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From: Longmire, Pamela
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Subject: FW: Meeting Summary for the 6-16 Prairie Island ISFSI LRA RAI Discussion
Attachments: Meeting Summary for the 6-16 Prairie Island ISFSI LRA RAI Discussion

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Subject: FW: Meeting Summary for the 6-16 Prairie Island ISFSI LRA RAI Discussion
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From: Longmire, Pamela

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Damiano, Debra

From: Chesnutt, Samuel <Samuel.Chesnutt@xenuclear.com>
Sent: Tuesday, June 24, 2014 4:03 PM
To: Longmire, Pamela
Cc: Eckholt, Gene F.
Subject: Meeting Summary for the 6-16 Prairie Island ISFSI LRA RAI Discussion
Attachments: PI LRA RAI Meeting Summary 6-16-2014.pdf

Dr. Longmire,

Attached is our summary of last week's meeting with you and your staff.

For completeness, we included copies of all handouts.

As we discussed after the meeting, I have included everyone who signed the attendance sheet, and all of the names I could identify from the call-in introductions. I know there were 2 representatives from OGC whom I do not know, but I'm hoping you can identify anyone I missed from your call-in request list.

It was a pleasure meeting you and your review team and we feel this was a very productive exchange of ideas. We are working on our RAI responses and will contact you when we have draft copies for your review.

If you have any questions, please feel free to call either Gene or myself. I can be reached at my cell, 303-358-5235.

Thanks,

Sam Chesnutt
Xcel Energy | Responsible By Nature
Projects Licensing Engineer
Prairie Island Nuclear Generating Plant
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Summary of Discussion with NRC Staff
Regarding PI ISFSI LRA RAI Responses

Date: June 16, 2014

Time: 1:00 pm CDT

Location: Telephone Conference – Call-in

Participants:

NRC
Dr. Pamela Longmire, Project Manager
Mark Lombard, SFST, Director
Al Csontos, SFST/SMMB
Zhian Li, SFST/CSDAB
Ricardo Torres, SFST/SMMB
Nate Jordan, SFST/CSDAB
Mathew Hiser, RES/DE
A.H. Hsia, SFST, Deputy Director
Robert Einziger, SFST/SMMB
David Pstrak, SFST/LID
Greg Oberson, RES/DE
Mica Baquera, RES/DE
Darrell Dunn, SFST/SMMB
David Tang, SFST/SMMB
Tim Lupold, SFST
Asud Chowdhury, CNWRA
Yiming Pan, CNWRA

NSPM
Mike Baumann, Director Nuclear Fuels
Martin Murphy, Director Regulatory Affairs
Peter Glass, Counsel
Terry Pickens, Director Regulatory Policy
Gene Eckholt, Manager, Projects Licensing
H. Oley Nelson, Projects Engineer
Sam Chesnutt, Projects Licensing

Others
Jim Wood, Exelon
Philippe Pham, Areva TN
Brian Gutherman, NEI
John Greeves, PIIC
Kimberly Harshaw, Pillsbury Law
Pam Cowan, Exelon
Rod McCullum, NEI

By Telephone
Carlyn Green, Ux Consulting
Phil Mahowald, PIIC
Kristina Banovac, SFST/LB
OGC (2)
Kyle Kriesel, NSPM, PINGP
Pete Wildenborg, NSPM, PINGP

Summary of Discussion with NRC Staff
Regarding PI ISFSI LRA RAI Responses

Topic: Discuss PI ISFSI License Renewal – 2nd Set of RAIs and NSPM Proposed Responses

This category 1 public meeting was held to discuss the 12 Requests for Additional Information (RAIs) provided in Reference 3, to support NRC review of the Prairie Island ISFSI License Renewal Application (LRA). The purpose of the meeting was to exchange information, obtain clarification of the information request, and gain a better understanding of NRC expectations for RAI responses.

References:

1. NSPM letter dated October 20, 2011, PI ISFSI LRA (ADAMS ML11304A068)
2. NSPM letter dated July 26, 2013, Response to RAI (ADAMS ML13210A272)
3. NRC letter dated May 27, 2014, Second RAI (ADAMS ML14147A527)
4. NRC Meeting Notice dated June 3, 2014 (ADAMS ML14154A130)

Enclosures:

1. NSPM presentation, PI ISFSI LRA, Discussion of Requests for Additional Information, June 16, 2014
2. NSPM DRAFT AMP, High Burnup Fuel Monitoring Program
3. NRC presentation, Elements of an Aging Management Program (AMP), June 16, 2014
4. NRC presentation, Fuel Performance AMP Development, June 16, 2014
5. NRC presentation, Concrete AMP Development, June 16, 2014
6. NRC presentation, Aging Management Program for Polymer-based Neutron Shield, June 16, 2014

Main Points of Discussion:

1. Introductions Dr. Longmire began the meeting with introductions of meeting participants both in the room and on the telephone.

2. NSPM presented information in Enclosures 1 and 2, which included draft response strategies to RAIs provided in Reference 3.

3. NSPM provided an introductory overview of the process used to develop the Aging Management Program for the Prairie Island ISFSI. This process was consistent with the development of Aging Management Programs for the plant license renewal effort and included:
    a. Identify in-scope components
    b. Identify the materials and environments for covered components
    c. Review aging effects using EPRI tools and reports
    d. Prepare an AMP – this is a program document
    e. Provide appropriate acceptance criteria in implementing procedures

4. AMP Contents – Acceptance Criteria
    The specification of Acceptance Criteria "against which the need for corrective actions will be evaluated" is addressed in Element 6 of NUREG-1927. NSPM explained that their aging monitoring inspections are consistent with inspections that are part of aging management programs for the plant. The inspection process identifies initial indications

Summary of Discussion with NRC Staff
Regarding PI ISFSI LRA RAI Responses

of aging (e.g., any evidence of corrosion) and then ensures that these conditions are documented and evaluated in the 10 CFR 50 Appendix B Corrective Action Program (CAP).

The NRC indicated that having more specific acceptance criteria in the AMP would be valuable to their review. Also, the identification of specific criteria at which corrective actions would be taken was discussed. NSPM explained that the broad range of conditions and locations of aging effects that might be observed do not support identification of specific values (e.g., corrosion depths) for initiating pre-specified corrective actions in the inspection procedures or in the AMP program level documents. In addition, it is undesirable to identify a specific value that would be considered acceptable for all cases. For example, the amount of corrosion that might be acceptable on a general surface might not be acceptable if it were all in one location.

NSPM will explain the use of the CAP program for evaluating conditions and determining corrective actions in the RAI response.

5. RAI-12, High Burnup Fuel AMP
   NSPM presented the Draft AMP, High Burnup Fuel Monitoring Program in Enclosure 2. NSPM intends to submit this AMP as part of the response to RAI-12. The High Burnup Fuel AMP relies on the joint EPRI and DOE "High Burnup Dry Storage Cask Research and Development Project (HDRP)," as a surrogate program for the high burnup fuel being stored at the PI ISFSI. The Draft High Burnup Fuel AMP includes the 10 elements of an AMP identified in NUREG-1927, and also includes an eleventh element to describe "Toll Gate Assessments." The Toll Gate Assessments element recognizes that the HDRP may identify lessons learned or other aging-related impacts at some time in the future, and provides for periodic assessments of new or additional industry operating experience information.

   The Draft AMP includes toll gate assessments at least 5, 15, 25, and 35 years after license renewal. Based on the current schedule to load the HDRP cask in 2017, the initial toll gate assessment after 5 years (approximately 2019) will allow an evaluation of temperature readings from loading and initial storage of the demonstration cask, and additional data will be addressed after another 10 years. The Draft AMP also provides for evaluation of data from the examination of stored fuel when it becomes available, which is expected to occur before storage of high burnup fuel at the PI ISFSI exceeds 20 years (in 2033). Discussion topics to be addressed in the RAI response include initial design actions to establish and maintain a dry, inert environment as preventive actions to prevent cladding oxidation.

6. RAI -1, SAR Updates
   SAR markups regarding storage periods (e.g., 20 or 25 years) will be provided along with justification for changes.

