the shielding material will be adequately managed such that the neutron radiation dose to the public remains acceptable during the period of extended operation. The performance of neutron radiation surveys prior to maintenance activities, in conjunction with personal dosimetry requirements, ensures the safety of occupational workers performing maintenance on the TN-32 dry storage casks.

Enclosure 1

Marked-up Version
Revised Aging Management Programs
(Pages A-1 through A-42)

North Anna Power Station ISFSI
Virginia Electric and Power Company

APPENDIX A: AGING MANAGEMENT PROGRAMS

A1.0 INTRODUCTION

This appendix summarizes the activities that manage the effects of aging for Independent Spent Fuel Storage Installation (ISFSI) subcomponents that have been identified in the North Anna ISFSI License Renewal Application (LRA) as being subject to aging management review. An Aging Management Program (AMP) has been developed for the ISFSI TN-32 dry storage cask, and a separate AMP has been developed for reinforced concrete pad No. 1. Section A2.1 and Section A2.2 provide a description of these AMPs, which includes an introduction to the AMP, an evaluation of the AMP in terms of the aging management program elements, a summary paragraph, and a conclusion.

The Aging Management Reviews (AMRs) in Section 3.0 provide tables that summarize the results of the AMRs. These tables identify the AMPs credited for managing the required aging effects for the applicable subcomponent and structural members listed in the AMR. The identified AMPs manage the aging effects applicable to the subcomponent, and provide reasonable assurance that the integrity of the subcomponent will be maintained during the period of extended operation.

A2.0 AGING MANAGEMENT PROGRAMS

A2.1 TN-32 Dry Storage Cask Aging Management Program

The purpose of the TN-32 Dry Storage Cask AMP is to define the aging management activities which are necessary to help ensure the integrity of the TN-32 dry storage cask. The AMR process identified loss of material from cask metallic subcomponents and loss of material and cracking from polymeric subcomponents as the aging effects of concern [RAI 3-4]. The TN-32 Dry Storage Cask AMP ensures loss of material and cracking from the cask subcomponents will be identified and managed during the period of extended operation prior to loss of intended function [RAI 3-4]. The TN-32 Dry Storage Cask AMP involves continuous monitoring of TN-32 dry storage cask interseal pressure, scheduled and opportunistic cask visual inspections, and radiation monitoring at the ISFSI perimeter fence and at reinforced concrete pad No. 1 [RAI 3-11]. An evaluation of the 10 program elements is presented below.

Element 1: Scope

The intended functions, materials, environments, aging mechanisms, and aging effects of the subcomponents in the scope of this program are identified in Table AMR Results-1, Transnuclear TN-32 Dry Storage Cask. The intended functions of the cask components include pressure boundary (PB), Radiation Shielding (RS), Heat Transfer (HT), Criticality Control (CC), Structural Support (SS), and Retrievability (RT). The aging effects monitored by this program ~~is~~are loss of material and cracking [RAI 3-4].

The mechanisms monitored or inspected by the TN-32 Dry Storage Cask AMP include:

- Galvanic, crevice and pitting corrosion of aluminum in an atmosphere/weather environment for the following components:
  - Lid seals
  - Vent and drain port cover seals
- Crevice and pitting corrosion of stainless steel in an atmosphere/weather environment for the following components:
  - Vent and drain port covers
  - Vent and drain port cover bolts [RAI 3-1]
  - Top neutron shield bolts [RAI 3-1]
  - Lid weld overlay
  - Flange weld overlay
- Radiolytic decomposition and thermal degradation of polypropylene and borated polyester in an air environment for the following components:
  - Top neutron shield
  - Radial neutron shield
- Galvanic, crevice, general, and pitting corrosion of carbon steel and low-alloy steel in an atmosphere/weather environment for the following components:
  - Cask shell
  - Lid
  - Lid bolts
  - Cask bottom
  - Trunnions
  - Outer shell
  - Top neutron shield enclosure
  - ~~Top neutron shield bolts~~ [RAI 3-1]
  - ~~Vent and drain port cover bolts~~ [RAI 3-1]
  - Flange

Element 2: Preventive Actions

This AMP is designated a *condition monitoring* activity. No preventive actions are performed.

Element 3: Parameters Monitored or Inspected

Interseal Pressure Monitoring

The interseal pressure of the TN-32 dry storage cask seals is continuously monitored by redundant pressure switches to verify the integrity of the TN-32 dry storage cask seals. Interseal pressure monitoring detects loss of material from the TN-32 dry storage cask seal subcomponents prior to loss of pressure boundary intended function. The interseal region is pressurized to help provide indication of cask seal integrity. A reduction of interseal pressure could indicate leakage due to loss of material that prevents the seal from performing its pressure-boundary function.

Radiation Monitoring

The radiation monitoring activities of the TN-32 Dry Storage Cask Aging Management Program ensure the radiation dose to members of the public and to occupational workers remains acceptable during the period of extended operation (PEO) [RAI 3-11]. As described in Section 7.3.3 of the ISFSI SAR (Reference A4.1), TLDs located along the perimeter fence are used for monitoring of radiation dose at the North Anna ISFSI. TLDs are capable of detecting gamma, neutron, and beta radiation. Monitoring of gamma and neutron radiation ensures the shielding materials in the cask are capable of performing their intended function. Portable radiation survey meters are used for work on or near reinforced concrete pad No. 1. Airborne radioactivity monitoring is not required because the TN-32 dry storage casks are sealed. The ISFSI is not normally occupied; therefore, area radiation monitors are not required. The TN-32 dry storage casks are also decontaminated prior to transport to the ISFSI.

Loss of material and cracking of the polymer neutron shields are plausible aging effects during the PEO [RAI3-4]. The aging effects can result in increased intermediate and fast neutron flux at the perimeter of the cask. As described in Element 4, the program will be updated to include enhanced detection of intermediate and fast neutrons at the ISFSI perimeter fence and at reinforced concrete pad No. 1 [RAI 3-11].

TLD radiation monitoring is supplemented by surveys performed during and following TN-32 dry storage cask loading, surveys performed prior to and during TN-32 dry storage cask maintenance activities, and quarterly gamma and neutron radiation surveys at the ISFSI perimeter fence. Protection of occupational workers is further assured by limiting access to the ISFSI and requiring gamma and neutron dosimetry be worn when accessing the ISFSI [RAI 3-11].

Radiation monitoring is used to detect loss of material and cracking ~~from~~of shielding components prior to loss of radiation shielding intended function [RAI 3-4].

Visual Inspections

Quarterly visual inspections are performed to detect loss of material from TN-32 dry storage cask visible external surfaces exposed to an atmosphere/weather environment. Visual inspections will also be implemented to detect loss of material from the normally inaccessible exterior locations of the in-service TN-32 dry storage casks. Visual inspections of the dry storage cask bottom and beneath the protective cover will be required during the ~~period of extended operation~~PEO.

A pre-application inspection was performed in 2015. The inspection included lifting one TN-32 dry storage cask to verify the condition of a TN-32 dry storage cask bottom and removal of the protective cover from one TN-32 dry storage cask to verify the condition of the normally inaccessible subcomponents beneath the cover, e.g., neutron shield. The aging effect monitored was loss of material. No detectable loss of material from the base metal was observed during the inspection. Details of the pre-application inspection cask selection and inspection results are presented in Appendix F: Additional Information, Section F2.0.

Visual inspections look for signs of degradation on the exterior surfaces of cask components, as well as rust stains on reinforced concrete pad No. 1. The inspections also identify loose debris next to the cask that could result in a localized area of corrosion. Visual inspections detect loss of material from TN-32 dry storage cask subcomponents prior to loss of pressure boundary, structural support, radiation shielding, and heat transfer intended functions. Loss of material is indicated by localized general corrosion, erosion, or wear. Conditions such as fabrication marks, scratches, surface abrasion, or material roughness, which have no effect on intended functions, are considered non-relevant. The parameter monitored is consistent with those identified in industry codes and standards.

Element 4: Detection of Aging Effects

Detection of the TN-32 dry storage cask aging effects of loss of material and cracking relies on continuous interseal pressure monitoring, TLD radiation monitoring, neutron radiation surveys, and visual inspections (scheduled, opportunistic, and pre-application) [RAI 3-4].

Interseal Pressure Monitoring

TN-32 dry storage cask interseal pressure is monitored continuously by redundant pressure switches at each TN-32 dry storage cask. Twice daily, the Operations Department verifies that no low pressure alarms are present, satisfying ISFSI Technical Specification Surveillance Requirement SR 3.1.4.1. (Reference A4.2). The aging effect monitored is loss of material.

A functional test of the pressure switches associated with each TN-32 dry storage cask is performed every 36 months to satisfy ISFSI Technical Specification Surveillance Requirement SR 3.1.4.2. This procedure verifies the TN-32 dry storage cask as-found interseal pressure, verifies the pressure switches actuate within the required range, and verifies the as-left interseal pressure.

An annual test of the TN-32 dry storage cask alarm panels is performed to ensure the ISFSI visual alarms on the dry storage cask alarm panels and the remote alarm in the Secondary Alarm Station respond to a test signal. This annual test also verifies alarms actuate on loss of power to the panels.

Excessive leakage past the TN-32 dry storage cask seals due to loss of material (corrosion) would actuate an alarm in the Secondary Alarm Station, which would initiate actions to verify seal integrity in accordance with approved procedures. Seal leakage is classified in accordance with the site Emergency Plan Implementing Procedures.

Discrepancies noted during the above monitoring activities are entered in the Dominion Corrective Action Program. The results of interseal pressure monitoring activities are maintained in Station Records.

Radiation Monitoring [RAI 3-11]

Each TN-32 dry storage cask is equipped with a top and radial polymer neutron shield. The top and radial neutron shields perform their intended functions by moderating neutrons originating in the stored fuel. The radial neutron shield is impregnated with boron to further reduce neutron dose at the dry storage cask perimeter by absorption of neutrons. With respect to neutron shielding, the TN-32 dry storage casks stored on reinforced concrete pad No. 1 are identical in design and construction. The neutron source term is unique for each cask, and is a function of fuel enrichment, fuel burnup, and fuel storage time.

Radiation monitoring of the ISFSI is currently provided by TLDs located at the ISFSI perimeter fence. Neutron and gamma radiation doses are obtained quarterly from the perimeter fence TLDs and trended.

Loss of material and cracking of the neutron shield polymer results in an upward shift in neutron energy and an increase in the neutron flux at the cask perimeter. The polymer material used in the TN-32 dry storage cask radial neutron shield is encased in rigid aluminum boxes around the cask shell. This structure minimizes movement and displacement of the polymer material that may result from loss of material and ultimately cracking. Although neutron streaming from the cask is considered unlikely, the TN-32 Dry Storage Cask Aging Management Program will be further enhanced to include modification of the TLDs located at the ISFSI perimeter fence to include enhanced neutron detection of intermediate and fast energy neutrons and performance of neutron radiation surveys at reinforced concrete pad No. 1.

The TLDs currently in use at North Anna are capable of detecting neutrons with energies ranging between thermal and 6 MeV. The TLD response, however, decreases significantly as neutron energy increases. To compensate for the reduced response at higher energies, each TLD at the ISFSI perimeter fence will be equipped with an additional chip, such as a CR 39 polycarbonate chip, or equivalent, to improve detection of neutrons in the intermediate and fast neutron energy spectra. Over 98% of the neutrons originating in the stored fuel (prior to moderation) are at energy levels below 6.38 MeV. The CR 39 chip has a relatively flat response to neutron energies in the range of 200 keV to 6 MeV. The additional chip, in combination with the TLDs currently in use at North Anna, will therefore provide a representative indication of neutron dose resulting from thermal, intermediate, and fast neutrons.

The radiation monitoring activities of the TN-32 Dry Storage Cask Aging Management Program will be further enhanced by the performance of annual neutron radiation surveys around the entire perimeter of reinforced concrete pad No.1 using a tissue equivalent proportional counter, such as the REM 500 neutron survey meter.

The annual neutron radiation survey will measure and record the neutron radiation levels at thirty-two locations around the cask array. Neutron measurements will be recorded at fifteen locations along the long axis of the reinforced concrete pad No. 1 on both the east and west sides at a point centrally located between every two adjacent casks and extending past the last cask on each end. The dose rate readings will be measured and recorded at a distance of approximately one foot outward from the edge of reinforced concrete pad No. 1. One additional measurement will be recorded at along the short axis at a point centrally located between the two casks at each end of the reinforced concrete pad No. 1.

All neutron dose rate readings will be taken at an approximate elevation corresponding to the maximum neutron flux. An elevation corresponding to the maximum neutron flux is the most likely location for radial neutron shield degradation to occur, and therefore serves as a leading indicator for axial and radial locations not specifically monitored during the annual neutron survey. The TN-32 dry storage cask elevation corresponding to the maximum neutron flux, as well as the survey locations will be specified in a station procedure.

A tissue equivalent proportional counter, such as the REM 500 neutron survey meter, will be used to measure neutron dose rate at all survey points. The REM 500 neutron survey meter is a sealed spherical tissue equivalent proportional counter that has a relatively linear dose rate response to neutron energies in the range of 70 keV to 20 MeV. For the annual neutron surveys, the REM 500 survey meter will be operated in accordance with the manufacturer's recommendations and station procedures, with sufficient count time to ensure the statistical accuracy of the measurements.

Dominion has previous operating experience using bubble dosimeters to determine the neutron energies at various distances from a TN-32 dry storage cask. The results revealed that nearly 100% of the neutrons at the cask surface have energies greater than 100 keV, while at a distance of ten feet, approximately 70% of the neutrons have energies greater than 100 keV. Given that 98% of the neutrons in a TN-32 dry storage cask have energies less than 6.38 MeV, the REM 500 neutron survey meter is capable of detecting neutrons emitted from a dry storage cask. Dominion has also used the REM 500 neutron survey meter to measure the neutron dose rates from a TN-32 dry storage cask with, and without, the top neutron shield in place. The dose rate measurements were recorded at a distance of approximately six feet above the top of the cask. The results of the survey are provided below:

Table A2.1-1 TN-32 Dry Storage Cask REM 500 Dose Rates

Location	mrem/hr (shield in place)	mrem/hr (shield removed)
Center of Cask Lid	0.3388	19.56
Above Lid Penetration B	0.75	10.4
Edge of Lid Bolt No. 10	1.771	10.01

The above results confirm the ability of the REM 500 neutron survey meter to detect the shift in neutron energies that would result from a loss of material and cracking of the shielding material.

The annual frequency of the neutron survey is justifiable based on continuous monitoring and quarterly reading of doses to the public by TLDs capable of detecting the neutron energies emitted by the TN-32 dry storage casks. Occupational workers are protected by the Dominion Radiological Work Control Program, as described below.

Personnel access to the ISFSI is restricted by a fence with locked gates. Station Security monitors the ISFSI and controls facility access. The Dominion Radiological Work Control Program requires a Radiation Work Permit (RWP) be prepared for maintenance activities at the ISFSI. The RWP ensures occupational workers are protected when work is performed in radiological controlled areas. When an RWP is initiated, health physics technicians perform surveys to determine the general radiological conditions at the job site, thus providing another opportunity to detect adverse conditions around the TN-32 dry storage cask(s). The RWP contains the survey results and additional radiological information necessary to protect maintenance personnel, such as required protective clothing, respirator requirements, and dose and dose rate limits. The RWP also specifies the required dosimetry for entry into the ISFSI. All activities in the vicinity of the TN-32 dry storage casks require neutron and gamma dosimetry to be worn. Maintenance personnel are restricted from entering the ISFSI boundary until they have read and understand the contents of the RWP, and have been briefed by health physics personnel.

For TN-32 dry storage cask maintenance activities (e.g., removal of a protective cover) an additional detailed neutron and gamma survey is performed prior to allowing maintenance to commence. For example, when a protective cover is removed, a detailed neutron survey of the top of the TN-32 dry storage cask is performed immediately after cover removal and prior to maintenance personnel accessing the top of the TN-32 dry storage cask. In accordance with station procedures, personnel performing radiation surveys are required to be qualified health physics technicians. Portable instruments used during surveys are verified to be calibrated and operable prior to use.

The annual neutron radiation survey at reinforced concrete pad No. 1 does not perform a detailed survey of individual casks and does not specifically identify an individual cask that has experienced cracking of the neutron shield. The survey is intended to provide an assessment of the general neutron radiation dose rates at reinforced concrete pad No. 1. When increasing trends are detected the condition will be entered into the Corrective Action Program. Corrective actions will require detailed surveys of individual casks to identify the source of the increased dose rates (Refer to Element 7).

The performance of health physics surveys prior to maintenance activities, in conjunction with personal dosimetry requirements, ensures the safety of occupational workers performing maintenance on the TN-32 dry storage casks. The enhanced neutron detection capability of TLDs located at the ISFSI perimeter fence, supplemented with annual neutron surveys at reinforced concrete pad No. 1, will provide reasonable assurance that the loss of material and cracking of the neutron shielding material will be adequately managed such that the neutron radiation dose to the public remains acceptable during the period of extended operation.

~~Detection of gamma and neutron radiation is accomplished by placement of TLDs at the ISFSI perimeter fence. The TLDs are capable of detecting neutrons with energy levels up to approximately 6 MeV, which represent 98 percent of the neutron population in the TN-32 dry storage cask prior to neutron moderation. While TLDs may not be capable of detecting all neutrons, they are effective in detecting adverse trends in neutron dose at the ISFSI perimeter fence.~~

~~TLD readings are obtained quarterly and recorded in approved Health Physics procedures. Results from this monitoring activity provide a means to detect deterioration of the TN-32 dry storage cask gamma and neutron shield. The quarterly monitoring of TLD readings is~~

~~used as an indicator that loss of material from the radiation shield is detected prior to a loss of intended function.~~

~~TLD radiation monitoring is supplemented by surveys performed during and following cask loading, surveys performed prior to and during cask maintenance activities, and quarterly surveys at the ISFSI perimeter fence. Calibration of survey instruments is verified prior to use.~~

~~Discrepancies noted during the above monitoring activities are entered into the Dominion Corrective Action Program. The monitoring results are maintained in Station Records.~~

~~ISFSI Technical Specification Limiting Condition for Operation 3.3.1 places limits on the maximum combined gamma and neutron dose rate at the sides and top of the TN-32 dry storage cask prior to transporting the dry storage cask to reinforced concrete pad No. 1 (Reference A4.2). These limits ensure that the dry storage cask average surface dose rates during transport, storage, and dry storage cask unloading are within the estimates contained in the ISFSI Safety Analysis Report (Reference A4.1).~~

Visual Inspections

Visual inspections identify loss of material on the external surfaces of the TN-32 dry storage cask subcomponents prior to loss of intended function. Quarterly visual inspections, performed by the system engineer are general inspections that are performed consistently with requirements for plant walkdowns to identify signs of coating defects, debris in the vicinity of the TN-32 dry storage casks, rust spots and stains, rust stains on reinforced concrete pad No. 1, physical damage, and bottom corrosion at the concrete/TN-32 dry storage cask interface. Quarterly inspection results have identified coating deficiencies but no visible loss of base material. Non-destructive examination (NDE) qualification is not required to perform the quarterly inspection.

The outer surfaces of the following carbon steel and low-alloy steel subcomponents requiring aging management are exposed to an atmosphere/weather environment and ~~are either fully or partially observable~~ will be inspected by an individual standing at ground level during the quarterly visual inspection: [RAI 3-9]

- Bottom vertical surfaces
- ~~Cask~~ Shell (partially visible)
- Outer Shell
- Trunnions (partially visible)
- Flange vertical surfaces (fully visible)

The following carbon steel and/or low-alloy steel dry storage cask subcomponents requiring aging management are exposed to an atmosphere/weather environment, but are not visible during the quarterly inspection: [RAI 3-9]

- Lid
- ~~Cask~~ Bottom horizontal surfaces
- Top Neutron Shield Enclosure
- Top Neutron Shield Bolts
- Lid Bolts
- Vent and Drain Port Cover Bolts

No stainless steel subcomponents requiring aging management are visible during the quarterly inspection. Procedures will be enhanced to identify the subcomponents that are fully visible and partially visible during the quarterly visual inspection. [RAI 3-9]

Inspection activities will be expanded to include opportunistic and scheduled NDE inspections of a TN-32 dry storage cask bottom and the subcomponents beneath a protective cover. Visual inspection of the flange stainless steel weld overlay and carbon and low-alloy steel subcomponents serve as a leading indicator for stainless, carbon, and low-alloy steel subcomponents requiring aging management, but not visible during the opportunistic and scheduled inspections, e.g., vent and drain port covers and bolts.

In the event a TN-32 dry storage cask is lifted, or a protective cover is removed, an opportunistic visual inspection will be performed on these normally inaccessible locations. A scheduled visual inspection of these locations will be performed on a frequency of every 20 ± 5 years from the date of the pre-application inspections conducted in October and November 2015 [RAI 3-10]. The selection criteria for the 20-year scheduled inspection will be the same as the criteria used to select the casks for the pre-application inspection (Refer to Section F2.1). The pre-application inspections did not identify loss of material from the base metal on the bottom of cask TN-32.49 or beneath the protective cover of cask TN-32.23 (Refer to Section F2.2). North Anna is located in a rural part of Virginia on a freshwater lake and is not located near industrial or chemical facilities. The TN-32 dry storage casks are not exposed to brackish water, saltwater spray, or high-sulfur emissions. An inspection frequency of 20 ± 5 years is therefore acceptable to detect loss of material prior to loss of intended function. The sample size of one cask is consistent with prior license renewal applications approved by the NRC.

The outer surfaces of the following subcomponents requiring aging management will be inspected by an individual standing on top of a cask whenever a protective cover is removed, and at least every 20 +/- 5 years: [RAI 3-9]

- Lid (partially visible)
- Lid Bolts and Neutron Shield Bolts (partially visible)
- Top Neutron Shield (partially visible)
- Flange horizontal surfaces including stainless steel weld overlay (partially visible)
- Trunnions (partially visible)

The horizontal surfaces of the cask bottom will be inspected whenever a cask is lifted, and at least every 20 +/- 5 years [RAI 3-10].

Dominion has chosen to utilize standard industry visual inspection techniques in accordance with NUREG-1927 (Reference A4.3). Opportunistic and 20-year scheduled TN-32 dry storage cask visual inspections will be performed by personnel qualified to perform visual inspections, i.e., VT-1 and VT-3. VT-1 and VT-3 examinations are performed per Dominion NDE Fleet procedures. VT-1 inspections are utilized for specific components/subassembly inspections and VT-3 inspections are utilized for general assembly inspections. In general, the inspection requirements of the VT-1 examination are more stringent than that of the VT-3 examination. For example, the maximum examination distance for a VT-1 examination is less than that allowed for a VT-3 examination. Refer to Section XI, Subarticle IWA-2210 of the ASME Boiler and Pressure Vessel Code for additional information on visual examination techniques.

The specific visual inspection methods that will be used for opportunistic and 20-year scheduled inspections of the TN-32 dry storage casks are as follows:

- Protective cover and subassembly interior/exterior surfaces (VT-3)
- Cask flange visible surfaces (VT-1)
- Overpressure system visible surfaces (VT-3)
- Neutron shield visible surfaces (VT-3)
- Cask lid visible surfaces and lid bolt heads (VT-3)
- Neutron shield bolts (VT-1 and/or VT-3)
- Protective cover bolts (VT-1 and/or VT-3)
- Upper and lower trunnions (VT-3)
- Cask bottom surface (VT-3)

The neutron shield and protective cover bolts inspection technique will be either a VT-1 or VT-3 examination depending upon whether the bolt is installed (VT-3) or if the bolt is removed for detailed examination (VT-1).

A pre-application visual inspection was also performed in Fall 2015. VT-1 and VT-3 examination methods were utilized during the inspection. Details of the TN-32 pre-application inspection are contained in Appendix F: Additional Information, Section F2.0.

Discrepancies noted during the above inspections are entered in the Dominion Corrective Action Program. The results of visual inspection activities are maintained in station records and will be evaluated for entry in AMID using the screening criteria of NEI 16-10, recommended in NEI 14-03 [RAI 3-14]. The visual inspection activities ensure loss of material is detected in TN-32 dry storage cask subcomponents prior to loss of intended function.

