SAFETY EVALUATION REPORT

FOR

LICENSE RENEWAL

CALVERT CLIFFS NUCLEAR POWER PLANT INDEPENDENT SPENT FUEL STORAGE INSTALLATION

DOCKET NO. 72-08

LICENSE NO. SNM-2505

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

Section Page

INTRODUCTION ... v

1 GENERAL INFORMATION ... 1-1
1.1 Specific Licensee Information ... 1-1
1.2 Specific Financial Information ... 1-1
1.3 Specific Environmental Review ... 1-2
1.4 Application Content ... 1-2
1.5 Interim Staff Guidance ... 1-2
1.6 Evaluation Findings ... 1-3

2 SCOPING EVALUATION ... 2-1
2.1 Scoping and Screening Methodology ... 2-1
2.1.1 Scoping Process ... 2-3
2.1.2 Structures, Systems, and Components within Scope of License Renewal ... 2-5
2.1.3 Structures, Systems, and Components NOT Within Scope of License Renewal ... 2-10
2.2 Evaluation Findings ... 2-11

3 AGING MANAGEMENT REVIEW ... 3-1
3.1 Review Objective ... 3-1
3.2 AMR Process ... 3-1
3.3 Aging Management Review Results: Materials, Service Environment, Aging Effects, and Aging Management Programs ... 3-1
3.3.1 Irradiated Fuel Assemblies (IFAs) ... 3-2
3.3.1.1 Materials and Environments ... 3-17
3.3.1.2 Aging Effects/Mechanisms on the Irradiated Fuel Assemblies During the Period of Extended Storage ... 3-18
3.3.1.3 Evaluation of Proposed Aging Management Activities ... 3-19
3.3.2 Dry Shielded Canister ... 3-20
3.3.2.1 Materials and Environments ... 3-20
3.3.2.2 Aging Effects/Mechanisms on the DSC subcomponents ... 3-22
3.3.2.3 Evaluation of Proposed Aging Management Activities ... 3-22
3.3.3 Horizontal Storage Module (HSM) ... 3-23
3.3.3.1 Materials and Environments ... 3-24
3.3.3.2 Aging Effects/Mechanisms on the HSM ... 3-26
3.3.3.3 Evaluation of Proposed Aging Management Activities ... 3-28
3.3.4 Transfer Cask ... 3-28
3.3.4.1 Materials and Environments ... 3-29
3.3.4.2 Aging Effects/Mechanisms on the Transfer Cask ... 3-30
3.3.4.3 Evaluation of Proposed Aging Management Activities ... 3-30
3.3.5 Transfer Cask Lifting Yoke ... 3-30
3.3.5.1 Materials and Environments ... 3-31
3.3.5.2 Aging Effects/Mechanisms on the Transfer Cask Lifting Yoke ... 3-31
3.3.5.3 Evaluation of Proposed Aging Management Activities ... 3-32
3.3.6 Cask Support Platform ... 3-32

3.3.6.1 Materials and Environments 3-33
3.3.6.2 Aging Effects/Mechanisms on the Cask Support Platform 3-33
3.3.6.3 Evaluation of Proposed Aging Management Activities 3-33
3.3.7 Spent Fuel Cask Handling Crane 3-34
3.3.8 Spent Fuel Handling Machine..3-34
3.3.9 Evaluation Findings 3-36
3.4 Time-Limited Aging Analyses Evaluation 3-36
3.4.1 Radiation, Decay Heat, and Thermal Cycling on HSM Concrete 3-37
3.4.2 Poison Plates (NUHOMS®-32P DSC)...3-38
3.4.3 DSC Fatigue Evaluation 3-38
3.4.4 Fuel Cladding Maximum Temperature 3-39
3.4.5 DSC Support Rail Steel 3-39
3.4.6 Transfer Cask Fatigue Evaluation 3-40
3.4.7 Transfer Cask Trunnions, Lifting Yoke Fatigue Evaluation..........................3-40
3.4.8 Bisco NS-3 in Transfer Cask 3-41
3.4.9 DSC Support Structure Thermal Analysis 3-42
3.4.10 Evaluation Findings 3-42
3.5 Aging Management Program...3-43
3.5.1 Dry Shielded Canister (DSC) External Surfaceds Aging Magagment Program 3-44
3.5.2 Horizontal Storage Module (HSM) Aging Management Program 3-52
3.5.3 Transfer Cask Aging Management Program 3-62
3.5.4 Transfer Cask Lifting Yoke Aging Management Program 3-66
3.5.5 Cask Support Platform Aging Management Program.................................3-70
3.5.6 High Burnup Fuel Aging Management Program...3-73
3.5.7 Evaluation Findings 3-79

4 CONCLUSION 4-1

APPENDIX A: AGING MANAGEMENT PROGRAMS…………………………………………A-1
APPENDIX B: REFERENCES……………………………………………………………......B-1

TABLES

Table Page

1.6-1 Existing Interim Staff Guidance Relevant to ISFSI License Renewal 1-4

2.1-1 Major Components and Classification.. 2-5
2.1-2 SSCs Within and Not Within Scope of License Renewal 2-6
2.1-3 SSC Subcomponents Within Scope of License Renewal (Irradiated Fuel Assembly, Dry Shielded Canister, Horizontal Storage Module) 2-8
2.1-4 SSC Subcomponents Within Scope of License Renewal (Transfer Cask, Transfer Cask Lifting Yoke, Cask Support Platform) 2-9
2.1-5 SSC Subcomponents Not Within Scope of License Renewal (Irradiated Fuel Assembly, Dry Shielded Canister, Horizontal Storage Module) 2-10
2.1-6 SSC Subcomponents Not Within Scope of License Renewal (Transfer Cask, Transfer Cask Lifting Yoke, Cask Support Platform) 2-11
3.3-1 Aging Management Review Results—Irradiated Fuel Assemblies (IFA) 3-3
3.3-2 Aging Management Review Results—Dry Shielded Canister (DSC).............................. 3-4
3.3-3 Aging Management Review Results—Horizontal Storage Moduel (HSM)..................... 3-6
3.3-4 Aging Management Review Results—Transfer Cask (TC) 3-10
3.3-5 Aging Management Review Results—Transfer Cask Lifting Yoke (TCLY).................. 3-13
3.3-6 Aging Management Review Results—Cask Support Platform (CSP).......................... 3-15

INTRODUCTION

By letter dated September 17, 2010 (ML102650247), as supplemented February 10, 2011 (ML110620134), March 9, 2011 (ML110730720), June 28, 2011 (ML11180A270), December 15, 2011 (ML113640129), July 27, 2012 (ML12212A216), April 24 (ML131190290), and June 14, 2013 (ML13170060), Plant (CCNPP) Independent Spent Fuel Storage Installation (ISFSI), Nuclear Material License No. SNM-2505, for a period of 40 years beyond the initial license period. The licensee submitted the license renewal application (LRA) in accordance with the regulatory requirements of 10 CFR 72.42. Pursuant to 10 CFR 72.42(b), this application constitutes a timely renewal. In the LRA, the licensee documented the technical bases for renewal of the license and commitments to actions for managing the potential aging effects of the systems, structures, and components (SSCs) of the ISFSI to ensure that these SSCs will maintain their intended functions during the period of extended operation.

The ISFSI is located on the CCNPP site near Lusby, MD, where Exelon Generation owns and operates two 2737 MWT nuclear generating units on the Calvert Cliffs site. The ISFSI is located outside the protected area, but within the owner controlled area approximately 701 m [2,300 ft] southwest of the nuclear power plant.

The NRC initially issued SNM-2505 on November 30, 1992, for use of the NUHOMS®-24P dry storage system. The principal components of the NUHOMS® system are a horizontal storage module (HSM) comprised of concrete and structural steel and a steel dry shielded canister (DSC) with an internal basket which holds the spent fuel. Each HSM contains one DSC and each DSC contains 24 fuel assemblies. The NRC subsequently approved use of the NUHOMS®-32P DSC through amendments 6 and 7 to the specific license. The NUHOMS®-32P DSC system stores eight more irradiated fuel assemblies than the NUHOMS®-24P DSC using the same external and internal shell dimensions.

In addition to these primary components, the ISFSI license includes transfer equipment to move the DSCs from the spent fuel pool to the HSMs. The transfer equipment consists of a transfer cask, a hydraulic ram, a truck, a trailer, and a cask skid. The transfer equipment interfaces with the existing spent fuel pool, the cask handling crane, and the site layout (i.e., roads and topography). The ISFSI currently consists of 96HSMs with 48 of the HSMs loaded with the NUHOMS®-24P DSCs and 48 of the HSMs loaded with the NUHOMS®-32P DSCs.

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

The NRC staff (staff) reviewed the technical bases for safe operation of the ISFSI for an additional 40 years beyond the term of the current operating license. This safety evaluation report (SER) summarizes the results of the staff's review for compliance with 10 CFR Part 72. In its review of the LRA and development of the SER, the staff followed the guidance provided in NUREG–1927, "Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance," dated March 2011 (NRC, 2011).

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

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

1 GENERAL INFORMATION

1.1 Specific Licensee Information

Pursuant to 10 CFR Part 72, the NRC issued SNM-2505 for CCNPP ISFSI for 20 years, on November 30, 1992. The current NRC license for the CCNPP ISFSI, that is in timely renewal, authorizes the construction and operation of 120 HSMs, of which currently 48 are NUHOMS®-24P and 48 are NUHOMS®-32P.

Exelon Generation stated in its application (ML102650247) that it is the sole owner and licensed operator of the Calvert Cliffs ISFSI. Exelon Generation is engaged in the business of generating electric power. The NRC license transfer order approving the ownership change from Calvert Cliffs Nuclear Power Plant, Inc. LLC, to Exelon Generation was issued on March 24, 2014 (ML14015A472).

1.2 Specific Financial Information

In its proposed merger application with Exelon Corporation, the licensee, submitted a decommissioning funding status (DFS) report, dated March 29, 2011 (ML110940057), and supplemented by letter dated June 24, 2011 (ML11187A302). The staff documented its review of the operating plants' DFS reports in SECY-11-0149, "Summary Findings Resulting from the Staff Review of the 2010 Decommissioning Funding Status Reports for Operating Power Reactor Licensees," dated October 26, 2011 (ML112620046).

The staff verified the calculations provided by the licensee in the afore-mentioned DFS report for Calvert Cliffs as of December 31, 2010. Based on its review of the 2011 DFS report, the NRC staff determined that Calvert Cliffs was providing adequate decommissioning funding assurance in accordance with the NRC's regulations.

In addition, in accordance with 10 CFR 72.30(b), the licensee provided an ISFSI decommissioning funding plan in connection with the licensing of the Calvert Cliffs ISFSI, which has subsequently been updated and submitted to the NRC. The licensee also stated that it is providing decommissioning funding assurance for the Calvert Cliffs ISFSI in accordance with 10 CFR 72.30(c)(5) [subsequently redesignated as 10 CFR 72.30(e)(5)], and that the Calvert Cliffs ISFSI decommissioning trust fund is separately identified and not included as part of the Calvert Cliffs radiological trust fund reported in CENG's DFS report. This is documented in the staff's SER on financial assurance. (ML113560438).

Additionally, in an electronic mail message of February 2, 2012, (ML12033A152) the licensee stated that it had been supplying Form 10-Q reports to the Securities and Exchange Commission to meet 10 CFR 72.80 financial reporting requirements. After the revised Decommission Planning Rule (76 FR 35512) became effective on December 17, 2012, the licensee provided the decommissioning funding plans as required by 10 CFR 72.30(c).

Based on its analysis, the staff concludes that the licensee has complied with the requirements of 10 CFR 72.30(c) with respect to providing decommissioning funding assurance for the Calvert Cliffs ISFSI for the license renewal period.

1.3 Specific Environmental Review

10 CFR 72.34 “Environment Report” requires that each application for an ISFSI or Monitored Retreivable Storage (MRS) license under this part must be accompanied by an Environmental Report which meets the requirements of Subpart A of Part 51 of this chapter. The staff Notice of Availability of Environmental Assessment and Finding of No Significant Impact for this action was published in the *Federal Register* on June 8, 2012 (77 FR 34093), and re-issued on October 23, 2014,), to include the NRC staff’s consideration of the impacts of continued storage of spent nuclear fuel (as documented in NUREG-2157, “Generic Environmental Impact Statement for Continued Storage of Spent Fuel”) as an appendix to the EA.

Specific Safety Review

The objective of this safety review is to determine that there is reasonable assurance that the ISFSI continues to meet the requirements of 10 CFR Part 72 during the period of extended operation. The NRC staff safety review is a detailed and in-depth assessment of the technical aspects of the CCNPP ISFSI license renewal application. Pursuant to 10 CFR 72.42(a), an application for ISFSI license renewal must include the following: (i) time-limited aging analyses (TLAAs) that demonstrate SSCs important to safety (ITS) will continue to perform their intended function for the requested period of extended operation and (ii) a description of the aging management programs (AMPs) for management of issues associated with aging that could adversely affect SSC ITS. The licensee stated (ML102650247) that it used guidance provided in the Surry Power Station ISFSI renewal since the LRA was submitted prior to issuance of NUREG–1927, “Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance” (NRC, 2011). The licensee provided both TLAAs and AMPs to assure that the identified in-scope SSCs will continue to perform their intended function during the period of extended operation. This review documents the staff’s evaluation of the licensee’s scoping and screening evaluation, aging management review, and supporting AMPs and TLAAs.

1.4 Application Content

The LRA provided the following information:

- General Information
- Scoping Evaluation
- Aging Management Reviews
- Time-Limited Aging Analyses
- Aging Management Programs
- ISFSI Updated Safety Analysis Report Supplement and Changes

In particular, the safety analysis report (SAR) Supplement and Changes provided in the application documents the changes and additions for which the licensee has committed.

1.5 Interim Staff Guidance

The staff develops Interim Staff Guidance (ISG) to clarify or to address issues not addressed in NUREG–1927. These ISGs are to be used by the staff, industry, and other interested stakeholders until incorporated into staff guidance documents such as regulatory guides and standard review plans. Table 1.6-1 lists the ISGs relevant to ISFSI license renewal.

1.6 Evaluation Findings

The staff reviewed the general information provided in Chapter 1 of the LRA (ML102650247; ML110620134; ML110730720; ML11180A270; ML113640129; ML12212A216; ML131190290; ML14267A065). The staff performed its review following the guidance provided in NUREG–1927, "Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance" (NRC, 2011) and ISGs as identified in Table 1.6-1.

Based on its review of this information, representations, and supplements, the staff finds:

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

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

Table 1.6-1. Existing Interim Staff Guidance Relevant to ISFSI License Renewal

Interim Staff Guidance Number	Interim Staff Guidance Title
SFST-ISG-1, Rev. 2	Damaged Fuel
SFST-ISG-2, Rev. 1	Fuel Retrievability
SFST-ISG-4, Rev. 1	Cask Closure Weld Inspections
SFST-ISG-5, Rev. 1	Confinement Evaluation
SFST-ISG-9, Rev. 1	Storage of Components Associated with Fuel Assemblies
SFST-ISG-10, Rev. 1	Alternatives to the ASME Code
SFST-ISG-11, Rev. 3	Cladding Considerations for the Transportation and Storage of Spent Fuel
SFST-ISG-15	Materials Evaluation
SFST-ISG-20	Transportation Package Design Changes Authorized Under 10 CFR Part 71 Without Prior NRC Approval
SFST-ISG-21	Use of Computational Modeling Software
SFST-ISG-22	Potential Rod Splitting Due to Exposure to an Oxidizing Atmosphere During Short-Term Cask Loading Operations in LWR or Other Uranium Oxide Based Fuel
SFST-ISG-24	Use of a Demonstration Program as a Surveillance Tool for Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years
SFST-ISG-25	Pressure Test and Helium Leakage Test of the Confinement Boundary for Spent Fuel Storage Canister

2 SCOPING EVALUATION

10 CFR 72.24 defines the required content of an application for an ISFSI specific license. Furthermore, 10 CFR 72.42 requires each LRA to include TLAAs that demonstrate that ITS SSCs will continue to perform their intended function for the requested period of extended operation; and a description of AMPs for management of issues associated with aging that could adversely affect SSCs ITS. In addition, 10 CFR 72.122(l) requires that storage systems be designed to allow ready retrieval of spent fuel, high-level radioactive waste and reactor-related greater than class C waste (GTCC) for further processing or disposal.

A scoping evaluation is necessary to identify the SSCs subject to an AMR. More specifically, the scoping evaluation is used to identify SSCs meeting any of the the following criteria:

1. ITS;

2. Not safety significant but their failure could prevent an ITS SSC from performing its intended functions; or

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

The licensee performed a scoping evaluation that provided the following information:

- A description of the scoping and screening methodology for the inclusion of SSCs and SSC subcomponents in the renewal scope;

- A list of the SSCs and SSC subcomponents identified to be within the scope of renewal and subject to an AMR, including their intended function, and safety classification or basis for inclusion in the renewal scope;

- A list of sources of information used; and

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

The following section discusses the staff's review and review findings on the licensee's scoping study.

2.1 Scoping and Screening Methodology

LRA Section 2.0, Scoping Evaluation, describes the methodology for identifying SSCs within the scope of license renewal and subject to an AMR. The licensee followed guidance consistent with the pilot site-specific renewal process developed for the Surry Power Station ISFSI, since the LRA was submitted prior to issuance of NUREG–1927, "Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance." The staff has determined that the scoping process and screening methodology presented in the LRA is commensurate with that provided in NUREG–1927. The licensee's scoping and screening methodology reviewed the design bases information as identified in the following documents:

- CC ISFSI USAR, Revision 17

- CCNPP UFSAR, Revision 40
- CC ISFSI SER
    - Amendment No. 0, November 1992
    - Amendment No. 1, July 1995
    - Amendment No. 2, June 30, 2000
    - Amendment No. 3, April 17, 2001
    - Amendment No. 4, August 29, 2001
    - Amendment No. 5, October 25, 2001
    - Amendment No. 6, June 10, 2005
    - Amendment No. 7, November 2, 2005
    - Errata for the U.S. NRC SER Related to Amendment No. 7 to Materials License No. SNM-2505 for the Calvert Cliffs ISFSI, November 23, 2005
- Calvert Cliffs ISFSI Materials License No. SNM-2505, Docket No. 72-8
- ISFSI Technical Specifications (TS) (Appendix A to ISFSI Materials License No. SNM-2505)
- NUH-002, Topical Report for the NUTECH Horizontal Modular Storage System for Irradiated Nuclear Fuel

Revision 21 of the ISFSI USAR (ML122750271) was used to review the LRA. A license amendment has been approved since the time the LRA was submitted, however it did not alter the design bases evaluated in the LRA. The staff reviewed the ISFSI USAR which provides a description of the ISFSI, and identifies ISFSI SSCs and their functions, including safety classifications as established by the safety analyses. The ISFSI USAR uses two types of definitions for SSC classification, pursuant to either 10 CFR 72.3 or 10 CFR 50.2. All ISFSI SSCs, except those used exclusively at the CCNPP, are classified as (i) Important to Safety or (ii) Not Important to Safety. ISFSI SSCs used exclusively inside the CCNPP are classified as either (i) Safety Related or (ii) Augmented Quality. The ISFSI USAR states that safety-related SSCs are controlled by the 10 CFR Part 50, Appendix B Quality Assurance (QA) program during the operational phase and the decommissioning phase. The ISFSI USAR further defines Augmented Quality components as subject to certain QA standards to meet regulatory or CCNPP requirements.