7. RAIs 2, 3, 4, 5, 6, and 7 regarding Concrete Pad, Groundwater, and Earthen Berm
   NSPM explained inspections, inspection frequencies, acceptance criteria, and the use of the CAP process to determine when corrective actions would be initiated. Further

explanations will be provided in the RAI responses. NSPM will also provide explanations of terminology based on EPRI aging management tools and reports, which have not been endorsed by NMSS.

8. RAI-8 and 9, Cask Inspections
   NSPM explained that any evidence of corrosion is documented and evaluated in the CAP program. Photographs from the baseline inspections (provided in Reference 2) were taken to provide a visual record as part of the CAP documentation and do not provide "conclusive evidence" that there was no observable loss of material. The CAP process is used to document inspections and determine when further actions are needed. This explanation will be provided in the RAI response.

9. RAI-11, Flammable Gas Generation
   NSPM explained new analysis that shows negligible flammable gas generation in neutron shield material. This analysis will be provided with the RAI response.

10. RAI-10, Neutron Shield AMP
    NSPM explained that new analysis shows negligible loss of hydrogen due to radiolytic degradation of neutron shield material. Quarterly surveys do not detect "any" degradation, but will identify degradation that could lead to a loss of safety function. NSPM discussed comparing survey data to a curve based on the safety analysis, and also trending of survey data as provided Reference 2. Further explanations will be considered in the RAI response.

11. NRC Presentation on Elements of an Aging Management Program (AMP)
    The NRC presented information in Enclosure 3, including the information and level of detail that should be provided for the 10 elements described in NUREG-1927. The overall structure of AMPs was also discussed with regards to the presentation of a "horizontal slice" of aging effects or a "vertical slice" that is more component oriented.

12. NRC Presentation on Fuel Performance AMP Development
    The NRC presented information in Enclosure 4, including the 10 elements of an AMP described in NUREG-1927. The use of future OE assessments that NSPM included in the Draft AMP under an eleventh element, "Toll Gate Assessments," was discussed under element 9, Administrative Controls. The NRC also discussed ISG-24, which is currently in draft form and is expected to be issued within a few weeks

13. NRC Presentation on Concrete AMP Development
    The NRC presented information in Enclosure 5 and noted that this is a generic presentation that includes horizontal storage modules.

14. NRC Presentation Aging Management Program for Polymer-based Neutron Shield
    The NRC presented information in Enclosure 6, including the 10 elements of an AMP described in NUREG-1927.

Summary of Discussion with NRC Staff
Regarding PI ISFSI LRA RAI Responses

Actions:

NSPM
Provide draft responses to RAIs as discussed.

NRC
No specific actions at this time.

Summary:
There was a good exchange of information between NSPM and the NRC, and the meeting was beneficial for identifying issues to be addressed in the RAI responses. Based on discussions and presentations made by both NSPM and the NRC, NSPM will prepare written responses to the 12 RAIs, including a revision to the High Burnup Fuel Monitoring Program AMP. Draft responses will be provided to the NRC Project Manager for preliminary review. Telephone conferences or other communications will be held to discuss remaining issues, so that final responses can be submitted by the July 29 schedule date.

Disposition of Summary Discussion with NRC:

1)	Summary for internal use	___x___
2)	Meeting summary with copy provided to NRC	___x___
3)	Docketed letter related to meeting	_____

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Prairie Island Independent Spent Fuel Storage Installation

License Renewal Application

Discussion of Requests for Additional Information

Rockville, Maryland

June 16, 2014

Attendees - NSPM

Mike Baumann – Director, Nuclear Fuel Supply

Martin Murphy – Director, Nuclear Licensing and Regulatory Affairs

Terry Pickens – Director, Regulatory Policy

Gene Eckholt – Manager, Projects Licensing

Oley Nelson – Engineer, Spent Nuclear Fuel Projects

Sam Chesnutt – Engineer, Projects Licensing

Agenda

- Introductions
- Objective of Meeting
- Background
- Discussion of Requests for Additional Information and NSPM Proposed Responses
- Closing Remarks

Acronyms

ACI	American Concrete Institute	NRC	Nuclear Regulatory Commission
AMP	Aging Management Program	NSPM	Northern States Power – Minnesota
AMR	Aging Management Review	OE	Operating Experience
CAP	Corrective Action Program	PINGP	Prairie Island Nuclear Generating Plant
DOE	Department of Energy	PEO	Period of Extended Operations
EPRI	Electric Power Research Institute	RAI	Request for Additional Information
GALL	Generic Aging Lessons Learned	SAR	Safety Analysis Report
ISFSI	Independent Spent Fuel Storage Installation	TLAA	Time Limited Aging Analysis
LRA	License Renewal Application	TN	Transnuclear

Objective Of Meeting

- Ensure clear understanding of RAIs
- Reach agreement on response strategies

Background

- ISFSI Operations commenced - 1995
- NSPM submitted PI ISFSI License Renewal Application (LRA) - October 2011
  - Requested 40 year extension beyond October 2013
- Submitted Responses to Initial Round of Technical RAIs - July 2013
- 2nd Set of RAIs – May 2014

Discussion of RAI-12

- **RAI-12:**

Provide an AMP for high burnup fuel addressing the 10 points in NUREG-1927; the AMP should be based on the DOE Cask Demonstration test plan.

Discussion of RAI-12 (Cont'd)

Response to RAI-12

- **Will provide an AMP based on DOE Demonstration plan**
- **AMP will include Toll Gate Assessments**
- **AMP will be included in revision to Appendix A of LRA, Aging Management Plan**

Discussion of RAI-1

- **RAI-1:**

Identify each instance in the safety analysis report (SAR) that refers to a limited storage system period – explain and justify their disposition.

Discussion of RAI-1 (Cont'd)

Response to RAI-1:

- Propose to provide markups of each instance in SAR that refers to a storage system period (e.g., 20 years)
- SAR update categories:
  - Delete storage period if no technical basis
  - Revise storage period if new analysis
  - Clarify how storage period applies during PEO
- Will provide complete list of SAR updates and justification of categorization

Discussion of RAI-2

- **RAI-2:**

Provide a revised Aging Management Program (AMP) for the concrete pad, or provide detailed justifications for why five listed aging effects / mechanisms do not require an AMP, for both above-grade and below-grade areas, as applicable.

Discussion of RAI-2

Response to RAI-2:

- Three of the listed aging effects / mechanisms for the concrete pad are addressed in the LRA, Table 3.4-1 (AMR) and A2.1-1 (AMP):
  - Cracking, Loss of Strength from cement aggregate reactions
  - Increase in porosity/permeability and Loss of Strength due to leaching of Ca(OH)2
  - Cracking due to Settlement

Discussion of RAI-2 (Cont'd)

- Will provide site-specific technical justification for exclusion of:
  - Cracking, Loss of Material from chemical attack
    - Not exposed to aggressive chemical environment
  - Cracking, Loss of Material / Bond from corrosion of embedded steel
    - Good quality, well consolidated, properly cured concrete pads.

Discussion of RAI-3

- **RAI-3:**

Specify which materials properties are covered by the aging effect "Change in Materials Properties" when referring to the aging mechanism "Leaching of Ca(OH)2" in the concrete pad and justify visual examination.

Discussion of RAI-3 (Cont'd)

Response to RAI-3:

- **Material properties that can be affected by leaching include:**
  - **Increase in porosity and permeability**
  - **Reduced strength**
  - **Lower pH**
- **Visual examination can detect evidence of leaching such as white lime deposits**

Discussion of RAI-4

- **RAI-4:**

Revise the license renewal application (LRA) to include a water chemistry program as part of the AMP for the concrete pad, or provide justification for exclusion.

Discussion of RAI-4 (Cont'd)

Response to RAI-4:

- Will revise AMP in Appendix A to LRA, to include groundwater chemistry
- Proposed Frequency is every six months
- Proposed acceptance criteria
  - Chloride ≤ 500 ppm
  - Sulfate ≤ 1500 ppm
  - pH ≥ 5.5

Discussion of RAI-5

- **RAI-5:**

Revise inspection frequencies consistent with ACI 349.3R or justify discrepancies. Also, justify opportunistic inspections of below-grade areas.