Element 5: Monitoring and Trending

The inspections and monitoring activities in this AMP are all performed periodically in order to identify areas of degradation. Results will be evaluated by qualified individuals consistent with industry guidelines, standards and regulations. Conditions adverse to quality noted during the inspection and monitoring activities, such as non-conformances, failures, malfunctions, deficiencies, deviations, or defective material and equipment are entered into the Dominion Corrective Action Program. Depending on significance, a more focused evaluation may be required to determine the extent of condition and determine if more frequent monitoring or inspection is required. As discussed below, visual inspections and radiation monitoring assessments appropriately consider cumulative experience from previous inspections and assessments in order to monitor and trend the progression of aging effects over time. Additionally, the Dominion Corrective Action Program includes trending of adverse conditions (including those related to interseal pressure monitoring, radiation monitoring, and visual inspections) as well as a process to prevent recurrence.

An enhancement will be made to perform an engineering evaluation every five years to review industry and plant-specific operating experience (including work order history). The initial operating experience evaluation during the period of extended operation will be scheduled to occur in January 2020 [RAI 3-10]. The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage the loss of material and cracking for the TN-32 dry storage casks [RAI 3-4]. Each element of the TN-32 Dry Storage Cask Aging Management Program will be reviewed to determine if updates to the AMP are required based on lessons learned from the operating experience review.

The results of the engineering evaluation will be entered in the Aging Management INPO Database (AMID), using the screening criteria as recommended in NEI 14-03, Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management [RAI 3-14].

Interseal Pressure Monitoring

Pressure monitoring of each TN-32 dry storage cask at the ISFSI is a continuous process. The absence of low pressure alarms is confirmed twice daily by the Operations Department. The functionality of the pressure switches is confirmed every 36 months. Pressure switches that do not meet established acceptance criteria are entered in the Dominion Corrective Action Program. Corrective actions include adjustment or replacement as well as review for extent of condition.

Radiation Monitoring [RAI 3-11]

In accordance with Dominion radiation survey procedures, neutron and gamma TLD readings are recorded quarterly and neutron survey results conducted at reinforced concrete pad No. 1 will be recorded annually. Annual trending of these parameters will be incorporated in the radiation survey procedures.

~~As previously described, both TLD readings and radiation survey readings taken at the ISFSI perimeter fence are evaluated quarterly.~~ Tables A2.1-~~1~~2 and A2.1-~~2~~3 provide the maximum and minimum historical neutron and gamma quarterly dose rates at the ISFSI perimeter fence from first quarter 2006 through fourth quarter 2015. Dose rates were determined by dividing the quarterly TLD dose by the number of exposure hours in the quarter.

Table A2.1-2 ISFSI Historical Neutron Dose Rates (2006 through 2015)

North Dose Rate (microrem/hr)		East Dose Rate (microrem/hr)		South Dose Rate (microrem/hr)		West Dose Rate (microrem/hr)	
Max	Min	Max	Min	Max	Min	Max	Min
118	35	64	18	157	43	96	26

Table A2.1-3 ISFSI Historical Gamma Dose Rates (2006 through 2015)

North Dose Rate (microrem/hr)		East Dose Rate (microrem/hr)		South Dose Rate (microrem/hr)		West Dose Rate (microrem/hr)	
Max	Min	Max	Min	Max	Min	Max	Min
16	5	18	4	26	11	24	10

The review of historical dose rates at the ISFSI perimeter fence shows no evidence that the neutron and/or gamma shielding is degrading. Notwithstanding, an enhancement will be implemented to perform an annual evaluation of ISFSI perimeter fence TLD radiation measurements and annual reinforced concrete pad No. 1 neutron radiation survey results for adverse trends ~~to ensure that deterioration of the TN-32 dry storage casks gamma and neutron shield material is detected prior to loss of intended function. Based on the review of 10 years of ISFSI boundary dose rates, quarterly recording and annual trending of dose rates at the ISFSI perimeter fence is adequate to detect a loss of shielding material prior to loss of intended function~~. These measures ensure that deterioration of the TN-32 dry storage casks gamma and neutron shield material is detected prior to loss of intended function.

~~Quarterly radiation surveys at the ISFSI perimeter fence and surveys associated with TN-32 dry storage cask loading and maintenance are performed to supplement the overall radiation monitoring program.~~

Dominion will develop procedures for annual trending of radiation values prior to entering the PEO. Engineering personnel will obtain the annual neutron radiation survey results conducted at reinforced concrete pad No. 1 and the four prior quarterly ISFSI perimeter fence TLD neutron and gamma dose values. The annual neutron dose rates recorded at each survey point and the quarterly neutron and gamma TLD readings will be plotted and trended. A separate graph will be plotted for each neutron radiation survey point. Neutron and gamma TLD readings will also be plotted on separate graphs, with each TLD location uniquely identified on each graph. Each graph will be updated annually so that trends can be easily observed on each graph over the 40-year PEO. The trending evaluation will consider information pertaining to cask loading and movement to assist in evaluating trends in ISFSI dose rates.

Baseline radiation values for TLD locations and annual survey locations will be established prior to the PEO. Movement or placement of additional TN-32 dry storage casks at the ISFSI can influence baseline radiation values. In the event a TN-32 dry storage cask is removed or additional casks are placed on reinforced concrete pad No.1, new baseline values will be established. In the event the TLDs located at the ISFSI perimeter fence are relocated, new TLD baseline values will be established.

Identification of an increasing trend in radiation values will require the condition to be entered in the Corrective Action Program.

Visual Inspections

Quarterly visual inspections determine the existence of loss of material in the TN-32 dry storage cask exterior regions and check for accumulation of debris and concrete staining. Observations regarding the material condition of the TN-32 dry storage casks external surfaces are recorded per the inspection procedure. 20-year scheduled and opportunistic visual inspections of normally inaccessible areas will be included in the aging management program in addition to the quarterly visual inspections.

As described in Element 4: Detection of Aging Effects, an enhancement will be made to perform a visual inspection of the normally inaccessible areas of a TN-32 dry storage cask(s) including a cask bottom and under a protective cover at least every 20 ± 5 years. Prior inspection results (including pre-application inspection results) will be reviewed to identify adverse trends. The pre-application inspections (refer to Element 10: Operating Experience) did not identify any detectable loss of material from the bottom of cask TN-32.49 or under the protective cover of cask TN-32.23. North Anna is located in a rural area of Virginia on a freshwater lake and is not located near industrial or chemical facilities. The TN-32 dry storage casks are not exposed to brackish water, saltwater spray, or high-sulfur emissions. An inspection frequency of every 20 ± 5 years is adequate to detect loss of material prior to loss of an intended function.

Element 6: Acceptance Criteria

The TN-32 Dry Storage Cask Aging Management Program acceptance criteria ensure that the particular structure and component intended functions are maintained under the existing licensing-basis design conditions during the ~~period of extended operation~~PEO.

Interseal Pressure Monitoring

The acceptance criterion for interseal pressure monitoring is the absence of a low pressure alarm. The alarm setpoint of 3,250 mbar is specified in ISFSI Technical Specifications Table 3-1 (Reference A4.2). Dominion procedures document the required setpoint tolerance. A Condition Report is entered into the Corrective Action Program for any pressure switch that actuates at less than the required setpoint or outside of the required tolerance.

Radiation Monitoring [RAI 3-11]

The aging management program will be enhanced to include annual trending of quarterly TLD neutron and gamma radiation measurements at the ISFSI perimeter fence and annual trending of neutron radiation survey results conducted annually at reinforced concrete pad No. 1. The acceptance criteria for trending of quarterly neutron and gamma TLD readings, and for trending of annual reinforced concrete pad No. 1 neutron survey results, is the absence of an increasing trend in radiation values, as determined by engineering evaluation. ISFSI Technical Specification Limiting Condition for Operation 3.3.1 places limits on the maximum combined neutron and gamma dose rates at the sides and top of a TN-32 dry storage cask prior to transporting a dry storage cask to reinforced concrete pad No. 1. These limits are intended to ensure that the dry storage cask average surface dose rates during transport, storage, and unloading are within the values contained in the SAR. The limits provide assurance that the dose to the general public is minimized, and the dose to occupational workers is as low as reasonably achievable.

After transport of a cask to the ISFSI, additional factors influence the measured dose at an individual cask, including the radiation emitted from adjacent casks and the decay of the spent fuel neutron source term. A direct correlation cannot be made between the measured dose rate for a cask located at the ISFSI to the dose rate measured for the cask prior to transport to the ISFSI (and the Technical Specification dose rate limits). However, the absence of an increasing trend would demonstrate that measured dose rates remain within the values contained in the SAR. ~~The acceptance criterion for radiation monitoring is the absence of an increasing trend (as determined by Engineering evaluation) in neutron and gamma quarterly TLD readings at the ISFSI perimeter fence.~~

Visual Inspections

The acceptance criteria for the quarterly visual inspections are:

- No coating defects (bubbling/blistering of paint)
- No loose debris in contact with the cask(s)
- No rust spots and stains
- No rust stains on the concrete
- No physical damage
- No baseplate corrosion at the concrete/cask interface

The acceptance criterion for the opportunistic and scheduled inspections of the TN-32 dry storage cask will be no detectable loss of material from the base metal as determined by VT-1 and/or VT-3 visual inspection.

Indications adverse to quality identified during the above inspection and monitoring activities, e.g., flaking of TN-32 dry storage cask coating, are entered into the Dominion Corrective Action Program for further evaluation. This low corrective action threshold ensures all conditions adverse to quality are captured and evaluated. If required, the engineering evaluation would include support by qualified Non-Destructive Examination staff to perform additional inspections to assess the extent of condition.

Element 7: Corrective Actions

Corrective actions for deviating conditions that are adverse to quality, e.g., failures, malfunctions, deficiencies, deviations, defective material and equipment, and non-conformances, are performed in accordance with Dominion Topical Report DOM-QA-1, "Nuclear Facility Quality Assurance Program Description" (Reference A4.4). Adherence to DOM-QA-1 ensures that, as required by 10 CFR 50, Appendix B, an adequate quality assurance program is implemented.

The Dominion Corrective Action Program is implemented in accordance with a nuclear fleet administrative procedure. The administrative procedure includes expectations for identification and reporting of conditions adverse to quality, conditions that affect personnel safety, nuclear safety, plant reliability, trending, and other conditions that do not meet station expectations. For conditions determined to be significantly adverse to quality the procedure provides measures to provide reasonable assurance that the cause of the condition is determined, corrective action is taken in a timely and accurate manner to preclude repetition, and the cause and corrective actions taken are documented and reported to appropriate levels of management. A condition significantly adverse to quality is defined as a condition adverse to quality that has, or if left uncorrected could have, an undesirable effect on plant safety, regulatory position, or environmental impact.

Station deficiencies are identified by the submission of condition reports (CRs). An attachment to the administrative procedure provides a detailed list of examples of conditions that require submission of a CR. At a minimum, CRs are submitted for any issue or concern that does not meet specific requirements of procedures, policies, management expectations, or accepted industry standards including all conditions that do not meet the AMP acceptance criteria. CRs are also required to be submitted for any issue where there is doubt about whether a CR should be submitted. The procedure also provides guidance for submittal of CRs anonymously.

Submitted CRs are initially reviewed by the submitters' supervisor. The supervisor answers screening questions to determine if Operations Shift Manager review is required. If so, the shift manager, or designee, performs an operability assessment. As required by 10 CFR 72.75, reportability determinations are also made. Further review of the CR is then performed by the Condition Report Review Team (CRT).

The CRT is a multi-discipline, multi-departmental team consisting of members from Engineering, Maintenance, Operations, Radiation Protection, Training, and Organizational Effectiveness. At least one member of the CRT should have, or previously held, a Senior Reactor Operators license. Functions of the CRT include:

- Identifying conditions that are adverse to quality
- Establishing corrective action assignments
- Assigning required significance level and level of evaluation to CRs (e.g., Root Cause Evaluation)
- Reviewing CRs for trending and notifying the Trend Coordinator for submission of an additional CR to address trending aspects
- Reviewing CRs for safety implications
- Reviewing CRs for initiation of work management activities
- Recommending compensatory measures
- Identifying events that should be communicated to the industry via the INPO Consolidated Event System
- Notifying senior management of significant events

CRs identified as adverse to quality by the CRT are further reviewed by the Corrective Action Assignment Review Team (CAART). The CAART is generally comprised of senior-level management, Manager level and above, and includes the Plant Manager. The CAART reviews the results and recommendations of the CRT and has the authority to make changes when appropriate. The CAART also identifies selected issues to be reviewed by the Facility Safety Review Committee.

The response to corrective action assignments is reviewed to verify the adequacy of the response and proposed corrective actions, including no corrective action. CRT or CAART may assign additional reviews when appropriate.

A self-assessment is performed at least every two years to determine the effectiveness of the Corrective Action Program. An aggregate review of all open conditions designated as adverse to quality is performed at least every eighteen months to ensure appropriate priorities have been assigned to these outstanding issues.

In the event ISFSI radiation trending shows an unexplained increase in neutron dose rates, the condition will be entered into the Corrective Action Program. The response to the condition will require health physics staff to perform more detailed cask surveys at multiple axial and radial locations to ascertain which cask is the source of increased radiation. The corrective actions could include increasing the number and frequency of cask surveys, use of temporary shielding, and/or returning the cask to the spent fuel pool to off-load the stored fuel and removal of the cask from service. As described in Element 10, the associated corrective actions and lessons learned will be shared with the industry in the AMID database. Dominion will also review the AMID database periodically to ensure aging management of the neutron shields is consistent with the most recent industry practices. [RAI 3-11]

Element 8: Confirmation Process

Adherence to the Dominion Quality Assurance Program ensures that, as required by 10 CFR Part 50, Appendix B, an adequate quality assurance program is implemented. The Quality Assurance program includes provisions for timely evaluation of adverse conditions, and implementation of any corrective actions required, including root cause evaluations and actions to prevent recurrence. Procedural controls are in place to ensure the response to corrective action assignments is reviewed to verify the adequacy of the response and the corrective actions. Condition reports are also reviewed for trending purposes.

An engineering evaluation will be performed every five years to review industry and plant-specific operating experience (including work order history). Each element of the aging management program will be reviewed to determine whether updates to the program are required based on lessons learned from the operating experience review. The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage loss of material ~~from~~and cracking of the TN-32 dry storage casks. [RAI 3-4]

Element 9: Administrative Controls

All activities associated with the North Anna ISFSI that are important to safety are conducted in accordance with Dominion Topical Report DOM-QA-1, "Nuclear Facility Quality Assurance Program Description" (Reference A4.4). Adherence to DOM-QA-1 ensures that, as required by 10 CFR 50, Appendix B, an adequate quality assurance program is implemented. DOM-QA-1 includes guidance for inspector requirements, record retention requirements, and document control. Administrative and technical procedures are reviewed, approved, and maintained as controlled documents in accordance with the Dominion procedure control process and the Quality Assurance Program. Administrative controls have been established to ensure records are identified, retained, maintained, and retrievable. Approved procedures define record retention requirements and storage methods.

Element 10: Operating Experience

The Dominion operating experience (OE) program is implemented in accordance with an administrative procedure. The goal of the OE Program is to effectively and efficiently use lessons learned from the industry to improve safety and reliability and to reduce the number and consequence of events. The procedure includes applicability screening of OE reports from the NRC, INPO, and vendors. Guidelines for use of the INPO Nuclear Network Forums are included in the procedure. The procedure also stipulates OE coordinator trending reviews at set frequencies and OE coordinator qualification requirements.

As stated in Element 8: Confirmation Process, additional reviews occur during the engineering evaluation of industry and plant-specific operating experience that will occur every five years to determine whether updates to the aging management program are needed to address lessons learned. The historical absence of significantly adverse findings for the ISFSI confirms that a review interval of five years is sufficient to address the potential need for any changes to the aging management programs.

A separate administrative procedure provides instruction for submitting Dominion OE to the INPO Consolidated Event System (ICES). The purpose of this procedure is to provide a method for identification and reporting of INPO ICES reports. The procedure includes reporting criteria and required reporting time frames. The review and sharing of operating experience will be enhanced to include use of the Aging Management INPO Database (AMID) in accordance with NEI 14-03, Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management. Additionally, the ISFSI component inspection results will be evaluated and entered into the AMID database using the screening criteria of NEI 16-10, as recommended by NEI 14-03. [RAI 3-14]

Key word searches were performed of the Dominion Corrective Action Program and the INPO OE database to ensure the aging effects of concern are accurately identified and lessons learned are reviewed for applicability to NAPS. The OE searches included a review of industry and North Anna and Surry-specific OE. The INPO OE database includes international and NRC related information. Transnuclear vendor bulletins were also reviewed. The review of the Dominion Corrective Action Program utilized the following search terms:

- Cask
- ISFSI
- TN-
- Transnuclear

The review of the INPO OE database utilized the following search terms:

- ISFSI
- Dry Storage
- Dry Cask
- Transnuclear

Table A2.1-4, North Anna ISFSI Aging-related Operating Experience, provides a listing of North Anna-specific OE directly related to aging of SSCs in the scope of license renewal and a brief summary of the corrective actions taken. The events can be categorized into TN-32 dry storage cask coating deficiencies and dry storage cask low pressure alarms, the most significant being low pressure alarms. Further discussion of these events is provided later in this section.

Table A2.1-4 North Anna ISFSI Aging-related Operating Experience

Date	Report	Title	Description/Corrective Actions
06/18/00	N-2000-1551	Crack in TN-32.06 Cask Coating	The coating was repaired in accordance with the manufacturer's instructions.
02/01/10	CR367334	TN-32.48 Pressure Alarm Response	Following a low pressure alarm, troubleshooting revealed the overpressure system (OP) pressure was less than the alarm setpoint but greater than the Technical Specification minimum required value. The OP system pressure was returned to normal. Helium leaks checks did not identify leakage from the OP System. Engineering recommended OP system pressure be checked during the performance of the scheduled pressure switch test the following month. OP system pressure and alarm setpoints were verified to be normal on March 9, 2010. No further actions were required. The OE review did not identify any additional low pressure alarms for dry storage cask TN-32.48. It was also noted during troubleshooting that one of the two pressure switches failed to alarm. This pressure switch was replaced.
8/29/2011	CR440206	ISFSI Pad 1 TN-32 Paint	During a walkdown following the seismic event of 8/23/2011, a concern was identified that the dry storage cask bottom coating may have been scratched due to movement of the dry storage casks. Transnuclear provided a response stating that no repair of the coating was required. The quarterly visual inspection procedure was revised to include inspection for bubbled/blistering paint and corrosion product stains on reinforced concrete pad No. 1 near the dry storage cask bottom. (Note: The results of the pre-application inspection performed in 2015 did identify deterioration of the bottom protective coating, but no detectable loss of material from the dry storage cask base metal.)
01/24/13	CR503456	Documentation of 0-PT-4.3 results	Rust stains resulting from coating defects (e.g., flaking) were noted on several dry storage casks and reinforced concrete pad No. 1 adjacent to the dry storage casks. It was concluded since these conditions are superficial that immediate action was not required. A work order was written to remove rust stains from concrete and TN-32 dry storage casks.

Table A2.1-4 North Anna ISFSI Aging-related Operating Experience

Date	Report	Title	Description/Corrective Actions
01/13/14	CR536973	Documentation of 0-PT-4.3 results	Items noted on this inspection were previously identified in CR503456. A comparison of pictures taken on 5/2/13 did not indicate further degradation had occurred. No further action was required other than continued monitoring during the quarterly visual inspections.
07/14/14	CR553872	Coating deficiencies found during 0-PT-4.3	Superficial coating defects, e.g., scratches, paint flaking, etc., were noted on three dry storage casks with no base metal exposed.
09/21/15	CR1010377	Cask TN-32-32 Over Pressure System Low Pressure Alarm	Initial troubleshooting of the cask low pressure alarm confirmed proper operation of the pressure switches and did not identify helium leakage from the overpressure system. Engineering established dry storage cask pressure monitoring frequency of once per month. Monitoring results were provided to Engineering for trending.
10/03/15	CR1012049	TN-32.37 low pressure switch alarm	Investigation revealed a face seal on a pressure switch was leaking. The seal was replaced and overpressure system pressure was restored to normal pressure.
10/14/15	CR1013461	ISFSI License Renewal, Bottom of Cask TN-32.49 Inspection Results	This condition report was written to document the completion of the pre-application cask bottom inspection. Engineering evaluation of results concluded that no corrective actions were required. Refer to Section F2.2.
11/18/15	CR1018794	TN-32.23 Cask Inspection results	This condition report was written to document the completion of the pre-application cask top inspection. Engineering evaluation of the results concluded that no corrective actions were required. Refer to Section F2.2.

As part of the OE review, recent license renewal applications submitted by Prairie Island Nuclear Generating Station and Calvert Cliffs Nuclear Power Plant were reviewed. The review confirmed the aging effects identified, associated examination techniques, and acceptance criteria are consistent with the industry.

The EPRI Dry Cask Storage Characterization Project documents an aging study of a Castor V/21 dry storage cask after approximately 15 years of dry storage. The project identified corrosion of stainless steel fasteners used to attach the V/21 dry storage cask rear breech plate, i.e., dry storage cask bottom. North Anna does not use Castor V/21 dry storage casks. Fuel rods from the Castor V/21 dry storage cask having a burnup of 35.7 GWD/MTU were removed and studied by Argonne National Laboratory (ANL). No detrimental aging of the low burnup fuel rods was identified.

Several technical data gaps have been identified related to the aging effects of V/21 dry storage casks and spent fuel, e.g., cladding hydride reorientation and embrittlement. The U.S. Department of Energy Office of Nuclear Energy developed the Gap Analysis to Support Extended Storage of Used Nuclear Fuel report to identify and prioritize the data gaps. This report was reviewed to ensure all technical data gaps were identified and prioritized correctly and to compare the gaps with those identified in similar reports from various agencies, including international studies. It was recommended that low burnup fuel from the Castor V/21 dry storage cask initially inspected by ANL be reexamined to better understand the long-term aging of low burnup fuel. It was noted that the fuel initially examined by ANL was loaded into a dry cask as opposed to one that experienced the prototypical drying cycle. The examined fuel, therefore, was not exposed to the residual moisture that may be present in a typical dry storage cask such as those in use at North Anna.

As identified in Section A3.0, Summary, Dominion has committed to reviewing industry operating experience to ensure the aging effects, inspection techniques, inspection frequencies, and acceptance criteria are consistent with the most recent industry standards and practices. The resolution of the technical data gaps described above will be included in the operating experience review.

Interseal Pressure Monitoring Operating Experience

A review of operating experience related to the TN-32 dry storage cask interseal pressure monitoring revealed no aging-related issues with the metallic O-ring seals on TN-32 dry storage casks. Refer to Table A2.1-4, North Anna ISFSI Aging-related Operating Experience for a list of condition reports and associated corrective actions for North Anna.

Based on industry and site-specific OE review, actuation of TN-32 dry storage cask low pressure alarms is not unexpected. North Anna has not experienced failure of the primary cask seal, which could result in leakage of radioactive materials to the outside atmosphere.

The alarms are generally the result of helium leakage from fittings on the overpressure system, low ambient temperature, or failed pressure switches. North Anna has developed a troubleshooting procedure for TN-32 dry storage cask low pressure alarms. The procedure includes troubleshooting cask pressure switches and checking the overpressure system for leakage.

In 1999 and 2000, low interseal pressure alarms occurred on five TN-32 dry storage casks in place at Surry Power Station. The five TN-32 dry storage casks were returned to the spent fuel pool and unloaded in order to examine the inner and outer seals. Inspection of the seals showed no evidence of corrosion of the inner seal; but the outer seal was observed to be corroded. Corrosion of the lid bolt heads was also identified during the inspection. The evaluation concluded the low pressure alarms were the result of corrosion from water intrusion inside the protective cover due to improper assembly of the Conax connector penetrating the apex of the protective cover. The introduction of water inside the cover resulted in galvanic corrosion of the aluminum covered outer seal in contact with the stainless steel weld overlay on the dry storage cask flange and lid. The loss of material due to galvanic corrosion of the aluminum outer metallic seal cover was sufficient to actuate the low pressure alarms. The metallurgical report also identified chlorine in the corrosion deposits, which most likely resulted from the surrounding atmospheric environment at Surry Power Station. A similar issue occurred in 2011 on a Transnuclear dry storage cask at Peach Bottom Atomic Power Station.