SSCs Important to Safety (ITS) are defined in 10 CFR 72.4 as those features of the ISFSI and spent fuel storage cask whose functions are (1) to maintain the conditions required to store spent fuel safely, (2) to prevent damage to the spent fuel container during handling and storage, or (3) to provide reasonable assurance that spent fuel can be received, handled, packaged, stored, and retrieved without undue risk to the health and safety of the public.

Safety-Related (SR) SSCs are defined in 10 CFR 50.3 as those which are relied upon to assure (1) the integrity of the reactor coolant pressure boundary, (2) the capability to shut down the reactor and maintain it in a safe shutdown condition, and (3) the capability to prevent or mitigate the consequences of accidents that could result in potential off-site exposures comparable to the 10 CFR 50.34(a)(1) or 10 CFR 100.11 guidelines.

The licensee used a scoping criteria consistent with the pilot site-specific renewal process developed for the Surry Power Station ISFSI, since the LRA was submitted prior to issuance of NUREG–1927, "Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance". The staff has determined that this scoping criteria is commensurate with that provided in NUREG–1927.

The licensee evaluated the ISFSI SSCs against the following scoping criteria:

- Criterion 1: the SSC is classified as important to safety (or safety-related) as it is relied on to do one of the following:
    - Maintain the conditions to store spent fuel safely;
    - Prevent damage to the spent fuel during handling and storage; or
    - Provide reasonable assurance that spent fuel can be received, handled, packaged, stored, and retrieved without undue risk to the health and safety of the public, as identified in the design bases.
- Criterion 2: the SSC is classified as not ITS (or non-safety related) but, according to the licensing basis, its failure could prevent fulfillment of a function that is ITS, or its failure as a support SSC could prevent fulfillment of a function that is ITS.

The licensee further clarified that the comments to the prelimary guidance used for the scoping criteria state that:

- The function performed by an SSC that causes it to be within the scope of license renewal is its intended function;
- SSCs which perform ISFSI support functions are generally not within the scope of license renewal;
- The fuel in storage is considered to be within scope of license renewal. The effects of aging of fuel shall be evaluated.

Staff reviewed the general information on the scoping and screening methodology. Staff finds the licensee's scoping and screening methodology acceptable.

2.1.1 Scoping Process

The licensee reviewed the ISFSI design bases documents listed in Section 2.1 of this SER to identify SSCs with safety functions meeting either scoping criterions 1 or 2, as defined in Section 2.1. The staff further reviewed the classification of the ISFSI SSCs, which is provided in Table 3.4-1 of the ISFSI USAR (ML12275A427) and presented in Table 2.1-1.

Table 2.1-1. Major Components and Classification

Component	10 CFR Part 72 Classification	10 CFR Part 50 Classification	CCNPP QA Program
Transfer Cask	Important to Safety	Safety-Related	SR
Dry Shielded Canister (NUHOMS®-24P)	Important to Safety	Safety-Related	SR
Basket			
Spacer Disks			
Support Rods			
End Shield Plug/Support (top and bottom)			
DSC Body			
End Closure Plates			
Helium			
Dry Shielded Canister (NUHOMS®-32P)	Important to Safety	Safety-Related	SR
Basket			
Egg-Crate			
End Shield Plug/Support (top and bottom)			
DSC Body			
End Closure Plates			
Helium			
Lifting Yoke		Safety-Related	SR
Horizontal Storage Module	Important to Safety		Augmented Quality
Concrete Shielding			
DSC Support Assembly			
Foundation			
Transfer Components	Not Important to Safety	Non-Safety-Related	NSR
Transfer Trailer/Skid			
Ram Assembly			
Vacuum Drying System	Not Important to Safety	Non-Safety-Related	NSR
Automatic Welding System	Not Important to Safety	Non-Safety-Related	NSR

CCNPP. “Calvert Cliffs Independent Spent Fuel Storage Installation Updated Safety Analysis Report.” Table 3.4-1. Rev. 20. Materials License No. SNM-2505. ML12275A427. Lusby, Maryland: Calvert Cliffs Nuclear Power Plant, LLC. September 2011.

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

Based on the scoping process discussed in Section 2.1.1 of the LRA the licensee identified eight SSCs of the ISFSI to be within the scope of license renewal. The LRA also identified those SSCs not within scope, and hence not subject to an AMR. The SSCs within and not within scope of license renewal are presented in Table 2.1-2.

Table 2.1-2. SSCs Within and Not Within Scope of License Renewal*

Structures, Systems and Components	Criterion 1	Criterion 2	In-Scope
Irradiated Fuel Assemblies	Yes	N/A	Yes
DSC	Yes(1)	N/A	Yes
HSM	Yes(1)	N/A	Yes
Transfer Cask	Yes(1)	N/A	Yes
Transfer Cask Lifting Yoke	Yes(1) (SR)	N/A	Yes
Cask Support Platform(2)	Yes(1) (SR)	N/A	Yes
Spent Fuel Cask Handling Crane	Yes(1) (SR)	N/A	Yes
Spent Fuel Handling Machine	No	Yes	Yes
Transfer Components(3)	No	No	No
Instrumentation	No	No	No
Support Equipment(4)	No	No	No
Welding Equipment(5)	No	No	No
Security Equipment(6)	No	No	No
Heavy Haul Path	No	No	No
Approach Slabs	No	No	No

*CCNPP. "Calvert Cliffs Site-Specific Independent Spent Fuel Storage Installation (ISFSI) License Renewal Application." Materials License No. SNM-2505. Table 2.3-1. ML102650247. Lusby, Maryland: Calvert Cliffs Nuclear Power Plant, LLC. September 2010.

[1]Table 3.3-1 of the NUH-002 Topical Report (ML110730769) states that the HSM, DSC, and on-site transfer cask are ITS. The licensee stated that other equipment ITS associated with the NUHOMS® system is the equipment required for handling operations within the plant's fuel building.

[2]The licensee stated that the cask support platform is not described in the ISFSI USAR.

[3]The licensee stated the transfer components include a hydraulic ram, a truck, a trailer, skid position system, power supplies, a cask support skid and a mobile yard crane for raising and lowering the HSM front access door.

[4]The licensee stated that the support equipment includes (but is not limited to) the annulus seal, vacuum drying system, slings, DSC lift rig, ISFSI electrical power supply, miscellaneous equipment (e.g., tools, hoses).

[5]The licensee stated that welding equipment includes RX-277 neutron shielding used by welder. The licensee further stated that this is credited in the shielding results listed in the ISFSI USAR Table 7.3-1 (ML12275A431) and ISFSI USAR Table 12.7-1 (ML12275A431).

[6]The licensee stated that the security equipment includes (but is not limited to) lighting, communication and alarm systems.

N/A Not Applicable
SR Safety Related

The SSCs identified in Table 2.1-2 to be within scope of license renewal include:

- Irradiated Fuel Assemblies (IFAs)

- Dry Shielded Canister (DSCs)
- Horizontal Storage Modules (HSMs)
- Transfer Cask (TC)
- Transfer Cask Lifting Yoke (TCLY)
- Cask Support Platform (CSP)
- Spent Fuel Cask Handling Crane
- Spent Fuel Handling Machine (SFHM)

The licensee stated these SSCs were found to meet scoping criterions 1 or 2 defined in Section 2.1 of this SER, and hence were subject to an AMR. The staff reviewed the CCNPP ISFSI USAR which describes the irradiated fuel assemblies, dry shielded canisters, transfer cask and transfer cask lifting yoke as major components of the ISFSI. The staff further reviewed the CCNPP USAR which describes the cask support platform (Section 9.7.2.3), spent fuel cask handling crane (Section 9.7.2.4), and spent fuel handling machine (Section 9.7.2.7). The CCNPP USAR identifies the cask support platform as part of the spent fuel shipping cask pit.

The licensee further screened the in-scope SSCs to identify and describe the subcomponents that support the SSC intended function. The licensee identified those SSC subcomponents and associated intended functions based on the design bases documents listed in Section 2.1 of this SER. The subcomponents within scope of license renewal are listed in Tables 2.1-3 and Table 2.1-4. The LRA did not separate the subcomponents according to the scoping criterions defined in Section 2.1 of this SER.

The staff's review of the subcomponents is predicated on the understanding that subcomponents may degrade under different modes or variable rates. This consideration is important since the performance of the subcomponents could impact the performance of in-scope SSC during the period of extended operation.

Table 2.1-3. SSC Subcomponents Within Scope of License Renewal (Irradiated Fuel Assembly, Dry Shielded Canisters, Horizontal Storage Module)*

Irradiated Fuel Assembly	Dry Shielded Canister	Horizontal Storage Module
Fuel Rod (Cladding and End Caps)	Basket	Reinforced Concrete Walls, Roof and Foundation
Guide Tubes	Guide Sleeves (Basket)	DSC Structural Steel Assembly
Spacer Grid Assemblies	Spacer Disks (Basket)	DSC Seismic Retainer
Lower End Fitting (and Connectors)	Support Rods (Basket)	Cask Docking Flange and Tie Restraints
Upper End Fitting (Connectors and Holdown Spring)	Rails (Basket)	Heat Shield
—	Rail Inserts (Basket)	Shielded Front Access Door and Door Supports
—	Fixed Neutron Absorbers (Basket)	Ventilation Air Openings (One Inlet/ Two Outlets)
—	DSC Shell with Bottom Shield Plug	Shielded Ventilation Air Inlet Plenum
—	Top Shield Plug	Ventilation Air Outlet Shielding Blocks
—	Cover Plates (Top and Bottom)	Lighting Protection System
—	Siphon and Vent Ports	Threaded Fasteners and Expansion Anchors
—	Ram Grapple Ring	Handrail

*CCNPP. "Calvert Cliffs Site-Specific Independent Spent Fuel Storage Installation (ISFSI) License Renewal Application." Materials License No. SNM-2505. Tables 3.2-1, 3.3-1 and 3.4-1. ML102650247. Lusby, Maryland: Calvert Cliffs Nuclear Power Plant, LLC. September 2010.

Table 2.1-4. SSC Subcomponents Within Scope of License Renewal (Transfer Cask, Transfer Cask Lifting Yoke, Cask Support Platform)*

Transfer Cask	Transfer Cask Lifting Yoke	Cask Support Platform
Structural Shell (Cask Body)	Lifting Hook Plates	Base Plate
Bottom Support Ring (Cask Body)	Lifting Beam Plates	Web Plates
Bottom Cover Plate (Cask Body)	Later Brace Plates	Mid Plate
Top Flange (Cask Body)	Support Brace Plates	Top Plate
Inner Shell (Cask Body)	Pin (Round Bar)	Honeycomb Energy Absorber
Lead (Cask Body)	Main Assembly Bolts, Nuts, Washers	Honeycomb Base Plate
Rails (Cask Attachments)	Hook Bearing Plate	Honeycomb Casing Plate
Upper Trunnions (Cask Attachments)	—	Honeycomb Outer Plate
Upper Trunnion Sleeves (Cask Attachments)	—	Bottom Location Plates

Table 2.1-4. SSC Subcomponents Within Scope of License Renewal (Transfer Cask, Transfer Cask Lifting Yoke, Cask Support Platform)*

Transfer Cask	Transfer Cask Lifting Yoke	Cask Support Platform
Upper Trunnion Nickel Alloy (Cask Attachments)	—	Lifting Lugs
Upper Trunnion Neutron Shielding (Cask Attachments)	—	—
Upper Trunnion Cover Plate (Cask Attachments)	—	—
Lower Trunnions (Cask Attachments)	—	—
Lower Trunnion Sleeves (Cask Attachments)	—	—
Lower Trunnion Sleeve Nickel Alloy Weld Overlay (Cask Attachments)	—	—
Lower Trunnion Neutron Shielding (Cask Attachments)	—	—
Ram Access Penetration Ring (Cask Penetration)	—	—
Upper and Lower Rings, Outer Shell, Relief Valve Support Plates (Cask Neutron Shield)	—	—
Inner and Outer Support Angle (Cask Neutron Shield)	—	—
Shielding Material (Cask Neutron Shield)	—	—
Inner, Outer, and Side Plates (Top Cover Assembly)	—	—
Ring; Eye Bolt Stand-offs (Top Cover Assembly)	—	—
Neutron Shielding (Top Cover Assembly)	—	—
Inner, Outer, and Side Plates (Bottom Cover Assembly)	—	—
Bottom Cover O-ring Seals	—	—
Neutron Shielding (Bottom Cover Assembly)	—	—
Cask Bottom Cover Plate	—	—
Neutron Shielding (Cask Bottom)	—	—
Bolts, Washers, and Threaded Fasteners for Top Cover Plate and Ram Access Plate	—	—

*CCNPP. "Calvert Cliffs Site-Specific Independent Spent Fuel Storage Installation (ISFSI) License Renewal Application." Materials License No. SNM-2505. Tables 3.5-1, 3.6-1 and 3.7-1. ML102650247. Lusby, Maryland: Calvert Cliffs Nuclear Power Plant, LLC. September 2010.

Staff reviewed the licensee's screening of the SSCs to identify subcomponents within the scope of license renewal. The staff's review considered the intended function of the subcomponent, its safety classification or basis for inclusion from the license renewal scope, and design bases information in the ISFSI USAR. Based on its review, the staff finds the licensee's screening evaluation results acceptable because the screening evaluation is consistent with NUREG-1927 and appropriately classifies the subcomponents within the scope of license renewal.

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

The licensee reviewed the in-scope SSCs to identify and describe any subcomponents that do not support the SSC intended function. Tables 2.1-5 and 2.1-6 tabulate these subcomponents, as identified by the licensee.

Table 2.1-5. SSC Subcomponents Not Within Scope of License Renewal
(Irradiated Fuel Assembly, Dry Shielded Canisters, Horizontal Storage Module)*

Irradiated Fuel Assembly	Dry Shielded Canister	Horizontal Storage Module
Holddown Spring Retainer and Upper End Plugs	Dry Film Lubricant	Ladder and Attachments
Fuel Assembly Control Components	Swagelok Quick Disconnects	Caulk, Sealants, Expansion Joint Fillers
Fuel Rod Pellets and Other Internal Portions	Siphon Tube	Dry Film Lubricants
—	Aluminum Coating (Carbon Steel Spacer Discs and Top Shield Plugs)	Polyvinyl Chloride Drain Pipe
—	Nickel-based Thread Lubricant; Thread Tape or Sealant	Electrical Conduit, Boxes, and Cable
—	Stainless Steel Plugs/ Bolts (Non-Structural)	Alignment Targets
—	DSC Lifting Lugs	—

*CCNPP. "Calvert Cliffs Site-Specific Independent Spent Fuel Storage Installation (ISFSI) License Renewal Application." Materials License No. SNM-2505. Tables 3.2-1, 3.3-1 and 3.4-1. ML102650247. Lusby, Maryland: Calvert Cliffs Nuclear Power Plant, LLC. September 2010.

Table 2.1-6. SSC Subcomponents Not Within Scope of License Renewal (Transfer Cask, Transfer Cask Lifting Yoke, Cask Support Platform)*

Transfer Cask	Transfer Cask Lifting Yoke	Cask Support Platform
Lubricants, sealants	Pin Handle	Tubing Manifold, Relief Valve, Pressure Gauge, Quick-Connect
Eyebolts for bottom access plate and top cover access plate	Pin Cradle Pipe	—
Cover plates, gaskets, and screws for annulus fill/drain valves	Rear Pin Stop	—
Swagelok relief valves for solid neutron shield	Pin Lock	—
Polyethylene caps for Swagelok valves	Support angles, and miscellaneous screws, bolts, nuts, and washers	—
Alignment pin for top cover plate	Bumpers and mounting flange plates, studs	—
Stick-on alignment targets	Eyebolts, connectors (safety anchor shackles), turnbuckles, wire rope	—

*CCNPP. "Calvert Cliffs Site-Specific Independent Spent Fuel Storage Installation (ISFSI) License Renewal Application." Materials License No. SNM-2505. Tables 3.5-1, 3.6-1 and 3.7-1. ML102650247. Lusby, Maryland: Calvert Cliffs Nuclear Power Plant, LLC. September 2010.

Staff reviewed the licensee's screening of the SSCs, which identified subcomponents not within the scope of license renewal. The review considered the intended function of the subcomponent, its safety classification or basis for exclusion from the license renewal scope, and design bases information in the ISFSI USAR. Based on its review, the staff finds the licensee's screening evaluation results acceptable because they are consistent with NUREG 1927 guidance and appropriately classified the subcomponents not within the scope of license renewal. ….

2.2 Evaluation Findings

The staff reviewed the scoping and screening evalution information presented in Chapter 2 of the LRA (ML102650247; ML110620134; ML110730720; ML11180A270; ML113640129; ML12212A216; ML131190290; ML14267A065). The staff performed its review following the guidance provided in NUREG–1927, "Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance" and ISGs as identified in Table 1.6-1. The staff also used the information provided in NUREG/CR–6407, "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety" in its review as a reference for classification of components as ITS to determine the accuracy and completeness of the licensee's scoping study.

Based on its review of this information, representations, and supplements, the staff finds:

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

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

3 AGING MANAGEMENT REVIEW

3.1 Review Objective

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

3.2 AMR Process

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

The licensee stated in the LRA that the materials of construction of the SSC subcomponents were identified through a review of pertinent design bases document, as listed in Section 2.1 of this SER. The licensee stated that the review was performed to quantify the environmental conditions to which the ISFSI SSCs are continuously or frequently exposed. The licensee clarified that these conditions are based on operating experience, unless design features have been implemented to preclude those conditions from recurring.

The licensee stated that aging effects requiring management during the renewed license period are those that could cause a loss of passive SSC intended function(s). The licensee clarified that both potential aging effects, as well as aging effects that have actually occurred based upon industry and Calvert Cliffs operating experience, were considered. The licensee further clarified that environmental stressors that are conditions not normally experienced (such as accident conditions), or that may be caused by a design problem, were considered event-driven situations and were not characterized as sources of aging. The licensee stated that such event-driven situations would be evaluated and corrective actions, if any, implemented at the time of the event. The licensee further stated that each subcomponent that was subjected to aging management review was evaluated to determine if the potential aging effects/mechanisms were credible considering the material, environment, and conditions of storage.

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

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

Tables 3-1 through 3-6 provide the results of the licensee's AMR and the AMPs credited for the identified aging mechanisms and effects for SSC subcomponents within the scope of license renewal as provided in its response to the 4th Request for Additional Information (RAI) letter dated September 18, 2014.