Discussion of RAI-5 (Cont'd)

Response to RAI-5:

- Inspection frequency for ISFSI concrete pad is proposed to be the same as other PINGP concrete structures
  - Above-grade – 5 years
  - Inaccessible – inspections of opportunity
    - Will clarify frequency in LRA Section A2.4.2
- Inspection frequency consistent with GALL, NUREG-1801, Rev.2, Section XI.S6, Structures Monitoring

Discussion of RAI-6

- **RAI-6:**

Describe the Corrective Action Program (CAP) and when inspection results of the concrete pad will initiate an Action Request, change to the AMP, or notification to the NRC. Also, address use of operating experience (OE) from other ISFSIs. Explain monitoring and trending of identified but uncorrected aging effects.

Discussion of RAI-6 (Cont'd)

Response to RAI-6:

- **CAP Action Request initiated when acceptance criteria are exceeded:**
  - **Cracking – identified size limits**
  - **Change in material properties – calcium streaks and deposits (indicative of leaching)**
  - **Loss of material – identified size limits for surface scaling, spalling**
- **Criteria are consistent with Tier 2 criteria in ACI 349.3R for conditions requiring evaluation**

Discussion of RAI-6 (Cont'd)

- CAP program is 10 CFR 50 Appendix B program
- CAP evaluations include:
  - Extent of condition evaluation
  - Actions to accept or repair as appropriate, including possible increase in inspection frequency or expansion of sample population
  - Evaluation for NRC reportability
  - Determination if AMP needs to be revised

Discussion of RAI-6 (Cont'd)

- Site OE program reviews issues identified by NRC and industry (e.g., INPO, Owners groups, TN cask users group)
  - Concrete OE issues are similar to other Plant concrete structure issues
  - OE reviews could lead to a CAP
  - CAP program evaluation will determine need for modifying the AMP
- AMP includes monitoring and trending

Discussion of RAI-7

- **RAI-7:**

Provide additional information in the AMP for the berm:

- ***Define "absence of aging effects"***
- ***Provide basis for inspection frequency***
- ***Identify material properties that will change due to dessication and explain visible signs of change***

Discussion of RAI-7 (Cont'd)

RAI-7 Discussion:

- **AMP for berm is consistent with PINGP AMP for earthen structures**
- **"Absence of aging effects" for the berm includes:**

  (aging effects terminology from EPRI reports)
  - **No loss of form – no indications of slope instability or settlement**
  - **No loss of material – no evidence of erosion**
  - **No change in material properties – no evidence of erosion**

Discussion of RAI-7 (Cont'd)

- Dessication is a drying of soils that results in a loss of soil adhesion – visible signs would include accelerated effects of erosion
- Inspection frequency of 5 years is based on Plant structural inspections, also consistent with GALL report, NUREG-1801 Rev. 2

Discussion of RAI-8

- **RAI-8:**

Provide a detailed technical basis for the acceptance criteria for visual examinations of the cask: the absence of any signs of aging, as indicated in LRA Section A2.6.2.

Discussion of RAI-8 (Cont'd)

Response to RAI-8

- **Acceptance criteria of the "absence of any of the aging effects listed in Table A2.1-1" ensures conservative initiation of an Action Request in the CAP program**
  - **Aging effect listed in Table A2.1-1 for casks is "Loss of Material" due to various corrosion mechanisms**
  - **Acceptance criteria are not met if Inspector observes any corrosion**

Discussion of RAI-8 (Cont'd)

- Any observed corrosion is evaluated in the CAP program
- CAP Program relies on engineering evaluations to determine actions
- Calculation referred to in the RAI provides basis for inspection frequency – is not a quantitative or actionable operation criterion

Discussion of RAI-9

- **RAI-9:**

Provide conclusive evidence to support no observable loss of material statement regarding the lead cask examination. Also, clarify photographs of the inspection and address observations regarding pits and measurable loss of material.

Discussion of RAI-9 (Cont'd)

Response to RAI-9:

- Use of visual examinations is consistent with NUREG 1927, Appx E, Component Specific Aging Management
- Only "conclusive evidence" is inspection report with documented observations by the inspector
- Inspector documented no observable depth to corrosion (including pitting corrosion)
- AMP will be revised to clarify "no measureable loss of material" should be "no observable loss of material"
- Discussion of photos and annotations

Discussion of RAI-11

- **RAI-11:**

Provide a TLAA to support position that there will be no buildup of flammable hydrogen based on radiolytic degradation of the neutron shield polymer. Provide AMP for the relief valve if needed.

Discussion of RAI-11 (Cont'd)

Response to RAI-11:

Will provide analysis:

- **Calculation of potential flammable gas generation based on methodology in NUREG/CR-6673**
  - **Conservatively includes energy deposition in resin from both gamma and neutron radiation**
- **The amount of gas generated is less than solubility capacity of resin**
- **Analysis concludes that the amount of flammable gas released from resin would be negligible**

Discussion of RAI-10

- **RAI-10:**

Provide an AMP to detect degradation of cask neutron shield. The current radiation monitoring program does not adequately address detector selection, measurement location selection, resolution of measurement data, time dependency of the decaying source term, or detection of cracks or unexpected degradation of the shield.

Discussion of RAI-10 (Cont'd)

Response to RAI-10:

- NSPM will provide additional support for position that there is no aging effect for neutron shield that could result in a loss of shielding intended function
  - Aging effects such as embrittlement, cracking, loss of elasticity do not affect intended function
  - Calculation discussed in response to RAI 11 shows hydrogen generated by radiolytic degradation will remain absorbed in the poly material
    - No loss of shielding

Discussion of RAI-10 (Cont'd)

- Will provide clarification that current surveys can detect degradation before loss of intended function
  - Intended function is to provide shielding for compliance with offsite dose regulations, as demonstrated by Safety Analysis
  - Loss of intended function would be defined as a reduction in shielding effectiveness that results in actual dose rates that exceed those based on the Safety Analysis

Discussion of RAI-10 (Cont'd)

- Neutron survey meters
  - Will discuss neutron energy spectrum used during survey meter calibration
  - Will explain that meter readings are conservatively higher than actual due to different neutron energy spectra in calibration source vs. casks
  - Shielding degradation could result in a shift to higher energy neutrons which would produce even higher measured values

Discussion of RAI-10 (Cont'd)

- **Measurement Locations**
  - **Survey measurements at consistent locations**
  - **Measurements taken approximately 2 m from casks – at a point straight out from each cask**
  - **Approximately 1 m above ground**
  - **Minimizes impact of dose from adjacent casks**

Discussion of RAI-10 (Cont'd)

- Measurement resolution
  - Meter scale is analog, 1 to 10 mr/hr; data typically recorded to nearest 1 mr
  - Elevation is at point of high dose rate
  - Consistent measurement locations provide representative sample of casks

Discussion of RAI-10 (Cont'd)

- Trending
  - Trending of 2-meter survey data shows dose rates below dose rates based on Safety Analysis
  - Increases in dose rate trends will detect degradation before loss of intended function

Closing Remarks


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A3.0 HIGH BURNUP FUEL MONITORING PROGRAM

The Prairie Island ISFSI provides for long-term dry fuel interim storage for High Burnup spent fuel assemblies, i.e., fuel assemblies with discharge burnups greater than 45 GWD/MTU, until such time that the spent fuel assemblies may be shipped off-site for final disposition. The cask system presently utilized at the Prairie Island ISFSI for the storage of High Burnup spent fuel is the Transnuclear TN-40HT which has a 40 fuel assembly capacity and is designed for outdoor storage. The first High Burnup fuel assembly was placed into storage operation at the Prairie Island ISFSI in April of 2013.