Corrective actions to prevent recurrence at Surry and North Anna Power Stations included use of silver-coated O-rings with silver-coated seals on all future casks. Additionally, the covers were modified on all casks to remove the Conax connector and install an access plate (referred to as the Subassembly) in the cover, which is bolted and sealed. Desiccant was also placed on top of the neutron shield to minimize moisture. Following these corrective actions, there has been no recurrence of water intrusion inside the protective covers.

In addition to corrosion of the outer lid seal, a second issue was identified when the TN-32 dry storage casks were returned to the spent fuel pool. The torque value applied to the lid bolts was determined to be less than the original specified torque value. Ten lid bolts on one TN-32 dry storage cask and three lid bolts on another TN-32 dry storage cask could be moved by hand. Although the torque was less than specified, cask containment integrity was maintained and no leakage to the environment resulted. It was concluded that the loss of bolt pre-load was the result of applying final lid bolt torque before the TN-32 dry storage cask achieved thermal equilibrium, and not the result of age-related loss of pre-load. In April 2001, Transnuclear issued an Information Bulletin to inform the industry of the above issues. The bulletin recommended final lid bolt torque be applied to the lid bolts after the TN-32 dry storage cask reaches thermal equilibrium.

Transnuclear also recommended use of Neolube or Loc-Tite N-5000 as the preferred lubricant for lid bolts. The bulletin recommendations have been implemented at NAPS, including the use of N-5000 lubricant.

There have been instances in the industry and at North Anna and Surry Power Stations where low pressure alarms have occurred as a result of non age-related conditions. These include alarms resulting from conditions such as leakage in the overpressure system, low atmospheric temperature, pressure switch setpoint drift, and pressure switch failure.

Radiation Monitoring Operating Experience

The review of site-specific and industry operating experience, as well as historical dose rates recorded at the ISFSI perimeter fence shows no evidence that the neutron and/or gamma shielding is degrading. An enhancement will be implemented to perform an annual evaluation of ISFSI perimeter radiation measurements for adverse trends to ensure that deterioration of the TN-32 dry storage casks shielding materials is detected prior to loss of intended function.

Visual Inspections Operating Experience

The North Anna ISFSI has been in operation for more than 17 years. A review of all previously completed quarterly inspections, as well as the Dominion Corrective Action Program, identified cases of minor coating degradation, i.e., no visible loss of base material, and rust stains on reinforced concrete pad No. 1. A separate aging management program has been developed to monitor the condition of reinforced concrete pad No. 1. TN-32 dry storage cask coating deficiencies are expected to occur over time. None of the previously identified coating deficiencies have challenged the intended functions of the cask subcomponents. As station resources permit, coating defects are corrected by removal of the existing coating and re-application of the coating. As of March 2016, nine TN-32 dry storage casks have been re-coated. Refer to Table A2.1-4, North Anna ISFSI Aging-related Operating Experience for a list of condition reports and associated corrective actions related to visual inspections.

August 2011 Seismic Event

On August 23, 2011, NAPS experienced a moment magnitude (M) 5.8 earthquake that was centered approximately 11 miles from the plant. The plant's seismic design basis was exceeded and Units 1 and 2 were shutdown without incident.

A walkdown of the ISFSI was performed on August 24, 2011. It was discovered that 25 of the 27 TN-32 dry storage casks had shifted from their original locations. Table F2-1 identifies the resulting movement of each cask. On August 29, 2011, a team consisting of personnel from Transnuclear Structural Analysis and Civil Construction groups as well as Dominion Nuclear Spent Fuel engineers performed a walkdown of the ISFSI.

Although 25 of the 27 TN-32 dry storage casks had shifted, there were no indications of damage to the TN-32 dry storage casks or the fuel inside the casks. After an M 3.4 aftershock, a follow-up inspection was performed on September 1, 2011 and included the following inspections/observations:

- Above-ground pressure monitoring systems including the remote monitoring panel were visually inspected and no damage was found. No pressure monitoring system alarms were received during the event. Electrical power at the ISFSI was not lost during the seismic event.
- Visual inspection of reinforced concrete pad No. 1 did not reveal any cracking or damage from the seismic event.
- Radiological surveys of the TN-32 dry storage casks did not indicate an increase in cask surface dose rates when compared to the dose rates obtained following cask loading.
- On August 30, 2011, inspections were performed on six randomly selected pressure switches. These inspections concluded that setpoints had not drifted outside of what would normally be expected and Helium pressure was consistent with expectations.

An Operability Determination concluded that the TN-32 dry storage casks were operable and performing as designed. To ensure a greater confidence that the TN-32 dry storage casks were not affected by the seismic event, Dominion performed the following detailed inspections on five TN-32 dry storage casks based on recommendations from Transnuclear:

- The tubing and valves connected to the NEMA box for evidence of cracking or deformation
- The protective cover subassembly for deformation or cracking
- The protective cover for evidence of moisture leakage
- The lower edge of the lid near the outer O-ring for evidence of moisture
- The overpressure tank mounting brackets for evidence of bending or loosening
- The top of the neutron shield for damage due to overpressure tank mounting brackets deformation
- The neutron shield bolts for damage
- The top of the neutron shield for damage
- The tubing and valves connected to the overpressure tank for evidence of cracking or deformation
- The protective cover bolts for evidence of bending or loosening

The inspections identified water intrusion and rust inside the NEMA electrical box associated with dry storage cask TN-32.36. The scope of the NEMA box inspections was expanded to inspect all remaining TN-32 dry storage casks to determine the extent of condition.

Water intrusion in three additional NEMA boxes was identified. Condition reports were initiated to document the deviating conditions. Work orders were initiated and repairs made to the NEMA boxes.

Pre-application Inspection

A pre-application inspection was performed at NAPS in Fall 2015 to evaluate the condition of the TN-32 dry storage casks. See Appendix F: Additional Information, Section F2.0, for the results of the pre-application inspection and the basis for cask selection.

Summary of Enhancements

The following enhancements will be made to the TN-32 Dry Storage Cask Aging Management Program:

1. Enhance Station procedures to identify the subcomponents of the TN-32 cask that are fully visible and partially visible during the quarterly visual inspection. [RAI 3-9]
2. Perform an engineering evaluation every 5 years to review industry and plant-specific operating experience (including work order history). The initial operating experience evaluation during the period of extended operation will be scheduled to occur in January 2020 [RAI 3-10]. The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage the loss of material and cracking for the TN-32 dry storage casks [RAI 3-4]. Each element of the TN-32 Dry Storage Cask Aging Management Program will be reviewed to determine if updates to the AMP are required based on lessons learned from the OE review. The results of the engineering evaluation will be entered in the Aging Management INPO Database (AMID), using the screening criteria as recommended in NEI 14-03, Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management. [RAI 3-14]
3. Perform an opportunistic visual inspection of a TN-32 dry storage cask bottom and under the protective cover in the event a dry storage cask is lifted or a protective cover is removed. The acceptance criterion is no detectable loss of material from the base metal as determined by VT-1 and/or VT-3 inspection. The ISFSI component inspection results will be evaluated and entered into the AMID database using the screening criteria as recommended by NEI 14-03. [RAI 3-14]
4. Perform a visual inspection (i.e. VT-1 and/or VT-3) of a TN-32 dry storage cask bottom and under the protective cover at least every 20 ± 5 years from the date of the pre-application inspection [RAI 3-10]. The selection criteria for the 20-year scheduled inspection will be the same as the criteria used to select the cask for the pre-application inspection. The 5-year periodic reviews of operating experience, as well as changes to the aging management program resulting from the review, will be considered in cask selection. The acceptance criterion is no detectable loss of material from the base metal as determined by VT-1 and/or VT-3 inspection. The ISFSI component inspection results will be evaluated and entered into the AMID database using the screening criteria as recommended by NEI 14-03 [RAI 3-14].

5. Develop Health Physics procedures for conducting an annual neutron survey at reinforced concrete pad No. 1 using a REM 500 neutron survey meter, or equivalent, prior to entering the period of extended operation. The survey point locations, including the approximate height corresponding to the maximum neutron flux, will be identified in the Health Physics survey procedure. [RAI 3-11]
6. Develop a procedure or engineering technical evaluation describing the methodology for performing annual trending of ISFSI radiation readings [RAI 3-11].
7. Modify all TLDs located at the ISFSI perimeter fence to include a CR 39 chip, or equivalent, prior to obtaining TLD baseline neutron and gamma radiation values [RAI 3-11].
8. Define baseline radiation values for the annual neutron survey locations and for the ISFSI TLD locations prior to entering the PEO. New baseline values will be established in the event a cask is removed from, or additional cask(s) are placed on, reinforced concrete pad No. 1. In the event the location of TLDs is changed new baseline TLD values will be established. [RAI 3-11]
9. Perform an annual survey at reinforced concrete pad No. 1 using a REM 500 tissue equivalent proportional counter, or equivalent [RAI 3-11].
10. ~~Perform an annual evaluation of neutron and gamma quarterly TLD readings to confirm the absence of an increasing trend (as determined by engineering evaluation).~~ Perform an annual evaluation of ISFSI perimeter fence TLD neutron and gamma radiation measurements, and reinforced concrete pad No. 1 neutron survey results for adverse trends. The acceptance criterion is the absence of an increasing trend in neutron or gamma radiation values (as determined by engineering evaluation) [RAI 3-11]. The trend results will be evaluated and entered into the AMID database using the screening criteria as recommended by NEI 14-03 [RAI 3-14].

Conclusion

Based on the operating experience review and pre-application inspection results, the TN-32 dry storage cask intended functions have not been challenged by age-related degradation. Existing procedures, along with proposed enhancements, provide reasonable assurance that the intended functions will be maintained consistent with the ISFSI design basis during the period of extended operation.

A2.2 Monitoring of Structures Aging Management Program

The purpose of Monitoring of Structures Aging Management Program (AMP) is to define the aging management activities which are necessary to help ensure the integrity of reinforced concrete pad No. 1 for storage of TN-32 dry storage casks. Reinforced concrete pad No. 1 on which the TN-32 dry storage casks rest is an above-ground, outdoor installation which is capable of withstanding the anticipated effects of "weathering." The aging management review process identified cracking, change in material properties, and loss of material as the aging effects of concern. The Monitoring of Structures Aging Management Program is a new program that ensures cracking, change in material properties, and loss of material from reinforced concrete pad No. 1 will be identified and managed during the period of extended operation prior to loss of intended function. The program includes visual inspections to manage the above-grade aging effects and groundwater chemistry monitoring to identify below-grade aging mechanisms. The reinforced concrete pad No. 1 is not located in groundwater; however, a groundwater chemistry program will be established to provide supplemental information for identifying conditions conducive to underground aging mechanisms. An evaluation of the 10 program elements is presented below.

Element 1: Scope

The Monitoring of Structures Aging Management Program manages the effects of aging for the North Anna ISFSI reinforced concrete pad No. 1, which is exposed to atmosphere/weather and soil. Reinforced concrete pad No. 1 has an intended function of maintaining structural integrity to provide uniform and substantial support for the TN-32 dry storage casks, and to ensure that decelerations experienced during design accidents are acceptable.

The applicable aging mechanisms and aging effects for reinforced concrete pad No. 1 are:

Aging Mechanism	Aging Effect(s)
Reaction with aggregates	Cracking
Freeze-thaw	Cracking
	Loss of material
Leaching of calcium hydroxide	Change in material properties
Settlement	Cracking

Element 2: Preventive Actions

The Monitoring of Structures Aging Management Program is designated a *condition monitoring* activity. No preventive actions are performed.

Element 3: Parameters Monitored or Inspected

This AMP describes periodic visual monitoring, which is performed to determine the surface condition of reinforced concrete pad No. 1. The surface condition is a leading indicator for the overall integrity of the pad. Visual inspections detect surface defects resulting from the aging mechanisms of reaction with aggregates (e.g., alkali-silica reaction), freeze-thaw, leaching of calcium hydroxide, or settlement. Surface indications of age-related degradation for reinforced concrete pad No. 1 include loss of material, cracking, and change in material properties (white stains, indicative of leaching ~~(change in material properties~~).

An opportunistic inspection of the normally inaccessible area of reinforced concrete pad No. 1 under the TN-32 dry storage cask will be performed whenever a cask is lifted. An opportunistic inspection will also be performed for all exposed ~~the inaccessible~~ below-grade ~~portions~~surfaces of the concrete pad if made available by excavation during the course of other work [RAI 3-9].

Supplemental information will be obtained from groundwater samples to be taken at the ISFSI site and analysis of the water chemistry will determine values for chlorides, sulfates, and pH at two groundwater wells every five years. This information will be utilized in identifying conditions conducive to underground aging mechanism due to an aggressive chemical environment. Measured values which exceed established acceptance criteria for these three parameters indicate a condition that could be detrimental for concrete in contact with the groundwater. However, reinforced concrete pad No.1 is not exposed to groundwater in the soil environment.

Element 4: Detection of Aging Effects

Visual inspections identify degradation of the physical condition due to aging effects on the surfaces for reinforced concrete pad No. 1 such that there is no loss of intended function. These visual inspections check for irregularities such as cracking, loss of material on the concrete surface, and effects from change in material properties (due to leaching). The inspections will be performed in accordance with a new procedure for structural monitoring of reinforced concrete pad No. 1. Qualification requirements for the person performing the inspection of reinforced concrete pad No. 1, and for the engineer evaluating the inspection results, shall comply with the requirements in American Concrete Institute (ACI) 349.3R, (Reference A4.5) and be consistent with the requirements listed in the North Anna procedure for inspections of plant structures.

No surveillance or inspection procedure currently directs the required aging management monitoring for reinforced concrete pad No. 1. A new concrete pad inspection procedure for structural monitoring of reinforced concrete pad No. 1 will be developed with a five-year inspection interval similar to concrete inspections performed within the plant.

The five-year inspection interval is consistent with applicable operating experience, and helps ensure that cracking, loss of material, and changes in material properties will be detected in a timely manner.

A new inspection procedure will direct that groundwater sampling be performed at two existing wells near reinforced concrete pad No. 1 every five years to determine whether the pad could be exposed to an aggressive chemical environment. The inspection interval of five years has been determined to be appropriate since the reinforced concrete pad No. 1 is not in contact with groundwater. As noted in Table 3.4-2, Groundwater Sample Results Summary, measurements of groundwater chemistry at the ISFSI location confirm that an aggressive environment for concrete does not exist.

Element 5: Monitoring and Trending

The inspection activities in this AMP are performed periodically in order to identify areas of degradation. Results will be evaluated by qualified individuals consistent with industry guidelines, standards, and regulations. Inspection results for structural inspections are retained in Station Records, and are summarized in engineering technical evaluations. Conditions adverse to quality noted during the inspection and monitoring activities, such as non-conformances, failures, malfunctions, deficiencies, deviations, or defective material and equipment are entered into the Dominion Corrective Action Program.

Depending on significance, a more focused evaluation may be required to determine the extent of condition and determine if more frequent monitoring or inspection is required. As discussed below, visual inspections consider the cumulative experience from previous inspections and assessments in order to monitor and trend the progression of aging effects over time. Additionally, the Dominion Corrective Action Program includes trending of adverse conditions as well as a process to prevent recurrence.

A new reinforced concrete pad No. 1 inspection procedure will require the pad to be visually inspected every five years. <u>The initial visual inspection during the period of extended operation will be scheduled to occur in November 2020 [RAI 3-10].</u> The inspection results will be evaluated and compared to the previous inspection results to detect adverse trends and determine if the frequency of inspections should be increased. A record of deficiencies found during the credited visual inspection will be updated with results from each inspection. These actions will provide a trending evaluation for the results of inspections for reinforced concrete pad No. 1.

An engineering evaluation will be performed every five years to review industry and plant-specific operating experience (including work order history). <u>The initial operating experience evaluation during the period of extended operation will be scheduled to occur in January 2020 [RAI 3-10].</u> The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage the loss of material, cracking, and change in material properties for reinforced concrete pad No. 1.

Each element of the Monitoring of Structures Aging Management Program will be reviewed to determine if updates are required based on lessons learned from the operating experience review. The results of the engineering evaluation will be entered into the Aging Management INPO Database (AMID), using the screening criteria recommended in NEI 14-03, Format, Content, and Implementation Guidance for Dry Storage Cask Storage Operations-Based Aging Management [RAI 3-14].

Element 6: Acceptance Criteria

Visual inspections for reinforced concrete pad No. 1 will determine whether adverse conditions such as cracking, loss of material, or change in material properties are present. Indications of adverse conditions will be documented using a Condition Report.

Cracks other than hairline cracks are to be noted during visual inspections. As described in ACI 349.3R, Evaluation of Existing Nuclear safety-related Concrete Structures (Reference A4.5), cracking of concrete surfaces is acceptable if all of the following conditions are satisfied by the results of the visual inspection:

- No evidence of leaching
- Pop-outs and voids are less than 20 mm (3/4 in.) in diameter
- Scaling is less than 5 mm (3/16 in.) in depth
- Spalling is less than 10 mm (3/8 in.) in depth and 100 mm (4 in.) in any dimension
- Cracks are passive (no indication of recent growth or indications of other degradation at the crack), and less than 0.4 mm (0.015 in.) in maximum width
- No evidence of excessive deflections, settlements, or other physical movements that could affect structural performance

Groundwater sampling acceptance criteria shall be established as follows:

- Chlorides < 500ppm
- Sulfates < 1,500 ppm
- pH > 5.5

If any one of the three values exceeds the acceptance criterion the condition is entered in the Dominion Corrective Action Program.

These values are consistent with guidance provided in NUREG-1801, Generic Aging Lessons Learned (Reference A4.6), and would demonstrate that reinforced concrete pad No. 1 is exposed to a non-aggressive groundwater environment.

Unacceptable results for cracking, loss of material, or change in material properties of concrete surfaces will require initiation of a Condition Report in accordance with the Dominion Corrective Action Program [RAI 3-12].

Element 7: Corrective Actions

Corrective actions for deviating conditions that are adverse to quality, e.g., failures, malfunctions, deficiencies, deviations, defective material and equipment, and non-conformances, are performed in accordance with Dominion Topical Report DOM-QA-1, "Nuclear Facility Quality Assurance Program Description" (Reference A4.4). Adherence to DOM-QA-1 ensures that, as required by 10 CFR 50, Appendix B, an adequate quality assurance program is implemented.

The Dominion Corrective Action Program is implemented in accordance with a nuclear fleet administrative procedure. The administrative procedure includes expectations for identification and reporting of conditions adverse to quality, conditions that affect personnel safety, affect nuclear safety, affect plant reliability, affect trending, and other conditions that do not meet station expectations. For conditions determined to be significantly adverse to quality, the procedure provides measures to provide reasonable assurance that the cause of the condition is determined, corrective action is taken in a timely and accurate manner to preclude repetition, and the cause and corrective actions taken are documented and reported to appropriate levels of management. A condition significantly adverse to quality is defined as a condition adverse to quality that has, or if left uncorrected could have, an undesirable effect on plant safety, regulatory position, or environmental impact.

Station deficiencies are identified by the submission of CRs. An attachment to the administrative procedure provides a detailed list of examples of conditions that require submission of a CR. At a minimum, CRs are submitted for any issue or concern that does not meet specific requirements of procedures, policies, management expectations, or accepted industry standards, including all conditions that do not meet the AMP acceptance criteria. CRs are also required to be submitted for any issue where there is doubt about whether a CR should be submitted. The procedure also provides guidance for submittal of CRs anonymously.

Submitted CRs are initially reviewed by the submitters' supervisor. The supervisor answers screening questions to determine if Operations Shift Manager review is required. If so, the shift manager, or designee, performs an operability assessment. As required by 10 CFR 72.75, reportability determinations are also made. Further review of the CR is then performed by the CRT.

The CRT is a multi-discipline, multi-departmental team consisting of members from Engineering, Maintenance, Operations, Radiation Protection, Training, and Organizational Effectiveness. At least one member of the CRT should have, or previously held, a Senior Reactor Operators license. Functions of the CRT include:

- Identifying conditions that are adverse to quality
- Establishing corrective action assignments
- Assigning required significance level and level of evaluation to CRs (e.g., Root Cause Evaluation)
- Reviewing CRs for trending and notifying the Trend Coordinator for submittal of an additional CR to address trending aspects
- Reviewing CRs for safety implications
- Reviewing CRs for initiation of work management activities
- Recommending compensatory measures
- Identifying events that should be communicated to the industry via the INPO Consolidated Event System
- Notifying senior management of significant events

CRs identified as adverse to quality by the CRT are further reviewed by the Corrective Action Assignment Review Team (CAART). The CAART is generally comprised of senior-level management, Manager level and above, and includes the Plant Manager. The CAART reviews the results and recommendations of the CRT and has the authority to make changes when appropriate. The CAART also identifies selected issues to be reviewed by the Facility Safety Review Committee.

The response to corrective action assignments is reviewed to verify the adequacy of the response and proposed corrective actions, including no corrective action. CRT or CAART may assign additional reviews when appropriate.

Engineering evaluations performed in accordance with the Corrective Action Program will determine whether corrective or mitigative actions are needed for maintaining the intended function of providing support for the TN-32 dry storage casks.

A self-assessment is performed at least every two years to determine the effectiveness of the Corrective Action Program. An aggregate review of all open conditions designated as adverse to quality is performed at least every eighteen months to ensure appropriate priorities have been assigned to these outstanding issues.

Element 8: Confirmation Process

Adherence to the Dominion Quality Assurance Program ensures that, as required by 10 CFR Part 50, Appendix B, an adequate quality assurance program is implemented. The Quality Assurance program includes provisions for timely evaluation of adverse conditions, and implementation of any corrective actions required, including root cause evaluations and actions to prevent recurrence. Procedural controls are in place to ensure the response to corrective action assignments is reviewed to verify the adequacy of the response and the corrective actions. Condition reports are also reviewed for trending purposes.

An engineering evaluation will be performed every five years to review industry and plant-specific operating experience (including work order history). The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage the loss of material, cracking, and change in material properties for reinforced concrete pad No. 1. Each element of the Monitoring of Structures Aging Management Program will be reviewed to determine if updates are required based on lessons learned from the operating experience review.

Element 9: Administrative Controls

All activities associated with the North Anna ISFSI that are important to safety are conducted in accordance with Dominion Topical Report DOM-QA-1, "Nuclear Facility Quality Assurance Program Description" (Reference A4.4). Adherence to DOM-QA-1 ensures that, as required by 10 CFR 50, Appendix B, an adequate quality assurance program is implemented. DOM-QA-1 includes guidance for inspector requirements, record retention requirements, and document control. Administrative and technical procedures are reviewed, approved, and maintained as controlled documents in accordance with the Dominion procedure control process and DOM-QA-1. Administrative controls have been established to ensure records are identified, retained, maintained, and retrievable. Approved procedures define record retention requirements and storage methods.

Element 10: Operating Experience

The Dominion Operating Experience (OE) Program is implemented in accordance with an administrative procedure. The goal of the OE Program is to effectively and efficiently use lessons learned from the industry to improve safety and reliability and to reduce the number and consequence of events. The procedure includes applicability screening of OE reports from the NRC, INPO, and vendors. Guidelines for use of the INPO Nuclear Network Forums are included in the procedure. The procedure also stipulates OE coordinator trending reviews at set frequencies and OE coordinator qualification requirements.

The review and sharing of operating experience will be enhanced to include use of the Aging Management INPO Database (AMID) in accordance with NEI 14-03, Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management. Additionally, the reinforced concrete pad No. 1 inspection results will be evaluated and entered into the AMID database using the screening criteria of NEI 16-10, as recommended by NEI 14-03. [RAI 3-14]

As stated in Element 8: Confirmation Process, additional reviews occur during the engineering evaluation of industry and plant-specific operating experience that occurs every five years to determine whether updates to the aging management program are needed to address lessons learned. The historical absence of significantly adverse findings for the ISFSI confirms that a review interval of five years is sufficient to address the potential need for any changes of aging management programs.

A separate administrative procedure provides instruction for submitting Dominion OE to the INPO Consolidated Event System (ICES). The purpose of this procedure is to provide a method for identification and reporting of INPO ICES reports. The procedure includes reporting criteria and required reporting time frames.

OE reviews for this AMP are based on relevant occurrences listed in the North Anna Corrective Action database, i.e., condition reports, and a search of the INPO OE summaries for industry experiences for domestic and international plants. These documents were reviewed for any applicable aging effects or mechanisms. Searches of those databases used the following keywords:

- ISFSI pad
- ISFSI
- Concrete

OE at North Anna indicates that the Monitoring of Structures Aging Management Program for plant structures has been effective in identifying structural degradation, implementing corrective actions, and trending the findings. When degradation has been identified for plant structures, corrective actions have been implemented to ensure that the integrity of the affected structure is restored and maintained such that intended functions will be maintained during the period of extended operation.