3.3.1 Irradiated Fuel Assemblies (IFAs)

The licensee stated that each DSC contains either 24 or 32 irradiated fuel assemblies (IFAs) with maximum average burnups of 47 GWD/MTU for the NUHOMS®-24P, and 52 GWd/MTU for the NUHOMS®-32P. The licensee identified the following IFA subcomponents in Section 3.2.1 of the LRA to be within the scope of renewal:

- Fuel rod cladding and end caps/plugs (IFA-1)
- Guide tubes (IFA-2)
- Spacer grid assemblies (IFA-3)
- Lower end fitting (and connectors) (IFA-4)
- Upper end fitting (connectors and holdown spring) (IFA-5)

The staff's evaluation of the AMR results for the IFAs and associated subcomponents is provided in this section.

Table 3.3-1. Aging Management Review Results—Irradiated Fuel Assemblies (IFA)

Item No.	Subcomponent	In Scope Classification Criterions 1 or 2	Materials	Environment	Aging Effect/Mechanism	AMR SER Section	AMP SER Section
IFA-1	Fuel Rod (Cladding and End Caps)	1	Zircaloy-4, Zirlo, M5[4]	Air and Gas;[1, 2] Residual Boron Coating;[3]	None Identified	3.3.1	3.5.6
IFA-2	Guide Tubes	1	Zircaloy-4; Stainless Steel; (Chrome Plated)	Air and Gas;[1]	None Identified	3.3.1	3.5.6
IFA-3	Spacer Grid Assemblies	1	Zircaloy-4	Air and Gas;[1]	None Identified	3.3.1	3.5.6
IFA-4	Lower End Fitting (and Connectors)	1	Stainless Steel; Inconel	Air and Gas;[1]	None Identified	3.3.1	3.5.6
IFA-5	Upper End Fitting (Connectors and Holddown Spring)	1	Stainless Steel; Inconel X-750	Air and Gas;[1]	None Identified	3.3.1	3.5.6

[1]The licensee defined the 'Air and Gas' environment outside the fuel rods (inside the DSC) to be helium at atmospheric pressure with trace amounts of air, water vapor, and fission product gases. The licensee stated that temperature and radiation were considered in the aging management review.
[2]The licensee defined the 'Air and Gas' environment inside the fuel rods to be pressurized helium and fission product gases.
[3]The licensee stated that residual boron may coat the irradiated fuel assemblies surfaces since they were exposed to a borated water environment in the SFP prior to storage. The licensee further stated that any boric acid residue remaining on the irradiated fuel assemblies will have no deleterious effects due to the minimal amount of water remaining on the irradiated fuel assembles and the materials of construction for the irradiated fuel assemblies.
[4]The licensee stated that a confirmatory program for high burnup fuel is being performed by the Department of Energy which will monitor the condition of high burnup fuel assemblies in dry storage. This confirmatory program includes Zircaloy-4, Zirlo, and M5 cladding materials that have been used at Calvert Cliffs but may not yet have been placed into dry storage at the time of ISFSI license renewal.

Table 3.3-2. Aging Management Review Results—Dry Shielded Canister (DSC)

Item No.	Subcomponent[1]	In Scope Classification Criterions 1 or 2	Materials	Environment	Aging Effect/Mechanism	AMR SER Section	AMP SER Section
DSC-1	Basket	1	Stainless Steel	Air and Gas;[2, 4]	None Identified	3.3.2	N/A
DSC-2	Guide Sleeves (Basket)	1	Stainless Steel	Air and Gas;[2, 4]	None Identified	3.3.2	N/A
DSC-3	Spacer Disks (Basket)	1	Stainless Steel / Aluminum Coated Carbon Steel	Air and Gas;[2, 4]	None Identified	3.3.2	N/A
DSC-4	Support Rods (Basket)	1	Stainless Steel / Aluminum Coated Carbon Steel	Air and Gas;[2, 4]	None Identified	3.3.2	N/A
DSC-5	Rails (Basket)	1	Stainless Steel	Air and Gas;[2, 4]	None Identified	3.3.2	N/A
DSC-6	Rail Inserts (Basket)	1	Aluminum	Air and Gas;[2, 4]	None Identified	3.3.2	N/A
DSC-7	Fixed Neutron Absorbers (Basket)	1	Borated Aluminum Alloy	Sheltered[3]	None Identified	3.3.2	N/A
DSC-8	DSC Shell w/ Bottom Shield Plug	1	Stainless Steel	Air and Gas;[2] Sheltered[3]	Loss of material due to crevice and pitting corrosion	3.3.2	3.5.1
DSC-9	DSC Shell w/ Bottom Shield Plug	1	Stainless Steel and Lead	Air and Gas;[2] Sheltered[3]	Cracking from stress corrosion cracking	3.3.2	3.5.1
DSC-10	Top Shield Plug	1	Stainless Steel and Lead	Air and Gas;[2, 4] Sheltered[3]	None Identified	3.3.2	N/A
DSC-11	Cover Plates (Top and Bottom)	1	Stainless Steel	Sheltered[3]	Loss of material due to crevice and pitting corrosion	3.3.2	3.5.1
DSC-12	Cover Plates (Top and Bottom)	1	Stainless Steel	Sheltered[3]	Cracking from stress corrosion cracking	3.3.2	3.5.1

Table 3.3-2. Aging Management Review Results—Dry Shielded Canister (DSC)

DSC-13	Siphon and Vent Ports	1	Stainless Steel	Air and Gas;[2, 4]	None Identified	3.3.2	N/A
DSC-14	Ram Grapple Ring	1	Stainless Steel	Sheltered[3]	Loss of material due to crevice and pitting corrosion	3.3.2	3.5.1
DSC-15	Ram Grapple Ring	1	Stainless Steel	Sheltered[3]	Cracking from stress corrosion cracking	3.3.2	3.5.1

[1]The licensee stated that the a DSC may not contain all of the listed subcomponents.
[2]The licensee defined the 'Air and Gas' environment inside the DSC cavity to be helium at atmospheric pressure with trace amounts of air, water vapor, and fission product gases.
[3]The licensee defined a 'Sheltered' environment applicable to DSC interior/exterior surfaces that are not part of the helium-filled DSC cavity.
[4]The licensee stated that one short exposure to borated water during loading operations is not considered an environment that impacts long term aging management.

Table 3.3-3. Aging Management Review Results—Horizontal Storage Module (HSM)

Item No.	Subcomponent	In Scope Classification Criterions 1 or 2	Materials	Environment	Aging Effect/Mechanism	AMR SER Section	AMP SER Section
HSM-1	Reinforced Concrete Walls, Roof and Foundation; Shielded Ventilation Air Inlet Plenum; Ventilation Air Outlet Shielding Blocks	1	Concrete	Yard, Air	Cracking due to freeze-thaw degradation	3.3.3	3.5.2
HSM-2	Reinforced Concrete Walls, Roof and Foundation; Shielded Ventilation Air Inlet Plenum; Ventilation Air Outlet Shielding Blocks	1	Concrete	Yard, Air	Loss of material (spalling, scaling) due to freeze-thaw degradation	3.3.3	3.5.2
HSM-3	Reinforced Concrete Walls, Roof and Foundation; Shielded Ventilation Air Inlet Plenum; Ventilation Air Outlet Shielding Blocks	1	Concrete	Yard, Air	Cracking due to moisture, chemical attack, or leaching	3.3.3	3.5.2
HSM-4	Reinforced Concrete Walls, Roof and Foundation; Shielded Ventilation Air Inlet Plenum; Ventilation Air Outlet Shielding Blocks	1	Concrete	Yard, Air	Loss of material (spalling, scaling) due to moisture, chemical attack, or leaching	3.3.3	3.5.2
HSM-5	Reinforced Concrete Walls, Roof and Foundation; Shielded Ventilation Air Inlet Plenum; Ventilation Air Outlet Shielding Blocks	1	Embedded Steel	Yard, Air	Corrosion due to moisture, chemical attack, or leaching	3.3.3	3.5.2
HSM-6	Reinforced Concrete Walls, Roof and Foundation; Shielded Ventilation Air Inlet Plenum; Ventilation Air Outlet Shielding Blocks	1	Concrete	Yard, Air	Increase in porosity/permeability due to leaching of $Ca(OH)_2$	3.3.3	3.5.2
HSM-7	Reinforced Concrete Walls, Roof and Foundation	1	Concrete	Yard, Air	Loss of strength due to leaching of $Ca(OH)_2$	3.3.3	3.5.2
HSM-8	Reinforced Concrete Walls,	1	Concrete	Yard, Air	Cracking due to cement	3.3.3	3.5.2

Table 3.3-3. Aging Management Review Results—Horizontal Storage Module (HSM)

	Roof and Foundation; Shielded Ventilation Air Inlet Plenum; Ventilation Air Outlet Shielding Blocks				aggregate reactions		
HSM-9	Reinforced Concrete Walls, Roof and Foundation; Shielded Ventilation Air Inlet Plenum; Ventilation Air Outlet Shielding Blocks	1	Concrete	Yard, Air	Loss of material due to cement aggregate reactions	3.3.3	3.5.2
HSM-10	Reinforced Concrete Walls, Roof and Foundation; Shielded Ventilation Air Inlet Plenum; Ventilation Air Outlet Shielding Blocks	1	Concrete	Yard, Air	Increase in porosity/permeability due to cement aggregate reactions	3.3.3	3.5.2
HSM-11	Reinforced Concrete Walls, Roof and Foundation; Shielded Ventilation Air Inlet Plenum; Ventilation Air Outlet Shielding Blocks	1	Concrete	Yard, Air	Loss of strength due to cement aggregate reactions	3.3.3	3.5.2
HSM-12	Reinforced Concrete Walls, Roof and Foundation; Shielded Ventilation Air Inlet Plenum; Ventilation Air Outlet Shielding Blocks	1	Concrete	Yard, Air	Cracking due to settlement or loss of bond with embedded steel	3.3.3	3.5.2
HSM-13	Reinforced Concrete Walls, Roof and Foundation; Shielded Ventilation Air Inlet Plenum; Ventilation Air Outlet Shielding Blocks	1	Concrete	Yard, Air	Cracking due to irradiation	3.3.3	3.5.2
HSM-14	Reinforced Concrete Walls, Roof and Foundation; Shielded Ventilation Air Inlet Plenum; Ventilation Air Outlet Shielding Blocks	1	Concrete	Yard, Air	Loss of material (spalling, scaling) due to irradiation	3.3.3	3.5.2
HSM-15	Reinforced Concrete Walls, Roof and Foundation	1	Concrete	Embedded/ Underground	Cracking due to freeze-thaw degradation	3.3.3	3.5.2
HSM-16	Reinforced Concrete Walls, Roof and Foundation	1	Concrete	Embedded/ Underground	Loss of material (spalling, scaling) due	3.3.3	3.5.2

Table 3.3-3. Aging Management Review Results—Horizontal Storage Module (HSM)

					to freeze-thaw degradation		
HSM-17	Reinforced Concrete Walls, Roof and Foundation	1	Concrete	Embedded/ Underground	Cracking due to moisture, chemical attack, or leaching	3.3.3	3.5.2
HSM-18	Reinforced Concrete Walls, Roof and Foundation	1	Concrete	Embedded/ Underground	Loss of material due to moisture, chemical attack, or leaching	3.3.3	3.5.2
HSM-19	Reinforced Concrete Walls, Roof and Foundation	1	Embedded Steel	Embedded/ Underground	Corrosion due to moisture, chemical attack, or leaching	3.3.3	3.5.2
HSM-20	Reinforced Concrete Walls, Roof and Foundation	1	Concrete	Embedded/ Underground	Increase in porosity/permeability due to leaching of $Ca(OH)_2$	3.3.3	3.5.2
HSM-21	Reinforced Concrete Walls, Roof and Foundation	1	Concrete	Embedded/ Underground	Loss of strength due to leaching of $Ca(OH)_2$	3.3.3	3.5.2
HSM-22	Reinforced Concrete Walls, Roof and Foundation	1	Concrete	Embedded/ Underground	Cracking due to irradiation	3.3.3	3.5.2
HSM-23	Reinforced Concrete Walls, Roof and Foundation	1	Concrete	Embedded/ Underground	Loss of material (spalling, scaling) due to irradiation	3.3.3	3.5.2
HSM-24	Reinforced Concrete Walls, Roof and Foundation	1	Concrete	Embedded/ Underground	Cracking due to cement aggregate reactions	3.3.3	3.5.2
HSM-25	Reinforced Concrete Walls, Roof and Foundation	1	Concrete	Embedded/ Underground	Loss of material due to cement aggregate reactions	3.3.3	3.5.2
HSM-26	DSC Structural Steel Assembly	1	Carbon Steel	Sheltered	Loss of material due to corrosion	3.3.3	3.5.2
HSM-27	DSC Structural Steel Assembly	1	Nitronic 60 Stainless Steel	Sheltered	None Identified	3.3.3	3.5.2
HSM-28	DSC Seismic Retainer	1	Carbon Steel	Sheltered	Loss of material due to corrosion	3.3.3	3.5.2
HSM-29	Cask Docking Flange and Tie Restraints	1	Carbon Steel	Sheltered	Loss of material due to corrosion	3.3.3	3.5.2
HSM-30	Cask Docking Flange and Tie Restraints	1	Carbon Steel	Yard	Loss of material due to corrosion	3.3.3	3.5.2

Table 3.3-3. Aging Management Review Results—Horizontal Storage Module (HSM)

HSM-31	Heat Shield	1	Stainless Steel	Sheltered	None Identified	3.3.3	N/A
HSM-32	Shielded Front Access Door and Door Supports	1	Carbon Steel	Yard	Loss of material due to corrosion	3.3.3	3.5.2
HSM-33	Shielded Front Access Door and Door Supports	1	Concrete	Embedded	None Identified	3.3.3	N/A
HSM-34	Ventilation Air Openings (One Inlet/ Two Outlets)	1	Stainless Steel	Yard	None Identified	3.3.3	N/A
HSM-35	Shielded Ventilation Air Inlet Plenum	1	Stainless Steel	Yard	None Identified	3.3.3	N/A
HSM-36	Ventilation Air Outlet Shielding Blocks	1	Stainless Steel	Yard	None Identified	3.3.3	N/A
HSM-37	Lighting Protection System	1	Copper	Yard	None Identified	3.3.3	N/A
HSM-38	Threaded Fasteners and Expansion Anchors	1	Stainless Steel	Yard Embedded/ Yard	None Identified	3.3.3	N/A
HSM-39	Handrail	1	Carbon Steel	Yard	None Identified	3.3.3	N/A

Table 3.3-4. Aging Management Review Results—Transfer Cask (TC)

Item No.	Subcomponent	In Scope Classification Criterions 1 or 2	Materials	Environment[1,2]	Aging Effect/Mechanism	AMR SER Section	AMP SER Section
TC-1	Structural Shell (Cask Body)	1	Carbon Steel	Embedded/ Borated Water	Loss of material due to general corrosion	3.3.4	3.5.3
TC-2	Structural Shell (Cask Body)	1	Carbon Steel	Embedded/ Borated Water	Loss of material due to pitting or crevice corrosion	3.3.4	3.5.3
TC-3	Bottom Support Ring (Cask Body)	1	Stainless Steel	Sheltered/ Borated Water	None Identified	3.3.4	N/A
TC-4	Bottom Cover Plate (Cask Body)	1	Stainless Steel	Sheltered/ Borated Water	None Identified	3.3.4	N/A
TC-5	Top Flange (Cask Body)	1	Stainless Steel	Sheltered/ Borated Water	None Identified	3.3.4	N/A
TC-6	Inner Shell (Cask Body)	1	Stainless Steel	Sheltered/ Borated Water	None Identified	3.3.4	N/A
TC-7	Lead (Cask Body)	1	Lead	Embedded	None Identified	3.3.4	N/A
TC-8	Rails (Cask Attachments)	1	Stainless Steel (Notronic 60)	Sheltered	None Identified	3.3.4	N/A
TC-9	Upper Trunnions (Cask Attachments)	1	Stainless Steel	Sheltered/ Borated Water	Cracking of material due to stress/strain from lifting	3.3.4	3.5.3
TC-10	Upper Trunnion Sleeves (Cask Attachments)	1	Stainless Steel	Embedded/ Borated Water	Cracking of material due to stress/strain from lifting	3.3.4	3.5.3
TC-11	Upper Trunnion Nickel Alloy (Cask Attachments)	1	Inconel	Sheltered/ Borated Water	Cracking of material due to stress/strain from lifting	3.3.4	3.5.3
TC-12	Upper Trunnion Neutron Shielding (Cask Attachments)	1	Bisco NS-3	Embedded	None Identified	3.3.4	N/A

Table 3.3-4. Aging Management Review Results—Transfer Cask (TC)

Item No.	Subcomponent	In Scope Classification Criterions 1 or 2	Materials	Environment[1,2]	Aging Effect/Mechanism	AMR SER Section	AMP SER Section
TC-13	Upper Trunnion Cover Plate (Cask Attachments)	1	Stainless Steel	Sheltered/ Borated Water	Cracking of material due to stress/strain from lifting	3.3.4	3.5.3
TC-14	Lower Trunnions (Cask Attachments)	1	Stainless Steel	Sheltered/ Borated Water	Cracking of material due to stress/strain from lifting	3.3.4	3.5.3
TC-15	Lower Trunnion Sleeves (Cask Attachments)	1	Stainless Steel	Sheltered/ Borated Water	Cracking of material due to stress/strain from lifting	3.3.4	3.5.3
TC-16	Lower Trunnion Sleeve Nickel Alloy Weld Overlay (Cask Attachments)	1	Stainless Steel	Sheltered/ Borated Water	Cracking of material due to stress/strain from lifting	3.3.4	3.5.3
TC-17	Lower Trunnion Neutron Shielding (Cask Attachments)	1	Bisco NS-3	Embedded/ Borated Water	None Identified	3.3.4	N/A
TC-18	Ram Access Penetration Ring (Cask Penetration)	1	Stainless Steel	Sheltered/ Borated Water	None Identified	3.3.4	N/A
TC-19	Upper and Lower Rings, Outer Shell, Relief Valve Support Plates (Cask Neutron Shield)	1	Stainless Steel	Sheltered/ Borated Water	None Identified	3.3.4	N/A
TC-20	Inner and Outer Support Angle (Cask Neutron Shield)	1	Stainless Steel	Sheltered/ Borated Water	None Identified	3.3.4	N/A
TC-21	Shielding Material (Cask Neutron Shield)	1	Bisco NS-3	Embedded	None Identified	3.3.4	N/A
TC-22	Inner, Outer, and Side Plates (Top Cover Assembly)	1	Stainless Steel	Sheltered/ Borated Water	None Identified	3.3.4	N/A

Table 3.3-4. Aging Management Review Results—Transfer Cask (TC)

Item No.	Subcomponent	In Scope Classification Criterions 1 or 2	Materials	Environment[1,2]	Aging Effect/Mechanism	AMR SER Section	AMP SER Section
TC-23	Ring; Eye Bolt Stand-offs (Top Cover Assembly)	1	24 Hot Galvanized Finish	Sheltered	None Identified	3.3.4	N/A
TC-24	Neutron Shielding (Top Cover Assembly)	1	Bisco NS-3	Embedded	None Identified	3.3.4	N/A
TC-25	Inner, Outer, and Side Plates (Bottom Cover Assembly)	1	Stainless Steel	Sheltered/ Borated Water	None Identified	3.3.4	N/A
TC-26	Bottom Cover O-ring Seals	1	Polymer (Ethylene Propylene)	Sheltered	Materials Property Change	3.3.4	N/A[3]
TC-27	Neutron Shielding (Bottom Cover Assembly)	1	Bisco NS-3	Embedded	None Identified	3.3.4	N/A
TC-28	Cask Bottom Cover Plate	1	Stainless Steel	Sheltered	None Identified	3.3.4	N/A
TC-29	Neutron Shielding (Cask Bottom)	1	Bisco NS-3	Embedded	None Identified	3.3.4	N/A
TC-30	Bolts, Washers, and Threaded Fasteners for Top Cover Plate and Ram Access Plate	1	Carbon Steel	Sheltered	Loss of material due to general corrosion	3.3.4	3.5.3
TC-31	Bolts, Washers, and Threaded Fasteners for Top Cover Plate and Ram Access Plate	1	Carbon Steel	Sheltered	Loss of material due to pitting or crevice corrosion	3.3.4	3.5.3

[1]The licensee defined a sheltered environment as ambient conditions on the interior of the transfer cask, conservatively including connecting and embedding surfaces. The licensee calrified that some subcomponents may have interior surfaces that are considered embedded. The licensee stated that aging effects were not identified for the embedded surfaces, hence requiring no aging management. The licensee further stated that temperature and radiation were considered in the aging management review.
[2]The licensee stated that all subcomponents are immersed in the borated water of the spent fuel pool and rinsed off with deionized water after use.[3]The licensee stated that the bottom cover o-ring seals are subject to routine replacement.