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

A description of the High Burnup Fuel Monitoring Program is provided below. Although the program is a confirmatory program, the description below uses each attribute of an effective AMP as described in NUREG-1927 for the renewal of a site-specific Part 72 license to the extent possible. In addition to the ten elements called for in NUREG-1927, the program includes an eleventh element, Toll Gate Assessments. This element is intended to provide periodic assessments of available information relative to the storage of high burnup spent fuel.

A3.1 Scope of Program

A3.1.1 NUREG-1927 Program Element

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

A3.1.2 PINGP Program Element

The High Burnup Fuel Monitoring Program relies upon the joint Electric Power Research Institute (ERPI) and Department of Energy's (DOE) "High Burnup Dry Storage Cask Research and Development Project" (HDRP) to monitor the condition of high burnup spent fuel assemblies in dry storage as a surrogate program for the high burnup fuel being stored at the Prairie Island ISFSI.

The HDRP is a program designed to collect data from a spent nuclear fuel dry storage system containing high burnup fuel. The program entails loading and storing a TN-32 bolted lid cask (the Research Project Cask) with intact high

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burnup spent nuclear fuel with four different kinds of cladding (including cladding types used at the Prairie Island Nuclear Generating Plant) at Dominion Virginia Power's North Anna Power Station. At the end of a long-term storage period, which may be up to 10 years or longer, the Research Project Cask will be transported to an off-site Fuel Examination Facility where the cask will be reopened and the fuel examined.

The scope of the High Burnup Fuel Monitoring Program includes those activities outlined in the "High Burnup Dry Storage Cask Research and Development Project Final Test Plan", February 27, 2014, (HDRPTP) prepared by the Electric Power Research Institute.

1) Monitoring temperatures inside and outside the cask.
2) Perform non-destructive and destructive examinations of sister rods to those in the Research Project Cask. These examinations include:
    a) Visual exams
    b) Cladding profilometry
    c) Rod internal pressure and content
    d) Hydride content and orientation
    e) Cladding mechanical testing
3) At the end of the long-term storage process, perform similar examinations of rods from the Research Project Cask.

A3.2 Preventive Actions

A3.2.1 NUREG-1927 Program Element

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

A3.2.2 PINGP Program Element

The High Burnup Fuel Monitoring Program consists of temperature monitoring, non-destructive examinations, and destructive examinations of fuel rods to confirm there is no degradation of a high burnup fuel assembly that would result in a loss of their intended function(s). No preventive or mitigating attributes are associated with these activities.

A3.3 Parameters Monitored or Inspected

A3.3.1 NUREG-1927 Program Element

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

A3.3.2 PINGP Program Element

The parameters monitored by the High Burnup Fuel Monitoring Program are outlined in the HDRPTP. The principle aging effect being monitored is a change in material properties, e.g., ductility, of the cladding due to hydride reorientation. The intended functions of the fuel cladding that are being monitored include:

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- Maintains a pressure boundary (PB)
- Provides structural/functional support (SS)

These functions combine to comply with regulations regarding the protection against degradation that leads to gross ruptures and the retrievability of the fuel.

The hydride reorientation aging mechanism is dependent upon the fuel cladding temperatures during the loading and storage operations. Hence the HDRPTP calls for monitoring of cask internal temperatures during loading and storage operations. These temperatures may then be used to infer the fuel cladding temperatures. The destructive examinations at the off-site Fuel Examination Facility will be used to determine the hydride content and orientation within the fuel cladding. The destructive examinations will also include fuel cladding ductility testing.

A3.4 Detection of Aging Effects

A3.4.1 NUREG-1927 Program Element

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

A3.4.2 PINGP Program Element

The use of information from the surrogate program is an acceptable method to ensure that the potential aging effects of high burnup fuel are identified and managed prior to the loss of intended functions.

The HDRPTP calls for monitoring of cask internal temperatures during the initial cask drying process at one minute intervals. During the long-term storage period temperatures would be collected twice a day. These frequencies will provide data for thermal models during the larger temperature transients encountered during the drying process as well as cladding time at temperature taking into account daily and seasonal temperature fluctuations. This information will provide inputs to the evaluation of hydride reorientation and ductility testing.

The destructive examinations are intended to be performed after a long-term storage period which may be up to 10 years or longer. These examinations will provide a direct indication of the degree of hydride reorientation and ductility of the cladding.

The schedule for the HDRP as outlined in the final test plan calls for the Research Project cask to be loaded and placed in storage in 2017. Thus, information from the destructive examination of the fuel placed into storage would not be expected until after 2027. This schedule provides sufficient time to obtain, evaluate and take any necessary action prior to the high burnup fuel being stored at the Prairie Island ISFSI beyond 20 years. The "toll gate" assessments

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described in program element A3.11 assure that information from the HDRP and other relevant sources will be regularly conducted in a timely manner.

A3.5 Monitoring and Trending

A3.5.1 NUREG-1927 Program Element

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

A3.5.2 PINGP Program Element

HDRPTP calls for submitting progress reports on a semi-annual basis while the Research Project Cask is in dry storage. It is expected that these reports will include trends of cask internal temperatures which may be used to infer the trend of the fuel cladding temperatures. As previously mentioned the hydride reorientation aging mechanism is dependent upon the fuel cladding temperatures during the loading and storage operations.

The destructive exams are scheduled to occur after a period of long-term storage and are expected to provide information on the extent of the hydride reorientation mechanism and its effect on the ductility of the cladding ductility prior to the high burnup fuel being stored at the Prairie Island ISFSI beyond 20 years.

A3.6 Acceptance Criteria

A3.6.1 NUREG-1927 Program Element

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

A3.6.2 PINGP Program Element

When information from the ductility testing of the fuel in the Research Project Cask becomes available, an Action Request will be initiated within the NSPM Corrective Action Program to perform a Condition Evaluation. The Condition Evaluation will determine if the results of the ductility testing indicate the need for corrective action to ensure that the fuel cladding will continue to perform its intended functions under the existing licensing-basis conditions.

A3.7 Corrective Actions

A3.7.1 NUREG-1927 Program Element

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

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A3.7.2 PINGP Program Element

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

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

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

As stated above, when information from the ductility testing of the fuel in the Research Project Cask becomes available, an Action Request will be initiated within the NSPM Corrective Action Program. Actions that are required to resolve inspection findings will be tracked to completion and trended within the Corrective Action Program.

A3.8 Confirmation Process

A3.8.1 NUREG-1927 Program Element

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

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A3.8.2 PINGP Program Element

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

The Corrective Action Program is also monitored for potentially adverse trends. The existence of an adverse trend due to recurring or repetitive adverse conditions will result in the initiation of an Action Request.

A3.9 Administrative Controls

A3.9.1 NUREG-1927 Program Element 9, Administrative Controls

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

A3.9.2 PINGP Program Element

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

A3.10 Operating Experience

A3.10.1 NUREG-1927 Program Element

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

A3.10.2 PINGP Program Element

It is recognized that there has been relatively little operating experience, to date, with dry storage of high burnup fuel. Hence this element is focused on the principle aging effect being monitored, e.g., ductility, of the cladding due to hydride reorientation.

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Ductility tests performed at the Argonne National Laboratory

Reference A5.7 describes the results of tests performed by Argonne National Laboratory that examined the possible effects of hydride reorientation on high burnup fuel cladding. The tests involved cladding segments of high burnup spent fuel rods that were subjected to a temperature transient to simulate bounding drying and storage operations. After the temperature, the radial-hydride reorientation was characterized and ring compression tests were performed. Test results show that the trend of the data generated clearly indicates that failure criteria for high-burnup cladding need to include the embrittling effects of radial-hydrides for drying-storage conditions that are likely to result in significant radial-hydride precipitation.

The cladding material used in the test is the same as most of the high burnup fuel cladding stored at the Prairie Island ISFSI. While the burnup of the cladding segments was higher than that allowed to be stored at the Prairie Island ISFSI it is reasonably close. The temperature transient heated the cladding to 400 ℃ which corresponds to the cladding temperature limit for the fuel stored at the Prairie Island ISFSI. The cooldown rate was conservatively slower than what would be expected for the fuel stored at the Prairie Island ISFSI. For these reasons the cladding used in the ring compression test should be a reasonable representation of the potential condition of the cladding of the fuel stored at the Prairie Island ISFSI.