Specific examples of relevant OE for age-related degradation of reinforced concrete pad No. 1 are listed below:

A 2004 engineering evaluation summarized inspections which were performed for the North Anna ISFSI reinforced concrete pad No. 1 in 1998, 1999, and 2004. The pad was constructed in five placements in December 1997. After the first placement, a condition report was written identifying discrepancies with the location of reinforcing bars, and supports for the embedded TN-32 dry storage cask lighting boxes. The findings of the resultant engineering evaluation concluded that the structural strength of the pad had not been reduced and the discrepancies were corrected prior to the remaining four placements. The evaluation recommended that Engineering inspect this same area within six months to identify any cracking that may have occurred, and perform an additional follow-up inspection approximately one year later.

Reinforced concrete pad No. 1 was first inspected on May 13, 1998. The inspection identified no adverse conditions beyond those previously reported, and no repairs were required at that time. Pad No. 1 was re-inspected on May 20, 1999, and was reported to be in good condition. Additional surface cracks were identified and previously-identified cracks were characterized to be wider than previously reported. The cracks were reported to be very shallow in depth and not a concern, so no repairs were required following the inspection. An engineering evaluation issued on May 27, 1999, reiterated a recommended action, based on the initial condition report to re-inspect reinforced concrete pad No. 1 in five years. No additional condition report was initiated since the recommended actions of the initial condition report continued to be followed.

Reinforced concrete pad No. 1 was reinspected on April 6, 2004. Twenty-one TN-32 dry storage casks had been placed on the pad by this time. Observations from the three inspections in 1998, 1999, and 2004 were recorded on sketches that were included with the summary engineering evaluation to support trending. Reinforced concrete pad No. 1 had cracks immediately adjacent to construction or control joints that had begun to unravel into the joint as anticipated, and were reported as joint spalls. In general, crack widths had stabilized and remained consistent with the inspection results reported in 1999. Light crazing (i.e., a network of fine cracks on the surface of the concrete) was present on numerous areas of reinforced concrete pad No. 1. The identified indications were shallow and did not jeopardize the structural integrity of reinforced concrete pad No. 1. The areas of crazing for the surface of reinforced concrete pad No. 1 were noted on the sketches that accompanied the summary engineering evaluation.

A post-seismic event walkdown of the ISFSI pad (reinforced concrete pad No. 1 for the TN-32 dry storage casks), including all support systems, was performed on September 1, 2011 to verify current conditions. Reinforced concrete pad No. 1 was checked, and no additional cracks or deformation were noted during this post-seismic walkdown.

During the performance of the pre-application inspections on October 14, 2015, reinforced concrete pad No. 1 was inspected as well as the concrete underneath the TN-32 dry storage cask that was lifted. Civil Engineering performed a visual inspection of the concrete under the TN-32 dry storage cask, as well as the entire pad, and had no concerns with the condition of reinforced concrete pad No. 1. The only cracking is hairline in nature, but does not require repair. This recent inspection of reinforced concrete pad No. 1 confirms the absence of age-related degradation. See Section F2.2, Pre-application Inspection Results for additional information.

The history of inspections for reinforced concrete pad No. 1 dates back to 1998. Results from five inspections in 1998, 1999, 2004, 2011, and 2015 confirm that cracks have formed on the surface of the pad, but none are affecting the structural integrity of the concrete or require repair.

A trend of inspection results that is maintained for reinforced concrete pad No. 1 shows that existing cracks are shallow and have stabilized. The shallow cracks have not provided a pathway for the atmosphere/weather environment to come into contact with the embedded steel and initiate corrosion which could adversely affect structural integrity.

The OE presented above provides reasonable assurance that the Monitoring of Structures Aging Management Program will be capable of detecting aging effects for reinforced concrete pad No. 1. Occurrences of aging that would be identified under the Monitoring of Structures Aging Management Program will be evaluated to ensure there is no loss of intended function. Guidance for re-evaluation, repair, or replacement is provided for locations where aging is found. There is confidence that continued implementation of the Monitoring of Structures Aging Management Program will effectively identify aging prior to loss of intended function.

Summary of Enhancements

The following enhancements will be made to the Monitoring of Structures Aging Management Program:

1. Perform an engineering evaluation every five years to review industry and plant-specific operating experience (including work order history). The initial operating experience evaluation during the period of extended operation will be scheduled to occur in January 2020 [RAI 3-10]. The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage the loss of material, cracking, and change in material properties for reinforced concrete pad No. 1. Each element of Monitoring of Structures Aging Management Program will be reviewed to determine if updates are required based on lessons learned from the OE review. The results of the engineering evaluation will be entered into the Aging Management INPO Database (AMID), using the screening criteria recommended in NEI 14-03, Format, Content, and Implementation Guidance for Dry Storage Cask Storage Operations-Based Aging Management [RAI 3-14].
2. Perform a visual inspection of ~~the~~ all exposed visible surfaces of reinforced concrete pad No. 1 at a frequency of every five years [RAI 3-9]. The acceptance criteria is specified in ACI-349.3R. The initial visual inspection during the period of extended operation will be scheduled to occur in November 2020 [RAI 3-10].
3. Perform groundwater sampling at the ISFSI site to determine values for chlorides, sulfates, and pH at two groundwater wells every five years. The acceptance criteria are:
    - Chlorides < 500ppm
    - Sulfates < 1,500 ppm
    - pH > 5.5
4. Perform an opportunistic inspection of the normally inaccessible area of reinforced concrete pad No. 1 beneath the TN-32 dry storage cask whenever a cask is lifted.
5. Perform an opportunistic inspection of ~~the inaccessible~~ all exposed below-grade ~~portions~~surfaces of reinforced concrete pad No. 1 if made available by excavation. The acceptance criteria is specified in ACI-349.3R [RAI 3-9].

As recommended by NEI 14-03, inspection results will be reviewed to determine if the results should be entered in the AMID database [RAI 3-14].

Conclusion

Based on the operating experience review and pre-application inspection results, the reinforced concrete pad No. 1 intended functions have not been challenged by age-related degradation. Existing procedures, along with proposed enhancements, provide reasonable assurance that the intended functions will be maintained consistent with the ISFSI design basis during the period of extended operation.

A3.0 SUMMARY

Operating experience indicates that while degradation of the TN-32 dry storage cask exterior surfaces has occurred, e.g., flaking of TN-32 dry storage cask coating, there have been no cases of loss of intended function due to dry storage cask exterior problems. Corrective actions have been effectively implemented when monitoring and inspection results have indicated degradation. On the basis of this on-going surveillance, the infrequency of observed instances of degradation, and corrective actions implemented, the effects of aging on the TN-32 dry storage casks will be effectively managed during the period of extended operation.

Operating experience from five inspections of reinforced concrete pad No. 1 confirm the absence of age-related degradation which could jeopardize the structural integrity of the pad. OE has not resulted in any changes for existing structural inspection procedures, or a need to invoke repair procedures.

The effects of aging associated with subcomponents within the scope of the TN-32 Dry Storage Cask Aging Management Program and the Monitoring of Structures Aging Management Program will be adequately managed so that there is reasonable assurance that their intended functions will be performed consistently with the design basis during the period of extended operation.

A4.0 REFERENCES (Appendix A: Aging Management Programs)

A4.1 North Anna Independent Spent Fuel Storage Installation Safety Analysis Report, Rev. 8, North Anna Power Station. ML14233A488

A4.2 Technical Specifications, Independent Spent Fuel Storage Installation, Amendment 4, North Anna Power Station.

A4.3 NUREG-1927, Standard Review Plan for Renewal of Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel, Rev. 0, Office of Nuclear Material Safety and Safeguards, Nuclear Regulatory Commission.

A4.4 DOM-QA-1, Nuclear Facility Quality Assurance Program Description, Topical Report, Dominion.

A4.5 ACI 349.3R, Evaluation of Existing Nuclear Safety Related Concrete Structures, American Concrete Institute, 2002.

A4.6 NUREG-1801, Generic Aging Lessons Learned (GALL) Report, Rev. 2. ML103490041

Serial No. 17-230
Docket No. 72-16

Enclosure 2

Clean Version
Revised Aging Management Programs
(Pages A-1 through A-41)

North Anna Power Station ISFSI
Virginia Electric and Power Company

APPENDIX A: AGING MANAGEMENT PROGRAMS

A1.0 INTRODUCTION

This appendix summarizes the activities that manage the effects of aging for Independent Spent Fuel Storage Installation (ISFSI) subcomponents that have been identified in the North Anna ISFSI License Renewal Application (LRA) as being subject to aging management review. An Aging Management Program (AMP) has been developed for the ISFSI TN-32 dry storage cask, and a separate AMP has been developed for reinforced concrete pad No. 1. Section A2.1 and Section A2.2 provide a description of these AMPs, which includes an introduction to the AMP, an evaluation of the AMP in terms of the aging management program elements, a summary paragraph, and a conclusion.

The Aging Management Reviews (AMRs) in Section 3.0 provide tables that summarize the results of the AMRs. These tables identify the AMPs credited for managing the required aging effects for the applicable subcomponent and structural members listed in the AMR. The identified AMPs manage the aging effects applicable to the subcomponent, and provide reasonable assurance that the integrity of the subcomponent will be maintained during the period of extended operation.

A2.0 AGING MANAGEMENT PROGRAMS

A2.1 TN-32 Dry Storage Cask Aging Management Program

The purpose of the TN-32 Dry Storage Cask AMP is to define the aging management activities which are necessary to help ensure the integrity of the TN-32 dry storage cask. The AMR process identified loss of material from cask metallic subcomponents and loss of material and cracking from polymeric subcomponents as the aging effects of concern [RAI 3-4]. The TN-32 Dry Storage Cask AMP ensures loss of material and cracking from the cask subcomponents will be identified and managed during the period of extended operation prior to loss of intended function [RAI 3-4]. The TN-32 Dry Storage Cask AMP involves continuous monitoring of TN-32 dry storage cask interseal pressure, scheduled and opportunistic cask visual inspections, and radiation monitoring at the ISFSI perimeter fence and at reinforced concrete pad No. 1 [RAI 3-11]. An evaluation of the 10 program elements is presented below.

Element 1: Scope

The intended functions, materials, environments, aging mechanisms, and aging effects of the subcomponents in the scope of this program are identified in Table AMR Results-1, Transnuclear TN-32 Dry Storage Cask. The intended functions of the cask components include pressure boundary (PB), Radiation Shielding (RS), Heat Transfer (HT), Criticality Control (CC), Structural Support (SS), and Retrievability (RT). The aging effects monitored by this program are loss of material and cracking [RAI 3-4].

The mechanisms monitored or inspected by the TN-32 Dry Storage Cask AMP include:

- Galvanic, crevice and pitting corrosion of aluminum in an atmosphere/weather environment for the following components:
  - Lid seals
  - Vent and drain port cover seals
- Crevice and pitting corrosion of stainless steel in an atmosphere/weather environment for the following components:
  - Vent and drain port covers
  - Vent and drain port cover bolts [RAI 3-1]
  - Top neutron shield bolts [RAI 3-1]
  - Lid weld overlay
  - Flange weld overlay
- Radiolytic decomposition and thermal degradation of polypropylene and borated polyester in an air environment for the following components:
  - Top neutron shield
  - Radial neutron shield
- Galvanic, crevice, general, and pitting corrosion of carbon steel and low-alloy steel in an atmosphere/weather environment for the following components:
  - Cask shell
  - Lid
  - Lid bolts
  - Cask bottom
  - Trunnions
  - Outer shell
  - Top neutron shield enclosure
  - Flange

<u>Element 2:</u> <u>Preventive Actions</u>

This AMP is designated a *condition monitoring* activity. No preventive actions are performed.

Element 3: Parameters Monitored or Inspected

Interseal Pressure Monitoring

The interseal pressure of the TN-32 dry storage cask seals is continuously monitored by redundant pressure switches to verify the integrity of the TN-32 dry storage cask seals. Interseal pressure monitoring detects loss of material from the TN-32 dry storage cask seal subcomponents prior to loss of pressure boundary intended function. The interseal region is pressurized to help provide indication of cask seal integrity. A reduction of interseal pressure could indicate leakage due to loss of material that prevents the seal from performing its pressure-boundary function.

Radiation Monitoring

The radiation monitoring activities of the TN-32 Dry Storage Cask Aging Management Program ensure the radiation dose to members of the public and to occupational workers remains acceptable during the period of extended operation (PEO) [RAI 3-11]. As described in Section 7.3.3 of the ISFSI SAR (Reference A4.1), TLDs located along the perimeter fence are used for monitoring of radiation dose at the North Anna ISFSI. TLDs are capable of detecting gamma, neutron, and beta radiation. Monitoring of gamma and neutron radiation ensures the shielding materials in the cask are capable of performing their intended function. Portable radiation survey meters are used for work on or near reinforced concrete pad No. 1. Airborne radioactivity monitoring is not required because the TN-32 dry storage casks are sealed. The ISFSI is not normally occupied; therefore, area radiation monitors are not required. The TN-32 dry storage casks are also decontaminated prior to transport to the ISFSI.

Loss of material and cracking of the polymer neutron shields are plausible aging effects during the PEO [RAI3-4]. The aging effects can result in increased intermediate and fast neutron flux at the perimeter of the cask. As described in Element 4, the program will be updated to include enhanced detection of intermediate and fast neutrons at the ISFSI perimeter fence and at reinforced concrete pad No. 1 [RAI 3-11].

TLD radiation monitoring is supplemented by surveys performed during and following TN-32 dry storage cask loading, surveys performed prior to and during TN-32 dry storage cask maintenance activities, and quarterly gamma and neutron radiation surveys at the ISFSI perimeter fence. Protection of occupational workers is further assured by limiting access to the ISFSI and requiring gamma and neutron dosimetry be worn when accessing the ISFSI [RAI 3-11].

Radiation monitoring is used to detect loss of material and cracking of shielding components prior to loss of radiation shielding intended function [RAI 3-4].

Visual Inspections

Quarterly visual inspections are performed to detect loss of material from TN-32 dry storage cask visible external surfaces exposed to an atmosphere/weather environment. Visual inspections will also be implemented to detect loss of material from the normally inaccessible exterior locations of the in-service TN-32 dry storage casks. Visual inspections of the dry storage cask bottom and beneath the protective cover will be required during the PEO.

A pre-application inspection was performed in 2015. The inspection included lifting one TN-32 dry storage cask to verify the condition of a TN-32 dry storage cask bottom and removal of the protective cover from one TN-32 dry storage cask to verify the condition of the normally inaccessible subcomponents beneath the cover, e.g., neutron shield. The aging effect monitored was loss of material. No detectable loss of material from the base metal was observed during the inspection. Details of the pre-application inspection cask selection and inspection results are presented in Appendix F: Additional Information, Section F2.0.

Visual inspections look for signs of degradation on the exterior surfaces of cask components, as well as rust stains on reinforced concrete pad No. 1. The inspections also identify loose debris next to the cask that could result in a localized area of corrosion. Visual inspections detect loss of material from TN-32 dry storage cask subcomponents prior to loss of pressure boundary, structural support, radiation shielding, and heat transfer intended functions. Loss of material is indicated by localized general corrosion, erosion, or wear. Conditions such as fabrication marks, scratches, surface abrasion, or material roughness, which have no effect on intended functions, are considered non-relevant. The parameter monitored is consistent with those identified in industry codes and standards.

Element 4: Detection of Aging Effects

Detection of the TN-32 dry storage cask aging effects of loss of material and cracking relies on continuous interseal pressure monitoring, TLD radiation monitoring, neutron radiation surveys, and visual inspections (scheduled, opportunistic, and pre-application) [RAI 3-4].

Interseal Pressure Monitoring

TN-32 dry storage cask interseal pressure is monitored continuously by redundant pressure switches at each TN-32 dry storage cask. Twice daily, the Operations Department verifies that no low pressure alarms are present, satisfying ISFSI Technical Specification Surveillance Requirement SR 3.1.4.1. (Reference A4.2). The aging effect monitored is loss of material.

A functional test of the pressure switches associated with each TN-32 dry storage cask is performed every 36 months to satisfy ISFSI Technical Specification Surveillance Requirement SR 3.1.4.2. This procedure verifies the TN-32 dry storage cask as-found interseal pressure, verifies the pressure switches actuate within the required range, and verifies the as-left interseal pressure.

An annual test of the TN-32 dry storage cask alarm panels is performed to ensure the ISFSI visual alarms on the dry storage cask alarm panels and the remote alarm in the Secondary Alarm Station respond to a test signal. This annual test also verifies alarms actuate on loss of power to the panels.

Excessive leakage past the TN-32 dry storage cask seals due to loss of material (corrosion) would actuate an alarm in the Secondary Alarm Station, which would initiate actions to verify seal integrity in accordance with approved procedures. Seal leakage is classified in accordance with the site Emergency Plan Implementing Procedures.

Discrepancies noted during the above monitoring activities are entered in the Dominion Corrective Action Program. The results of interseal pressure monitoring activities are maintained in Station Records.

Radiation Monitoring [RAI 3-11]

Each TN-32 dry storage cask is equipped with a top and radial polymer neutron shield. The top and radial neutron shields perform their intended functions by moderating neutrons originating in the stored fuel. The radial neutron shield is impregnated with boron to further reduce neutron dose at the dry storage cask perimeter by absorption of neutrons. With respect to neutron shielding, the TN-32 dry storage casks stored on reinforced concrete pad No. 1 are identical in design and construction. The neutron source term is unique for each cask, and is a function of fuel enrichment, fuel burnup, and fuel storage time.

Radiation monitoring of the ISFSI is currently provided by TLDs located at the ISFSI perimeter fence. Neutron and gamma radiation doses are obtained quarterly from the perimeter fence TLDs and trended.

Loss of material and cracking of the neutron shield polymer results in an upward shift in neutron energy and an increase in the neutron flux at the cask perimeter. The polymer material used in the TN-32 dry storage cask radial neutron shield is encased in rigid aluminum boxes around the cask shell. This structure minimizes movement and displacement of the polymer material that may result from loss of material and ultimately cracking. Although neutron streaming from the cask is considered unlikely, the TN-32 Dry Storage Cask Aging Management Program will be further enhanced to include modification of the TLDs located at the ISFSI perimeter fence to include enhanced neutron detection of intermediate and fast energy neutrons and performance of neutron radiation surveys at reinforced concrete pad No. 1.

The TLDs currently in use at North Anna are capable of detecting neutrons with energies ranging between thermal and 6 MeV. The TLD response, however, decreases significantly as neutron energy increases. To compensate for the reduced response at higher energies, each TLD at the ISFSI perimeter fence will be equipped with an additional chip, such as a CR 39 polycarbonate chip, or equivalent, to improve detection of neutrons in the intermediate and fast neutron energy spectra. Over 98% of the neutrons originating in the stored fuel (prior to moderation) are at energy levels below 6.38 MeV. The CR 39 chip has a relatively flat response to neutron energies in the range of 200 keV to 6 MeV. The additional chip, in combination with the TLDs currently in use at North Anna, will therefore provide a representative indication of neutron dose resulting from thermal, intermediate, and fast neutrons.

The radiation monitoring activities of the TN-32 Dry Storage Cask Aging Management Program will be further enhanced by the performance of annual neutron radiation surveys around the entire perimeter of reinforced concrete pad No.1 using a tissue equivalent proportional counter, such as the REM 500 neutron survey meter.

The annual neutron radiation survey will measure and record the neutron radiation levels at thirty-two locations around the cask array. Neutron measurements will be recorded at fifteen locations along the long axis of the reinforced concrete pad No. 1 on both the east and west sides at a point centrally located between every two adjacent casks and extending past the last cask on each end. The dose rate readings will be measured and recorded at a distance of approximately one foot outward from the edge of reinforced concrete pad No. 1. One additional measurement will be recorded at along the short axis at a point centrally located between the two casks at each end of the reinforced concrete pad No. 1.

All neutron dose rate readings will be taken at an approximate elevation corresponding to the maximum neutron flux. An elevation corresponding to the maximum neutron flux is the most likely location for radial neutron shield degradation to occur, and therefore serves as a leading indicator for axial and radial locations not specifically monitored during the annual neutron survey. The TN-32 dry storage cask elevation corresponding to the maximum neutron flux, as well as the survey locations will be specified in a station procedure.

A tissue equivalent proportional counter, such as the REM 500 neutron survey meter, will be used to measure neutron dose rate at all survey points. The REM 500 neutron survey meter is a sealed spherical tissue equivalent proportional counter that has a relatively linear dose rate response to neutron energies in the range of 70 keV to 20 MeV. For the annual neutron surveys, the REM 500 survey meter will be operated in accordance with the manufacturer's recommendations and station procedures, with sufficient count time to ensure the statistical accuracy of the measurements.

Dominion has previous operating experience using bubble dosimeters to determine the neutron energies at various distances from a TN-32 dry storage cask. The results revealed that nearly 100% of the neutrons at the cask surface have energies greater than 100 keV, while at a distance of ten feet, approximately 70% of the neutrons have energies greater than 100 keV. Given that 98% of the neutrons in a TN-32 dry storage cask have energies less than 6.38 MeV, the REM 500 neutron survey meter is capable of detecting neutrons emitted from a dry storage cask. Dominion has also used the REM 500 neutron survey meter to measure the neutron dose rates from a TN-32 dry storage cask with, and without, the top neutron shield in place. The dose rate measurements were recorded at a distance of approximately six feet above the top of the cask. The results of the survey are provided below:

Table A2.1-1 TN-32 Dry Storage Cask REM 500 Dose Rates

Location	mrem/hr (shield in place)	mrem/hr (shield removed)
Center of Cask Lid	0.3388	19.56
Above Lid Penetration B	0.75	10.4
Edge of Lid Bolt No. 10	1.771	10.01

The above results confirm the ability of the REM 500 neutron survey meter to detect the shift in neutron energies that would result from a loss of material and cracking of the shielding material.

The annual frequency of the neutron survey is justifiable based on continuous monitoring and quarterly reading of doses to the public by TLDs capable of detecting the neutron energies emitted by the TN-32 dry storage casks. Occupational workers are protected by the Dominion Radiological Work Control Program, as described below.

Personnel access to the ISFSI is restricted by a fence with locked gates. Station Security monitors the ISFSI and controls facility access. The Dominion Radiological Work Control Program requires a Radiation Work Permit (RWP) be prepared for maintenance activities at the ISFSI. The RWP ensures occupational workers are protected when work is performed in radiological controlled areas. When an RWP is initiated, health physics technicians perform surveys to determine the general radiological conditions at the job site, thus providing another opportunity to detect adverse conditions around the TN-32 dry storage cask(s). The RWP contains the survey results and additional radiological information necessary to protect maintenance personnel, such as required protective clothing, respirator requirements, and dose and dose rate limits. The RWP also specifies the required dosimetry for entry into the ISFSI. All activities in the vicinity of the TN-32 dry storage casks require neutron and gamma dosimetry to be worn. Maintenance personnel are restricted from entering the ISFSI boundary until they have read and understand the contents of the RWP, and have been briefed by health physics personnel.

For TN-32 dry storage cask maintenance activities (e.g., removal of a protective cover) an additional detailed neutron and gamma survey is performed prior to allowing maintenance to commence. For example, when a protective cover is removed, a detailed neutron survey of the top of the TN-32 dry storage cask is performed immediately after cover removal and prior to maintenance personnel accessing the top of the TN-32 dry storage cask. In accordance with station procedures, personnel performing radiation surveys are required to be qualified health physics technicians. Portable instruments used during surveys are verified to be calibrated and operable prior to use.

The annual neutron radiation survey at reinforced concrete pad No. 1 does not perform a detailed survey of individual casks and does not specifically identify an individual cask that has experienced cracking of the neutron shield. The survey is intended to provide an assessment of the general neutron radiation dose rates at reinforced concrete pad No. 1. When increasing trends are detected the condition will be entered into the Corrective Action Program. Corrective actions will require detailed surveys of individual casks to identify the source of the increased dose rates (Refer to Element 7).