Table 3.3-5. Aging Management Review Results—Transfer Cask Lifting Yoke (TCLY)

Item No.	Subcomponent	In Scope Classification Criterions 1 or 2	Materials	Environment[1]	Aging Effect/Mechanism	AMR SER Section	AMP SER Section
TCLY-1	Lifting Hook Plates	1	Carbon Steel	Sheltered/ Borated Water	Loss of material due to general corrosion	3.3.5	3.5.4
TCLY-2	Lifting Hook Plates	1	Carbon Steel	Sheltered/ Borated Water	Loss of material due to pitting or crevice corrosion	3.3.5	3.5.4
TCLY-3	Lifting Hook Plates	1	Carbon Steel	Sheltered/ Borated Water	Cracking of material due to stress/strain from lifting	3.3.5	3.5.4
TCLY-4	Lifting Beam Plates	1	Carbon Steel	Sheltered/ Borated Water	Loss of material due to general corrosion	3.3.5	3.5.4
TCLY-5	Lifting Beam Plates	1	Carbon Steel	Sheltered/ Borated Water	Loss of material due to pitting or crevice corrosion	3.3.5	3.5.4
TCLY-6	Lifting Beam Plates	1	Carbon Steel	Sheltered/ Borated Water	Cracking of material due to stress/strain from lifting	3.3.5	3.5.4
TCLY-7	Later Brace Plates	1	Carbon Steel	Sheltered/ Borated Water	Loss of material due to general corrosion	3.3.5	3.5.4
TCLY-8	Later Brace Plates	1	Carbon Steel	Sheltered/ Borated Water	Loss of material due to pitting or crevice corrosion	3.3.5	3.5.4
TCLY-9	Support Brace Plates	1	Carbon Steel	Sheltered/ Borated Water	Loss of material due to general corrosion	3.3.5	3.5.4

Table 3.3-5. Aging Management Review Results—Transfer Cask Lifting Yoke (TCLY)

Item No.	Subcomponent	In Scope Classification Criterions 1 or 2	Materials	Environment[1]	Aging Effect/Mechanism	AMR SER Section	AMP SER Section
TCLY-10	Support Brace Plates	1	Carbon Steel	Sheltered/ Borated Water	Loss of material due to pitting or crevice corrosion	3.3.5	3.5.4
TCLY-11	Pin (Round Bar)	1	Carbon Steel	Sheltered/ Borated Water	Loss of material due to general corrosion	3.3.5	3.5.4
TCLY-12	Pin (Round Bar)	1	Carbon Steel	Sheltered/ Borated Water	Loss of material due to pitting or crevice corrosion	3.3.5	3.5.4
TCLY-13	Main Assembly Bolts, Nuts, Washers	1	Carbon Steel	Sheltered	Loss of material due to general corrosion	3.3.5	3.5.4
TCLY-14	Main Assembly Bolts, Nuts, Washers	1	Carbon Steel	Sheltered	Loss of material due to pitting or crevice corrosion	3.3.5	3.5.4
TCLY-15	Hook Bearing Plate	1	Bronze	Sheltered	None Identified	3.3.5	N/A

[1]The licensee stated that that all subcomponents are immersed in the borated water of the spent fuel pool and rinsed off with deionized water after use.

Table 3.3-6. Aging Management Review Results—Cask Support Platform (CSP)

Item No.	Subcomponent	In Scope Classification Criterions 1 or 2	Materials	Environment	Aging Effect/Mechanism	AMR SER Section	AMP SER Section
CSP-1	Base Plate	1	Stainless Steel	Borated Water	Loss of material due to pitting or stress corrosion cracking	3.3.6	3.5.5
CSP-2	Web Plates	1	Stainless Steel	Borated Water	Loss of material due to pitting or stress corrosion cracking	3.3.6	3.5.5
CSP-3	Mid Plate	1	Stainless Steel	Borated Water	Loss of material due to pitting or stress corrosion cracking	3.3.6	3.5.5
CSP-4	Top Plate	1	Stainless Steel	Borated Water	Loss of material due to pitting or stress corrosion cracking	3.3.6	3.5.5
CSP-5	Honeycomb Energy Absorber	1	Aluminum	Compressed Air	None Identified	3.3.6	N/A
CSP-6	Honeycomb Base Plate	1	Stainless Steel	Borated Water	Loss of material due to pitting or stress corrosion cracking	3.3.6	3.5.5
CSP-7	Honeycomb Casing Plate	1	Stainless Steel	Borated Water	Loss of material due to pitting or stress corrosion cracking	3.3.6	3.5.5
CSP-8	Honeycomb Outer Plate	1	Stainless Steel	Borated Water	Loss of material due to pitting or stress corrosion	3.3.6	3.5.5

					cracking		
CSP-9	Bottom Location Plates	1	Stainless Steel	Borated Water	Loss of material due to pitting or stress corrosion cracking	3.3.6	3.5.6
CSP-10	Lifting Lugs	1	Stainless Steel	Borated Water	Loss of material due to pitting or stress corrosion cracking	3.3.6	3.5.5

3.3.1.1 **Materials and Environments**

The licensee referred to the IFA internal environment as the fuel rod interior. The licensee specified that the fuel rods were pressurized with helium during manufacturing. The licensee further clarified that the fuel rod internal environment, defined as “Air/Gas” in Table 3.3-1 of this SER, was assumed to be a combination of the original helium fill gas and fission products produced during reactor operation.

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

- Fuel Cladding and End Plugs (IFA-1)

The licensee specified that the fuel cladding and end-plugs are made of zirconium-based alloys (zircaloy-4, Zirlo, or M5). The licensee specified that it’s assumption in the LRA is that the internal environment consists of helium (fill gas) and the fission products, and the external environment consists predominantly of helium with trace amounts of water vapor, fission product gases, and air defined as Air/Gas.

- Guide Tubes (IFA-2)

The licensee identified the materials of construction for the guide tubes as zirconium-based alloy (Zircaloy-4) and stainless steel. The licensee specified that stainless steel sleeves have been installed in guide tubes that exhibit wear or are used to house control element assemblies. The licensee specified, in Table 3.2-1 of the AMP, that the environment that the guide tubes are exposed to is the Air/Gas environment.

- Spacer Grid Assemblies (IFA-3)

The licensee specified that the IFAs are held together by spacer grids. These spacer grids maintain the fuel rod pitch over the length of the rod. The licensee specified that the grids are fabricated from Zircaloy-4. The licensee specified, in Table 3.2-1 of the AMP, that the environment that the spacer grid assemblies are exposed to is the Air/Gas environment.

- Lower End Fitting and related subcomponents (IFA-4)

The licensee specified that the lower end fitting consists of an Inconel grid welded to a cast stainless steel plate. The licensee specified that it also consists of the support legs which serve as alignment posts, support plate alignment pins, and other subcomponents. The licensee identified the exposed environment for the lower end fittings (and related subcomponents) as the Air/Gas environment.

- Upper End Fitting and related subcomponents (IFA-5)

The licensee specified that the upper end fitting consists of a stainless steel flow plate, a stainless steel holddown plate, five machined posts, and five Inconel X-750 compression springs. The licensee identified the exposed environment for the upper end fittings (and related subcomponents) as the Air/Gas environment.

The staff reviewed the accuracy of the materials of construction and service environments of the IFAs with the ISFSI design bases referenced in the LRA. Based on its review, the staff concludes that the licensee adequately identified the materials of construction and service environment of the IFAs.

The licensee identified the external environment that the irradiated fuel assemblies are exposed to as being the internal environment of the cask (the internal DSC atmosphere). As part of the AMR, the licensee specified that this environment was assumed to be predominantly helium with trace amounts of water vapor, fission product gases, and air.

The licensee further specified that these gases have collectively been grouped into the “Air/Gas” environment in Table 3.2-1 of the LRA. This is also in Table 3.3-2 of this SER.

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

In addition, the licensee also specified that following initial cask loading, the maximum allowable temperature of the fuel cladding for the NUHOMS®-24P and NUHOMS®-32P DSCs was limited to 635°F for normal storage conditions as specified in Section 8.1.3.2 and Section 12.8.1.3.2 of the ISFSI USAR. The licensee further specified, in Section 3.2.3 of the LRA, and staff confirms, that the fuel cladding temperature will decrease over time while in storage.

3.3.1.2 Aging Effects/Mechanisms on the Irradiated Fuel Assemblies During the Period of Extended Storage

The licensee specified that storage of fuel with burnup

of less than 45 GWd/MTU is not considered susceptible to radial hydride formation, per guidance in ISG-11, Rev. 3. The licensee further specified that results of the Dry Cask Storage Characterization Project in Idaho support the conclusion that the condition of the IFAs being stored at the ISFSI will not degrade under extended storage.

The licensee also determined that for IFAs with burnup greater than 45 GWd/MTU, the likelihood of this degradation mechanism occurring is minimized by limiting peak cladding temperature to less than 400°C [752°F]. Per Attachment 2 of the 4th RAI response,the Calvert Cliffs ISFSI Technical Specification 3.1.1(3) limits the maximum assembly average burnup to 47 GWd/MTU and 52 GWd/MTU for IFAs stored in the NUHOMS®-24P DSC and NUHOMS®-32P DSC, respectively. As specified in Section 8.1.3.2 and Section 12.8.1.3.2 of the ISFSI USAR, the maximum allowable fuel cladding temperatures for normal storage at the ISFSI is 335°C (635°F). Per Appendix B of the LRA, the maximum fuel cladding temperatures at the initiation of storage for the 24P and 32P DSCs were calculated to be 322°C (612°F) and 313°C (596°F), respectively. The licensee asserts that due to the reduction in decay heat over time, that after 20 years of storage the peak cladding temperatures are expected to be much lower. The licensee referenced, in Appendix B of its 4th RAI response, PNL-6189 which was used for calculating the cladding temperature limit and is applicable for a 40-year storage period. The licensee specified that the maximum cladding temperature from the PNL-6189 is well below the 400°C [752°F] limit, as defined in ISG-11, Rev.3. Guidance in ISG-11, Rev. 3 specifies that in order to assure integrity of the cladding material the maximum calculated fuel cladding temperature should not exceed 400°C (752°F) for normal conditions of storage. As a result, the licensee recognizes that ISG-11, Rev. 3 is considered to adequately bound cladding conditions associated with the higher burnups up to 52 GWd/MTU in this case.

Based on the above assessment, the licensee determined there are no aging effects/mechanisms that require management for IFAs stored in the inert environment in the DSC. The staff reviewed the identified aging mechanisms and effects for the IFAs. The staff determined the AMR to be comprehensive and acceptable based on the ISFSI design bases referenced in the LRA. Based on its review, the staff finds the licensee's identification of aging mechanisms and effects for the IFAs consistent with ISG-11, rev. 3 guidance and therefore acceptable.

3.3.1.3 **Evaluation of Proposed Aging Management Activities**

Per 10 CFR 72.122 (l), storage systems must be designed for ready retrieval of the spent fuel. According to ISG-2, Rev 1, "a fuel assembly is "ready retrievable" if it remains structurally sound (i.e., no gross degradation) and could be handled by normal means (i.e., does not pose operational safety problems during removal)." The guidance in ISG-11, Rev 3 also indicates that if the maximum fuel temperature was maintained below 400°C [752°F] and the fuel was stored in a dry inert atmosphere that it is expected that the fuel would stay structurally sound during normal and off-normal conditions of operation. Unless the fuel assemblies are canned or handled by other appropriate means, they must remain structurally sound in order to meet the regulations and perform their intended function in order to provide reasonable assurance that the fuel can be retrieved without undue risk. Thus, the fuel assemblies are in the scope of this renewal.

As discussed in Section 3.3.1.2 of this SER, the licensee specified that storage of fuel with burnup of less than 45 GWd/MTU are not considered susceptible to radial hydride formation, per guidance in ISG-11, Rev. 3. The NRC staff determined through the fuel testing in Idaho where low burnup fuel was stored for 15 years in a dry inert atmosphere and showed no signs of degradation, that no degradation will occur during additional storage periods up to 100 years. Therefore the staff finds that no TLAA or AMP is necessary to store the low burnup fuel for up to a total of 60 years as requested.

In addition to the storage of low burnup fuel, the licensee plans to store high burnup fuel on the ISFSI. Some differences exists between low and high burnup fuel which include: (i) additional cladding oxidation which causes higher hydrogen content in high burnup zirconium-based alloy cladding and (ii) higher cladding stress due to potentially greater fission gas release. NRC staff established ISG-11, Rev 3 with models that extrapolate the expected performance of low and high burnup fuel during storage. The models in ISG-11 Rev 3 indicate acceptable fuel performance during the initial 20 year period of operation (2013–2033) for normal and off-normal operation. Based upon this data, the staff has reasonable assurance that HBF performance will continue as expected throughout the term of this renewed licensee. Because the operating experience in this area is limited, the licensee will perform further confirmation of the model extrapolations during the period of extended operation to ensure the models remain conservative and maintain acceptable fuel performance. The licensee identified a confirmation method through a surrogate high burnup fuel surveillance program, established as part of the AMP in Attachment 2 of the 4th RAI response entitled "High Burnup Fuel Aging Management Program," which the staff finds is in conformance with ISG-24. This surveillance program will be used to confirm that the high burnup fuel performance continues as expected and to support the conclusions drawn in ISG-11, Rev 3 prior to moving into the period of extended operation beyond the initial 20 year period. Thus, the NRC staff requires this high burnup fuel surveillance AMP to provide this confirmatory information, and hence it has included a license condition (license condition 22) to document this requirement. .

3.3.2 Dry Shielded Canister

The licensee stated that the irradiated fuel assemblies placed in dry storage at the Calvert Cliffs ISFSI are currently contained in NUHOMS®-24P and NUHOMS®-32P DSC. The licensee identified the following DSC components to be within the scope of the renewal:

- DSC Basket including: Guide Sleeves, Spacer Disks, Support Rods, Rails, Rail Inserts, and Fixed Neutron Absorbers (DSC-1 through DSC-7)
- DSC Shell w/ Bottom shield Plug (DSC-8 and DSC-9)
- Top Shield Plug (DSC-10)
- Cover Plates (Top and Bottom) (DSC-11 and DSC-12)
- Siphon and Vent Ports (DSC-13)
- Ram Grapple Ring (DSC-14 and DSC-15)

The licensee summarized the AMR results for the DSC in LRA Table 3.3-1 the staff's evaluation of the AMR results is provided in this section.

3.3.2.1 **Materials and Environments**

The licensee identified the materials of construction for the DSC subcomponents that were subject to AMR in LRA Table 3.3-1. The AMR for the DSC subcomponents was updated in its response to the 4th RAI. The main structural materials, including the shell cover plates and grapple ring, are constructed from stainless steel. Aluminum coated carbon steel, aluminum, borated aluminum alloys and lead are used in internal subcomponents. The staff reviewed the DSC design bases as well as the information presented in Chapter 3 of the Calvert Cliffs ISFSI USAR Rev. 21 and confirms that the licensee adequately identified the materials of construction for the DSC and its associated subcomponents.

The licensee described the NUHOMS®-24P and NUHOMS®-32P DSCs in Section 3.3 of the LRA. Each DSC serves as a confinement vessel during transfer of IFAs to and from the HSM, and during storage of IFAs in an HSM. The DSC shell is an all-welded stainless steel cylinder. Chapter 1 of the NUH-002 topical report described the containment boundary (i.e., confinement boundary) as the cylindrical shell, top and bottom shield plug assemblies, top and bottom cover plates, and associated welds. A single NUHOMS®-24P DSC is sized to hold 24 PWR fuel assemblies, and a single NUHOMS®-32P DSC is sized to hold 32 PWR fuel assemblies. The shielded end plugs provide shielding during closure and transfer operations, and also provide shielding at the front access to the HSM. The top and bottom shield end plugs are made of stainless-steel-encased lead. The DSC shield plug and the cover plate assemblies are independently seal welded to provide a redundant confinement boundary. Likewise, the siphon port, vent port, and their cover plates are redundantly sealed. The NUHOMS®-24P and NUHOMS®-32P DSCs utilize different internal basket assemblies. The internal basket assembly of the NUHOMS®-24P DSC has 24 guide sleeves supported by spacer disks at intervals corresponding to the fuel assembly spacer grids, and support rods maintain the spacer disk location. All canister structural components are fabricated from type 304 stainless steel. However, the licenesee stated that the spacer disks and support rods may be fabricated from aluminum-coated carbon steel. The internal basket assembly of the NUHOMS®-32P DSC has 32 guide sleeves supported by an egg-crate design made of stainless steel and aluminum (borated and unborated plates) to support the guide sleeves. The staff reviewed the information provided in the LRA.