While the tests were performed on defueled irradiated fuel rod segments, there was no information in Reference A5.7 of the potential gap between the cladding and the fuel pellets. The size of this gap and the presence of the fuel pellets could have a significant impact on the ductility of a fuel rod to pinch type loads. Thus, the results of the ring compression tests may not be applicable to fuel rods in dry storage.

The ring compression test was used as a ductility screening test and to simulate pinch-type loading during cask transportation or cask drops from rod/grid-spacer and rod/rod mechanical interactions. This type of pinch load would occur when a cask is dropped horizontally or when a cask tips over. The current licensing basis for the cask stored at the Prairie Island ISFSI is that the loaded casks are always in the vertical position and cask tip over events are not credible. Thus, the results of the ring compression tests may not be applicable to fuel rods stored at the Prairie Island ISFSI.

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A3.11 Toll Gate Assessments

A3.11.1 NUREG-1927 Program Element

It is understood that licensees will have formal operating experience assessment programs that evaluate the impact of applicable industry operating experience to their operation. Hence, NUREG-1927 does not include a separate program element for a formal periodic assessment of any new or additional information. When NUREG-1927 was finalized, the need to formally address degradation mechanisms characterized by little to no prior operating experience through future surrogate monitoring programs, such as the HDRP, was not anticipated. Given the unique nature of this confirmatory program, NSPM is electing to go

beyond the guidance of NUREG-1927 and will periodically perform formal assessments of aggregated feedback from the HDRP, along with other information that may be available in the future at specific points in time during the period of extended operations. NSPM is aware that industry and NRC are engaged in public discussions about augmenting NUREG-1927 for this purpose and that the term "toll gates" has been coined to describe such intended periodic assessments. Accordingly, this element is being added to the program to describe specific periodic future assessments that will be conducted as part of this confirmatory program.

A3.11.2 PINGP Program Element

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

Toll Gate	Year*	Assessment
1	5	Evaluate, if available, information obtained from the HDRP loading and initial period of storage (during which the highest temperatures are likely to be observed) along with other available sources of information. If the HDRP cask has not been loaded at this point and no other information is available, move the next Toll Gate assessment forward 5 years.
2	15	Complete any outstanding evaluations from Toll Gate 1. Evaluate, if available, information obtained from the destructive examination of the fuel placed into storage in the HDRP along with other available sources of information. If the aggregate of this information confirms ability of the High Burnup Fuel Assemblies to continue to perform intended function(s) for the remainder of the renewal period, subsequent toll gate assessments may be cancelled. If the HDRP fuel has not been examined at this point and no other information is available, move the next Toll Gate assessment forward 5 years.
3	25	Complete any outstanding evaluations from Toll Gates 1 & 2 and evaluate any other new information. If the aggregate of this information confirms ability of the High Burnup Fuel Assemblies to continue to perform intended function(s) for the remainder of the renewal period, subsequent toll gate assessments may be cancelled. If the information is inconclusive, move the next Toll Gate assessment forward 5 years
4	35	Complete any outstanding evaluations from Toll Gates 1-3 and evaluate any other new information.

*Calculated from the effective date of the renewed license

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At each of these toll gates, the impact of the aggregate feedback will be assessed and actions taken when warranted. The toll gates amplify the existing practice of continuously evaluating site-specific and industrywide operational experience for impacts on aging management. These evaluations will address any lessons learned and take appropriate corrective actions, including:

- Perform repairs or replacements
- Modify this confirmatory program in a timely manner
- Adjust age-related degradation monitoring and inspection programs (e.g., scope, frequency)

The above toll gates are not, by definition, stopping points. No particular action other than performing an assessment is required to continue cask operation. To proceed through a toll gate, an assessment of aggregated available operating experience (both domestic and international), including data from monitoring and inspection programs, NRC-generated communications, and other information will be performed. The evaluation will include an assessment of the ability of the High Burnup Fuel Assemblies to continue to perform their intended function(s) until the next toll gate is approached.

The above toll gates also represent formal opportunities for NSPM to take corrective actions, such as repairs or replacements, and to make adjustments to this program in support of operations through the period of extended operations. The evaluations and assessments will be retained as records within NSPM's record management system.

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

A5.1 NUREG-1927, *Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance*, March 2011.

A5.2 EPRI Report 1002882, *Dry Cask Storage Characterization Project, Final Report*, September 2002.

A5.3 Letter from D.A. Christian, Virginia Electric and Power Company to D.A. Cool (NRC), *Surry Independent Spent Fuel Storage Installation License Renewal Application*, dated April 29, 2002, ADAMS Accession Number ML021290068.

A5.4 Transnuclear Information Bulletin, April 2001.

A5.5 Letter from G. L. Stathes, Exelon Generation Company to Director Spent Fuel Project Office (NRC), *Submittal of Independent Spent Fuel Storage Installation (ISFSI) Cask Event Report*, dated December 01, 2010, ADAMS Accession Number ML110060275.

A5.6 American Concrete Institute, ACI 349.3R-96, *Evaluation of Existing Nuclear Safety-Related Concrete Structures*, January 1996.

A5.7 M.C. Billone, T.A. Burtseva, and R.E. Einziger, "Ductile-to-Brittle Transition Temperature for High-Burnup Cladding Alloys Exposed to Simulated Drying-Storage Conditions," in the Journal of Nuclear Materials, Volume 433, Issues 1–3, pages 431–448, February 2013.

A5.8 Letter from R. McCullum (NEI) to M. Lombard (NRC), dated March 22, 2013, "Industry Analysis and Confirmatory Information Gathering Program

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to Support the Long-Term Storage of High Burnup Fuel (HBF)," (ADAMS Accession No. ML13084A045).

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Elements of an Aging Management Program (AMP)

Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission

PINGP ISFSI Public Meeting
June 16, 2014

Regulatory Basis

U.S.NRC
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- **10 CFR 72.42(a), 72.240(c):**
  - TLAAs that demonstrate that ITS SSCs will continue to perform their intended function for the period of extended operation.
  - A description of the AMP for management of issues associated with aging that could adversely affect ITS SSCs.
- **Guidance: NUREG-1927 AMP Elements:**

1. Scope of the Program
2. Preventive Actions
3. Parameters Monitored/Inspected
4. Detection of Aging Effects
5. Monitoring and Trending
6. Acceptance Criteria
7. Corrective Actions
8. Confirmation Process
9. Administrative Controls
10. Operating Experience

- **Increased efficiency and reduced number/rounds of Requests for Additional Information with complete AMPs**

AMP Elements

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1. Scope of the Program

NUREG-1927: *The scope should include the specific SSCs subject to an AMR*

- Component and subcomponent
- Material of construction
- Environment
- Aging mechanisms for material/environment combination
- Aging effects corresponding to the aging mechanism

2. Preventive Actions

NUREG-1927: *Preventive actions should mitigate or prevent the applicable aging effects*

- Actions to minimize, control, or prevent the degradation mechanism

(e.g. peak cladding temperatures below ISG-11, rev. 3 limit during drying)

AMP Elements

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3. Parameters Monitored or Inspected

NUREG-1927: *Parameters monitored or inspected should be linked to the effects of aging on the intended functions of the particular structure and component*

- Parameters (e.g. cracking, loss of material, temperature, fluence, etc.)
- Location (e.g. at highest heat location, at 1 m from cask)

4. Detection of aging effects

NUREG-1927: *Detection of aging effects should occur before there is a loss of any structure and component intended function*

- Method/technique (e.g. visual, volumetric, and/or surface inspections or surveys)
  - Justification & qualification that technique can achieve proposed acceptance criteria for detecting potential aging effects to be monitored or inspected
- Frequency of inspection (e.g. inspection intervals)
- Sample size (dependent on operational experience trending)
- Data collection (clearinghouse for operational experience)
- Timing (new or one-time inspections)

AMP Elements

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5. Monitoring & Trending

NUREG-1927: *Should provide for prediction of the extent of the effects of aging and timely corrective or mitigative actions*

- Assess effects per prior inspections and industry-wide operational experience
- Track trending of aging effects (e.g. corrosion rate, crack growth rate, etc.)