The performance of health physics surveys prior to maintenance activities, in conjunction with personal dosimetry requirements, ensures the safety of occupational workers performing maintenance on the TN-32 dry storage casks. The enhanced neutron detection capability of TLDs located at the ISFSI perimeter fence, supplemented with annual neutron surveys at reinforced concrete pad No. 1, will provide reasonable assurance that the loss of material and cracking of the neutron shielding material will be adequately managed such that the neutron radiation dose to the public remains acceptable during the period of extended operation.

Visual Inspections

Visual inspections identify loss of material on the external surfaces of the TN-32 dry storage cask subcomponents prior to loss of intended function. Quarterly visual inspections, performed by the system engineer are general inspections that are performed consistently with requirements for plant walkdowns to identify signs of coating defects, debris in the vicinity of the TN-32 dry storage casks, rust spots and stains, rust stains on reinforced concrete pad No. 1, physical damage, and bottom corrosion at the concrete/TN-32 dry storage cask interface. Quarterly inspection results have identified coating deficiencies but no visible loss of base material. Non-destructive examination (NDE) qualification is not required to perform the quarterly inspection.

The outer surfaces of the following carbon steel and low-alloy steel subcomponents requiring aging management are exposed to an atmosphere/weather environment and will be inspected by an individual standing at ground level during the quarterly visual inspection: [RAI 3-9]

- Bottom vertical surfaces
- Shell (partially visible)
- Outer Shell
- Trunnions (partially visible)
- Flange vertical surfaces (fully visible)

The following carbon steel and/or low-alloy steel dry storage cask subcomponents requiring aging management are exposed to an atmosphere/weather environment, but are not visible during the quarterly inspection: [RAI 3-9]

- Lid
- Bottom horizontal surfaces
- Top Neutron Shield Enclosure
- Top Neutron Shield Bolts
- Lid Bolts
- Vent and Drain Port Cover Bolts

No stainless steel subcomponents requiring aging management are visible during the quarterly inspection. Procedures will be enhanced to identify the subcomponents that are fully visible and partially visible during the quarterly visual inspection. [RAI 3-9]

Inspection activities will be expanded to include opportunistic and scheduled NDE inspections of a TN-32 dry storage cask bottom and the subcomponents beneath a protective cover. Visual inspection of the flange stainless steel weld overlay and carbon and low-alloy steel subcomponents serve as a leading indicator for stainless, carbon, and low-alloy steel subcomponents requiring aging management, but not visible during the opportunistic and scheduled inspections, e.g., vent and drain port covers and bolts.

In the event a TN-32 dry storage cask is lifted, or a protective cover is removed, an opportunistic visual inspection will be performed on the normally inaccessible locations. A scheduled visual inspection of these locations will be performed on a frequency of every 20 ± 5 years from the date of the pre-application inspections conducted in October and November 2015 [RAI 3-10]. The selection criteria for the 20-year scheduled inspection will be the same as the criteria used to select the casks for the pre-application inspection (Refer to Section F2.1). The pre-application inspections did not identify loss of material from the base metal on the bottom of cask TN-32.49 or beneath the protective cover of cask TN-32.23 (Refer to Section F2.2). North Anna is located in a rural part of Virginia on a freshwater lake and is not located near industrial or chemical facilities. The TN-32 dry storage casks are not exposed to brackish water, saltwater spray, or high-sulfur emissions. An inspection frequency of 20 ± 5 years is therefore acceptable to detect loss of material prior to loss of intended function. The sample size of one cask is consistent with prior license renewal applications approved by the NRC.

The outer surfaces of the following subcomponents requiring aging management will be inspected by an individual standing on top of a cask whenever a protective cover is removed, and at least every 20 +/- 5 years: [RAI 3-9]

- Lid (partially visible)
- Lid Bolts and Neutron Shield Bolts (partially visible)
- Top Neutron Shield (partially visible)
- Flange horizontal surfaces including stainless steel weld overlay (partially visible)
- Trunnions (partially visible)

The horizontal surfaces of the cask bottom will be inspected whenever a cask is lifted, and at least every 20 +/- 5 years [RAI 3-10].

Dominion has chosen to utilize standard industry visual inspection techniques in accordance with NUREG-1927 (Reference A4.3). Opportunistic and 20-year scheduled TN-32 dry storage cask visual inspections will be performed by personnel qualified to perform visual inspections, i.e., VT-1 and VT-3. VT-1 and VT-3 examinations are performed per Dominion NDE Fleet procedures. VT-1 inspections are utilized for specific components/subassembly inspections and VT-3 inspections are utilized for general assembly inspections. In general, the inspection requirements of the VT-1 examination are more stringent than that of the VT-3 examination. For example, the maximum examination distance for a VT-1 examination is less than that allowed for a VT-3 examination. Refer to Section XI, Subarticle IWA-2210 of the ASME Boiler and Pressure Vessel Code for additional information on visual examination techniques.

The specific visual inspection methods that will be used for opportunistic and 20-year scheduled inspections of the TN-32 dry storage casks are as follows:

- Protective cover and subassembly interior/exterior surfaces (VT-3)
- Cask flange visible surfaces (VT-1)
- Overpressure system visible surfaces (VT-3)
- Neutron shield visible surfaces (VT-3)
- Cask lid visible surfaces and lid bolt heads (VT-3)
- Neutron shield bolts (VT-1 and/or VT-3)
- Protective cover bolts (VT-1 and/or VT-3)
- Upper and lower trunnions (VT-3)
- Cask bottom surface (VT-3)

The neutron shield and protective cover bolts inspection technique will be either a VT-1 or VT-3 examination depending upon whether the bolt is installed (VT-3) or if the bolt is removed for detailed examination (VT-1).

A pre-application visual inspection was also performed in Fall 2015. VT-1 and VT-3 examination methods were utilized during the inspection. Details of the TN-32 pre-application inspection are contained in Appendix F: Additional Information, Section F2.0.

Discrepancies noted during the above inspections are entered in the Dominion Corrective Action Program. The results of visual inspection activities are maintained in station records and will be evaluated for entry in AMID using the screening criteria of NEI 16-10, recommended in NEI 14-03 [RAI 3-14]. The visual inspection activities ensure loss of material is detected in TN-32 dry storage cask subcomponents prior to loss of intended function.

Element 5: Monitoring and Trending

The inspections and monitoring activities in this AMP are all performed periodically in order to identify areas of degradation. Results will be evaluated by qualified individuals consistent with industry guidelines, standards and regulations. Conditions adverse to quality noted during the inspection and monitoring activities, such as non-conformances, failures, malfunctions, deficiencies, deviations, or defective material and equipment are entered into the Dominion Corrective Action Program. Depending on significance, a more focused evaluation may be required to determine the extent of condition and determine if more frequent monitoring or inspection is required. As discussed below, visual inspections and radiation monitoring assessments appropriately consider cumulative experience from previous inspections and assessments in order to monitor and trend the progression of aging effects over time. Additionally, the Dominion Corrective Action Program includes trending of adverse conditions (including those related to interseal pressure monitoring, radiation monitoring, and visual inspections) as well as a process to prevent recurrence.

An enhancement will be made to perform an engineering evaluation every five years to review industry and plant-specific operating experience (including work order history). The initial operating experience evaluation during the period of extended operation will be scheduled to occur in January 2020 [RAI 3-10]. The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage the loss of material and cracking for the TN-32 dry storage casks [RAI 3-4]. Each element of the TN-32 Dry Storage Cask Aging Management Program will be reviewed to determine if updates to the AMP are required based on lessons learned from the operating experience review.

The results of the engineering evaluation will be entered in the Aging Management INPO Database (AMID), using the screening criteria as recommended in NEI 14-03, Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management [RAI 3-14].

Interseal Pressure Monitoring

Pressure monitoring of each TN-32 dry storage cask at the ISFSI is a continuous process. The absence of low pressure alarms is confirmed twice daily by the Operations Department. The functionality of the pressure switches is confirmed every 36 months. Pressure switches that do not meet established acceptance criteria are entered in the Dominion Corrective Action Program. Corrective actions include adjustment or replacement as well as review for extent of condition.

Radiation Monitoring [RAI 3-11]

In accordance with Dominion radiation survey procedures, neutron and gamma TLD readings are recorded quarterly and neutron survey results conducted at reinforced concrete pad No. 1 will be recorded annually. Annual trending of these parameters will be incorporated in the radiation survey procedures.

Tables A2.1-2 and A2.1-3 provide the maximum and minimum historical neutron and gamma quarterly dose rates at the ISFSI perimeter fence from first quarter 2006 through fourth quarter 2015. Dose rates were determined by dividing the quarterly TLD dose by the number of exposure hours in the quarter.

Table A2.1-2 ISFSI Historical Neutron Dose Rates (2006 through 2015)

North Dose Rate (microrem/hr)		East Dose Rate (microrem/hr)		South Dose Rate (microrem/hr)		West Dose Rate (microrem/hr)	
Max	Min	Max	Min	Max	Min	Max	Min
118	35	64	18	157	43	96	26

Table A2.1-3 ISFSI Historical Gamma Dose Rates (2006 through 2015)

North Dose Rate (microrem/hr)		East Dose Rate (microrem/hr)		South Dose Rate (microrem/hr)		West Dose Rate (microrem/hr)	
Max	Min	Max	Min	Max	Min	Max	Min
16	5	18	4	26	11	24	10

The review of historical dose rates at the ISFSI perimeter fence shows no evidence that the neutron and/or gamma shielding is degrading. Notwithstanding, an enhancement will be implemented to perform an annual evaluation of ISFSI perimeter fence TLD radiation measurements and annual reinforced concrete pad No. 1 neutron radiation survey results for adverse trends. These measures ensure that deterioration of the TN-32 dry storage casks gamma and neutron shield material is detected prior to loss of intended function.

Dominion will develop procedures for annual trending of radiation values prior to entering the PEO. Engineering personnel will obtain the annual neutron radiation survey results conducted at reinforced concrete pad No. 1 and the four prior quarterly ISFSI perimeter fence TLD neutron and gamma dose values. The annual neutron dose rates recorded at each survey point and the quarterly neutron and gamma TLD readings will be plotted and trended. A separate graph will be plotted for each neutron radiation survey point. Neutron and gamma TLD readings will also be plotted on separate graphs, with each TLD location uniquely identified on each graph. Each graph will be updated annually so that trends can be easily observed on each graph over the 40-year PEO. The trending evaluation will consider information pertaining to cask loading and movement to assist in evaluating trends in ISFSI dose rates.

Baseline radiation values for TLD locations and annual survey locations will be established prior to the PEO. Movement or placement of additional TN-32 dry storage casks at the ISFSI can influence baseline radiation values. In the event a TN-32 dry storage cask is removed or additional casks are placed on reinforced concrete pad No.1, new baseline values will be established. In the event the TLDs located at the ISFSI perimeter fence are relocated, new TLD baseline values will be established.

Identification of an increasing trend in radiation values will require the condition to be entered in the Corrective Action Program.

Visual Inspections

Quarterly visual inspections determine the existence of loss of material in the TN-32 dry storage cask exterior regions and check for accumulation of debris and concrete staining. Observations regarding the material condition of the TN-32 dry storage casks external surfaces are recorded per the inspection procedure. 20-year scheduled and opportunistic visual inspections of normally inaccessible areas will be included in the aging management program in addition to the quarterly visual inspections.

As described in Element 4: Detection of Aging Effects, an enhancement will be made to perform a visual inspection of the normally inaccessible areas of a TN-32 dry storage cask(s) including a cask bottom and under a protective cover at least every 20 ± 5 years. Prior inspection results (including pre-application inspection results) will be reviewed to identify adverse trends. The pre-application inspections (refer to Element 10: Operating Experience) did not identify any detectable loss of material from the bottom of cask TN-32.49 or under the protective cover of cask TN-32.23. North Anna is located in a rural area of Virginia on a freshwater lake and is not located near industrial or chemical facilities. The TN-32 dry storage casks are not exposed to brackish water, saltwater spray, or high-sulfur emissions. An inspection frequency of every 20 ± 5 years is adequate to detect loss of material prior to loss of an intended function.

Element 6: Acceptance Criteria

The TN-32 Dry Storage Cask Aging Management Program acceptance criteria ensure that the particular structure and component intended functions are maintained under the existing licensing-basis design conditions during the PEO.

Interseal Pressure Monitoring

The acceptance criterion for interseal pressure monitoring is the absence of a low pressure alarm. The alarm setpoint of 3,250 mbar is specified in ISFSI Technical Specifications Table 3-1 (Reference A4.2). Dominion procedures document the required setpoint tolerance. A Condition Report is entered into the Corrective Action Program for any pressure switch that actuates at less than the required setpoint or outside of the required tolerance.

Radiation Monitoring [RAI 3-11]

The aging management program will be enhanced to include annual trending of quarterly TLD neutron and gamma radiation measurements at the ISFSI perimeter fence and annual trending of neutron radiation survey results conducted annually at reinforced concrete pad No. 1. The acceptance criteria for trending of quarterly neutron and gamma TLD readings, and for trending of annual reinforced concrete pad No. 1 neutron survey results, is the absence of an increasing trend in radiation values, as determined by engineering evaluation. ISFSI Technical Specification Limiting Condition for Operation 3.3.1 places limits on the maximum combined neutron and gamma dose rates at the sides and top of a TN-32 dry storage cask prior to transporting a dry storage cask to reinforced concrete pad No. 1. These limits are intended to ensure that the dry storage cask average surface dose rates during transport, storage, and unloading are within the values contained in the SAR. The limits provide assurance that the dose to the general public is minimized, and the dose to occupational workers is as low as reasonably achievable.

After transport of a cask to the ISFSI, additional factors influence the measured dose at an individual cask, including the radiation emitted from adjacent casks and the decay of the spent fuel neutron source term. A direct correlation cannot be made between the measured dose rate for a cask located at the ISFSI to the dose rate measured for the cask prior to transport to the ISFSI (and the Technical Specification dose rate limits). However, the absence of an increasing trend would demonstrate that measured dose rates remain within the values contained in the SAR.

Visual Inspections

The acceptance criteria for the quarterly visual inspections are:

- No coating defects (bubbling/blistering of paint)
- No loose debris in contact with the cask(s)
- No rust spots and stains
- No rust stains on the concrete
- No physical damage
- No baseplate corrosion at the concrete/cask interface

The acceptance criterion for the opportunistic and scheduled inspections of the TN-32 dry storage cask will be no detectable loss of material from the base metal as determined by VT-1 and/or VT-3 visual inspection.

Indications adverse to quality identified during the above inspection and monitoring activities, e.g., flaking of TN-32 dry storage cask coating, are entered into the Dominion Corrective Action Program for further evaluation. This low corrective action threshold ensures all conditions adverse to quality are captured and evaluated. If required, the engineering evaluation would include support by qualified Non-Destructive Examination staff to perform additional inspections to assess the extent of condition.

Element 7: Corrective Actions

Corrective actions for deviating conditions that are adverse to quality, e.g., failures, malfunctions, deficiencies, deviations, defective material and equipment, and non-conformances, are performed in accordance with Dominion Topical Report DOM-QA-1, "Nuclear Facility Quality Assurance Program Description" (Reference A4.4). Adherence to DOM-QA-1 ensures that, as required by 10 CFR 50, Appendix B, an adequate quality assurance program is implemented.

The Dominion Corrective Action Program is implemented in accordance with a nuclear fleet administrative procedure. The administrative procedure includes expectations for identification and reporting of conditions adverse to quality, conditions that affect personnel safety, nuclear safety, plant reliability, trending, and other conditions that do not meet station expectations. For conditions determined to be significantly adverse to quality the procedure provides measures to provide reasonable assurance that the cause of the condition is determined, corrective action is taken in a timely and accurate manner to preclude repetition, and the cause and corrective actions taken are documented and reported to appropriate levels of management. A condition significantly adverse to quality is defined as a condition adverse to quality that has, or if left uncorrected could have, an undesirable effect on plant safety, regulatory position, or environmental impact.

Station deficiencies are identified by the submission of condition reports (CRs). An attachment to the administrative procedure provides a detailed list of examples of conditions that require submission of a CR. At a minimum, CRs are submitted for any issue or concern that does not meet specific requirements of procedures, policies, management expectations, or accepted industry standards including all conditions that do not meet the AMP acceptance criteria. CRs are also required to be submitted for any issue where there is doubt about whether a CR should be submitted. The procedure also provides guidance for submittal of CRs anonymously.

Submitted CRs are initially reviewed by the submitters' supervisor. The supervisor answers screening questions to determine if Operations Shift Manager review is required. If so, the shift manager, or designee, performs an operability assessment. As required by 10 CFR 72.75, reportability determinations are also made. Further review of the CR is then performed by the Condition Report Review Team (CRT).

The CRT is a multi-discipline, multi-departmental team consisting of members from Engineering, Maintenance, Operations, Radiation Protection, Training, and Organizational Effectiveness. At least one member of the CRT should have, or previously held, a Senior Reactor Operators license. Functions of the CRT include:

- Identifying conditions that are adverse to quality
- Establishing corrective action assignments
- Assigning required significance level and level of evaluation to CRs (e.g., Root Cause Evaluation)
- Reviewing CRs for trending and notifying the Trend Coordinator for submission of an additional CR to address trending aspects
- Reviewing CRs for safety implications
- Reviewing CRs for initiation of work management activities
- Recommending compensatory measures
- Identifying events that should be communicated to the industry via the INPO Consolidated Event System
- Notifying senior management of significant events

CRs identified as adverse to quality by the CRT are further reviewed by the Corrective Action Assignment Review Team (CAART). The CAART is generally comprised of senior-level management, Manager level and above, and includes the Plant Manager. The CAART reviews the results and recommendations of the CRT and has the authority to make changes when appropriate. The CAART also identifies selected issues to be reviewed by the Facility Safety Review Committee.

The response to corrective action assignments is reviewed to verify the adequacy of the response and proposed corrective actions, including no corrective action. CRT or CAART may assign additional reviews when appropriate.

A self-assessment is performed at least every two years to determine the effectiveness of the Corrective Action Program. An aggregate review of all open conditions designated as adverse to quality is performed at least every eighteen months to ensure appropriate priorities have been assigned to these outstanding issues.

In the event ISFSI radiation trending shows an unexplained increase in neutron dose rates, the condition will be entered into the Corrective Action Program. The response to the condition will require health physics staff to perform more detailed cask surveys at multiple axial and radial locations to ascertain which cask is the source of increased radiation. The corrective actions could include increasing the number and frequency of cask surveys, use of temporary shielding, and/or returning the cask to the spent fuel pool to off-load the stored fuel and removal of the cask from service. As described in Element 10, the associated corrective actions and lessons learned will be shared with the industry in the AMID database. Dominion will also review the AMID database periodically to ensure aging management of the neutron shields is consistent with the most recent industry practices. [RAI 3-11]

Element 8: Confirmation Process

Adherence to the Dominion Quality Assurance Program ensures that, as required by 10 CFR Part 50, Appendix B, an adequate quality assurance program is implemented. The Quality Assurance program includes provisions for timely evaluation of adverse conditions, and implementation of any corrective actions required, including root cause evaluations and actions to prevent recurrence. Procedural controls are in place to ensure the response to corrective action assignments is reviewed to verify the adequacy of the response and the corrective actions. Condition reports are also reviewed for trending purposes.

An engineering evaluation will be performed every five years to review industry and plant-specific operating experience (including work order history). Each element of the aging management program will be reviewed to determine whether updates to the program are required based on lessons learned from the operating experience review. The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage loss of material and cracking of the TN-32 dry storage casks. [RAI 3-4]

Element 9: Administrative Controls

All activities associated with the North Anna ISFSI that are important to safety are conducted in accordance with Dominion Topical Report DOM-QA-1, "Nuclear Facility Quality Assurance Program Description" (Reference A4.4). Adherence to DOM-QA-1 ensures that, as required by 10 CFR 50, Appendix B, an adequate quality assurance program is implemented. DOM-QA-1 includes guidance for inspector requirements, record retention requirements, and document control. Administrative and technical procedures are reviewed, approved, and maintained as controlled documents in accordance with the Dominion procedure control process and the Quality Assurance Program. Administrative controls have been established to ensure records are identified, retained, maintained, and retrievable. Approved procedures define record retention requirements and storage methods.

Element 10: Operating Experience

The Dominion operating experience (OE) program is implemented in accordance with an administrative procedure. The goal of the OE Program is to effectively and efficiently use lessons learned from the industry to improve safety and reliability and to reduce the number and consequence of events. The procedure includes applicability screening of OE reports from the NRC, INPO, and vendors. Guidelines for use of the INPO Nuclear Network Forums are included in the procedure. The procedure also stipulates OE coordinator trending reviews at set frequencies and OE coordinator qualification requirements.

As stated in Element 8: Confirmation Process, additional reviews occur during the engineering evaluation of industry and plant-specific operating experience that will occur every five years to determine whether updates to the aging management program are needed to address lessons learned. The historical absence of significantly adverse findings for the ISFSI confirms that a review interval of five years is sufficient to address the potential need for any changes to the aging management programs.

A separate administrative procedure provides instruction for submitting Dominion OE to the INPO Consolidated Event System (ICES). The purpose of this procedure is to provide a method for identification and reporting of INPO ICES reports. The procedure includes reporting criteria and required reporting time frames. The review and sharing of operating experience will be enhanced to include use of the Aging Management INPO Database (AMID) in accordance with NEI 14-03, Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management. Additionally, the ISFSI component inspection results will be evaluated and entered into the AMID database using the screening criteria of NEI 16-10, as recommended by NEI 14-03. [RAI 3-14]

Key word searches were performed of the Dominion Corrective Action Program and the INPO OE database to ensure the aging effects of concern are accurately identified and lessons learned are reviewed for applicability to NAPS. The OE searches included a review of industry and North Anna and Surry-specific OE. The INPO OE database includes international and NRC related information. Transnuclear vendor bulletins were also reviewed. The review of the Dominion Corrective Action Program utilized the following search terms:

- Cask
- ISFSI
- TN-
- Transnuclear

The review of the INPO OE database utilized the following search terms:

- ISFSI
- Dry Storage
- Dry Cask
- Transnuclear

Table A2.1-4, North Anna ISFSI Aging-related Operating Experience, provides a listing of North Anna-specific OE directly related to aging of SSCs in the scope of license renewal and a brief summary of the corrective actions taken. The events can be categorized into TN-32 dry storage cask coating deficiencies and dry storage cask low pressure alarms, the most significant being low pressure alarms. Further discussion of these events is provided later in this section.

Table A2.1-4 North Anna ISFSI Aging-related Operating Experience

Date	Report	Title	Description/Corrective Actions
06/18/00	N-2000-1551	Crack in TN-32.06 Cask Coating	The coating was repaired in accordance with the manufacturer's instructions.
02/01/10	CR367334	TN-32.48 Pressure Alarm Response	Following a low pressure alarm, troubleshooting revealed the overpressure system (OP) pressure was less than the alarm setpoint but greater than the Technical Specification minimum required value. The OP system pressure was returned to normal. Helium leaks checks did not identify leakage from the OP System. Engineering recommended OP system pressure be checked during the performance of the scheduled pressure switch test the following month. OP system pressure and alarm setpoints were verified to be normal on March 9, 2010. No further actions were required. The OE review did not identify any additional low pressure alarms for dry storage cask TN-32.48. It was also noted during troubleshooting that one of the two pressure switches failed to alarm. This pressure switch was replaced.
8/29/2011	CR440206	ISFSI Pad 1 TN-32 Paint	During a walkdown following the seismic event of 8/23/2011, a concern was identified that the dry storage cask bottom coating may have been scratched due to movement of the dry storage casks. Transnuclear provided a response stating that no repair of the coating was required. The quarterly visual inspection procedure was revised to include inspection for bubbled/blistering paint and corrosion product stains on reinforced concrete pad No. 1 near the dry storage cask bottom. (Note: The results of the pre-application inspection performed in 2015 did identify deterioration of the bottom protective coating, but no detectable loss of material from the dry storage cask base metal.)
01/24/13	CR503456	Documentation of 0-PT-4.3 results	Rust stains resulting from coating defects (e.g., flaking) were noted on several dry storage casks and reinforced concrete pad No. 1 adjacent to the dry storage casks. It was concluded since these conditions are superficial that immediate action was not required. A work order was written to remove rust stains from concrete and TN-32 dry storage casks.