The external surface of each DSC is exposed to a sheltered environment within the interior of an HSM along with neutron fluence and integrated gamma dose from the stored spent fuel assemblies. While the sheltered environment is designed to protect the DSC from precipitation and wetting, lead system inspection of HSMs and DSCs at the Calvert Cliffs ISFSI in 2012 found evidence of rain water intrusion through ventilation outlet vents that contacted a DSC along with the presence of surface deposits which contained detectable levels of chloride (ADAMS Accession Nos. ML12212A216; ML131190290). The licensee stated in the LRA that results from these inspections will serve as baseline for monitoring and trending during future inspections under the DSC External Surfaces Aging Management Program.

The normal operating temperature of the outside DSC surface is highest at the top of the cylinder and was expected to be 119°C [247°F] for the NUHOMS®-24P DSC and 144°C [292°F] for the NUHOMS®-32P DSC {for 21°C [70°F] ambient air} during the original license term. These surface temperatures are conservatively extended into the license renewal period in the LRA; however, in response to an RAI, the licensee provided a revised evaluation indicating the temperature of the DSC surface was a function of the initial loading condition and location on the DSC surface. The DSC surface temperature decreases with time as a result of radioactive decay. Thermal analysis results indicate that portions of the DSC shell are below 80°C [176°F] for a heat loads between 2 and 19 kW. The licensee has indicated that the maximum design bases heat loads of the DSCs in use at the Calvert Cliffs are 15.84 kW for the 24P DSC, and 21.12 kW for the 32P DSC. The maximum DSC shell temperature falls below 80°C [176°F] for the highest heat load NUHOMS®-24P after 19.5 years in storage and after 35.5 years in storage for the highest heat load NUHOMS®-32P (ADAMS Accession No. ML131190290).

Table 3.3-1 of the LRA indicates the air and gas environment is considered to be helium inside a DSC with possible trace amounts of air, water vapor, and fission product gases. Design temperatures of 204 and 238°C [400 and 460°F] were used for the NUHOMS®-24P and NUHOMS®-32P DSCs, respectively, for the DSC internal structures in the AMR. The heat generated in the fuel regions of the IFAs inside a sealed DSC is transferred to the DSC shell by conduction, convection, and radiation. The helium temperature and DSC internal structure temperature, which is a function of the fuel temperature, will decrease over time. The normal expected helium temperatures, with 21°C [70°F] ambient temperatures, during the original license term, were determined to be 183°C [362°F] for the NUHOMS®-24P and an average gas temperature of 251°C [484°F] for the NUHOMS–32P. However, the licensee stated that for the NUHOMS®-32P, the use of 238°C [460°F] is appropriate because only the fatigue analysis of the DSC shell utilizes temperature as an input, which is lower than the average helium gas temperature.

The staff reviewed the licensee's description of the environment for the DSC and its associated subcomponents. The staff also reviewed the site description data in Chapter 2 of the Calvert Cliffs ISFSI USAR Rev. 21 as well as the information contained in the lead system inspection of HSMs and DSCs at the Calvert Cliffs ISFSI in 2012 and confirms that the licensee adequately defined the climatic characteristics of the site region. The staff confirmed that the neutron fluence interacting with the DSC is bound by the neutron fluence seen by the IFA poison plates, which was defined in Section 3.4.2 of this SER. The licensee characterized the neutron fluence for the poison plates, as discussed in Section 3.4.2 of this SER, to be on the order of 10^{14} neutrons/cm^2, which is below the neutron embrittlement threshold value of 10^{17} neutrons/cm^2 defined in Regulatory Guide 1.199.

3.3.2.2 **Aging Effects/Mechanisms on the DSC subcomponents**

The licensee did not identify aging effects/mechanisms that could lead to a loss of intended function of the DSC subcomponents that are inside the DSC shell and contained within an air and gas environment consisting of helium and trace quantities of air in the LRA. This includes the DSC Basket Guide Sleeves, Spacer Disks, Support Rods, Rails, Rail Inserts, and Fixed Neutron Absorbers and the DSC shell Bottom Shield Plug. The staff reviewed the licensee's assessment as well as the information contained in Chapter 1 of the Calvert Cliffs ISFSI USAR Rev 21 and NUHOMS®-24P design information. Because the controlled atmosphere inside the DSC consists of helium and only trace amounts of air, the staff confirmed the licensee's assessment thatno identified aging effects could lead to a loss of intended function for the DSC subcomponents inside the DSC shell.

For the welded stainless steel DSC shell, the licensee did not identify in the LRA any aging effects/mechanisms that could lead to a loss of intended function. However, based on subsequent review of research and operating experience, the licensee has identified in its response to the 4th RAI potential aging effects that could lead to a loss of intended safety function that include:

- Loss of material due to corrosion (e.g. Crevice corrosion and/or pitting that may be a precursor to stress corrosion cracking).
- Cracking due to stress corrosion cracking (SCC).

The staff reviewed the licensee's identification of aging mechanisms and effects for the cask body and associated subcomponents. Based on its review of the credible aging effects listed in NUREG–1801 and the operating experience provided in NRC information notice 2012-20, NRC sponsored testing (NUREG/CR-7170) and recent industry sponsored review (EPRI-3002002528) the staff determined that the licensee performed a comprehensive AMR for the material and environment combinations. Therefore, staff finds the licensee's identification of aging effects for the welded stainless steel DSC shell and associated subcomponents acceptable.

3.3.2.3 **Evaluation of Proposed Aging Management Activities**

The licensee has developed a DSC External Surfaces Aging Management Program to manage the identified aging effects for the DSC shell, including the exterior surfaces of the bottom lid, the outer suface of the outer top cover plate, and the exterior surfaces of the welds, during the extended period of operation. The staff reviewed the license renewal application and references therein, including consensus codes and standards and operating experience reports and concluded that an AMP is acceptable for ensuring that the identified aging effects will not result in a loss of intended function.

3.3.3 Horizontal Storage Module (HSM)

The licensee stated in the LRA that the HSM consists of the concrete shielding, the dry shielded canister (DSC) support assembly, and the foundation. The licensee further stated that the HSM is considered "important to safety" because it protects the spent fuel container during storage. Each HSM structure is constructed from reinforced concrete and structural steel. The thick concrete walls and roof provide neutron and gamma shielding. Inlets and outlets, and associated pathways, allow for the dissipation of fuel decay heat.

The licensee further stated in the LRA that the concrete HSM is designed in accordance with American Concrete Institute (ACI) 349-85 and the level of testing, inspection, and documentation provided during construction and maintenance is in accordance with the CCNPP QAP (QAP). The licensee also clarified that the approach slabs in front of the HSMs are constructed separately from the HSM foundations, and both of these structures have been designed to minimize differential settlement over the life of the facility.

The licensee identified the following HSM subcomponents as within scope of renewal, which were listed in Table 3.4-1, "Aging Management Review Results for the HSM," of the response to the 4th RAI:

- Reinforced concrete walls, roof, and foundation (HSM-1 through HSM-25)
- DSC structural steel support assembly (HSM-26 and HSM-27)
- DSC seismic retainer (HSM-28)
- Cask docking flange and tie-down restraints (HSM-29 and HSM-30)
- Heat shield (HSM-31)
- Shielded front access door and door supports (HSM-32 and HSM-33)
- Ventilation air openings (one inlet, two outlets) (HSM-34)
- Shielded ventilation air inlet plenum (HSM-1 through HSM-14, and HSM-35)
- Ventilation air outlet shielding blocks (HSM-1 through HSM-14, and HSM-36)
- Lightning protection system (HSM-37)
- Threaded fasteners and expansion anchors (HSM-38)
- Handrail (HSM-39)

The staff reviewed the accuracy of the description with the design bases as described in the ISFSI USAR. The ISFSI USAR states that each HSM structure is constructed in place at the ISFSI site in units of 12, configured in a 2 x 6 array. Each array of 12 HSMs is constructed on a common reinforced concrete foundation slab. The HSM is designed to provide neutron and gamma shielding to achieve a nominal 20 mrem/hr contact dose rate. Nominal contact dose rates at the HSM access door and vents are designed to be less than 100 mrem/hr. Three foot thick end walls provide shielding on the sides of each HSM array. The front walls of the HSMs are thickened to 3-1/2'. Two foot thick interior common walls provide shielding between modules to prevent scatter in adjacent modules during DSC loading and retrieval. The roof slab for the HSMs is 3' thick. The HSM provides passive cooling of the spent fuel by thermal radiation, conduction, and convection. An internal slab and roof caps are provided to shield the ventilation inlet and outlet openings.

The staff confirmed the accuracy of the list of HSM subcomponents provided in the LRA with Table 1.3-1 in the ISFSI USAR. The design safety functions of the Horizontal Storage Module (HSM), are to provide structural support, radiation shielding, and heat transfer, as defined in NUREG–1927. Based on its review, the staff concludes that the description of the HSM is correct and acceptable.

3.3.3.1 **Materials and Environments**

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

1. Reinforced concrete walls, roof, and foundation

The licensee stated in the supplemented LRA that the roof slab, outer walls, between-module walls, and the foundation are made of concrete and reinforcing steel. The licensee further stated that the foundations of the HSMs are established in soil which will not undergo reduction in strength or increased settlement under design bases earthquake conditions.

2. DSC structural steel support assembly

The licensee stated in the supplemented LRA that the DSC support assembly is made of structural steel and Nitronic 60 stainless steel. The Nitronic 60 sliding rails are designed to slide the DSC into and out of the HSM without undue galling, scratching, gouging, or other damage. The rails are coated with a dry film lubricant. The staff reviewed design bases information for the HSM (ADAMS Accession No. ML110730769), which describes the support assembly as fabricated from structural steel. The design bases also states that the top surfaces of the rails are coated with a dry film lubricant (Everlube 823), which is designed for a radiation environment. The support assembly surfaces are also coated with a sacrificial anodic coating (zinc paint), galvanizing, or hard plating for corrosion protection.

3. DSC seismic retainer

The licensee stated in the supplemented LRA that the DSC seismic retainer is made of carbon steel.

4. Cask docking flange and tie-down restraints

The licensee stated in the supplemented LRA that the cask docking flange and tie restraints are made of carbon steel. The staff reviewed design bases information for the HSM which describes the tie-down restraints as embedments provided in the front wall of the HSM. The design bases also states that the HSM embedments are designed as conventional hooks in accordance with ACI 349.85.

5. Heat shield

The licensee stated in the supplemented LRA that the heat shield is fabricated of stainless steel.

6. Shielded front access door and door supports

The licensee stated in the supplemented LRA that the shielded front access door and door supports are made of carbon steel and embedded concrete. The HSM access door consists of a 1-3/4 inch steel plate, 10-3/4 inches of concrete shielding material, and a ¼ inch steel cover plate. Steel angle sections are attached to embedded plates in the HSM front wall to form guides to slide the HSM door vertically. The staff reviewed design bases information for the HSM which describes the door assembly to include a solid neutron-absorbing material for gamma and neutron shielding. Table 4.1-1 of the ISFSI USAR states that the initial NUHOMS®-24P design uses 2.00" of Bisco NS-3 as the neutron shielding material, which was later revised for the specific design bases to be 10.75" of concrete. The licensee confirmed in the response to the 4^{th} RAI that Bisco NS-3 is not used in any of the HSMs at the ISFSI.

7. Ventilation air openings (one inlet, two outlets)

The licensee stated in the supplemented LRA that the ventilation air openings (one inlet/ two outlets) are made of stainless steel. The staff reviewed design bases information for the HSM (ADAMS Accession No. ML110730769), which describes the air inlet and outlets as covered with stainless steel wire bird screen to prevent foreign material from entering the HSM.

8. Shielded ventilation air inlet plenum

The licensee stated in the supplemented LRA that the shielded ventilation air inlet plenum is made of concrete and stainless steel.

9. Ventilation air outlet shielding blocks

The licensee stated in the supplemented LRA that the ventilation air outlet shielding blocks is made of concrete and stainless steel.

10. Lightning protection system

The licensee stated in the supplemented LRA that the lighting protection system is made of copper. The staff reviewed design bases information for the HSM which states that the lightning protection system was installed in compliance with the National Fire Protection Association (NFPA), No. 78, "Lightning Protection Code."

11. Threaded fasteners and expansion anchors

The licensee stated in the supplemented LRA that the threaded fasteners and expansion anchors are made of stainless steel.

12. Handrail

The licensee stated in the supplemented LRA that the handrail is made of stainless steel.

For all HSM subcomponents, the licensee identified environmental conditions that include any conditions known to exist on a recurring basis. These conditions were stated to be based on operating experience, unless design features have been implemented to preclude those conditions from recurring.

The licensee stated that the HSM exteriors are exposed to an outdoor environment that includes extreme winter or summer conditions. The external environment for the HSMs is bounded by the ambient temperature range of −19.4 to 37.8°C [−3 to 103°F]. The licensee used the term "Yard, Air" to describe the external environment in Table 3.4-1 of the response to the 4th RAI, "Aging Management Review Results for the HSM." The licensee further used the term "Embedded/Underground" to describe the below-grade environment of the concrete structures.

The licensee considered the internal environment of the HSM a sheltered environment with no air conditioning (ADAMS Accession No. ML102650247). The subcomponents inside the HSM are protected from outdoor effects (e.g. no precipitation), but are subject to higher temperatures and radiation in an air environment. The licensee used the term "Sheltered" for this environment in Table 3.4-1 of the supplemented LRA, "Aging Management Review Results for the HSM."

The staff reviewed the design bases documents, including the NUH-002 topical report and the ISFSI USAR, to ensure that the materials of construction and environments were adequately described. More specifically, the design bases states that the HSM concrete structure was designed per American Concrete Institute (ACI) 349-85 and fabricated per ACI 318-83. The structural steel components were designed and fabricated to compliance of American Institute of Steel Construction (AISC), "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings," 8th edition. The staff reviewed Table 2.3-1, "Meteorological Extremes in the Calvert Cliffs Region," in Section 2.3 of the ISFSI USAR and confirmed that the licensee has adequately provided the climatic characteristics of the site region. The staff concludes that the licensee adequately identified the materials of construction and service environment of the concrete pads.

3.3.3.2 **Aging Effects/Mechanisms on the HSM**

The licensee stated that a review of industry operating experience identified a large number of events related to dry storage. Many of these were event-driven incidents, and most were not related to aging management. However for the incidents that involved aging mechanisms, barrier analyses were conducted to assess Calvert Cliffs' susceptibility to these mechanisms. The licensee clarified that the operating experience review indicated the aging mechanisms are bounded by the AMR performed for the Calvert Cliffs SSCs.

The licensee listed all applicable aging effects/mechanisms for the HSM in Table 3.4-1, "Aging Management Review for the HSM," of the response to the 4th RAI. More specifically, the licensee identified the following aging effects/mechanisms that could lead to a loss of design safety functions of the above-grade reinforced concrete structure:

- Cracking due to freeze-thaw degradation (HSM-1)
- Loss of material (spalling, scaling) due to freeze-thaw degradation (HSM-2)
- Cracking due to moisture, chemical attack, or leaching (HSM-3)

- Loss of material due to moisture, chemical attack, or leaching (HSM-4)
- Corrosion due to moisture, chemical attack, or leaching (HSM-5)
- Increase in porosity/permeability due to leaching of $Ca(OH)_2$ (HSM-6)
- Loss of strength due to leaching of $Ca(OH)_2$ (HSM-7)
- Cracking due to cement aggregate reactions (HSM-8)
- Loss of material due to cement aggregate reactions (HSM-9)
- Increase in porosity/permeability due to cement aggregate reactions (HSM-10)
- Loss of strength due to cement aggregate reactions (HSM-11)
- Cracking due to settlement or loss of bond with embedded steel (HSM-12)
- Cracking due to irradiation (HSM-13)
- Loss of material (spalling, scaling) due to irradiation (HSM-14)

The licensee further identified the following aging effects/mechanisms that could lead to a loss of design safety functions of the below-grade reinforced concrete structure:

- Cracking due to freeze-thaw degradation (HSM-15)
- Loss of material (spalling, scaling) due to freeze-thaw degradation (HSM-16)
- Cracking due to moisture, chemical attack, or leaching (HSM-17)
- Loss of material due to moisture, chemical attack, or leaching (HSM-18)
- Corrosion due to moisture, chemical attack, or leaching (HSM-19)
- Increase in porosity/permeability due to leaching of $Ca(OH)_2$ (HSM-20)
- Loss of strength due to leaching of $Ca(OH)_2$ (HSM-21)
- Cracking due to irradiation (HSM-22)
- Loss of material (spalling, scaling) due to irradiation (HSM-23)
- Cracking due to cement aggregate reactions (HSM-24)
- Loss of material due to cement aggregate reactions (HSM-25)

The licensee identified the following aging effects/mechanisms that could lead to a loss of design safety functions for the carbon steel HSM subcomponents:

- Loss of material due to corrosion (HSM-26, HSM-28 through HSM-30, HSM-32)

The licensee further clarified in the supplemented LRA that the aging mechanism for the carbon steel is general corrosion. The licensee also provided TLAAs in the supplemented LRA to address the aging mechanisms of neutron/gamma irradiation, high temperature dehydration, and thermal cycling of the HSM concrete, which were reviewed in Section 3.4 of this SER.

The licensee also stated (Attachment 2 of the 4th RAI response), that the in-service HSMs (#1 through #72) have embedment around the vent areas to which the vent screens are bolted. The new modular HSMs have structural mounting bolts attaching the outlet vent modules. The licensee clarified that, to date, there has been no "Freeze-Thaw" degradation on either the in-service or new HSMs.

The staff recognizes that the applicant did not identify any aging effects/mechanisms for the stainless steel subcomponents. However, the licensee's AMP for the HSM (reviewed in Section 3.5.2 of this SER) includes visual inspection for the aging effect of loss of material due to general, pitting and crevice corrosion in both steel components on the external surface of the HSM and the DSC structural support steel components. The HSM AMP also stated that the acceptance criteria for the DSC support structure for both stainless and carnon steel components shall be based on the design methodologies defined in the ISFSI USAR Section 4.2.1.1 (ADAMS Accession No. ML12275A428). This USAR section references "American Institute of Steel Construction (AISC), "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings," 8th Edition.

The staff reviewed the ISFSI design bases, applicable industry-wide operating experience and guidance provided in consensus codes and standards [ACI 349.3R-02, ACI 201.1R-08 and ASCE 11-99]. Based on its review, the staff finds the licensee's identification of aging mechanisms and effects for the HSM acceptable.

3.3.3.3 **Evaluation of Proposed Aging Management Activities**

The licensee proposed an AMP, "HSM Aging Management Program," to manage the identified aging effects or mechanisms for the HSM. The staff reviewed the supplemented license renewal application and references therein, including design bases and operating experience reports, and concluded that an AMP is acceptable for ensuring the identified aging effects will not lead to a loss of intended function.