6. Acceptance Criteria

NUREG-1927: *Acceptance criteria, against which the need for corrective action will be evaluated, should ensure SSC intended function is maintained under the existing* licensing-basis *design conditions during the renewal period*

- Criteria for evaluating inspection results for operable aging effects
- Domestic and International consensus codes and standards, or previously used criteria if relevancy is justified and established
- Technical basis for these criteria should be provided
- Separate criteria should be provided for each aging effect

AMP Elements

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7. Corrective Actions

NUREG-1927: *Corrective actions, including root cause determination and prevention of recurrence, should be timely*

- **CAP commensurate with 10 CFR 71 Subpart G, or 10 CFR 50 Appendix B**
- Maintenance plans, corrective actions for the specific degradation effects (e.g. repair, replacement, mitigation activities, and extent of condition)
  - Actions to prevent reoccurrence
  - Justification for repair, replace, and/or mitigate deferral
  - Analysis of how action may affect other subcomponents
- Consideration of corrective actions on other components
- Plans for OE incorporation into the remediation plan

8. Confirmation Process

NUREG-1927: *Confirmation process should ensure that preventive actions are adequate & appropriate corrective actions have been completed & are effective*

- **QA Program consistent with 10 CFR 72 Subpart G, or 10 CFR 50 Appendix B**
- Method to confirm actions required are taken
- Follow up action to determine success (e.g. effectiveness of repair)

AMP Elements

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9. Administrative Controls

NUREG-1927: *Administrative controls should provide a formal review and approval process*

- **CAP commensurate with 10 CFR 71 Subpart G, or 10 CFR 50 Appendix B**
- Inspector requirements
- Record retention requirements
- Review process of examination results
- Frequency/methods for reporting inspection results to NRC
- Frequency for updating AMP based on industry-wide operational experience

10. Operating Experience

NUREG-1927: *Include past corrective actions resulting in program enhancements; objective evidence to support a determination that the effects of aging will be adequately managed so that the structure and component intended functions will be maintained during the period of extended operation*

- Provide specific industry-wide operational experience that supports the use of an examination method, inspection frequency, and/or inspection criteria

Path Forward

U.S.NRC
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- Staff developed generic AMP guidance for specific near-term aging effects:
  - Fuel performance
  - Concrete
  - Polymer-based neutron shielding

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Fuel Performance AMP Development

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U.S. Nuclear Regulatory Commission

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AMP Element 1:
Scope of the Program

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NUREG-1927: The scope of the program should include the specific structures and components subject to an AMR

- Components/Materials of Construction
  - Spent Fuel with maximum burnup of XXX
  - Cladding types XXX with maximum cladding temperature of XXX
- Environment
  - Dry helium
- Aging effects for material/environment combinations
  - DOE Cask Demo Project:
    - Fuel cladding breach
    - Assembly distortion
    - Residual moisture after drying
    - Changes in the hydride structure of the cladding

AMP Element 2:
Preventive Actions

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NUREG-1927: Preventive actions should mitigate or prevent the applicable aging effects

- NRC considerations:
  - Casks/Canisters dried per the accepted procedure in NUREG -1536, Standard Review Plan for Dry Cask Storage Systems
  - Backfilled with helium cover gas
  - Maximum cladding temperature is maintained below the recommended ISG-11 Rev 3 limits

AMP Element 3:

Parameters Monitored/ Inspected

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NUREG-1927: Parameters monitored or inspected should be linked to the effects of aging on the intended functions of the particular structure and component

- Surveillance demonstration program meeting ISG-24:
  - Maximum cladding temperature
  - Inspection for the presence of fission gas in the cover gas
  - Inspection for presence of water vapor in the cover gas
  - Inspection for hydrogen to determine that any radiolysis of residual or bound water does not produce a flammable condition
  - Profilometry at the completion of the storage period to determine creep deformation
  - Gas puncturing at completion of storage to determine cladding stress for creep calculations
  - Cladding metallography at the completion of storage to determine condition of cladding hydrides

AMP Element 4:
Detection of Aging Effects

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NUREG-1927: Define method or technique, frequency, sample size, data collection, and timing to ensure timely detection of aging effects

- Surveillance demonstration program meeting ISG-24:
  - Calibrated thermocouple lances to measure the radial and axial temperature profile
  - Fission gas analysis technique for the cover gas with sensitivity to detect release of 1% of the fission gas produced in 1% of the cask rods with the lowest burnup in the demonstration
  - Residual moisture detection technique with sensitivity to detect the vapor pressure at the bottom of the demonstration system
  - Hydrogen detection technique with sensitivity to detect 2% hydrogen in the cover gas of the demonstration

AMP Element 5:
Monitoring & Trending

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NUREG-1927: Should provide for prediction of the extent of the effects of aging and timely corrective or mitigative actions

- As information/data from a fuel performance surveillance demonstration program becomes available, the licensee will monitor, evaluate, and trend the information via their Operating Experience Program and/or the Corrective Action Program to determine what actions should be taken to manage fuel and cladding performance, if any
- Similarly, the licensee will use its Operating Experience Program and/or Corrective Action Program to determine what actions should be taken if it receives information/ data from other sources than the demonstration program on fuel performance

AMP Element 6:
Acceptance Criteria

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NUREG-1927: Acceptance criteria, against which the need for corrective action will be evaluated; should ensure that SSC functions are maintained

- ISG-24 acceptance criteria provide detailed guidance
- Cask internals and fuel performance criteria:
  - Temperature: spatial distribution and time history accurately determined necessary since the behavior of the rods in the demonstration to the behavior expected of the rods in storage is temperature dependent.
  - Cladding Creep: total creep strain extrapolated to the total approved storage duration based on the best fit to the data, accounting for initial condition uncertainty shall be less than 1% - ISG-11 temperature limits are based on limiting creep to <1%

AMP Element 6:
Acceptance Criteria

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NUREG-1927: Acceptance criteria, against which the need for corrective action will be evaluated; should ensure that SSC functions are maintained

- Cask internals and fuel performance criteria:
  - Hydrogen – maximum hydrogen content of the cover gas over the approved storage period shall be extrapolated from the gas measurements to be less than 5% - limit for precluding possible flammable mixture
  - Drying – The moisture content in the cask , accounting for measurement uncertainty, shall indicate no greater than one liter of residual water after the drying process is complete –Drying limit, in terms of residual moisture, in the SRP NUREG-1536
  - Fuel rod breach – fission gas analysis shall not indicate more than 1% of the fuel rod cladding breaches. – Recommended maximum number of cladding breaches during normal conditions of storage for containment analysis by ISG-5

AMP Element 7:
Corrective Actions

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NUREG-1927: Corrective actions, including root cause determination and prevention of recurrence, should be timely

- Licensee Corrective Action Program commensurate with 10 CFR 72 Subpart G, or 10 CFR 50 Appendix B
- Licensee Corrective Action Program to capture and evaluate surveillance demonstration program data, other information/data, and additional operating experience to initiate corrective and/or preventative actions:
  - Corrective actions to prevent reoccurrence
  - Extent of condition to other susceptible components
  - Timely corrective actions

AMP Elements 8:
Confirmation Process

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NUREG-1927: Confirmation process should ensure that preventive actions are adequate & appropriate corrective actions have been completed & are effective

- Licensee Quality Assurance Program consistent with 10 CFR 72 Subpart G, or 10 CFR 50 Appendix B
- Follow up action to determine success
- Method to confirm any actions required are taken

AMP Elements 9:
Administrative Controls

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NUREG-1927: Administrative controls should provide a formal review and approval process

- Licensee Quality Assurance Program consistent with 10 CFR 72 Subpart G, or 10 CFR 50 Appendix B
- Training requirements for inspectors
- Records retention requirements
- As specified in the DOE Cask demonstration Project Plan or alternate surveillance demonstration program meeting the ISG-24 guidance
- Frequency for updating AMP based on industry-wide operational experience