Table A2.1-4 North Anna ISFSI Aging-related Operating Experience

Date	Report	Title	Description/Corrective Actions
01/13/14	CR536973	Documentation of 0-PT-4.3 results	Items noted on this inspection were previously identified in CR503456. A comparison of pictures taken on 5/2/13 did not indicate further degradation had occurred. No further action was required other than continued monitoring during the quarterly visual inspections.
07/14/14	CR553872	Coating deficiencies found during 0-PT-4.3	Superficial coating defects, e.g., scratches, paint flaking, etc., were noted on three dry storage casks with no base metal exposed.
09/21/15	CR1010377	Cask TN-32-32 Over Pressure System Low Pressure Alarm	Initial troubleshooting of the cask low pressure alarm confirmed proper operation of the pressure switches and did not identify helium leakage from the overpressure system. Engineering established dry storage cask pressure monitoring frequency of once per month. Monitoring results were provided to Engineering for trending.
10/03/15	CR1012049	TN-32.37 low pressure switch alarm	Investigation revealed a face seal on a pressure switch was leaking. The seal was replaced and overpressure system pressure was restored to normal pressure.
10/14/15	CR1013461	ISFSI License Renewal, Bottom of Cask TN-32.49 Inspection Results	This condition report was written to document the completion of the pre-application cask bottom inspection. Engineering evaluation of results concluded that no corrective actions were required. Refer to Section F2.2.
11/18/15	CR1018794	TN-32.23 Cask Inspection results	This condition report was written to document the completion of the pre-application cask top inspection. Engineering evaluation of the results concluded that no corrective actions were required. Refer to Section F2.2.

As part of the OE review, recent license renewal applications submitted by Prairie Island Nuclear Generating Station and Calvert Cliffs Nuclear Power Plant were reviewed. The review confirmed the aging effects identified, associated examination techniques, and acceptance criteria are consistent with the industry.

The EPRI Dry Cask Storage Characterization Project documents an aging study of a Castor V/21 dry storage cask after approximately 15 years of dry storage. The project identified corrosion of stainless steel fasteners used to attach the V/21 dry storage cask rear breech plate, i.e., dry storage cask bottom. North Anna does not use Castor V/21 dry storage casks. Fuel rods from the Castor V/21 dry storage cask having a burnup of 35.7 GWD/MTU were removed and studied by Argonne National Laboratory (ANL). No detrimental aging of the low burnup fuel rods was identified.

Several technical data gaps have been identified related to the aging effects of V/21 dry storage casks and spent fuel, e.g., cladding hydride reorientation and embrittlement. The U.S. Department of Energy Office of Nuclear Energy developed the Gap Analysis to Support Extended Storage of Used Nuclear Fuel report to identify and prioritize the data gaps. This report was reviewed to ensure all technical data gaps were identified and prioritized correctly and to compare the gaps with those identified in similar reports from various agencies, including international studies. It was recommended that low burnup fuel from the Castor V/21 dry storage cask initially inspected by ANL be reexamined to better understand the long-term aging of low burnup fuel. It was noted that the fuel initially examined by ANL was loaded into a dry cask as opposed to one that experienced the prototypical drying cycle. The examined fuel, therefore, was not exposed to the residual moisture that may be present in a typical dry storage cask such as those in use at North Anna.

As identified in Section A3.0, Summary, Dominion has committed to reviewing industry operating experience to ensure the aging effects, inspection techniques, inspection frequencies, and acceptance criteria are consistent with the most recent industry standards and practices. The resolution of the technical data gaps described above will be included in the operating experience review.

Interseal Pressure Monitoring Operating Experience

A review of operating experience related to the TN-32 dry storage cask interseal pressure monitoring revealed no aging-related issues with the metallic O-ring seals on TN-32 dry storage casks. Refer to Table A2.1-4, North Anna ISFSI Aging-related Operating Experience for a list of condition reports and associated corrective actions for North Anna.

Based on industry and site-specific OE review, actuation of TN-32 dry storage cask low pressure alarms is not unexpected. North Anna has not experienced failure of the primary cask seal, which could result in leakage of radioactive materials to the outside atmosphere.

The alarms are generally the result of helium leakage from fittings on the overpressure system, low ambient temperature, or failed pressure switches. North Anna has developed a troubleshooting procedure for TN-32 dry storage cask low pressure alarms. The procedure includes troubleshooting cask pressure switches and checking the overpressure system for leakage.

In 1999 and 2000, low interseal pressure alarms occurred on five TN-32 dry storage casks in place at Surry Power Station. The five TN-32 dry storage casks were returned to the spent fuel pool and unloaded in order to examine the inner and outer seals. Inspection of the seals showed no evidence of corrosion of the inner seal; but the outer seal was observed to be corroded. Corrosion of the lid bolt heads was also identified during the inspection. The evaluation concluded the low pressure alarms were the result of corrosion from water intrusion inside the protective cover due to improper assembly of the Conax connector penetrating the apex of the protective cover. The introduction of water inside the cover resulted in galvanic corrosion of the aluminum covered outer seal in contact with the stainless steel weld overlay on the dry storage cask flange and lid. The loss of material due to galvanic corrosion of the aluminum outer metallic seal cover was sufficient to actuate the low pressure alarms. The metallurgical report also identified chlorine in the corrosion deposits, which most likely resulted from the surrounding atmospheric environment at Surry Power Station. A similar issue occurred in 2011 on a Transnuclear dry storage cask at Peach Bottom Atomic Power Station.

Corrective actions to prevent recurrence at Surry and North Anna Power Stations included use of silver-coated O-rings with silver-coated seals on all future casks. Additionally, the covers were modified on all casks to remove the Conax connector and install an access plate (referred to as the Subassembly) in the cover, which is bolted and sealed. Desiccant was also placed on top of the neutron shield to minimize moisture. Following these corrective actions, there has been no recurrence of water intrusion inside the protective covers.

In addition to corrosion of the outer lid seal, a second issue was identified when the TN-32 dry storage casks were returned to the spent fuel pool. The torque value applied to the lid bolts was determined to be less than the original specified torque value. Ten lid bolts on one TN-32 dry storage cask and three lid bolts on another TN-32 dry storage cask could be moved by hand. Although the torque was less than specified, cask containment integrity was maintained and no leakage to the environment resulted. It was concluded that the loss of bolt pre-load was the result of applying final lid bolt torque before the TN-32 dry storage cask achieved thermal equilibrium, and not the result of age-related loss of pre-load. In April 2001, Transnuclear issued an Information Bulletin to inform the industry of the above issues. The bulletin recommended final lid bolt torque be applied to the lid bolts after the TN-32 dry storage cask reaches thermal equilibrium.

Transnuclear also recommended use of Neolube or Loc-Tite N-5000 as the preferred lubricant for lid bolts. The bulletin recommendations have been implemented at NAPS, including the use of N-5000 lubricant.

There have been instances in the industry and at North Anna and Surry Power Stations where low pressure alarms have occurred as a result of non age-related conditions. These include alarms resulting from conditions such as leakage in the overpressure system, low atmospheric temperature, pressure switch setpoint drift, and pressure switch failure.

Radiation Monitoring Operating Experience

The review of site-specific and industry operating experience, as well as historical dose rates recorded at the ISFSI perimeter fence shows no evidence that the neutron and/or gamma shielding is degrading. An enhancement will be implemented to perform an annual evaluation of ISFSI perimeter radiation measurements for adverse trends to ensure that deterioration of the TN-32 dry storage casks shielding materials is detected prior to loss of intended function.

Visual Inspections Operating Experience

The North Anna ISFSI has been in operation for more than 17 years. A review of all previously completed quarterly inspections, as well as the Dominion Corrective Action Program, identified cases of minor coating degradation, i.e., no visible loss of base material, and rust stains on reinforced concrete pad No. 1. A separate aging management program has been developed to monitor the condition of reinforced concrete pad No. 1. TN-32 dry storage cask coating deficiencies are expected to occur over time. None of the previously identified coating deficiencies have challenged the intended functions of the cask subcomponents. As station resources permit, coating defects are corrected by removal of the existing coating and re-application of the coating. As of March 2016, nine TN-32 dry storage casks have been re-coated. Refer to Table A2.1-4, North Anna ISFSI Aging-related Operating Experience for a list of condition reports and associated corrective actions related to visual inspections.

August 2011 Seismic Event

On August 23, 2011, NAPS experienced a moment magnitude (M) 5.8 earthquake that was centered approximately 11 miles from the plant. The plant's seismic design basis was exceeded and Units 1 and 2 were shutdown without incident.

A walkdown of the ISFSI was performed on August 24, 2011. It was discovered that 25 of the 27 TN-32 dry storage casks had shifted from their original locations. Table F2-1 identifies the resulting movement of each cask. On August 29, 2011, a team consisting of personnel from Transnuclear Structural Analysis and Civil Construction groups as well as Dominion Nuclear Spent Fuel engineers performed a walkdown of the ISFSI.

Although 25 of the 27 TN-32 dry storage casks had shifted, there were no indications of damage to the TN-32 dry storage casks or the fuel inside the casks. After an M 3.4 aftershock, a follow-up inspection was performed on September 1, 2011 and included the following inspections/observations:

- Above-ground pressure monitoring systems including the remote monitoring panel were visually inspected and no damage was found. No pressure monitoring system alarms were received during the event. Electrical power at the ISFSI was not lost during the seismic event.
- Visual inspection of reinforced concrete pad No. 1 did not reveal any cracking or damage from the seismic event.
- Radiological surveys of the TN-32 dry storage casks did not indicate an increase in cask surface dose rates when compared to the dose rates obtained following cask loading.
- On August 30, 2011, inspections were performed on six randomly selected pressure switches. These inspections concluded that setpoints had not drifted outside of what would normally be expected and Helium pressure was consistent with expectations.

An Operability Determination concluded that the TN-32 dry storage casks were operable and performing as designed. To ensure a greater confidence that the TN-32 dry storage casks were not affected by the seismic event, Dominion performed the following detailed inspections on five TN-32 dry storage casks based on recommendations from Transnuclear:

- The tubing and valves connected to the NEMA box for evidence of cracking or deformation
- The protective cover subassembly for deformation or cracking
- The protective cover for evidence of moisture leakage
- The lower edge of the lid near the outer O-ring for evidence of moisture
- The overpressure tank mounting brackets for evidence of bending or loosening
- The top of the neutron shield for damage due to overpressure tank mounting brackets deformation
- The neutron shield bolts for damage
- The top of the neutron shield for damage
- The tubing and valves connected to the overpressure tank for evidence of cracking or deformation
- The protective cover bolts for evidence of bending or loosening

The inspections identified water intrusion and rust inside the NEMA electrical box associated with dry storage cask TN-32.36. The scope of the NEMA box inspections was expanded to inspect all remaining TN-32 dry storage casks to determine the extent of condition.

Water intrusion in three additional NEMA boxes was identified. Condition reports were initiated to document the deviating conditions. Work orders were initiated and repairs made to the NEMA boxes.

Pre-application Inspection

A pre-application inspection was performed at NAPS in Fall 2015 to evaluate the condition of the TN-32 dry storage casks. See Appendix F: Additional Information, Section F2.0, for the results of the pre-application inspection and the basis for cask selection.

Summary of Enhancements

The following enhancements will be made to the TN-32 Dry Storage Cask Aging Management Program:

1. Enhance Station procedures to identify the subcomponents of the TN-32 cask that are fully visible and partially visible during the quarterly visual inspection. [RAI 3-9]
2. Perform an engineering evaluation every 5 years to review industry and plant-specific operating experience (including work order history). The initial operating experience evaluation during the period of extended operation will be scheduled to occur in January 2020 [RAI 3-10]. The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage the loss of material and cracking for the TN-32 dry storage casks [RAI 3-4]. Each element of the TN-32 Dry Storage Cask Aging Management Program will be reviewed to determine if updates to the AMP are required based on lessons learned from the OE review. The results of the engineering evaluation will be entered in the Aging Management INPO Database (AMID), using the screening criteria as recommended in NEI 14-03, Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management. [RAI 3-14]
3. Perform an opportunistic visual inspection of a TN-32 dry storage cask bottom and under the protective cover in the event a dry storage cask is lifted or a protective cover is removed. The acceptance criterion is no detectable loss of material from the base metal as determined by VT-1 and/or VT-3 inspection. The ISFSI component inspection results will be evaluated and entered into the AMID database using the screening criteria as recommended by NEI 14-03. [RAI 3-14]
4. Perform a visual inspection (i.e. VT-1 and/or VT-3) of a TN-32 dry storage cask bottom and under the protective cover at least every 20 ± 5 years from the date of the pre-application inspection [RAI 3-10]. The selection criteria for the 20-year scheduled inspection will be the same as the criteria used to select the cask for the pre-application inspection. The 5-year periodic reviews of operating experience, as well as changes to the aging management program resulting from the review, will be considered in cask selection. The acceptance criterion is no detectable loss of material from the base metal as determined by VT-1 and/or VT-3 inspection. The ISFSI component inspection results will be evaluated and entered into the AMID database using the screening criteria as recommended by NEI 14-03 [RAI 3-14].

5. Develop Health Physics procedures for conducting an annual neutron survey at reinforced concrete pad No. 1 using a REM 500 neutron survey meter, or equivalent, prior to entering the period of extended operation. The survey point locations, including the approximate height corresponding to the maximum neutron flux, will be identified in the Health Physics survey procedure. [RAI 3-11]
6. Develop a procedure or engineering technical evaluation describing the methodology for performing annual trending of ISFSI radiation readings [RAI 3-11].
7. Modify all TLDs located at the ISFSI perimeter fence to include a CR 39 chip, or equivalent, prior to obtaining TLD baseline neutron and gamma radiation values [RAI 3-11].
8. Define baseline radiation values for the annual neutron survey locations and for the ISFSI TLD locations prior to entering the PEO. New baseline values will be established in the event a cask is removed from, or additional cask(s) are placed on, reinforced concrete pad No. 1. In the event the location of TLDs is changed new baseline TLD values will be established. [RAI 3-11]
9. Perform an annual survey at reinforced concrete pad No. 1 using a REM 500 tissue equivalent proportional counter, or equivalent [RAI 3-11].
10. Perform an annual evaluation of ISFSI perimeter fence TLD neutron and gamma radiation measurements, and reinforced concrete pad No. 1 neutron survey results for adverse trends. The acceptance criterion is the absence of an increasing trend in neutron or gamma radiation values (as determined by engineering evaluation) [RAI 3-11]. The trend results will be evaluated and entered into the AMID database using the screening criteria as recommended by NEI 14-03 [RAI 3-14].

Conclusion

Based on the operating experience review and pre-application inspection results, the TN-32 dry storage cask intended functions have not been challenged by age-related degradation. Existing procedures, along with proposed enhancements, provide reasonable assurance that the intended functions will be maintained consistent with the ISFSI design basis during the period of extended operation.

A2.2 Monitoring of Structures Aging Management Program

The purpose of Monitoring of Structures Aging Management Program (AMP) is to define the aging management activities which are necessary to help ensure the integrity of reinforced concrete pad No. 1 for storage of TN-32 dry storage casks. Reinforced concrete pad No. 1 on which the TN-32 dry storage casks rest is an above-ground, outdoor installation which is capable of withstanding the anticipated effects of "weathering." The aging management review process identified cracking, change in material properties, and loss of material as the aging effects of concern. The Monitoring of Structures Aging Management Program is a new program that ensures cracking, change in material properties, and loss of material from reinforced concrete pad No. 1 will be identified and managed during the period of extended operation prior to loss of intended function. The program includes visual inspections to manage the above-grade aging effects and groundwater chemistry monitoring to identify below-grade aging mechanisms. The reinforced concrete pad No. 1 is not located in groundwater; however, a groundwater chemistry program will be established to provide supplemental information for identifying conditions conducive to underground aging mechanisms. An evaluation of the 10 program elements is presented below.

<u>Element 1: Scope</u>

The Monitoring of Structures Aging Management Program manages the effects of aging for the North Anna ISFSI reinforced concrete pad No. 1, which is exposed to atmosphere/weather and soil. Reinforced concrete pad No. 1 has an intended function of maintaining structural integrity to provide uniform and substantial support for the TN-32 dry storage casks, and to ensure that decelerations experienced during design accidents are acceptable.

The applicable aging mechanisms and aging effects for reinforced concrete pad No. 1 are:

Aging Mechanism	Aging Effect(s)
Reaction with aggregates	Cracking
Freeze-thaw	Cracking
	Loss of material
Leaching of calcium hydroxide	Change in material properties
Settlement	Cracking

<u>Element 2: Preventive Actions</u>

The Monitoring of Structures Aging Management Program is designated a *condition monitoring* activity. No preventive actions are performed.

Element 3: Parameters Monitored or Inspected

This AMP describes periodic visual monitoring, which is performed to determine the surface condition of reinforced concrete pad No. 1. The surface condition is a leading indicator for the overall integrity of the pad. Visual inspections detect surface defects resulting from the aging mechanisms of reaction with aggregates (e.g., alkali-silica reaction), freeze-thaw, leaching of calcium hydroxide, or settlement. Surface indications of age-related degradation for reinforced concrete pad No. 1 include loss of material, cracking, and change in material properties (white stains, indicative of leaching).

An opportunistic inspection of the normally inaccessible area of reinforced concrete pad No. 1 under the TN-32 dry storage cask will be performed whenever a cask is lifted. An opportunistic inspection will also be performed for all exposed below-grade surfaces of the concrete pad if made available by excavation during the course of other work [RAI 3-9].

Supplemental information will be obtained from groundwater samples to be taken at the ISFSI site and analysis of the water chemistry will determine values for chlorides, sulfates, and pH at two groundwater wells every five years. This information will be utilized in identifying conditions conducive to underground aging mechanism due to an aggressive chemical environment. Measured values which exceed established acceptance criteria for these three parameters indicate a condition that could be detrimental for concrete in contact with the groundwater. However, reinforced concrete pad No.1 is not exposed to groundwater in the soil environment.

Element 4: Detection of Aging Effects

Visual inspections identify degradation of the physical condition due to aging effects on the surfaces for reinforced concrete pad No. 1 such that there is no loss of intended function. These visual inspections check for irregularities such as cracking, loss of material on the concrete surface, and effects from change in material properties (due to leaching). The inspections will be performed in accordance with a new procedure for structural monitoring of reinforced concrete pad No. 1. Qualification requirements for the person performing the inspection of reinforced concrete pad No. 1, and for the engineer evaluating the inspection results, shall comply with the requirements in American Concrete Institute (ACI) 349.3R, (Reference A4.5) and be consistent with the requirements listed in the North Anna procedure for inspections of plant structures.

No surveillance or inspection procedure currently directs the required aging management monitoring for reinforced concrete pad No. 1. A new concrete pad inspection procedure for structural monitoring of reinforced concrete pad No. 1 will be developed with a five-year inspection interval similar to concrete inspections performed within the plant.

The five-year inspection interval is consistent with applicable operating experience, and helps ensure that cracking, loss of material, and changes in material properties will be detected in a timely manner.

A new inspection procedure will direct that groundwater sampling be performed at two existing wells near reinforced concrete pad No. 1 every five years to determine whether the pad could be exposed to an aggressive chemical environment. The inspection interval of five years has been determined to be appropriate since the reinforced concrete pad No. 1 is not in contact with groundwater. As noted in Table 3.4-2, Groundwater Sample Results Summary, measurements of groundwater chemistry at the ISFSI location confirm that an aggressive environment for concrete does not exist.

Element 5: Monitoring and Trending

The inspection activities in this AMP are performed periodically in order to identify areas of degradation. Results will be evaluated by qualified individuals consistent with industry guidelines, standards, and regulations. Inspection results for structural inspections are retained in Station Records, and are summarized in engineering technical evaluations. Conditions adverse to quality noted during the inspection and monitoring activities, such as non-conformances, failures, malfunctions, deficiencies, deviations, or defective material and equipment are entered into the Dominion Corrective Action Program.

Depending on significance, a more focused evaluation may be required to determine the extent of condition and determine if more frequent monitoring or inspection is required. As discussed below, visual inspections consider the cumulative experience from previous inspections and assessments in order to monitor and trend the progression of aging effects over time. Additionally, the Dominion Corrective Action Program includes trending of adverse conditions as well as a process to prevent recurrence.

A new reinforced concrete pad No. 1 inspection procedure will require the pad to be visually inspected every five years. The initial visual inspection during the period of extended operation will be scheduled to occur in November 2020 [RAI 3-10]. The inspection results will be evaluated and compared to the previous inspection results to detect adverse trends and determine if the frequency of inspections should be increased. A record of deficiencies found during the credited visual inspection will be updated with results from each inspection. These actions will provide a trending evaluation for the results of inspections for reinforced concrete pad No. 1.

An engineering evaluation will be performed every five years to review industry and plant-specific operating experience (including work order history). The initial operating experience evaluation during the period of extended operation will be scheduled to occur in January 2020 [RAI 3-10]. The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage the loss of material, cracking, and change in material properties for reinforced concrete pad No. 1.

Each element of the Monitoring of Structures Aging Management Program will be reviewed to determine if updates are required based on lessons learned from the operating experience review. The results of the engineering evaluation will be entered into the Aging Management INPO Database (AMID), using the screening criteria recommended in NEI 14-03, Format, Content, and Implementation Guidance for Dry Storage Cask Storage Operations-Based Aging Management [RAI 3-14].

Element 6: Acceptance Criteria

Visual inspections for reinforced concrete pad No. 1 will determine whether adverse conditions such as cracking, loss of material, or change in material properties are present. Indications of adverse conditions will be documented using a Condition Report.

Cracks other than hairline cracks are to be noted during visual inspections. As described in ACI 349.3R, Evaluation of Existing Nuclear safety-related Concrete Structures (Reference A4.5), cracking of concrete surfaces is acceptable if all of the following conditions are satisfied by the results of the visual inspection:

- No evidence of leaching
- Pop-outs and voids are less than 20 mm (3/4 in.) in diameter
- Scaling is less than 5 mm (3/16 in.) in depth
- Spalling is less than 10 mm (3/8 in.) in depth and 100 mm (4 in.) in any dimension
- Cracks are passive (no indication of recent growth or indications of other degradation at the crack), and less than 0.4 mm (0.015 in.) in maximum width
- No evidence of excessive deflections, settlements, or other physical movements that could affect structural performance

Groundwater sampling acceptance criteria shall be established as follows:

- Chlorides < 500ppm
- Sulfates < 1,500 ppm
- pH > 5.5

If any one of the three values exceeds the acceptance criterion the condition is entered in the Dominion Corrective Action Program.

These values are consistent with guidance provided in NUREG-1801, Generic Aging Lessons Learned (Reference A4.6), and would demonstrate that reinforced concrete pad No. 1 is exposed to a non-aggressive groundwater environment.

Unacceptable results for cracking, loss of material, or change in material properties of concrete surfaces will require initiation of a Condition Report in accordance with the Dominion Corrective Action Program [RAI 3-12].

Element 7: Corrective Actions

Corrective actions for deviating conditions that are adverse to quality, e.g., failures, malfunctions, deficiencies, deviations, defective material and equipment, and non-conformances, are performed in accordance with Dominion Topical Report DOM-QA-1, "Nuclear Facility Quality Assurance Program Description" (Reference A4.4). Adherence to DOM-QA-1 ensures that, as required by 10 CFR 50, Appendix B, an adequate quality assurance program is implemented.

The Dominion Corrective Action Program is implemented in accordance with a nuclear fleet administrative procedure. The administrative procedure includes expectations for identification and reporting of conditions adverse to quality, conditions that affect personnel safety, affect nuclear safety, affect plant reliability, affect trending, and other conditions that do not meet station expectations. For conditions determined to be significantly adverse to quality, the procedure provides measures to provide reasonable assurance that the cause of the condition is determined, corrective action is taken in a timely and accurate manner to preclude repetition, and the cause and corrective actions taken are documented and reported to appropriate levels of management. A condition significantly adverse to quality is defined as a condition adverse to quality that has, or if left uncorrected could have, an undesirable effect on plant safety, regulatory position, or environmental impact.

Station deficiencies are identified by the submission of CRs. An attachment to the administrative procedure provides a detailed list of examples of conditions that require submission of a CR. At a minimum, CRs are submitted for any issue or concern that does not meet specific requirements of procedures, policies, management expectations, or accepted industry standards, including all conditions that do not meet the AMP acceptance criteria. CRs are also required to be submitted for any issue where there is doubt about whether a CR should be submitted. The procedure also provides guidance for submittal of CRs anonymously.