3.3.4 Transfer Cask

The licensee stated that the transfer cask provides radiological shielding during the DSC closure operations and during transfer of the DSC to the HSM. To ensure structural integrity, the transfer cask also provides protection of the DSC against potential natural and operational hazards during transport and transfer of the DSC to the HSM. Both solid neutron and lead gamma shielding are incorporated into the transfer cask design. The major transfer cask components are divided into sub-components that are included in Table 3.5-1 in the LRA, along with the particular function the individual sub-component performs to support the overall cask intended functions. The licensee identified the following DSC components to be within the scope of the renewal:

- Cask Body: Structural Shell, Bottom Support Ring, Bottom Cover Plate, Top Flange, Inner Shell, Lead (TC-1 through TC-7)

- Cask Attachments; Rails, Upper Trunnions, Upper Trunnion Sleeves, Upper Trunnion Nickel Alloy, Upper Trunnion Neutron Shielding, Upper Trunnion Cover Plate, Lower Trunnions, Lower Trunnion Sleeves, Lower Trunnion Sleeve Nickel Alloy Weld Overlay, Lower Trunnion Neutron Shielding (TC-8 through TC-17)

- Cask Penetration: Ram Access Penetration Ring (TC-18)

- Cask Neutron Shield: Upper and Lower Rings, Outer Shell Relief Valve Support Plates, Inner and Outer Support Angle, Shielding Material (TC-19 through TC-21)

- Top Cover Assembly: Inner, Outer, and Side Plates, Ring; Eye Bolt Stand-offs, Neutron Shielding (TC-22 through TC-24)

- Bottom Cover Assembly: Inner, Outer, and Side Plates, Bottom Cover O-ring Seals, Neutron Shielding (TC-25 through TC-27)

- Cask Bottom Cover Plate (TC-28)

- Cask Bottom Neutron Shielding (TC-29)

- Bolts, Washers, and Threaded Fasteners for Top Cover Plate and Ram Access Plate (TC-30 and TC-31)

The licensee summarized the AMR results for the transfer cask in LRA table 3.5-1 the staff's evaluation of the AMR results is provided in this section.

3.3.4.1 **Materials and Environments**

The licensee identified the materials of construction for the Transfer Cask subcomponents that were subject to AMR in LRA Table 3.5-1. The AMR for the Transfer Cask subcomponents was updated in response to a request for additional information. The transfer cask body is constructed from carbon steel and stainless steel, trunnions are constructed from stainless steel and nickel alloy. The transfer cask uses Bisco NS-3 as a neutron absorber in several locations and lead as a gamma shielding material. The staff reviewed the Transfer Cask design bases as well as the information presented in Chapter 4 of the Calvert Cliffs ISFSI USAR, Rev. 21. along with general description information and confirmed that the licensee adequately identified the materials of construction for the DSC and its associated subcomponents.

Exposure environments for the transfer cask include (1) borated water during fuel loading while the transfer cask is in the SFP (2) demineralized water in the annulus between the DSC and inner cavity wall of the transfer cask (3) demineralized water on external surfaces during decontamination (4) Ambient outside conditions during transfer to and loading operations at the ISFSI (5) radiation exposure from the loaded DSC during transfer and (6) a sheltered environment during storage when not in use. Exposure temperatures during storage are considered to be the same as the ambient environment and the transfer cask has been evaluated over the ambient temperature range from -3 to 103^{o}F as described in Chapter 3 of the Calvert Cliffs ISFSI USAR, Rev. 21.

3.3.4.2 **Aging Effects/Mechanisms on the Transfer Cask**

Aging effects applicable to the transfer cask include fatigue of the cask and the cask trunnions as a result of lifting operations during the transfer of DSC from the spent fuel pool to the ISFSI HSMs.

The licensee's evaluation indicted that the exposure times to borated water, deionized water, radiation and outdoor environments are short duration events that do not contribute to the aging of the transfer cask materials during the renewal period. Rather, it is the prolonged or frequently recurring exposure to environmental conditions and stresses that must be evaluated for aging effects, such as those encountered during storage or staging prior to use for DSC transfers. Because of the materials of construction, only the carbon steel subcomponents requires aging management. This includes the structural shell of the transfer cask body, bolts/washers associated with the top cover, and the bottom plate. No credit is taken for the coating on the top cover assembly. The Licensee determined that the prolonged exposure to a sheltered environment went the transfer cask is not in use may result in the following aging effect for the transfer cask:

- Loss of Material due to General Corrosion and Pitting (Sheltered Environment).

The staff reviewed the licensee's identification of aging mechanisms and effects for the Transfer cask and associated subcomponents. Based on its review of the credible aging effects listed in NUREG–1801 as well as operational experience with similar systems the staff determined that the licensee performed a comprehensive AMR for the material and environment combinations, and therefore, . the staff finds the licensee's identification of aging effects for the transfer cask and associated subcomponents acceptable.

3.3.4.3 **Evaluation of Proposed Aging Management Activities**

The Licensee has included AREVA Technical Report 10955-0101 in Appendix B to the LRA which contains a time-limited aging analyses (TLAA) that evaluates fatigue of the transfer cask and transfer cask trunnions to demonstrate safe operation over the extended service life of the ISFSI. The staff have reviewed the AREVA Technical Report and concluded the TLAA for the fatigue of the transfer cask and transfer cask trunnions is acceptable for ensuring that the identified aging effects will not result in a loss of intended function.

The licensee credits the Transfer Cask Aging Management Program to manage the identified aging effects for the transfer cask and associated subcomponents during the extended period of operation. The staff reviewed the license renewal application and references therein, including consensus codes and standards cited for inspection methods and acceptance criteria and concluded that an AMP is acceptable for ensuring that the identified aging effects will not result in a loss of intended function.

3.3.5 Transfer Cask Lifting Yoke

The licensee stated that the transfer cask lifting yoke is a special lifting device which provides the means for performing all cask handling operations within the plant's auxiliary building. It is designed to support a loaded transfer cask weighing up to 109.25 tons. The lifting yoke is a passive, open hook design with two parallel lifting beams designed to be compatible with the spent fuel cask handling crane hook and load block. A lifting pin connects the spent fuel cask handling crane hook and the transfer cask lifting yoke. The lifting yoke engages the outer shoulder of the transfer cask lifting trunnions. The licensee identified the following DSC components to be within the scope of the renewal:

- Lifting Hook Plates (TCLY-1 through TCLY-3)
- Lifting Beam Plates (TCLY-4 through TCLY-6)
- Later Brace Plates (TCLY-7 and TCLY-8)
- Support Brace Plates (TCLY-9 and TCLY-10)
- Pin (Round Bar) (TCLY-11 and TCLY-12)
- Main Assembly Bolts, Nuts, Washers (TCLY-13 and TCLY-14)
- Hook Bearing Plate (TCLY-15)

The licensee summarized the AMR results for the transfer cask lifting yoke in LRA Table 3.6-1 the staff's evaluation of the AMR results is provided in this section.

3.3.5.1 **Materials and Environments**

The licensee identified the materials of construction for the Transfer Cask subcomponents that were subject to AMR in LRA Table 3.5-1. The AMR for the Transfer Cask subcomponents was updated in response to a request for additional information. The transfer cask lifting yoke is constructed from carbon steel for the main structural components. Stainless steel is used for the sling assembly and the connecting pit to attach the yoke to the cask handling crane hook. The bearing plates are bronze. The staff reviewed the Transfer Cask design bases as well as the information presented in Chapter 4 of the Calvert Cliffs ISFSI USAR, Rev. 21.

Exposure environments for the transfer cask lifting yoke include (1) borated water during fuel loading while the transfer cask is in the SFP (2) demineralized water during decontamination (3) Ambient outside conditions during transfer to and loading operations at the ISFSI and (4) a sheltered environment during storage when not in use. Exposure temperatures are not provided but during storage are considered to be the same as the ambient environment and during use the exposure temperature would be similar to that of the transfer cask temperature range of -3 to 103F as described in Chapter 3 of the Calvert Cliffs ISFSI USAR, Rev. 21.

3.3.5.2 **Aging Effects/Mechanisms on the Transfer Cask Lifting Yoke**

Aging effects applicable to the transfer cask lifting yoke include fatigue as a result of lifting operations during the transfer of DSC from the spent fuel pool to the ISFSI HSMs.

The licensee's evaluation indicted that the exposure times to borated water, deionized water, radiation and outdoor environments are short duration events that do not contribute to the aging of the transfer cask lifting yoke materials during the renewal period. Rather, it is the prolonged or frequently recurring exposure to environmental conditions and stresses that must be evaluated for aging effects, such as those encountered during storage or staging prior to use for DSC transfers. Because of the materials of construction, no aging effects were identified for the stainless steel and bronze subcomponents. Only the carbon steel subcomponents require aging management and this includes the Lifting Hook Plates, Lifting Beam Plates, Later Brace Plates, Support Brace Plates, and the Main Assembly Bolts, Nuts and Washers. The Licensee determined that the prolonged exposure to a sheltered environment when the transfer cask is not in use may result in the following aging effect for the transfer cask:

- Loss of Material due to General Corrosion and Pitting (Sheltered Environment)

The staff reviewed the licensee's identification of aging mechanisms and effects for the Transfer Cask Lifting Yoke and associated subcomponents. Based on its review of the credible aging effects listed in NUREG–1801 as well as operational experience with similar systems the staff determined that the licensee performed a comprehensive AMR for the material and environment combinations, and therefore, the staff finds the licensee's identification of aging effects for the transfer cask lifting yoke and associated subcomponents acceptable.

3.3.5.3 **Evaluation of Proposed Aging Management Activities**

The Licensee has included AREVA Technical Report 10955-0201 in Appendix B to the LRA which contains a time-limited aging analyses (TLAA) that evaluates fatigue of the transfer cask lifting yoke to demonstrate safe operation over the extended service life of the ISFSI. The AREVA Technical report indicates structural adequacy against fatigue failure for up to 286 transfer cask loading/unloading operations. The staff have reviewed the AREVA Technical Report and concluded the TLAA for the fatigue of the transfer cask and transfer cask trunnions is acceptable for ensuring that the identified aging effects will not result in a loss of intended function.

The licensee credits the Transfer Cask Lifting Yoke Aging Management Program to manage the identified aging effects for the transfer cask lifting yoke and associated subcomponents during the extended period of operation. The staff reviewed the license renewal application and references therein, including consensus codes and standards cited for inspection methods and acceptance criteria and concluded that an AMP is acceptable for ensuring that the identified aging effects will not result in a loss of intended function.

3.3.6 Cask Support Platform

The cask support platform is located in the cask pit area of the Unit 1 SFP. The cask support platform serves to elevate the pit floor surface so that the lifting trunnions on the transfer cask do not interfere with the cask seismic restraint. The licensee identified the following cask support platform subcomponents to be within the scope of the renewal:

- Base Plate (CSP-1)
- Web Plates (CSP-2)
- Mid Plate (CSP-3)
- Top Plate (CSP-4)
- Honeycomb Energy Absorber (CSP-5)

- Honeycomb Base Plate (CSP-6)
- Honeycomb Casing Plate (CSP-7)
- Honeycomb Outer Plate (CSP-8)
- Bottom Location Plates (CSP-9)
- Lifting Lugs (CSP-10)

The licensee summarized the AMR results for the cask support platform in LRA Table 3.7-1 the staff's evaluation of the AMR results is provided in this section.

3.3.6.1 **Materials and Environments**

The licensee identified the materials of construction for the cask support platform subcomponents that were subject to AMR in LRA Table 3.7-1. Materials used in the cask support platform include stainless steel for the main structural components. The honeycomb energy absorber is constructed from aluminum. The staff reviewed the cask support platform design bases and confirmed that the licensee adequately identified the materials of construction for the cask support platform and its associated subcomponents.

The cask support platform is continuously exposed to a borated water environment as it remains in the SFP during and between DSC transfers. However, the Hexcel aluminum honeycomb material inside the cask support platform shell is maintained in a compressed air environment and is not contacted by the borated water.

3.3.6.2 **Aging Effects/Mechanisms on the Cask Support Platform**

The licensee determined that only the stainless steel subcomponents of the cask support platform are susceptible to aging during the renewal period. Based on the stainless steel material and borated water environment combination, the following aging effects were determined to require management during the renewed license period:

- Loss of Material and Cracking due to Pitting and Stress Corrosion Cracking (Borated Water) – Stainless Steel

This includes the cask support platform Base Plate, Web Plates, Mid Plate, Top Plate, Honeycomb Base Plate, Honeycomb Casing Plate, Honeycomb Outer Plate, Bottom Location Plates, and Lifting Lugs. No aging effects were identified for the Hexcel aluminum honeycomb material inside the cask support platform shell.

The staff reviewed the licensee's identification of aging mechanisms and effects for the cask support platform and associated subcomponents. Based on its review of the credible aging effects listed in NUREG–1801 as well as operational experience with similar systems the staff determined that the licensee performed a comprehensive AMR for the material and environment combinations. The staff finds the licensee's identification of aging effects for the cask support platform and associated subcomponents acceptable.

3.3.6.3 **Evaluation of Proposed Aging Management Activities**

The licensee credits the Chemistry Control Program with managing the aging effects for stainless steel in a borated water environment. The staff reviewed the license renewal application and references therein and concluded that an AMP is acceptable for ensuring that the identified aging effects will not result in a loss of intended function.

3.3.7 Spent Fuel Cask Handling Crane

The licensee provided in the LRA an aging management review for the spent fuel cask handling crane (ADAMS Accession No. ML102650247). The CCNPP USAR states that the spent fuel cask handling crane, which is designed to meet the single-failure-proof criteria of NUREG–0554 (NRC, 1979) and NUREG–0612 (NRC-1980), is used to handle heavy loads during the dry cask storage operations in the spent fuel pool area. The licensee stated that the operation of the spent fuel cask handling crane is controlled by 10 CFR Part 50, therefore an AMR for license renewal under 10 CFR Part 72 was not performed. The licensee also stated that Calvert Cliffs will remain responsible for maintaining the spent fuel pool and associated support equipment until such time that all irradiated fuel assemblies are transferred offsite. Moreover, the licensee stated that the requirements of 10 CFR 50.54(bb) will ensure that components covered under 10 CFR Part 50 which support its ISFSI operation will continue to be appropriately maintained for the remainder of the ISFSI renewal period.

The licensee credited the AMPs, as described in Table 16-2, Item 11 of the CCNPP USAR, for managing the aging effects of the spent fuel cask handling crane. The licensee implemented preventive maintenance tasks in accordance with its preventive maintenance program procedures to manage general corrosion of carbon steel components of fuel handling equipment and fatigue, wear, and mechanical degradation of carbon steel wire rope. The licensee stated that visual inspections of the spent fuel cask handling crane are performed annually or prior to its use for fuel transfer operations. The licensee concluded that the spent fuel cask handling crane is adequately managed by its AMPs under 10 CFR Part 50, so that there is reasonable assurance that the SSC intended functions will be maintained.

The staff verified the information presented in the CCNPP UFSAR to ensure that aging effects for the spent fuel cask handling crane are adequately managed under 10 CFR Part 50. Table 16-2, Item 11, of the CCNPP UFSAR references the CCNPP license renewal application (Appendix A, Section 3.2, “Fuel Handling Equipment and Other Heavy Load Handling Cranes”). The CCNPP LRA states that the Aging Management Review of the spent fuel cask handling crane included general corrosion/oxidation, fatigue, wear and mechanical degradation/distortion as applicable aging mechanisms. The staff finds that the AMR results and the implemeneted AMP for the spent fuel cask handling crane, as approved by the Division of License Renewal under 10 CFR 54, are sufficient to satisfy the requirements for 10 CFR Part 72 specific license renewal.

3.3.8 Spent Fuel Handling Machine

The licensee provided in the LRA an aging management review for the spent fuel handling machine (SFHM) (ADAMS Accession No. ML102650247). The SFHM is a bridge and trolley arrangement that rides on rails set in concrete on each side of the spent fuel pool. The SFHM transfers fuel between storage locations in the spent fuel pool area. The licensee stated that the SFHM operation is controlled by 10 CFR Part 50, therefore an AMR for license renewal under 10 CFR Part 72 was not performed. The licensee also stated that the requirements of 10 CFR 50.54(bb) will ensure that components covered under 10 CFR Part 50 which support its

ISFSI operation will continue to be appropriately maintained for the remainder of the ISFSI renewal period.

The licensee credited the AMPs, as described in Table 16-2, items 12 and 13 of CCNPP UFSAR (ADAMS Accession No. ML082660398), for managing the aging effects of the SFHM sucomponents, as identified in those tables. The LRA (ADAMS Accession No. ML10265247) states that the SFHM includes carbon steel subcomponents and the stainless steel wire rope. The LRA further defines the SFHM subcomponents to be made of carbon steel and a stainless steel wire rope. The LRA also identifies the aging mechanisms of general corrosion/oxidation, fatigue, wear and mechanical degradation. The licensee stated in the LRA that inspections of the SFHM and associated components are performed prior to its use for refueling campaigns, which include performing a walk down for foreign material and cleanliness; inspecting for damaged, corroded, or deteriorated parts; and checking cleanliness of rail surfaces. The licensee concluded in the LRA that the spent fuel handling machine is adequately managed by its AMPs under 10 CFR Part 50, so there is reasonable assurance that the SSC intended functions will be maintained.

The staff verified the information presented in the CCNPP UFSAR (ADAMS Accession No. ML082660398), to ensure that aging effects for the spent fuel handling machine are adequately managed under 10 CFR Part 50. Table 16-2, "Aging Management Programs, Indexed by LRA Section and System," items 12 and 13, identified the aging effects of general corrosion of the SFHM carbon steel components, and fatigue, wear, and mechanical degradation of the stainless steel wire rope. Table 16-2, item 12 credits the Performance Evaluation Program (PEM) for monitoring of the SFHM and associated components. Table 16-2, item 12 further states that the PEM includes checks of the SFHM and associated components prior to refueling campaigns (i.e., defuel/refuel or fuel shuffle). These procedures require performing a walkdown for foreign material and cleanliness, inspecting the SFHM and associated equipment for damaged, corroded, or deteriorated parts, and checking cleanliness of rail surfaces. Table 16-2, item 13 states that that, in accordance with Operations Section Performance Evaluations, "Fuel Transfer System," the hoisting ropes and drive cables for the fuel upending machines and transfer carriages are visually inspected for damage. The PEM provides for wire rope inspection for the SFHM, RRM. The SFHM procedures require visual inspection of the hoisting rope while running the hoist through the full length of travel. The CCNPP USAR (ADAMS Accession No. ML082660398) states that the plant's nuclear operations procedures have numerous levels of controls and reviews, including assignment of responsibility for conducting performance evaluations as required, reviewing all the evaluations for accuracy and completeness, and analyzing data for trends, if applicable. Specific responsibilities are assigned to CCNPP personnel for monitoring these programs through periodic audits. These controls provide reasonable assurance that the associated activities will continue to be an effective means of monitoring the fuel handling equipment for the effects of general corrosion/oxidation.

The staff reviewed the information presented in the LRA (ADAMS Accession No. ML102650247) and described in the CCNPP UFSAR (ADAMS Accession No. ML082660398) pertinent to the AMPs credited for managing the aging effects of the spent fuel handling machine under 10 CFR Part 50. The staff finds that the AMR results and the implemeneted AMP for the spent fuel handling machine, as approved by the Division of License Renewal under 10 CFR Part 54, are sufficient to satisfy the requirements for 10 CFR Part 72 specific license renewal.