AMP Element 10:
Operating Experience

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NUREG-1927: Include past corrective actions; provide objective evidence to support a determination that the effects of aging will be adequately managed so that the SSC intended functions will be maintained during the period of extended operation

- Surrogate surveillance demonstration programs with storage conditions and fuel types similar to those in the dry storage system that satisfies the ISG-24 acceptance criteria is a viable method to obtain operating experience
- Licensee intends to rely on the information from the Department of Energy (DOE) High Burnup Fuel Cask Research and Development program with similar types of HBU fuel as provided in the response to RAI 3-2
- DOE Dry Cask Storage Demonstration Project is viable as a surrogate surveillance program for the industry
- Additional data/research to assess fuel performance

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Concrete AMP Development

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U.S. Nuclear Regulatory Commission

PINGP ISFSI Public Meeting
June 16, 2014

Concrete AMP Criteria

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- **<u>Valid criteria include applicable consensus codes/standards and/or NUREG guidance</u>, e.g.:**
  - ACI 349.3R, “Evaluation of Existing Nuclear Safety-Related Concrete Structures”
  - ASME Code Section XI, Subsection IWL, “Requirements for Class CC Concrete Components of Light-Water-Cooled Plants”
  - NUREG-1801, “Generic Aging Lessons Learned (GALL) Report”
- **<u>Applicant may propose AMPs based on alternate criteria:</u>**
  - Exclusion of aging effects/mechanisms in the above codes/standards **should be justified** with a site-specific technical basis (e.g., engineering analysis, operational experience data).
  - Justification should demonstrate that the excluded aging mechanisms will not adversely affect the ability of the in-scope structure to perform its intended ITS function during the license period of extended operation.

Aging Effects/Mechanisms

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Mechanism	Effect
Freeze-thaw	Cracking, loss of material (spalling, scaling)
Chemical attack [Cl, SO_4]	Cracking, loss of material (spalling, scaling)
Aggregate reactions/expansion	Cracking and loss of strength
Corrosion of embedded steel	Cracking, loss of material (spalling, scaling) and loss of bond
Leaching of $Ca(OH)_2 \rightarrow CaCO_3$	Increase in porosity/permeability, loss of strength
Settlement	Cracking, distortion
Gamma irradiation	Cracking, reduction in strength (change in mechanical properties)
High temperature dehydration	Cracking, reduction in strength (change in mechanical properties)

Not necessarily all-inclusive

Gamma Radiation / Thermal Dehydration

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- Reductions in strength and elastic modulus **not managed** by this AMP – ***visual examination not sufficient***
- TLAA may be used to demonstrate that no part of the concrete exceeds critical cummulative fluences per ACI 349.3R:
  - **10^{17} neutrons/m^2; 10^{10} rad (gamma dose)**

"Change in Materials Properties"

- Definition per either ASTM C1562 or EPRI 1002950 **not implicit**, i.e.:
  - increases in permeability and porosity
  - reduction in pH value, tensile strength, compressive strength, modulus of elasticity, and bond strength
- Reference to this "aging effect" **must include proper definition** in the LRA

AMP Element 1:
Scope of the Program

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NUREG-1927: The scope of the program should include the specific structures and components subject to an AMR

1. **Visual inspection** of all above-grade (accessible, inaccessible) and below-grade (underground) concrete areas
   - ACI 349.3R: "All safety-related structures should be visually inspected at intervals not to exceed 10 years"
2. **Groundwater chemistry program** to manage below-grade (underground) effects
   - Corrosion of embedded steel
   - Chemical attack (chloride, sulfate induced degradation)
3. **Periodic radiation surveys**
   - Controlled Area: Compliance with 10 CFR 72.104.
   - Near cask (1m): Monitor effectiveness as neutron shield; SAR validation

AMP Element 2:
Preventive Actions

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NUREG-1927: Preventive actions should mitigate or prevent the applicable aging effects

- Program is for ***Condition Monitoring***
- Design in accordance to **ACI 318 or ACI 349**, as applicable.

  Otherwise,

  - For locations in moderate (100-500 day-inch/yr) and severe (>500 day-inch/yr) weathering conditions, concrete mix design must meet the air content & water-to-cement ratio requirements of ASTM C260 or ASME Sect. III, Div. 2.
  - Petrographic examination (ASTM C295 or equivalent) must demonstrate reactive aggregates do not lead to loss of function.
- Site-specific AMP required if:
  - Dewatering system used to prevent settlement
  - Embedded aluminum components without protective insulating coating

AMP Element 3:

Parameters Monitored/ Inspected

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NUREG-1927: Parameters monitored or inspected should be linked to the effects of aging on the intended functions of the particular structure and component

- **Quantify effects including cracking, material loss (spalling, scaling), loss of bond, increased porosity/permeability.**
- ACI 201.1R and SEI ASCE 11-99: exemplary visuals of effects.
- **Evaluation should identify**, e.g:
  - affected surface area
  - geometry/depth of defect
  - cracking, crazing, curling
  - delaminations, deflections
  - honeycombing, bug holes
  - popouts, voids
  - exposure of embedded steel
  - staining/ evidence of corrosion
  - dusting, efflorescence of any color
- **Contributing factors should be documented**, e.g.:
  - surface geometry supporting ponding
  - widening due to abrasion/ other weather effects

AMP Element 4:

Detection of Aging Effects

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NUREG-1927: Define method or technique, frequency, sample size, data collection, and timing to ensure timely detection of aging effects

- **Method/technique**
  - ***AMP must include justification that the technique can achieve the acceptance criteria***
  - ABOVE-GRADE (accessible): visual (e.g., feeler gauges, crack comparators)
  - ABOVE-GRADE (inaccessible)/ BELOW-GRADE (underground)
    - Visual: site-qualified system with valid sensitivity/resolution (e.g., video/ fiber optic camera)
    - Ground water monitoring program: qualified chemical analysis method (e.g. ICP-MS, IC)
    - Radiation surveys: calibrated detector for expected energy range
- **Frequency of Inspection (commensurate with ACI 349.3R)**
  - ABOVE-GRADE (accessible and inaccessible): ≤ 5 years
  - BELOW-GRADE (underground): ≤ 10 years
  - ***Use of opportunistic inspections in lieu of planned inspections must include valid technical basis (engineering justification, operational experience data).***

AMP Element 4:

Detection of Aging Effects (cont.)

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NUREG-1927: Define method or technique, frequency, sample size, data collection, and timing to ensure timely detection of aging effects

- **Frequency of Inspection (cont.)**
  - Water chemistry program/ radiation survey measurements: ≤ 5 years, or justified
  - Daily inspections of inlet/outlet vents to ensure ACI 349.3R temperature limits (or technical specifications) are not exceeded.
- **Sample size:**
  - All surface areas as stated in scope, or justified size
  - Locations justified by application
- **Data collection**
  - Commensurate with ACI 562, ACI 224.1R guidelines for quantitative crack analysis (width, depth, extent)
- **Timing**
  - Lead canister inspection / frequency specified by AMP
  - Inspection frequencies may be accelerated per site CAP
- **Inspector Qualifications**
  - Commensurate with ACI 349.3R

AMP Element 5:
Monitoring & Trending

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NUREG-1927: Should provide for prediction of the extent of the effects of aging and timely corrective or mitigative actions

- **Commensurate with:**
  - Defect evaluation standards/references (e.g. ACI 201.1R, ACI 562, ACI 224.1R for crack evaluation)
  - Acceptance criteria and inspector qualifications (e.g., ACI 349.3R, ASME Code Section XI)

- **AMP should describe CAP components/procedures used to:**
  - Update a given SSC baseline based on previous inspections
  - Track trending of parameter, or effect not corrected in a previous inspection, i.e.:
    - Crack growth rates
    - Corrosion rates
    - Pore density/ affected areas
    - Radiation data

AMP Element 6:
Acceptance Criteria

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NUREG-1927: Acceptance criteria, against which the need for corrective action will be evaluated; should ensure that SSC functions are maintained