Submitted CRs are initially reviewed by the submitters' supervisor. The supervisor answers screening questions to determine if Operations Shift Manager review is required. If so, the shift manager, or designee, performs an operability assessment. As required by 10 CFR 72.75, reportability determinations are also made. Further review of the CR is then performed by the CRT.

The CRT is a multi-discipline, multi-departmental team consisting of members from Engineering, Maintenance, Operations, Radiation Protection, Training, and Organizational Effectiveness. At least one member of the CRT should have, or previously held, a Senior Reactor Operators license. Functions of the CRT include:

- Identifying conditions that are adverse to quality
- Establishing corrective action assignments
- Assigning required significance level and level of evaluation to CRs (e.g., Root Cause Evaluation)
- Reviewing CRs for trending and notifying the Trend Coordinator for submittal of an additional CR to address trending aspects
- Reviewing CRs for safety implications
- Reviewing CRs for initiation of work management activities
- Recommending compensatory measures
- Identifying events that should be communicated to the industry via the INPO Consolidated Event System
- Notifying senior management of significant events

CRs identified as adverse to quality by the CRT are further reviewed by the Corrective Action Assignment Review Team (CAART). The CAART is generally comprised of senior-level management, Manager level and above, and includes the Plant Manager. The CAART reviews the results and recommendations of the CRT and has the authority to make changes when appropriate. The CAART also identifies selected issues to be reviewed by the Facility Safety Review Committee.

The response to corrective action assignments is reviewed to verify the adequacy of the response and proposed corrective actions, including no corrective action. CRT or CAART may assign additional reviews when appropriate.

Engineering evaluations performed in accordance with the Corrective Action Program will determine whether corrective or mitigative actions are needed for maintaining the intended function of providing support for the TN-32 dry storage casks.

A self-assessment is performed at least every two years to determine the effectiveness of the Corrective Action Program. An aggregate review of all open conditions designated as adverse to quality is performed at least every eighteen months to ensure appropriate priorities have been assigned to these outstanding issues.

Element 8: Confirmation Process

Adherence to the Dominion Quality Assurance Program ensures that, as required by 10 CFR Part 50, Appendix B, an adequate quality assurance program is implemented. The Quality Assurance program includes provisions for timely evaluation of adverse conditions, and implementation of any corrective actions required, including root cause evaluations and actions to prevent recurrence. Procedural controls are in place to ensure the response to corrective action assignments is reviewed to verify the adequacy of the response and the corrective actions. Condition reports are also reviewed for trending purposes.

An engineering evaluation will be performed every five years to review industry and plant-specific operating experience (including work order history). The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage the loss of material, cracking, and change in material properties for reinforced concrete pad No. 1. Each element of the Monitoring of Structures Aging Management Program will be reviewed to determine if updates are required based on lessons learned from the operating experience review.

Element 9: Administrative Controls

All activities associated with the North Anna ISFSI that are important to safety are conducted in accordance with Dominion Topical Report DOM-QA-1, "Nuclear Facility Quality Assurance Program Description" (Reference A4.4). Adherence to DOM-QA-1 ensures that, as required by 10 CFR 50, Appendix B, an adequate quality assurance program is implemented. DOM-QA-1 includes guidance for inspector requirements, record retention requirements, and document control. Administrative and technical procedures are reviewed, approved, and maintained as controlled documents in accordance with the Dominion procedure control process and DOM-QA-1. Administrative controls have been established to ensure records are identified, retained, maintained, and retrievable. Approved procedures define record retention requirements and storage methods.

Element 10: Operating Experience

The Dominion Operating Experience (OE) Program is implemented in accordance with an administrative procedure. The goal of the OE Program is to effectively and efficiently use lessons learned from the industry to improve safety and reliability and to reduce the number and consequence of events. The procedure includes applicability screening of OE reports from the NRC, INPO, and vendors. Guidelines for use of the INPO Nuclear Network Forums are included in the procedure. The procedure also stipulates OE coordinator trending reviews at set frequencies and OE coordinator qualification requirements.

The review and sharing of operating experience will be enhanced to include use of the Aging Management INPO Database (AMID) in accordance with NEI 14-03, Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management. Additionally, the reinforced concrete pad No. 1 inspection results will be evaluated and entered into the AMID database using the screening criteria of NEI 16-10, as recommended by NEI 14-03. [RAI 3-14]

As stated in Element 8: Confirmation Process, additional reviews occur during the engineering evaluation of industry and plant-specific operating experience that occurs every five years to determine whether updates to the aging management program are needed to address lessons learned. The historical absence of significantly adverse findings for the ISFSI confirms that a review interval of five years is sufficient to address the potential need for any changes of aging management programs.

A separate administrative procedure provides instruction for submitting Dominion OE to the INPO Consolidated Event System (ICES). The purpose of this procedure is to provide a method for identification and reporting of INPO ICES reports. The procedure includes reporting criteria and required reporting time frames.

OE reviews for this AMP are based on relevant occurrences listed in the North Anna Corrective Action database, i.e., condition reports, and a search of the INPO OE summaries for industry experiences for domestic and international plants. These documents were reviewed for any applicable aging effects or mechanisms. Searches of those databases used the following keywords:

- ISFSI pad
- ISFSI
- Concrete

OE at North Anna indicates that the Monitoring of Structures Aging Management Program for plant structures has been effective in identifying structural degradation, implementing corrective actions, and trending the findings. When degradation has been identified for plant structures, corrective actions have been implemented to ensure that the integrity of the affected structure is restored and maintained such that intended functions will be maintained during the period of extended operation.

Specific examples of relevant OE for age-related degradation of reinforced concrete pad No. 1 are listed below:

A 2004 engineering evaluation summarized inspections which were performed for the North Anna ISFSI reinforced concrete pad No. 1 in 1998, 1999, and 2004. The pad was constructed in five placements in December 1997. After the first placement, a condition report was written identifying discrepancies with the location of reinforcing bars, and supports for the embedded TN-32 dry storage cask lighting boxes. The findings of the resultant engineering evaluation concluded that the structural strength of the pad had not been reduced and the discrepancies were corrected prior to the remaining four placements. The evaluation recommended that Engineering inspect this same area within six months to identify any cracking that may have occurred, and perform an additional follow-up inspection approximately one year later.

Reinforced concrete pad No. 1 was first inspected on May 13, 1998. The inspection identified no adverse conditions beyond those previously reported, and no repairs were required at that time. Pad No. 1 was re-inspected on May 20, 1999, and was reported to be in good condition. Additional surface cracks were identified and previously-identified cracks were characterized to be wider than previously reported. The cracks were reported to be very shallow in depth and not a concern, so no repairs were required following the inspection. An engineering evaluation issued on May 27, 1999, reiterated a recommended action, based on the initial condition report to re-inspect reinforced concrete pad No. 1 in five years. No additional condition report was initiated since the recommended actions of the initial condition report continued to be followed.

Reinforced concrete pad No. 1 was reinspected on April 6, 2004. Twenty-one TN-32 dry storage casks had been placed on the pad by this time. Observations from the three inspections in 1998, 1999, and 2004 were recorded on sketches that were included with the summary engineering evaluation to support trending. Reinforced concrete pad No. 1 had cracks immediately adjacent to construction or control joints that had begun to unravel into the joint as anticipated, and were reported as joint spalls. In general, crack widths had stabilized and remained consistent with the inspection results reported in 1999. Light crazing (i.e., a network of fine cracks on the surface of the concrete) was present on numerous areas of reinforced concrete pad No. 1. The identified indications were shallow and did not jeopardize the structural integrity of reinforced concrete pad No. 1. The areas of crazing for the surface of reinforced concrete pad No. 1 were noted on the sketches that accompanied the summary engineering evaluation.

A post-seismic event walkdown of the ISFSI pad (reinforced concrete pad No. 1 for the TN-32 dry storage casks), including all support systems, was performed on September 1, 2011 to verify current conditions. Reinforced concrete pad No. 1 was checked, and no additional cracks or deformation were noted during this post-seismic walkdown.

During the performance of the pre-application inspections on October 14, 2015, reinforced concrete pad No. 1 was inspected as well as the concrete underneath the TN-32 dry storage cask that was lifted. Civil Engineering performed a visual inspection of the concrete under the TN-32 dry storage cask, as well as the entire pad, and had no concerns with the condition of reinforced concrete pad No. 1. The only cracking is hairline in nature, but does not require repair. This recent inspection of reinforced concrete pad No. 1 confirms the absence of age-related degradation. See Section F2.2, Pre-application Inspection Results for additional information.

The history of inspections for reinforced concrete pad No. 1 dates back to 1998. Results from five inspections in 1998, 1999, 2004, 2011, and 2015 confirm that cracks have formed on the surface of the pad, but none are affecting the structural integrity of the concrete or require repair.

A trend of inspection results that is maintained for reinforced concrete pad No. 1 shows that existing cracks are shallow and have stabilized. The shallow cracks have not provided a pathway for the atmosphere/weather environment to come into contact with the embedded steel and initiate corrosion which could adversely affect structural integrity.

The OE presented above provides reasonable assurance that the Monitoring of Structures Aging Management Program will be capable of detecting aging effects for reinforced concrete pad No. 1. Occurrences of aging that would be identified under the Monitoring of Structures Aging Management Program will be evaluated to ensure there is no loss of intended function. Guidance for re-evaluation, repair, or replacement is provided for locations where aging is found. There is confidence that continued implementation of the Monitoring of Structures Aging Management Program will effectively identify aging prior to loss of intended function.

Summary of Enhancements

The following enhancements will be made to the Monitoring of Structures Aging Management Program:

1. Perform an engineering evaluation every five years to review industry and plant-specific operating experience (including work order history). The initial operating experience evaluation during the period of extended operation will be scheduled to occur in January 2020 [RAI 3-10]. The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage the loss of material, cracking, and change in material properties for reinforced concrete pad No. 1. Each element of Monitoring of Structures Aging Management Program will be reviewed to determine if updates are required based on lessons learned from the OE review. The results of the engineering evaluation will be entered into the Aging Management INPO Database (AMID), using the screening criteria recommended in NEI 14-03, Format, Content, and Implementation Guidance for Dry Storage Cask Storage Operations-Based Aging Management [RAI 3-14].
2. Perform a visual inspection of all exposed visible surfaces of reinforced concrete pad No. 1 at a frequency of every five years [RAI 3-9]. The acceptance criteria is specified in ACI-349.3R. The initial visual inspection during the period of extended operation will be scheduled to occur in November 2020 [RAI 3-10].
3. Perform groundwater sampling at the ISFSI site to determine values for chlorides, sulfates, and pH at two groundwater wells every five years. The acceptance criteria are:
    - Chlorides < 500ppm
    - Sulfates < 1,500 ppm
    - pH > 5.5
4. Perform an opportunistic inspection of the normally inaccessible area of reinforced concrete pad No. 1 beneath the TN-32 dry storage cask whenever a cask is lifted.
5. Perform an opportunistic inspection of all exposed below-grade surfaces of reinforced concrete pad No. 1 if made available by excavation. The acceptance criteria is specified in ACI-349.3R [RAI 3-9].

As recommended by NEI 14-03, inspection results will be reviewed to determine if the results should be entered in the AMID database [RAI 3-14].

Conclusion

Based on the operating experience review and pre-application inspection results, the reinforced concrete pad No. 1 intended functions have not been challenged by age-related degradation. Existing procedures, along with proposed enhancements, provide reasonable assurance that the intended functions will be maintained consistent with the ISFSI design basis during the period of extended operation.

A3.0 SUMMARY

Operating experience indicates that while degradation of the TN-32 dry storage cask exterior surfaces has occurred, e.g., flaking of TN-32 dry storage cask coating, there have been no cases of loss of intended function due to dry storage cask exterior problems. Corrective actions have been effectively implemented when monitoring and inspection results have indicated degradation. On the basis of this on-going surveillance, the infrequency of observed instances of degradation, and corrective actions implemented, the effects of aging on the TN-32 dry storage casks will be effectively managed during the period of extended operation.

Operating experience from five inspections of reinforced concrete pad No. 1 confirm the absence of age-related degradation which could jeopardize the structural integrity of the pad. OE has not resulted in any changes for existing structural inspection procedures, or a need to invoke repair procedures.

The effects of aging associated with subcomponents within the scope of the TN-32 Dry Storage Cask Aging Management Program and the Monitoring of Structures Aging Management Program will be adequately managed so that there is reasonable assurance that their intended functions will be performed consistently with the design basis during the period of extended operation.

A4.0 REFERENCES (Appendix A: Aging Management Programs)

A4.1 North Anna Independent Spent Fuel Storage Installation Safety Analysis Report, Rev. 8, North Anna Power Station. ML14233A488

A4.2 Technical Specifications, Independent Spent Fuel Storage Installation, Amendment 4, North Anna Power Station.

A4.3 NUREG-1927, Standard Review Plan for Renewal of Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel, Rev. 0, Office of Nuclear Material Safety and Safeguards, Nuclear Regulatory Commission.

A4.4 DOM-QA-1, Nuclear Facility Quality Assurance Program Description, Topical Report, Dominion.

A4.5 ACI 349.3R, Evaluation of Existing Nuclear Safety Related Concrete Structures, American Concrete Institute, 2002.

A4.6 NUREG-1801, Generic Aging Lessons Learned (GALL) Report, Rev. 2. ML103490041

Enclosure 3

Marked-up Version
Revised ISFSI Safety Analysis Report Supplement
(Pages C-1 through C-11)

North Anna Power Station ISFSI
Virginia Electric and Power Company

APPENDIX C: ISFSI SAR SUPPLEMENT

C1.0 INTRODUCTION

This appendix provides a proposed supplement to the North Anna ISFSI Safety Analysis Report (SAR). Section C2.0 of this appendix contains a proposed new section for the ISFSI SAR to be added under Chapter 9, Conduct of Operations. Section C3.0 of this appendix identifies changes to the existing ISFSI SAR that are necessary to reflect the period of extended operation.

The proposed new ISFSI SAR Section 9.7, Aging Management, provides a brief description of the activities for managing the effects of aging. This proposed new ISFSI SAR section also provides a summary of the analysis of time-limited aging analyses (TLAAs) for the period of extended operation. Following issuance of the renewed license (SNM-2507) for the North Anna ISFSI, Dominion will incorporate the proposed supplement in the North Anna ISFSI SAR as part of a periodic SAR update in accordance with 10 CFR 72.70(c).

C2.0 PROPOSED NEW NORTH ANNA ISFSI SAR SECTIONS

C2.1 Aging Management (New ISFSI SAR Section 9.7)

Renewal of North Anna ISFSI license SNM-2507 involved 1) Scoping, 2) Aging Management Review (AMR), and 3) Aging Management. Scoping of systems, structures and components (SSCs) identified the ISFSI major components in the scope of license renewal. The AMR process evaluated the SSCs in the scope of license renewal for applicable aging effects and mechanisms based on material and environment. Aging Management Programs (AMPs) were developed to adequately manage the effects of aging.

The scoping results identified the TN-32 dry storage cask, the spent fuel assemblies stored in the cask, and reinforced concrete pad No. 1 as being in the scope of license renewal.

The AMR addressed aging effects/mechanisms that could adversely affect the ability of the structures or components to perform their intended functions during the period of extended operation. The results of the AMR determined that there are aging effects that require aging management for both the TN-32 dry storage cask and reinforced concrete pad No. 1. The potential aging effects for the cask and concrete pad No. 1 are identified in Table C2.1-1, Table of Aging Effects (New ISFSI SAR Table 9.7-1).

Table C2.1-1 Table of Aging Effects (New ISFSI SAR Table 9.7-1)

Material	Environment	Aging Effect	Mechanism
Aluminum	Atmosphere / Weather	Loss of Material	Crevice Corrosion
			Pitting Corrosion
			Galvanic Corrosion
Carbon Steel and Low-Alloy Steel	Atmosphere / Weather	Loss of Material	Crevice Corrosion
			Pitting Corrosion
			Galvanic Corrosion
			General Corrosion
Stainless Steel	Atmosphere / Weather	Loss of Material	Crevice Corrosion
			Pitting Corrosion
Polypropylene (encased in carbon steel)	Air	Loss of Material	Radiolytic Decomposition
			Thermal Degradation
		Cracking [RAI 3-4]	Radiolytic Decomposition
			Thermal Degradation
Borated Polyester (encased in Aluminum)	Air	Loss of Material	Radiolytic Decomposition
			Thermal Degradation
		Cracking [RAI 3-4]	Radiolytic Decomposition
			Thermal Degradation
Concrete	Atmosphere / Weather	Loss of Material	Freeze-thaw
		Cracking	Freeze-thaw
			Reaction with Aggregates
		Change in Material Properties	Leaching of Calcium Hydroxide
	Soil	Cracking	Reaction with Aggregates
			Settlement

A review of AMPs needed to manage the effects of aging identified existing aging management activities and the need to add new aging management activities. The AMPs provide reasonable assurance that the ISFSI reinforced concrete pad No. 1 and TN-32 dry storage cask subcomponents within the scope of license renewal will continue to perform their intended functions consistent with the design basis for the period of extended operation. The following sections describe aging management program activities used to manage the effects of aging.

C2.1.1 Aging Management Programs (New ISFSI SAR Section 9.7.1)

C2.1.1.1 TN-32 Dry Storage Cask Aging Management Program (New ISFSI SAR Section 9.7.1.1)

This Aging Management Program defines the aging management activities which are necessary to help ensure the integrity of the TN-32 dry storage casks manufactured by AREVA-Transnuclear.

The North Anna ISFSI is a facility to place and store spent fuel in licensed containers (dry storage casks) until such time that the fuel may be shipped off-site for final disposition. The TN-32 dry storage casks at the North Anna ISFSI are designed for outdoor storage.

The aging management activities described and credited to manage the effects of aging for the TN-32 dry storage casks will provide reasonable assurance that there will not be a loss of intended function.

Specifically, the TN-32 Dry Storage Cask Aging Management Program ensures loss of material from the cask metallic subcomponents and loss of material and cracking in polymeric subcomponents will be identified and managed during the period of extended operation prior to loss of intended function. [RAI 3-4]

The TN-32 Dry Storage Cask Aging Management Program includes 1) continuous interseal pressure monitoring of the in-service dry storage casks, 2) quarterly visual inspection of dry storage casks that are in-service at the North Anna ISFSI, and 3) quarterly TLD radiation monitoring at the ISFSI perimeter fence. The program credits existing activities, including radiation surveys performed during maintenance activities at the ISFSI, restricting personnel access to the ISFSI, and the use of dosimetry monitoring for personnel accessing the ISFSI. The radiation monitoring activities of the program ensure that radiation doses to members of the public and to occupational workers remains acceptable during the period of extended operation. [RAI 3-11]

Section C2.1.1.1.1 identifies additional program activities that ensure the aging effects of concern are adequately managed during the period of extended operation.

Pressure monitoring of the dry storage cask provides a means to detect seal degradation. Visual inspections identify degradation of the physical condition of the exterior surfaces of the TN-32 dry storage cask. These inspections check for loss of material (corrosion) from the TN-32 dry storage cask. Radiation monitoring provides a means to detect degradation of shielding material internal to the TN-32 dry storage casks.

C2.1.1.1.1 **Program Enhancements (New ISFSI SAR Section 9.7.1.1.1)**

~~The following additional activities are included in the TN-32 Dry Storage Cask Aging Management Program to ensure the aging effect of concern is adequately managed during the period of extended operation:~~

1. Enhance Station procedures to identify the subcomponents of the TN-32 cask that are fully visible and partially visible during the quarterly visual inspection. [RAI 3-9]
2. Perform an engineering evaluation every five years to review industry and plant-specific operating experience (including work order history). The initial operating experience evaluation during the period of extended operation will be scheduled to occur in January 2020. [RAI 3-14]
   The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage the loss of material and cracking from the TN-32 dry storage casks [RAI 3-4]. Each element of the TN-32 Dry Storage Cask Aging Management Program will be reviewed to determine if updates to the AMP are required based on lessons learned from the operating experience review. The results of the engineering evaluation will be entered into the Aging Management INPO Database (AMID), using the screening criteria as recommended in NEI 14-03, Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management. [RAI 3-14]
3. Perform an opportunistic visual inspection of a TN-32 dry storage cask bottom and under the protective cover in the event a cask is lifted or a protective cover is removed. The acceptance criterion is no detectable loss of material from the base metal as determined by VT-1 and/or VT-3 inspection. The ISFSI component inspection results will be evaluated and entered into the AMID database using the screening criteria as recommended by NEI 14-03. [RAI 3-14]
4. Perform a visual inspection (i.e. VT-1 and/or VT-3) of a TN-32 dry storage cask bottom and under the protective cover at least every 20 ± 5 years from the date of the pre-application inspection [RAI 3-10]. The selection criteria for this scheduled inspection will utilize the same criteria as

that used for the pre-application inspection. The five-year periodic reviews of operating experience, as well as changes to the aging management program resulting from the review, will be considered during cask selection. The acceptance criterion is no detectable loss of material from the base metal as determined by VT-1 and/or VT-3 inspection. The ISFSI component inspection results will be evaluated and entered into the AMID database using the screening criteria as recommended by NEI 14-03 [RAI 3-14].

5. Develop Health Physics procedures for conducting an annual neutron survey at reinforced concrete pad No. 1 using a REM 500 neutron survey meter, or equivalent, prior to entering the period of extended operation. The survey point locations, including the approximate height corresponding to the maximum neutron flux, will be identified in the Health Physics survey procedure. [RAI 3-11]

6. Develop a procedure or engineering technical evaluation describing the methodology for performing annual trending of ISFSI radiation readings [RAI 3-11].

7. Modify all TLDs located at the ISFSI perimeter fence to include a CR 39 chip, or equivalent, prior to obtaining TLD baseline neutron and gamma radiation values [RAI 3-11].

8. Define baseline radiation values for the annual neutron survey locations and for the ISFSI TLD locations prior to entering the period of extended operation. New baseline values will be established in the event a cask is removed from, or additional cask(s) are placed on, reinforced concrete pad No. 1. In the event the location of TLDs is changed new baseline TLD values will be established. [RAI 3-11]

9. Perform an annual survey at reinforced concrete pad No. 1 using a REM 500 tissue equivalent proportional counter, or equivalent [RAI 3-11].

10. ~~Perform an annual evaluation of neutron and gamma quarterly TLD readings to confirm the absence of an increasing trend (as determined by engineering evaluation).~~ Perform an annual evaluation of ISFSI perimeter fence TLD neutron and gamma radiation measurements, and reinforced concrete pad No. 1 neutron survey results for adverse trends. The initial trending evaluation will be completed no

later than October 2018. The acceptance criterion is the absence of an increasing trend in neutron or gamma radiation values (as determined by engineering evaluation). [RAI 3-11]. The trend results will be evaluated and entered into the AMID database using the screening criteria as recommended by NEI 14-03 [RAI 3-14].

C2.1.1.1.2 **Acceptance Criteria (New ISFSI SAR Section 9.7.1.1.2)**

The acceptance criterion for interseal pressure monitoring is:

- The absence of a low pressure alarm

~~Visual inspections identify degradation of the physical condition of the exterior surfaces of the TN 32 dry storage cask. These inspections check for loss of material (corrosion) from the TN 32 dry storage cask. Pressure monitoring of the dry storage cask provides a means to detect seal degradation. Radiation monitoring provides a means to detect degradation of shielding material internal to the TN 32 dry storage casks.~~

The acceptance criteria for the quarterly visual inspection are:

- No coating defects (bubbling/blistering of paint)
- No loose debris in contact with the cask(s)
- No rust spots and stains
- No rust stains on the concrete
- No physical damage
- No baseplate corrosion at the concrete/cask interface

The acceptance criterion for the opportunistic and 20 ± 5 -year scheduled visual inspections is:

- ~~n~~No detectable loss of material from the base metal as determined by the results of the VT-1 and/or VT-3 visual inspection.

The acceptance criterion for the annual evaluation of reinforced concrete pad No. 1 neutron survey results, and neutron and gamma TLD readings, is:

- The absence of an increasing trend (as determined by engineering evaluation)

Monitoring and inspection results that exceed established acceptance criteria will be entered into the Corrective Action

Program. Engineering evaluations determine if conditions identified as adverse to quality are significant enough to compromise the ability of a TN-32 dry storage cask to perform its intended functions.