3.3.9 Evaluation Findings

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

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

F3.2 The licensee's review process to be comprehensive in identifying all pertinent aging mechanisms and effects applicable to the in-scope SSCs and provided a summary of the information in the LRA with a commitment to incorporate Attachment 4 of the 4th RAI response, safety analysis report (SAR) supplement and changes, into the USAR.

3.4 Time-Limited Aging Analyses Evaluation

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

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

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

2. Consider the effects of aging;

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

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

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

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

The licensee identified the following TLAAs meeting all six criteria per 10 CFR 72.3:

1. Radiation, Decay Heat, and Thermal Cycling on HSM Concrete

2. Poison Plates (NUHOMS®-32P DSC)

3. DSC Fatigue Evaluation

4. Fuel Cladding Maximum Temperature

5. DSC Support Rail Steel

6. Transfer Cask Fatigue Evaluation

7. Transfer Cask Trunnions, Lifting Yoke Fatigue Evaluation

8. Bisco NS-3 in Transfer Cask

9. DSC Support Structure Thermal Analysis

Based on its review of the design bases documents, the staff confirmed that the licensee identified all calculations and analyses meeting all six criteria in 10 CFR 72.3 and therefore concludes that the licensee adequately identified all TLAAs.

3.4.1 Radiation, Decay Heat, and Thermal Cycling on HSM Concrete

The licensee provided a calculation in the LRA to address the aging mechanism of neutron and gamma irradiation. For an HSM containing a NUHOMS®-24P DSC, Section 3.4.3 of the LRA states that the expected gamma energy fluence deposited in the HSM concrete is 6.8×10^{10} MeV/cm^2-sec and the cumulative neutron fluence is 1.44×10^{14} neutrons/cm^2 in 60 years based on an extrapolation of a neutron fluence of 1.2×10^{14} neutrons/cm^2 in 50 years (ADAMS Accession No. ML110740080). The licensee further stated that the expected gamma fluence for the NUHOMS®-32P DSC is less than the gamma fluence determined for the NUHOMS–24P. The licensee also indicated that the neutron fluence for the NUHOMS®-32P would remain below the threshold value which would result in neutron-induced degradation of the concrete based upon calculations that support the use of the higher burnup limit of 52 GWd/MTU for the NUHOMS®-32P DSC (ADAMS Accession No. ML12275A436). Thus, the licensee concluded that there will be a negligible temperature rise in the HSM concrete at the level of gamma energy fluence, and the neutron fluence level is below the threshold value that would result in neutron-induced degradation of the concrete.

In TLAA Section 4.2 (ADAMS Accession No. ML102650247), the licensee also addressed the aging mechanism of high temperature dehydration. The licensee stated that the maximum temperature of concrete at the beginning of storage with the NUHOMS®-24P was established to be below 150°F using a bounding decay at the beginning of storage life. The licensee further stated that the maximum temperature of the concrete at the beginning of storage with a NUHOM-32P is 157°F. The maximum concrete temperatures for both systems is below the limit of 200°F. The licensee stated that the maximum concrete temperatures for the additional 40 years of service will be lower because the decay heat reduces monotonically as a function of time. Hence, the heating effect on the concrete, for the future 40 years of service, will be much less severe than the past 20 years of service (ADAMS Accession No. ML110740080).

The licensee also included TLAAs in the supplemented LRA to address the aging mechanism of thermal cycling fatigue of the HSM. The licensee stated that the design bases topical report (ADAMS Accession No. ML110740080) provided an analysis of thermal cycling of HSM based on the 50-year storage life. The number of cycles will increase from 18,250 to 21,900 when the design life is extended from 50 years of storage to 60 years of storage. These are still significantly below the limit of 10,000,000 identified in the design bases topical report. Therefore, thermal cycling will have negligible impact on the HSM reinforced concrete.

The staff reviewed the design bases calculation presented in the design bases in the topical report and the ISFSI USAR, including the assumptions and calculations. The staff determined that the TLAAs for the HSM are acceptable because they adequately predict the extent of degradation due to radiation, decay heat, and thermal cycling and provide a valid technical basis for concluding that HSM will continue to perform its intended safety functions..

3.4.2 Poison Plates (NUHOMS®-32P DSC)

The licensee evaluated the aging effects of neutron radiation on the B^{10} content of the neutron poison plates used in the 32P DSCs. The licensee asserts, in the LRA, that the neutron flux from irradiated fuel will result in negligible depletion of the B^{10} content in the neutron absorber materials over the life of the storage system. The licensee demonstrated this by using the neutron activity per assembly (4.175×10^8 n/s) corresponding to the extended burnup limits up to 52,000 MWD/MTU. The licensee specified that it used a surface area of 25,000 cm^2 which is less than that calculated for the fuel compartment (34658 cm^2). Staff determined this to be acceptable since it conservatively assumes a higher concentration of neutrons per cm^2. The licensee used the calculated scalar flux to determine the total neutron fluence (1.7×10^{14} n/cm^2) over the 60 year period. The licensee specifies it ignores the fact that the flux in that region would be mostly fast and epithermal and declining over time. Staff determined this method to be conservative because it assumes all neutrons interact with the B^{10} in the poison plates. The licensee specified a minimum areal density of 10 mg B^{10}/cm^2 for the neutron absorber poison plates. However, for conservatism, the licensee specifies that a reduced areal density of 7.5 mg B^{10}/cm^2 was used in the analysis. Staff determined that this is conservative because it assumes a smaller number of B^{10} atoms per cm^2 in the poison plate material. In the LRA, the licensee compared the resulting limiting number of B^{10} atoms per cm^2 to the total calculated neutron fluence for 60 years to demonstrate that the number of B^{10} atoms/cm^2 exceeds the neutron fluence for the total storage period of 60 years. Staff determined the assumptions used by the licensee to be appropriate and conservative. Based on its review, the staff finds the licensee's evaluation of the poison plates used in the 32P DSC acceptable.

3.4.3 DSC Fatigue Evaluation

In TLAA Section 4.1 (ADAMS Accession No. ML102650247), the licensee evaluated the NUHOMS®-24P and NUHOMS®-32P DSCs for fatigue for a 60-year service life. The licensee has stated that the NUHOMS®-24P and NUHOMS®-32P DSCs are designed with sufficient clearance in the radial and axial direction to permit free thermal expansion and this design feature acts to minimize the thermal cycling and fatigue of the DSC. The licensee has stated that with increased time the decay heat also decreases which reduces the possibility of fatigue due to thermal expansion.

The licensee evaluated fatigue of the NUHOMS®-24P and NUHOMS®-32P DSCs for 60 years of operation using the ASME Boiler and Pressure Vessel (B&PV) Code Section III NB–3222.4(d) (ASME 1999). NB–3222.4(d) specifies six criteria that are used to determine whether a detailed fatigue analysis is necessary. The licensee provided calculations for the NUHOMS®-24P and NUHOMS®-32P DSCs to show that a detailed fatigue analyses is not required.

The staff reviewed the calculations for each of the six criteria in the fatigue assessment provided by the licensee in LRA for the NUHOMS®-24P and NUHOMS®-32P DSCs. In addition, the staff reviewed ASME B&PV Code Section III Div. I Section III NB–3222.4(d) (ASME 1999). The staff verified that the DSC fatigue evaluation meets all of the six criteria in Section III NB–3222.4(d) including (1) atmospheric to service pressure cycle, (2) normal service pressure fluctuation, (3) temperature difference startup and shutdown, (4) temperature difference-normal service, (5) temperature difference-dissimilar metals, and (6) mechanical loads. Because all six criteria of ASME B&PV Code Section III Div. 1 in Section III NB–3222.4(d) (ASME 1999) are met, a detailed fatigue analyses is not required and the staff concludes that the design and operating conditions of the NUHOMS®-24P and NUHOMS®-32P DSCs will not create any potential risk of fatigue failure during 60 years of operation.

3.4.4 Fuel Cladding Maximum Temperature

In TLAA Section 4.2 (ADAMS Accession No. ML102650247), the licensee evaluated the maximum fuel cladding temperatures expected during storage for both the NUHOMS®-24P and NUHOMS®-32P DSCs. The licensee stated that the maximum fuel cladding temperature for the NUHOMS®-24P DSC at the initiation of storage was calculated to be 322°C [612°F], assuming long term storage at an ambient temperature of 70°F. The licensee further stated in the LRA that the maximum fuel cladding temperature for the NUHOMS®-32P DSC at the initiation of storage was calculated to be 313°C [596°F], assuming long term storage at an ambient temperature of 70°F. The peak cladding temperatures are expected to decrease during long-term storage due to the monotonic reduction in decay heat as a function of time (Figure 8.1-28, ADAMS Accession No. ML122750271). Therefore, the licensee states that fuel cladding temperatures will remain below the limits for the additional 40 years of storage.

The staff reviewed the ISFSI USAR to determine the expected maximum fuel cladding temperatures. In Section 8.1.3.2 of the ISFSI USAR (ADAMS Accession No. ML122750271), a peak fuel clad temperature limit of 335°C [635°F] for normal conditions of storage is specified as a design parameter for the Calvert Cliffs NUHOMS® system. The ISFSI USAR also states that the evaluation presented in Section 3.3.7 (ADAMS Accession No. ML122750271), "Materials Handling and Storage," was not affected by the addition of the NUHOMS®-32P DSC to the NUHOMS® system, with the exception of peak cladding temperatures which are higher than those of the NUHOMS®-24P DSC. For long-term storage, HSM passive ventilation maintains the maximum normal operating fuel clad temperature at 327°C [620°F] or less (assuming 103°F ambient temperature). ISG-11, Rev. 3 (NRC, 2003) specifies the maximum fuel cladding temperature for normal conditions of storage should not exceed 400°C [752°F]. During short-term conditions, such as DSC draining and drying, transfer of the DSC to/from the HSM and off-normal and accident temperature excursions, the fuel cladding temperature maximum value is 448°C [838°F], as stated in the ISFSI USAR (ADAMS Accession No. ML122750271) which is below the 570°C [1,058°F] fuel cladding temperature limit given in ISG–11, Rev. 3.

The staff has reviewed the licensee's TLAA evaluation for the maximum fuel cladding temperature. The staff also notes that a High Burnup Fuel Aging Management Program has been included as a confirmatory program to ensure ISG-11, Rev. 3 assumptions are valid. Because the licensee has effectively demonstrated that the maximum fuel cladding temperature will remain below the design limits for the period of extended operation, the staff finds the TLAA for maximum fuel cladding temperature acceptable.

3.4.5 DSC Support Rail Steel

In TLAA Section 4.1 (ML102650247), the licensee evaluated the NUHOMS®-24P and NUHOMS®-32P DSCs for fatigue for a 60-year service life. The licensee has stated that the NUHOMS®-24P and NUHOMS®-32P DSCs are designed with sufficient clearance in the radial and axial direction to permit free thermal expansion and this design feature acts to minimize the thermal cycling and fatigue of the DSC. The licensee has stated that with increased time the decay heat also decreases which reduces to possibility of fatigue due to thermal expansion.

The licensee evaluated fatigue of the NUHOMS®-24P and NUHOMS®-32P DSCs for 60 years of operation using the ASME B&PV Code Section III NB–3222.4(d) (ASME 1999). NB–3222.4(d) specifies six criteria that are used to determine whether a detailed fatigue analysis is necessary. The licensee provided calculations for the NUHOMS®-24P and NUHOMS®-32P DSCs to show that a detailed fatigue analyses is not required (CCNPP 2010 ADAMS Accession No. ML102650247).

The staff reviewed the calculations for each of the six criteria in the fatigue assessment provided by the licensee in LRA for the NUHOMS®-24P and NUHOMS®-32P DSCs. In addition, the staff reviewed ASME B&PV Code Section III Div. I Section III NB–3222.4(d). The staff verified that the DSC fatigue evaluation meets all of the six criteria in Section III NB–3222.4(d) including (1) atmospheric to service pressure cycle, (2) normal service pressure fluctuation, (3) temperature difference startup and shutdown, (4) temperature difference-normal service, (5) temperature difference-dissimilar metals, and (6) mechanical loads. Because all six criteria of ASME B&PV Code Section III Div 1 in Section III NB–3222.4(d) are met, a detailed fatigue analyses is not required and the design and operating conditions of the NUHOMS®-24P and NUHOMS®-32P DSCs will not create any potential risk of fatigue failure during 60 years of operation.

3.4.6 Transfer Cask Fatigue Evaluation

In Section 4.3 (ADAMS Accession No. ML102650247), the licensee evaluated the transfer cask for fatigue for a 60-year service life in accordance with the criteria of ASME B&PV Code Section III Div. 1 NC–3219.2. The licensee has provided calculations based on conservative assumptions to show that all six criteria in NC–3219.2 Condition B that are used to determine whether a detailed fatigue analysis is necessary have been met.

The staff reviewed the transfer cask fatigue analysis (ADAMS Accession No. ML102650247), in which the licensee presented detailed calculations for each of the six criteria of NC–3219.2 Condition B and verified that the transfer cask fatigue evaluation meets all six criteria in Section III NC–3219.2. The staff have determined that a detailed fatigue analysis of the transfer cask is not required based on the design and operating parameters because the transfer cask service loads do not create a potential risk for fatigue failure during 60 years of operation.

3.4.7 Transfer Cask Trunnions, Lifting Yoke Fatigue Evaluation

In Section 4.3 (ADAMS Accession No. ML102650247), the licensee evaluated fatigue of the transfer cask trunnions and lifting yoke system for the planned 60-year service life in accordance with Section III NB–3222.4 and fatigue curves given in Appendix I of ASME B&PV Code Section III Div. 1.

The staff reviewed the fatigue assessment in the licensee-provided calculation (ADAMS Accession No. ML102650247). The allowable fatigue cycles for each subcomponent of the transfer cask trunnions and transfer cask lifting yoke systems for both the NUHOMS®-24P and NUHOMS®-32P DSCs, taken from reference 28, are shown in the following tables:

Allowable Fatigue Cycles for NUHOMS®-24P

Transfer Cask Components	Allowable Fatigue Cycles
Upper Trunnion	$>10^{11}$
Trunnion Sleeve	$>10^{6}$
Lifting Hook	1.7×10^{5}
Lifting Beam	$>10^{6}$

Allowable Fatigue Cycles for NUHOMS®-32P

Transfer Cask Components	Allowable Fatigue Cycles
Upper Trunnion	$>10^{11}$
Trunnion Sleeve	$>10^{6}$
Lifting Hook	5,147
Lifting Beam	3.73×10^{5}

The tables show that 5,147 fatigue cycles for the NUHOMS®-32P lifting hook is the limiting number. Based on the limit of 5,147 fatigue cycles and considering there are assumed to be 6 mechanical load fluctuations associated with each canister loading cycle and that each lift could generate 3 stress cycles the licensee concluded that for the lifting hook was 5,147/(3 × 6) = 286 transfer cask loading/unloading operations can be performed without concern of fatigue failure.

Staff verified the licensee’s fatigue evaluation used the correct maximum stress values given in (ADAMS Accession No. ML102650247) and used the appropriate fatigue curves given in Appendix I of of the Code Section III Division 1 (ASME 1992). The staff concludes that, based upon the current approved design basis which allows for a total of 120 HSMs, the licensee will not exceed 286 transfer cask loading/unloading operations for the 60-year service life for the transfer cask lifting hook.

In addition, the staff also reviewed the licensee’s AMPs for (1) the transfer cask which include visual examination of the transfer cask and penetrant testing of the transfer cask trunnions to detect for indications of aging including cracking associated with stresses/strains from lifting operations, and (2) transfer cask lifting yoke which include visual examination of the transfer cask lifting yoke and magnetic particle testing of the transfer cask lifting yoke hook plates to detect for indications of aging including cracking associated with stresses/strains from lifting operations. The staff’s review of the licensee’s AMPs for the transfer cask and the transfer cask lifting yoke are included in Sections 3.5.3 and 3.5.4, respectively, of this SER. The staff have concluded that the non-destructive examination (NDE) methods that are utilized to inspect the transfer cask trunnions and lifting yoke are sufficient to detect aging as a result of fatigue from normal operations.

3.4.8 Bisco NS-3 in Transfer Cask

As part of the TLAA performed for the Transfer Cask in the LRA, the licensee evaluated the aging effects of the 3 inch Bisco NS-3 polymer material used in the transfer cask as a result of neutron and gamma radiation being emitted from the DSC. The licensee specified that it used the bounding gamma and neutron dose rates for the 24P and 32P DSCs at 1 inch from the transfer cask. To evaluate the effects from gamma radiation, the licensee increased the bounding gamma dose rate of 135 mrem/hr for accident conditions (assuming the NS-3 is replaced by air) by a factor of 4. This conservatively equated to approximately 3 x 10^5 Rads over the 60-year service life. This is significantly below the material exposure limit of 1.5 x 10^{10} Rads as specified by the licensee in the LRA. The licensee indicated that the transfer casks are only subjected to this gamma exposure when a fuel-loaded DSC is in the transfer cask during loading and transfer operations which are short term durations.

The licensee specified that the following methodology was used to evaluate the aging effects as a result of neutron radiation exposure. Dose rate spectra results from various NUHOMS ISFSI evaluations were used to estimate the integrated neutron fluence, which is estimated to be approximately 3.16 x 10^{14} neutrons/cm^2 over the service life of 60 years for NS-3 in the transfer cask. The licensee specified that this is below the thermal neutron exposure limit for the NS-3 material of 1.5 x 10^{19} neutrons/cm^2, and therefore concluded that there is no significant hydrogen loss in the NS-3 material expected due to radiation exposure.

The staff evaluated the methodology used by the licensee to calculate the bounding gamma dose and the projected value used for the integrated neutron fluence at 60 years and determined these to be conservative, and therefore, b.ased on its review, the staff finds the licensee's evaluation for the NS-3 material in the transfer cask acceptable.

3.4.9 DSC Support Structure Thermal Analysis

In response to a staff RSI (ADAMS Accession No. ML110620134), the licensee provided details of the thermal fatigue evaluation of the steel DSC support structure inside each HSM unit. The licensee's original thermal fatigue evaluation was based on a 50-year service life with the assumption of one thermal cycle per day. If the assumption of one thermal cycle per day was used for a 60-year storage life, a total of 21,900 thermal cycles would be calculated. However, as stated in the RSI response, the licensee considered this value as overly conservative. Based on climate conditions at Calvert Cliffs, the licensee assumed that thermal effects resulting in stress reversal would only occur during spring and fall, which the licensee equates to 183 days/year. Based on this assumption, the licensee calculated the number of thermal cycles that would occur during the 60-year service life to be 10,980 cycles.

ASME B&PV Code Section III, NF–3331.1 states that components subject to greater than 20,000 cycles of fatigue loading require fatigue design. On the basis that the calculated 10,980 thermal cycles is below the ASME B&PV code criterion, the licensee concluded that thermal cycling of the DSC support structure is not a concern for a 60-year service life.