- ***Visual:*** **Commensurate with ACI 349.3R (3-Tier Quantitative Criteria):**
  - Acceptance without further evaluation
  - Acceptance after review
  - Acceptance requiring further evaluation
- ***Groundwater Chemistry Program:*** **ASME Code Section XI, NUREG-1801**
  - Aggressive below-grade environment: pH < 5.5, chlorides > 500 ppm, or sulfates > 1500 ppm
- ***Radiation Surveys***
  - Controlled area: 10 CFR 72.104
  - Near cask (1 m): Per bounding value/ justified variance (fluence, energy range)
- ***Alternative acceptance criteria may be provided*****, but must:**
  - Include a quantitative basis (justifiable by OE, engineering analysis/standards)
  - Avoid use of non quantifiable phrases (e.g. significant, moderate, minor, little, slight, few, etc.)
  - Be achievable – Method/technique must be able to meet the stated values (i.e. sufficient resolution/sensitivity)

AMP Element 7:
Corrective Actions

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NUREG-1927: Corrective actions, including root cause determination and prevention of recurrence, should be timely

- **CAP commensurate with 10 CFR 72 Subpart G, or 10 CFR 50 Appendix B.**
  - Justification for non-repairs (e.g., engineering analysis)
  - Cracking: ACI 224.1R, ACI 562 and ACI RAP Bulletins
  - Spalling/scaling: ACI 562, ACI 506R, and ACI RAP Bulletins
- **AMP should provide criteria applied to determine which inspection results will require either:**
  - An Action Request (e.g, Tier 2 Acceptance per ACI 349.3R)
  - Modification to the existing AMP
  - Notification to the NRC (e.g., Tier 3 Acceptance per ACI 349.3R)
- **AMP should provide details on how CAP will capture and evaluate operating experience from other ISFSIs with similar in-scope SSCs.**
  - Clarify how external OE will initiate any of the above action items

AMP Elements 8/9:
Confirmation Process/Admin Controls

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NUREG-1927:

- The confirmation process should ensure that preventive actions are adequate and appropriate corrective actions have been completed and are effective
- Administrative controls should provide a formal review and approval process

- **Licensee's Quality Assurance Program consistent with 10 CFR 72 Subpart G, or 10 CFR 50 Appendix B.**

AMP Element 10:
Operating Experience

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NUREG-1927: Include past corrective actions; provide objective evidence to support a determination that the effects of aging will be adequately managed so that the SSC intended functions will be maintained during the period of extended operation

Source Review:

- **Internal/External Condition Reports**
  - Identify age-related degradation
    - Include justification for CRs not identified as age-related degradation
  - Consider CARs for proposed:
    - Acceptance criteria
    - Frequency of inspection
- **Information Notices**
- **Acceptable Industry Initiatives** (e.g. DOE cask demo, EPRI-sponsored inspections)
- **OE presented in LRA should support the proposed AMP**

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Additional Slides

Radiation Acceptance Criteria

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NUREG-1536 (SRP Spent Fuel Dry Storage Systems/ General License)

Section 6.5.4.3 – Dose Rates

Guidance for the selection of points at which the dose rates should be calculated.

- For normal and off-normal conditions, applicant should indicate the dose rate at all locations accessible to occupational personnel during cask loading, transport to the ISFSI, and maintenance and surveillance operations.
  - Locations include points at or near various cask components and in the immediate vicinity of the cask and the bottom of the transfer cask.
    - e.g.: vent areas, trunnion areas, peak side of the cask, peak top of the cask, the canister-gap region
  - Calculate dose rates at 1m from these locations

NUREG 1567 (SRP Spent Fuel Dry Storage Facilities)

Section 11.4.3 – Dose Assessment

- Estimated dose rates should be provided for representative points within the restricted areas as well as on and beyond the perimeter of the controlled area.

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Aging Management Program for Polymer-based Neutron Shield

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PINGP ISFSI Public Meeting
June 16, 2014

Bases

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- **10 CFR 72.42(a), 240(c)(2), and 240(c)(3) require for license renewal to include:**
  1) TLAAs that demonstrate that important to safety (ITS) SSCs will continue to perform their intended functions for the requested period of extended operation; and
  2) A description of the AMP for management of issues associated with aging that could adversely affect ITS SSCs.
- Neutron shield is identified as an ITS component that requires an aging management program
  - **NUREG-1927:** Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance

Polymer-based Neutron Shield Intended Function

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- Neutron shield achieves its safety function by:
  - slowing down neutrons to reduce their energies and hence radiation
  - absorbing neutrons (primarily low energy) by boron-10 in the polymer to reduce the intensity of neutron radiation

Polymer-based Neutron Shield degradation

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- Polymer will degrade due to exposure to heat (thermolysis) or high level radiation(radiolysis)
- Aging effects
  - Cracking
  - Loss of material, shrinkage and loss of polymer chemical bond due to thermolysis and radiolysis
  - Loss of B-10 content due to neutron depletion

Polymer-based Neutron Shield degradation (Cont.d)

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- Loss of shielding function because of:
  - Formation of neutron streaming paths due to cracking
  - Loss of neutron moderation and absorption capacity due to:
    - Reduction in polymer material thickness and effective density
    - Loss of B-10

Polymer-based Neutron Shield AMP Elements

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1. ***Scope of Program:***

This program monitors the performance of the polymer-based neutron shield for spent fuel cask during the extended period of operation of an ISFSI

2. ***Preventive Actions:***

This AMP is a condition monitoring program. No preventative actions are needed.

Polymer-based Neutron Shield AMP Elements (Cont.d)

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3. *Parameters Monitored/Inspected:*

- One intuitive way to monitor the performance of the neutron shield is to monitor neutron radiation outside the cask
- The parameter to be monitored is the difference between measured and calculated neutron radiations

Polymer-based Neutron Shield AMP Elements (Cont.d)

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4. *Detection of Aging Effects:*

- Persistent unexpected difference between measured and calculated neutron radiation levels
- Shift in spectrum of the neutrons measured outside the cask
- Change in the radiation profile in either axial and/or azimuthal directions

Polymer-based Neutron Shield AMP Elements (Cont.d)

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5. *Monitoring and Trending:*

- Monitor the radiation measurement results, including radiation intensity and neutron spectrum
- Trend the difference between measured and calculated neutron radiations
- For trending analyses:
  - Neutron source as a function of time should be determined via calculation
  - Expected polymer shrinkage should be determined via TLAA
  - The measured radiation should factor out the background radiation

Polymer-based Neutron Shield AMP Elements (Cont.d)

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6. *Acceptance Criteria:*

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

Polymer-based Neutron Shield AMP Elements (Cont.d)

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6. *Acceptance Criteria (cont.d):*

- A baseline should be established for the difference between measured and calculated neutron radiations
- Expected polymer shrinkage should be determined via TLAA
- The measured radiation should factor out the background radiation
- Measurement personnel should be qualified for the measurement task including operation of the detectors

Polymer-based Neutron Shield AMP Elements (Cont.d)

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7. *Corrective Actions:*

- Corrective actions must be taken if loss of intended function or potential loss of intended function is determined
- Corrective action(s) must be effective and long lasting, temporary neutron shield is not acceptable as a solution
- A TLAA demonstrating that there is no longer a need for the neutron shielding function due to neutron source decay is an acceptable option

Polymer-based Neutron Shield AMP Elements (Cont.d)

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8. *Confirmation Process:*

- Site quality assurance (QA) procedures, review and approval processes, and administrative controls should be implemented in accordance with the requirements of 10 CFR Part 72, Subpart G

9. *Administrative Controls:*

- Programs implemented to meet the requirements of 10 CFR Part 72, Subpart G, are acceptable for addressing this element

Polymer-based Neutron Shield AMP Elements (Cont.d)

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10. *Operating Experience (OE):*

- OE is a critical component of an AMP
- The effectiveness of an AMP is verified by OE
- AMP should be updated and improved based on site-specific and industry OE events
- A periodic review and revision of the AMP should be made based on tollgate schedule
- AMP should include specific requirement for implementing the above-mentioned items

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