C2.1.1.1.3 **Extent of Visual Inspections (New ISFSI SAR Section 9.7.1.1.3)**

Quarterly, the visible outer surfaces of the following dry storage cask subcomponents within the scope of license renewal will be inspected by an individual standing at ground level: [RAI 3-9]

- Bottom vertical surfaces
- Trunnions
- Flange vertical surfaces
- Shell
- Outer Shell

During opportunistic and 20 ± 5-year visual inspections conducted with the dry storage cask protective cover removed, the visible outer surfaces of the following dry storage cask subcomponents within the scope of license renewal will be visually inspected by an individual standing at the top of the cask: [RAI 3-9]

- Lid
- Lid Bolts and Neutron Shield Bolts
- Top Neutron Shield
- Flange horizontal surfaces including stainless steel weld overlay
- Trunnions

During opportunistic and 20 ± 5-year visual inspections conducted during dry storage cask lift operations, the horizontal surface of a dry storage cask bottom will be visually inspected.

~~The acceptance criterion for interseal pressure monitoring is the absence of a low pressure alarm.~~

~~The acceptance criterion for the annual evaluation of neutron and gamma quarterly TLD readings is the absence of an increasing trend (as determined by engineering evaluation).~~

~~Monitoring and inspection results that exceed established acceptance criteria will be entered in the Corrective Action Program. Engineering evaluations determine if conditions identified as adverse to quality are significant enough to compromise the ability of a TN-32 dry storage cask to perform its intended functions.~~

C2.1.1.2 **Monitoring of Structures Aging Management Program (New ISFSI SAR Section 9.7.1.2)**

The Monitoring of Structures Aging Management Program is a new program, which defines the aging management activities ~~which~~ that are necessary to help ensure the integrity of reinforced concrete pad No. 1. Reinforced concrete pad No. 1 on which the TN-32 dry storage casks rest is an above-ground, outdoor installation. The Monitoring of Structures Aging Management Program verifies the capability of reinforced concrete pad No. 1 to perform its intended functions.

Specifically, the Monitoring of Structures Aging Management Program ensures that cracking, change in material properties (white stains, indicative of leaching), and loss of material from reinforced concrete pad No. 1 will be identified and managed during the period of extended operation prior to loss of intended function.

Periodic visual monitoring is performed to determine the surface condition of reinforced concrete pad No. 1, which is a leading indicator for the overall integrity of the pad. Visual inspections detect surface defects resulting from the aging mechanisms of reaction with aggregates, freeze-thaw, leaching of calcium hydroxide, or settlement.

C2.1.1.2.1 **Program Activities (New ISFSI SAR Section 9.7.1.2.1)**

The Monitoring of Structures Aging Management Program includes the following activities:

1. Perform an engineering evaluation every five years to review industry and plant-specific operating experience (including work order history). The initial operating experience evaluation during the period of extended operation will be scheduled to occur in January 2020. [RAI 3-10] The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage the loss of material, cracking, and change in material properties for reinforced

concrete pad No. 1. Each element of the Monitoring of Structures Aging Management Program will be reviewed to determine if updates are required based on lessons learned from the operating experience review. The results of the engineering evaluation will be entered into the Aging Management INPO Database (AMID), using the screening criteria as recommended in NEI 14-03, Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management. [RAI 3-14]

2. Perform a visual inspection of ~~the visible~~ all exposed [RAI 3-9] surfaces of reinforced concrete pad No. 1 every five years. The initial visual inspection during the period of extended operation will be scheduled to occur in November 2020. [RAI 3-10]
3. Perform groundwater sampling at the ISFSI site to determine values for chlorides, sulfates, and pH at two groundwater wells every five years.
4. Perform an opportunistic inspection of the normally inaccessible area of reinforced concrete pad No. 1 beneath a TN-32 dry storage cask in the event a dry storage cask is lifted.
5. Perform an opportunistic visual inspection of ~~the inaccessible~~ all exposed below-grade ~~portions~~ surfaces of reinforced concrete pad No. 1, if made available by excavation. [RAI 3-9]

As recommended by NEI 14-03, inspection results will be reviewed to determine if the results should be entered in the AMID database. [RAI 3-14]

~~Periodic visual monitoring is performed to determine the surface condition of reinforced concrete pad No. 1, which is a leading indicator for the overall integrity of the pad. Visual inspections detect surface defects resulting from the aging mechanisms of reaction with aggregates, freeze thaw, leaching of calcium hydroxide, or settlement.~~

~~Surface indications of age related degradation for reinforced concrete pad No. 1 include:~~

- ~~Loss of material~~
- ~~Cracking~~
- ~~Change in material properties (white stains, indicative of leaching)~~

C2.1.1.2.2 **Acceptance Criteria (New ISFSI SAR Section 9.7.1.2.2)**

The acceptance criteria listed in ACI 349.3R is used for all visual inspections.

~~Chlorides, sulfates, and pH are monitored. Groundwater sampling is performed at two locations at the ISFSI every five years.~~ The acceptance criteria for groundwater monitoring are:

1. Chlorides < 500ppm
2. Sulfates <1,500ppm
3. pH >5.5

Reinforced concrete pad No. 1 is not located in the groundwater. However, a groundwater chemistry monitoring program will be established to provide supplemental information for identifying conditions conducive to underground aging mechanisms.

Monitoring and inspection results that exceed established acceptance criteria are entered into the Corrective Action Program. Engineering evaluations determine if conditions identified as adverse to quality are significant enough to compromise the ability of reinforced concrete pad No. 1 to perform its intended functions.

C2.2 Time-Limited Aging Analyses (New ISFSI SAR Section 9.7.2)

As required by 10 CFR 72.42(a)(1), an application for a renewed ISFSI license must include ISFSI-specific TLAAs. The TLAA identification process required a review of the design basis documents and calculations to provide a reasonable assurance that TLAAs were identified.

Once a TLAA is identified, an evaluation is performed to disposition each ISFSI-specific TLAA using one of three different approaches described below:

i. The analyses will remain valid for the period of extended operation.

ii. The analyses have been projected to the end of the period of extended operation.

iii. The effects of aging on the intended function(s) will be adequately managed for the period of extended operation.

Based on review of design basis documents and calculations, no TLAAs were identified for the North Anna ISFSI.

C3.0 PROPOSED CHANGES TO EXISTING NORTH ANNA ISFSI SAR

C3.1 ISFSI SAR Section A.1.3: Criticality Evaluation

Revise the second to last paragraph of the ISFSI SAR Section A.1.3 to reflect evaluation of the fixed neutron poison in the TN-32 dry storage cask:

> "....An appraisal of the fixed neutron poisons has shown that they will remain effective for the ~~20~~ 60-year storage period, and there is no credible way to lose them. The analysis and evaluation of the criticality design and performance have demonstrated that the cask will provide for the safe storage of spent fuel for a minimum of ~~20~~ 60 years with an adequate subcritical margin."

This change reflects the extended license period to 60 years and is based on previous analysis showing that boron depletion is negligible for storage periods well beyond 60 years.

C3.2 ISFSI SAR Section A.1.4: Thermal Evaluation

Revise the last paragraph of ISFSI SAR Section A.1.4 to reflect evaluation of the thermal design of the TN-32 dry storage cask:

> "The thermal design of the TN-32 cask is in compliance with 10 CFR 72 and applicable design and acceptance criteria have been satisfied. The evaluation of the thermal design provides reasonable assurance that the TN-32 cask will allow the safe storage of spent fuel for ~~20~~ 60 years."
>
> This change reflects the extended license period to 60 years. Since the maximum temperature for the cask and the fuel stored within the cask during the storage period is realized immediately after loading spent fuel into the cask and fuel temperature decreases with time, the thermal calculations supporting storage for the extended license period remain valid.

Serial No. 17-230
Docket No. 72-16

Enclosure 4

Clean Version
Revised ISFSI Safety Analysis Report Supplement
(Pages C-1 through C-10)

North Anna Power Station ISFSI
Virginia Electric and Power Company

APPENDIX C: ISFSI SAR SUPPLEMENT

C1.0 INTRODUCTION

This appendix provides a proposed supplement to the North Anna ISFSI Safety Analysis Report (SAR). Section C2.0 of this appendix contains a proposed new section for the ISFSI SAR to be added under Chapter 9, Conduct of Operations. Section C3.0 of this appendix identifies changes to the existing ISFSI SAR that are necessary to reflect the period of extended operation.

The proposed new ISFSI SAR Section 9.7, Aging Management, provides a brief description of the activities for managing the effects of aging. This proposed new ISFSI SAR section also provides a summary of the analysis of time-limited aging analyses (TLAAs) for the period of extended operation. Following issuance of the renewed license (SNM-2507) for the North Anna ISFSI, Dominion will incorporate the proposed supplement in the North Anna ISFSI SAR as part of a periodic SAR update in accordance with 10 CFR 72.70(c).

C2.0 PROPOSED NEW NORTH ANNA ISFSI SAR SECTIONS

C2.1 Aging Management (New ISFSI SAR Section 9.7)

Renewal of North Anna ISFSI license SNM-2507 involved 1) Scoping, 2) Aging Management Review (AMR), and 3) Aging Management. Scoping of systems, structures and components (SSCs) identified the ISFSI major components in the scope of license renewal. The AMR process evaluated the SSCs in the scope of license renewal for applicable aging effects and mechanisms based on material and environment. Aging Management Programs (AMPs) were developed to adequately manage the effects of aging.

The scoping results identified the TN-32 dry storage cask, the spent fuel assemblies stored in the cask, and reinforced concrete pad No. 1 as being in the scope of license renewal.

The AMR addressed aging effects/mechanisms that could adversely affect the ability of the structures or components to perform their intended functions during the period of extended operation. The results of the AMR determined that there are aging effects that require aging management for both the TN-32 dry storage cask and reinforced concrete pad No. 1. The potential aging effects for the cask and concrete pad No. 1 are identified in Table C2.1-1, Table of Aging Effects (New ISFSI SAR Table 9.7-1).

Table C2.1-1 Table of Aging Effects (New ISFSI SAR Table 9.7-1)

Material	Environment	Aging Effect	Mechanism
Aluminum	Atmosphere / Weather	Loss of Material	Crevice Corrosion
			Pitting Corrosion
			Galvanic Corrosion
Carbon Steel and Low-Alloy Steel	Atmosphere / Weather	Loss of Material	Crevice Corrosion
			Pitting Corrosion
			Galvanic Corrosion
			General Corrosion
Stainless Steel	Atmosphere / Weather	Loss of Material	Crevice Corrosion
			Pitting Corrosion
Polypropylene (encased in carbon steel)	Air	Loss of Material	Radiolytic Decomposition
			Thermal Degradation
		Cracking [RAI 3-4]	Radiolytic Decomposition
			Thermal Degradation
Borated Polyester (encased in Aluminum)	Air	Loss of Material	Radiolytic Decomposition
			Thermal Degradation
		Cracking [RAI 3-4]	Radiolytic Decomposition
			Thermal Degradation
Concrete	Atmosphere / Weather	Loss of Material	Freeze-thaw
		Cracking	Freeze-thaw
			Reaction with Aggregates
		Change in Material Properties	Leaching of Calcium Hydroxide
	Soil	Cracking	Reaction with Aggregates
			Settlement

A review of AMPs needed to manage the effects of aging identified existing aging management activities and the need to add new aging management activities. The AMPs provide reasonable assurance that the ISFSI reinforced concrete pad No. 1 and TN-32 dry storage cask subcomponents within the scope of license renewal will continue to perform their intended functions consistent with the design basis for the period of extended operation. The following sections describe aging management program activities used to manage the effects of aging.

C2.1.1 Aging Management Programs (New ISFSI SAR Section 9.7.1)

C2.1.1.1 TN-32 Dry Storage Cask Aging Management Program (New ISFSI SAR Section 9.7.1.1)

This Aging Management Program defines the aging management activities which are necessary to help ensure the integrity of the TN-32 dry storage casks manufactured by AREVA-Transnuclear.

The North Anna ISFSI is a facility to place and store spent fuel in licensed containers (dry storage casks) until such time that the fuel may be shipped off-site for final disposition. The TN-32 dry storage casks at the North Anna ISFSI are designed for outdoor storage.

The aging management activities described and credited to manage the effects of aging for the TN-32 dry storage casks will provide reasonable assurance that there will not be a loss of intended function.

Specifically, the TN-32 Dry Storage Cask Aging Management Program ensures loss of material from the cask metallic subcomponents and loss of material and cracking in polymeric subcomponents will be identified and managed during the period of extended operation prior to loss of intended function. [RAI 3-4]

The TN-32 Dry Storage Cask Aging Management Program includes
1) continuous interseal pressure monitoring of the in-service dry storage casks, 2) quarterly visual inspection of dry storage casks that are in-service at the North Anna ISFSI, and 3) quarterly TLD radiation monitoring at the ISFSI perimeter fence. The program credits existing activities, including radiation surveys performed during maintenance activities at the ISFSI, restricting personnel access to the ISFSI, and the use of dosimetry monitoring for personnel accessing the ISFSI. The radiation monitoring activities of the program ensure that radiation doses to members of the public and to occupational workers remains acceptable during the period of extended operation. [RAI 3-11]

Section C2.1.1.1.1 identifies additional program activities that ensure the aging effects of concern are adequately managed during the period of extended operation.

Pressure monitoring of the dry storage cask provides a means to detect seal degradation. Visual inspections identify degradation of the physical condition of the exterior surfaces of the TN-32 dry storage cask. These inspections check for loss of material (corrosion) from the TN-32 dry storage cask. Radiation monitoring provides a means to detect degradation of shielding material internal to the TN-32 dry storage casks.

C2.1.1.1.1 Program Enhancements (New ISFSI SAR Section 9.7.1.1.1)

1. Enhance Station procedures to identify the subcomponents of the TN-32 cask that are fully visible and partially visible during the quarterly visual inspection. [RAI 3-9]
2. Perform an engineering evaluation every five years to review industry and plant-specific operating experience (including work order history). The initial operating experience evaluation during the period of extended operation will be scheduled to occur in January 2020. [RAI 3-14]
   The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage the loss of material and cracking from the TN-32 dry storage casks [RAI 3-4]. Each element of the TN-32 Dry Storage Cask Aging Management Program will be reviewed to determine if updates to the AMP are required based on lessons learned from the operating experience review. The results of the engineering evaluation will be entered into the Aging Management INPO Database (AMID), using the screening criteria as recommended in NEI 14-03, Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management. [RAI 3-14]
3. Perform an opportunistic visual inspection of a TN-32 dry storage cask bottom and under the protective cover in the event a cask is lifted or a protective cover is removed. The acceptance criterion is no detectable loss of material from the base metal as determined by VT-1 and/or VT-3 inspection. The ISFSI component inspection results will be evaluated and entered into the AMID database using the screening criteria as recommended by NEI 14-03. [RAI 3-14]
4. Perform a visual inspection (i.e. VT-1 and/or VT-3) of a TN-32 dry storage cask bottom and under the protective cover at least every 20 ± 5 years from the date of the pre-application inspection [RAI 3-10]. The selection criteria for this scheduled inspection will utilize the same criteria as that used for the pre-application inspection. The five-year periodic reviews of operating experience, as well as changes to the aging management program resulting from the review, will be considered during cask selection. The acceptance criterion is no detectable loss of material from the base metal

as determined by VT-1 and/or VT-3 inspection. The ISFSI component inspection results will be evaluated and entered into the AMID database using the screening criteria as recommended by NEI 14-03 [RAI 3-14].

5. Develop Health Physics procedures for conducting an annual neutron survey at reinforced concrete pad No. 1 using a REM 500 neutron survey meter, or equivalent, prior to entering the period of extended operation. The survey point locations, including the approximate height corresponding to the maximum neutron flux, will be identified in the Health Physics survey procedure. [RAI 3-11]
6. Develop a procedure or engineering technical evaluation describing the methodology for performing annual trending of ISFSI radiation readings [RAI 3-11].
7. Modify all TLDs located at the ISFSI perimeter fence to include a CR 39 chip, or equivalent, prior to obtaining TLD baseline neutron and gamma radiation values [RAI 3-11].
8. Define baseline radiation values for the annual neutron survey locations and for the ISFSI TLD locations prior to entering the period of extended operation. New baseline values will be established in the event a cask is removed from, or additional cask(s) are placed on, reinforced concrete pad No. 1. In the event the location of TLDs is changed new baseline TLD values will be established. [RAI 3-11]
9. Perform an annual survey at reinforced concrete pad No. 1 using a REM 500 tissue equivalent proportional counter, or equivalent [RAI 3-11].
10. Perform an annual evaluation of ISFSI perimeter fence TLD neutron and gamma radiation measurements, and reinforced concrete pad No. 1 neutron survey results for adverse trends. The initial trending evaluation will be completed no later than October 2018. The acceptance criterion is the absence of an increasing trend in neutron or gamma radiation values (as determined by engineering evaluation). [RAI 3-11]. The trend results will be evaluated and entered into the AMID database using the screening criteria as recommended by NEI 14-03 [RAI 3-14].

C2.1.1.1.2 Acceptance Criteria (New ISFSI SAR Section 9.7.1.1.2)

The acceptance criterion for interseal pressure monitoring is:

- The absence of a low pressure alarm

The acceptance criteria for the quarterly visual inspection are:

- No coating defects (bubbling/blistering of paint)
- No loose debris in contact with the cask(s)
- No rust spots and stains
- No rust stains on the concrete
- No physical damage
- No baseplate corrosion at the concrete/cask interface

The acceptance criterion for the opportunistic and 20 ± 5 year scheduled visual inspections is:

- No detectable loss of material from the base metal as determined by the results of the VT-1 and/or VT-3 visual inspection.

The acceptance criterion for the annual evaluation of reinforced concrete pad No. 1 neutron survey results, and neutron and gamma TLD readings, is:

- The absence of an increasing trend (as determined by engineering evaluation)

Monitoring and inspection results that exceed established acceptance criteria will be entered into the Corrective Action Program. Engineering evaluations determine if conditions identified as adverse to quality are significant enough to compromise the ability of a TN-32 dry storage cask to perform its intended functions.

C2.1.1.1.3 Extent of Visual Inspections (New ISFSI SAR Section 9.7.1.1.3)

Quarterly, the visible outer surfaces of the following dry storage cask subcomponents within the scope of license renewal will be inspected by an individual standing at ground level: [RAI 3-9]

- Bottom vertical surfaces
- Trunnions
- Flange vertical surfaces
- Shell
- Outer Shell

During opportunistic and 20 ± 5-year visual inspections conducted with the dry storage cask protective cover removed, the visible outer surfaces of the following dry storage cask subcomponents within the scope of license renewal will be visually inspected by an individual standing at the top of the cask: [RAI 3-9]

- Lid
- Lid Bolts and Neutron Shield Bolts
- Top Neutron Shield
- Flange horizontal surfaces including stainless steel weld overlay
- Trunnions

During opportunistic and 20 ± 5-year visual inspections conducted during dry storage cask lift operations, the horizontal surface of a dry storage cask bottom will be visually inspected.

C2.1.1.2 Monitoring of Structures Aging Management Program (New ISFSI SAR Section 9.7.1.2)

The Monitoring of Structures Aging Management Program is a new program, which defines the aging management activities that are necessary to help ensure the integrity of reinforced concrete pad No. 1. Reinforced concrete pad No. 1 on which the TN-32 dry storage casks rest is an above-ground, outdoor installation. The Monitoring of Structures Aging Management Program verifies the capability of reinforced concrete pad No. 1 to perform its intended functions.

Specifically, the Monitoring of Structures Aging Management Program ensures that cracking, change in material properties (white stains, indicative of leaching), and loss of material from reinforced concrete pad No. 1 will be identified and managed during the period of extended operation prior to loss of intended function.

Periodic visual monitoring is performed to determine the surface condition of reinforced concrete pad No. 1, which is a leading indicator for the overall integrity of the pad. Visual inspections detect surface defects resulting from the aging mechanisms of reaction with aggregates, freeze-thaw, leaching of calcium hydroxide, or settlement.

C2.1.1.2.1 Program Activities (New ISFSI SAR Section 9.7.1.2.1)

The Monitoring of Structures Aging Management Program includes the following activities:

1. Perform an engineering evaluation every five years to review industry and plant-specific operating experience (including work order history). The initial operating experience evaluation during the period of extended operation will be scheduled to occur in January 2020. [RAI 3-10]
   The evaluation will also review previous inspection results to determine if any adverse trends are identified warranting additional corrective actions to manage the loss of material, cracking, and change in material properties for reinforced concrete pad No. 1. Each element of the Monitoring of Structures Aging Management Program will be reviewed to determine if updates are required based on lessons learned from the operating experience review. The results of the engineering evaluation will be entered into the Aging Management INPO Database (AMID), using the screening criteria as recommended in NEI 14-03, Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management. [RAI 3-14]
2. Perform a visual inspection of all exposed [RAI 3-9] surfaces of reinforced concrete pad No. 1 every five years. The initial visual inspection during the period of extended operation will be scheduled to occur in November 2020. [RAI 3-10]

3. Perform groundwater sampling at the ISFSI site to determine values for chlorides, sulfates, and pH at two groundwater wells every five years.
4. Perform an opportunistic inspection of the normally inaccessible area of reinforced concrete pad No. 1 beneath a TN-32 dry storage cask in the event a dry storage cask is lifted.
5. Perform an opportunistic visual inspection of all exposed below-grade surfaces of reinforced concrete pad No. 1, if made available by excavation. [RAI 3-9]

As recommended by NEI 14-03, inspection results will be reviewed to determine if the results should be entered in the AMID database. [RAI 3-14]

C2.1.1.2.2 **Acceptance Criteria (New ISFSI SAR Section 9.7.1.2.2)**

The acceptance criteria listed in ACI 349.3R is used for all visual inspections.

The acceptance criteria for groundwater monitoring are:

1. Chlorides < 500ppm
2. Sulfates <1,500ppm
3. pH >5.5

Reinforced concrete pad No. 1 is not located in the groundwater. However, a groundwater chemistry monitoring program will be established to provide supplemental information for identifying conditions conducive to underground aging mechanisms.

Monitoring and inspection results that exceed established acceptance criteria are entered into the Corrective Action Program. Engineering evaluations determine if conditions identified as adverse to quality are significant enough to compromise the ability of reinforced concrete pad No. 1 to perform its intended functions.

C2.2 Time-Limited Aging Analyses (New ISFSI SAR Section 9.7.2)

As required by 10 CFR 72.42(a)(1), an application for a renewed ISFSI license must include ISFSI-specific TLAAs. The TLAA identification process required a review of the design basis documents and calculations to provide a reasonable assurance that TLAAs were identified.

Once a TLAA is identified, an evaluation is performed to disposition each ISFSI-specific TLAA using one of three different approaches described below:

i. The analyses will remain valid for the period of extended operation.

ii. The analyses have been projected to the end of the period of extended operation.

iii. The effects of aging on the intended function(s) will be adequately managed for the period of extended operation.

Based on review of design basis documents and calculations, no TLAAs were identified for the North Anna ISFSI.

C3.0 PROPOSED CHANGES TO EXISTING NORTH ANNA ISFSI SAR

C3.1 ISFSI SAR Section A.1.3: Criticality Evaluation

Revise the second to last paragraph of the ISFSI SAR Section A.1.3 to reflect evaluation of the fixed neutron poison in the TN-32 dry storage cask:

> "....An appraisal of the fixed neutron poisons has shown that they will remain effective for the ~~20~~ 60-year storage period, and there is no credible way to lose them. The analysis and evaluation of the criticality design and performance have demonstrated that the cask will provide for the safe storage of spent fuel for a minimum of ~~20~~ 60 years with an adequate subcritical margin."

This change reflects the extended license period to 60 years and is based on previous analysis showing that boron depletion is negligible for storage periods well beyond 60 years.

C3.2 ISFSI SAR Section A.1.4: Thermal Evaluation

Revise the last paragraph of ISFSI SAR Section A.1.4 to reflect evaluation of the thermal design of the TN-32 dry storage cask:

> "The thermal design of the TN-32 cask is in compliance with 10 CFR 72 and applicable design and acceptance criteria have been satisfied. The evaluation of the thermal design provides reasonable assurance that the TN-32 cask will allow the safe storage of spent fuel for ~~20~~ 60 years."

This change reflects the extended license period to 60 years. Since the maximum temperature for the cask and the fuel stored within the cask during the storage period is realized immediately after loading spent fuel into the cask and fuel temperature decreases with time, the thermal calculations supporting storage for the extended license period remain valid.