The staff reviewed the licensee response to the RSI (ADAMS Accession No. ML11062013) and the ASME B&PV Code Section III, NF–3331.1 criteria. The staff finds the licensee's revised estimate of yearly thermal cycles to be acceptable for use in the fatigue evaluation for the DSC support structure. Staff verified that the DSC support structure does not require high cycle fatigue evaluation described in ASME B&PV Code Section III, NF–3331.1 over a 60-year service life.

3.4.10 Evaluation Findings

The staff reviewed the TLAAs provided in the LRA against the regulatory requirements of 10 CFR 72.42. The staff verified that the TLAAs assumptions, calculations, and analyses are adequate and bound the environments and aging mechanisms for the pertinent SSCs. Based on its review of the information and representations, the staff finds:

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

3.5 Aging Management Program

Pursuant to 10 CFR 72.42(a)(2) requirements, the licensee must provide a description of AMPs for management of issues associated with aging that could adversely affect SSCs ITS. The licensee provided six AMPs in the Attachment 2 to the 4th RAI response:

1. Dry Shielded Canister (DSC) External Surfaces Aging Management Program
2. Horizontal Storage Module (HSM) Aging Management Program
3. Transfer Cask Aging Management Program
4. Transfer Cask Lifting Yoke Aging Management Program
5. Cask Support Platform Aging Management Program
6. High Burnup Fuel Aging Management Program

As specified in license condition 18, the AMP summarized in Attachment 4 of the 4th RAI response will be incorporated into the FSAR required of 10 CFR 72.70(a) after issuance of the license. Changes are incorporated into the FSAR pursuant to 10 CFR 72.48. Consistent with 10 CFR 72.48, modifications that would require a change to the terms, conditions, or specifications incorporated in the CoC may not be altered through the 10 CFR 72.48 change process. Because staff considers some of the information and activities in the AMPs summarized in Attachment 4 of the supplemented LRA, to be necessary to make the requisite safety findings for reasonable assurance, some conditions have been added to the license in this regard. (See license conditions 19 through 23). These license conditions were added because the staff has relied on specific information in the AMPs to obtain reasonable assurance that the SSCs within the scope of the pertinent AMPs will maintain their intended function through the period of extended operation. The staff has provided a description of the specific license conditions in the SER sections addressing those specific AMP details.

Operating experience is an important component for ensuring that in-scope SSCs will maintain their intended function throughout the period of extended operation. However, operating experience on age-related degradation of dry storage systems in some areas is presently limited. Standard rules for in-service inspections, as codified in ASME Boiler and Pressure Vessel (B&PV) Code (Code), are also not yet established for dry storage systems. Instead, the staff has agreed with the licensee's use of specific criteria in the Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components." NRC's Part 72 regulations do not currently provide for a process to allow for relief requests of inspection requirements in ASME

B&PV Section XI in the same manner as 10 CFR 50.55a, "Codes and Standards". In the future, new operating experience on age-related degradation of dry storage systems may provide a basis for the development of future Code inspection requirements, and, potentially, for a relief process that could apply to such requirements.

3.5.1 Dry Shielded Canister (DSC) External Surfaceds Aging Magagment Program

The licensee proposed the, "DSC External Surfaces Aging Management Program," in the LRA. The AMP detailed the activities to be performed to ensure the stainless steel DSCs will maintain their intended design safety function per 10 CFR 72.42(a)(2). This section contains the staff review of the adequacy of the DSC External Surfaces AMP to address the identified aging mechanisms and effects of the stainless steel DSC.

The licensee indicated the purpose of the DSC External Surfaces AMP is to manage the aging effects on the external surfaces of the DSC shell assembly for the period of extended operation. The program manages aging effects through inspection of external surfaces for evidence of loss of material due to corrosion, pitting (e.g., crevice corrosion and pitting), and cracking due to SCC. The staff reviewed the AMP against the criteria provided in Section 3.6.1 of NUREG–1927. The staff's evaluation of each of the program elements is as follows:

1. Scope of Program

The licensee defined the scope of the program to include monitoring of the exterior surfaces of the DSC including the DSC shell and cover plate for the effects of aging associated with stress corrosion cracking. The licensee examined two HSMs and DSCs as part of lead canister inspection activities in June 2012 (ADAMS Accession No. ML12212A216). Systems examined included DSC-6 in HSM 15, which was loaded in November 1996 and was identified to have the highest integrated neutron, gamma, and thermal exposure at the time of the inspection and DSC-11 in HSM-1 which was loaded in November 1993 (the first loading) and represents one of the lowest heat load canisters ever loaded. The licensee has indicated that these systems will continue to be inspected in the future for trending purposes but additional DSCs may be added for subsequent inspections. The licensee stated that the expected integrated thermal and radiological source terms of the more recently loaded NUHOMS®-32P canisters will surpass that of DSC-6 in HSM 15 examined in June 2012.

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

2. Preventive Actions

The licensee stated that the DSC External Surfaces AMP consists of condition monitoring to confirm there is no degradation of the DSC shell or cover plates that would result in a loss of the pressure/confinement boundary intended function. The licensee stated that no new preventive or mitigating attributes are associated with these activities.

The staff reviewed the licensee's AMP and confirms that no preventive or mitigating attributes, beyond those identified in the design bases, are necessary and therefore, finds that the condition-monitoring program provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the welded stainless steel DSCs.

3. Parameters Monitored or Inspected

The licensee stated that the DSC External Surfaces AMP provides visual inspections to monitor for signs of material degradation on the external surfaces of the DSC shell assembly and cover plate. The visual inspection is intended to identify the following parameters that could be precursors to, or actual signs of, the effects of stress corrosion cracking:

- Crevice and pitting corrosion (loss of material)
- Surface cracking

The licensee stated that the DSC External Surfaces AMP will continue to collect and analyze samples of surface deposits on selected DSCs to allow for trending of surface chloride concentration with visual results from inspections at Calvert Cliffs and other sites. The licensee stated that the selection of DSCs for surface deposit collection will consider the age of the DSC (with preference for the oldest in the population inspected), the availability of access to undisturbed deposits on the surface of the DSC, the personnel dose required to retrieve the samples, and visual examination results (priority may be given to deposit collection on DSCs failing to meet visual acceptance criteria).

The staff reviewed the licensee's Parameters Monitored or Inspected for the visual inspections of the DSC External Surfaces and analyses of collected surface deposits including surface chloride concentration measurements. The staff finds that the Parameters Monitored or Inspected are adequate since they include both precursors and actual signs that provide a valid basis for detection of the effects of corrosion and stress corrosion cracking. The staff therefore finds these Parameters Monitored or Inspected provide reasonable assurance for detecting and managing the aging mechanisms and effects, and ensuring the intended function of the welded stainless steel DSCs will be maintained during the period of extended operation.

4. Detection of Aging Effects

The licensee stated that aging effects due to loss of material from crevice and pitting corrosion, and cracking due to SCC of stainless steel DSCs will be managed using visual inspection in accordance with ASME Section XI and performed by site qualified individuals. The licensee has indicated that visual inspections conducted as part of the DSC External Surface AMP will be based on proven technology reasonably available at the time the inspection is conducted and which is capable of meeting the physical access and environmental constraints of the HSM interior. The licensee has indicated that the June 2012 visual inspection was conducted with a GE Everest Ca-Zoom 6.2 PTZ100, which is a remote controlled high definition pan-tilt-zoom (PTZ) camera system with a 100mm head, attached 10 watt flood and spot lights capable of providing 240 lumens each, and a resolving power of 0.5 mil (0.0005 in.) diameter wire at 6.0 ft. distance. The camera system is capable of handling dose rates up to ~1000 R/hr (GE, 2014). The inspection was performed by lowering the camera system through the HSM rear outlet vent which allowed for viewing of the majority portion of the DSC, its support structure, and the interior surfaces of the HSM. Inspection of DSC surfaces was also performed through the partially open door by mounting the camera on a pole. The licensee indicated that this delivery method, and a camera which meets or exceeds the above specifications, will be treated as the baseline means for performing the inspection for the purposes of developing the DSC External Surfaces AMP.

The licensee indicated that the DSC External Surface AMP will take a graded approach to visual inspection of the DSC, with higher standards of inspection applied as needed based on the results of prior inspections. The minimum inspection of the DSC will be performed to ASME Section XI Article IWA-2213 VT-3 standards. The licensee stated that VT-3 examination is suitable for identifying signs of pitting corrosion that are considered pre-cursors to stress corrosion cracking. In addition the licensee stated that cleaning of the DSC surface is not required by VT-3, and will not be performed, since it could invalidate the DSCs use as a lead canister for future inspections by removing accumulated chlorides.

The licensee stated that the DSC external surface area covered by each VT-3 examination will be similar to that visible in June 2012, and should include:

- 100% of the bottom end of the DSC visible from the HSM doorway opening including the grapple ring, and excluding areas obstructed by the seismic restraint and the sides of bottom shield plug where access is restricted by the small HSM doorway gap;

- 100% of the top cover including the closure weld and excluding areas obstructed by the HSM rail back stops;

- 100% of the DSC shell from and including the center circumferential weld (WJ-3) to the top end of the DSC (near the back wall of the HSM), including the longitudinal weld in this region (WJ-2) and excluding the portion of the shell obstructed by the HSM rails. The condition of the DSC shell at the support rail contact region will be accessed based on the appearance of the visible regions immediately adjacent to the crevice location;

- The portion of the DSC shell from the center circumferential weld to the bottom end of the DSC (near the HSM doorway), including the longitudinal weld in this region (WJ-1) and excluding the portion of the shell obstructed by the HSM rails, will be imaged.

The licensee indicated that at the discretion of the inspector, unless required by the results of a prior inspection, the inspection of selected areas on the DSC may be upgraded to the standards of ASME Section XI Article IWA-2210 VT-1 if access, dose, lighting and camera resolution allow. The licensee also indicated that potential candidate areas for this enhanced inspection for DSCs located in an HSM of the design inspected in June 2012 are the DSC top cover plate and closure weld, the section of the longitudinal weld WJ-2 nearest the top end of the DSC shell, the grapple ring, and portions of the DSC bottom shield plug facing the HSM door.

The licensee stated that the qualification of inspection personnel shall be accomplished in accordance with site procedures for the type of inspection conducted, and shall meet the requirements of ASME Section XI Article IWA-2300.

The staff reviewed the licensee’s Detection of Aging Effects and determined that the visual inspection method and approach described in the DSC external surfaces AMP is appropriate for detecting the effects of aging including localized corrosion such as pitting and crevice corrosion and stress corrosion cracking of the welded stainless steel DSCs. The staff reviewed the DSC external surface coverage proposed by the licensee in the DSC Externals Surfaces AMP and has determined that the areas of coverage are appropriate for detecting aging of the welded stainless steel DSCs.

The staff reviewed inspection criteria provided by the licensee in the DSC External Surfaces AMP and determined that the graded approach indicated by the licensee, using VT-3 and VT-1 inspection methods, is appropriate for detecting indications of aging on the welded stainless steel DSC surfaces. The staff reviewed the minimum inspection equipment requirements for conducting the inspections as well as the GE Everest Ca-Zoom 6.2 PTZ100 product information and has confirmed the equipment capabilities cited by the licensee are adequate to meet the cited inspection criteria in the DSC External Surfaces AMP. The staff confirmed that the Everest Ca-Zoom 6.2 PTZ100 has sufficient resolving power to perform VT-3, VT-1 (ASME, 2008 Section XI) and EVT-1 (EPRI 2005, BWRVIP-03) examinations. The staff also reviewed the personnel qualifications and has confirmed that these requirements are appropriate for personnel conducting visual examinations.

Pursuant to Control of Special Processes in 10 CFR 72.158, the licensee shall establish measures to ensure that special processes, including nondestructive testing (such as visual inspections), are controlled and accomplished by qualified personnel using qualified procedures (with identified parameters to be inspected or monitored) in accordance with applicable codes, standards, specifications, criteria, and other special requirements.

The staff reviewed the information contained in the LRA, including results from the lead system inspection and other past ISFSI monitoring activities. However, results from inspection activities to assess age-related degradation of dry storage systems are presently limited, thus the LRA contained only limited operating experience. The staff, therefore, reviewed the licensee's AMP to determine if the licensee was able to demonstrate with reasonable assurance that the DSC subcomponents would continue to perform their intended function through the renewal period. The licensee identified specific (1) inspection intervals, (2) areas of inspection coverage, (3) detection requirements, and (4) detection methods in the DSC AMP in order to demonstrate that the DSC subcomponents will be adequately inspected to prevent a loss of intended function through the renewal period.

As part of this review, the staff considered information from technical references pertinent to age related degradation of materials, including NUREG-1801 reactor renewal guidance, applicable consensus codes and standards, NRC reports, and other peer-reviewed technical references. Based upon that review, the staff concludes that, with the specific (1) inspection intervals, (2) areas of inspection coverage, (3) detection requirements, and (4) detection methods in the DSC AMP, the licensee has demonstrated with reasonable assurance that the DSC subcomponents will maintain their intended function through the renewal period. The staff has determined that the specific (1) inspection intervals, (2) areas of inspection coverage, (3) detection requirements, and (4) detection methods in the DSC AMP are appropriate based upon the technical references pertinent to age related degradation of DSC materials in similar environments. Therefore, with the inclusion of the specific (1) inspection intervals, (2) areas of inspection coverage, (3) detection requirements, and (4) detection methods in the DSC AMP, the staff concludes that signs of deterioration will be adequately detected and appropriately addressed before degradation reaches a level where the DSC subcomponent would be challenged in performing its intended function.

Because the staff relied upon the specific (1) inspection intervals, (2) areas of inspection coverage, (3) detection requirements, and (4) detection methods in the DSC AMP in reaching its reasonable assurance finding, the staff has added a specific license condition to prevent changes to these AMP criteria absent a license amendment.

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

5. Monitoring and Trending

The licensee stated that the June 2012 inspection is considered to be the baseline inspection for the DSC External Surfaces AMP for DSC-6 and DSC-11. In addition the licensee indicated that the first inspection of any additional DSC added to the inspection population will be considered the baseline for that DSC. The licensee identified the following trends to be considered in the DSC External Surfaces AMP:

- DSC surface chloride concentration

- Changes in DSC surface appearance with emphasis on increases in pit density or the extent of the pitted/stained area compared to the baseline.

The licensee stated that the trending information will feed both of the upcoming Calvert Cliffs DSC inspections, as identified in the toll gate assessments for the DSC External Surfaces AMP (Table A.1.3-1, ADAMS Accession No. ML14267A065). The licensee further stated that these toll gate assessments include evaluation of information obtained form Calvert Cliffs DSC inspections, and information from any other inspections of NUHOMS DSCs at other sites, if available. The licensee indicated that the next Calvert Cliffs DSC inspection is scheduled for 2017 and a subsequent inspection is scheduled for 2022. The licensee indicated the inspection may be completed within a time period of one year before or after the date indicated. The licensee has stated that after the 2022 inspection the frequency of the inspection will be as determined by the monitoring/trending and inspection acceptance criteria. While the baseline inspection frequencies will be five years, the licensee has indicated that if no acceptance criteria have failed in prior inspections and measured DSC surface chloride concentration measurements and trends indicate they would remain below the critical surface chloride concentrations for SCC the interval between inspections would be increased to 10 years. Because the staff is relying upon this 5 year inspection frequency to obtain reasonable assurance, a license condition has been added requiring this inspection frequency and various inspection attributes (license condition 23). Therefore a license amendment would be required to effect a change in the inspection frequency from 5 years to 10 year intervals. The staff would expect the toll gate assessment to provide the basis for a license amendment request to extend the inspection interval.

The staff reviewed the licensee's Monitoring and Trending AMP element and determined that the licensee's monitoring and trending methods provide acceptable means to monitor for aging effects on the DSC external surfaces including monitoring of surface deposit compositions and examination for evidence of localized corrosion that may be precursors to SCC to allow for the timely implementation of corrective actions. The staff reviewed the licensee's approach to determining the frequency of inspection based on the condition of the DSC observed in previous inspections, the measured chloride concentration on the DSC surface and information obtained from research on the minimum chloride concentrations necessary to initiate SCC. The staff finds the approach by the licensee to be appropriate for the monitoring of aging on the DSC external surfaces. The staff finds that the Monitoring and Trending provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the welded stainless steel DSCs.

6. Acceptance Criteria

The licensee has stated that the acceptance criteria for the DSC External Surface AMP are defined to ensure that the need for corrective actions will be identified before loss of intended functions. Visual examination via the use of a remote digital camera is based on ASME VT-3 examination, or ASME VT-1 examination if required by a prior inspection, or equivalent (ASME Section XI Table IWA-2211-1). Inspection acceptance criteria are as follows:

- Indications of crevice corrosion or heavy pitting corrosion are absent, or have not increased in extent or density from the previously evaluated baseline.

- Discoloration or stains identified in baseline inspections have not increased in extent, and new areas of discoloration or staining have not appeared since the prior inspection.

- Cracks are absent within the material.

The licensee has stated that based on the results of the inspection, the DSC will be determined to be either Acceptable, Acceptable with Defects, or Unacceptable. The Licensee has stated that the conditions that could lead to these determinations are as follows:

- Acceptable signifies that a component is free of significant deficiencies or degradation that could lead to the loss of intended function.

- Acceptable with Defects signifies that a component contains deficiencies or degradation but will remain able to perform its design bases function until the next inspection. The licensee has stated that signs of new or increased areas of pitting, crevice corrosion, or staining, compared to the baseline could lead to such a determination.

- Unacceptable signifies a component contains deficiencies or degradation that either prevents (or could prevent prior to the next inspection) the ability to perform their design bases function. An example would be positive identification of the presence of cracks on the DSC surface with length exceeding the requirements of the Code Section XI Table IWB-3514-2 acceptance criteria for surface examination of in-service austenitic steel components.

The licensee has also stated that the appropriate response will be based on the results of the DSC inspection as follows:

- Acceptable: No further actions are necessary until the next inspection.

- Acceptable with Defects: A condition report will be initiated in the site corrective action program (CAP) to document this evaluation and determine if the subject location should be inspected to ASME Section XI VT-1 standards during the next regularly scheduled AMP inspection. The licensee has stated that ASME (fitness for service) FFS-1 Section 6 (ASME, 2007) also provides a standard method that may be used for evaluating the acceptability of pitting degradation itself in pressurized components based on data obtained from visual inspection.

- Unacceptable: A condition report will be initiated in the site corrective action program to drive further evaluation, characterization, and other actions as needed to preserve the DSC intended function. Description and timing of these actions shall be as described the Corrective Actions element of this AMP.

The licensee stated that acceptance of any degraded condition for continued service is in accordance with facility procedural requirements, includes an engineering evaluation using plant design procedures, industry codes and standards, and conforms to the site license.

The staff reviewed the licensee's acceptance criteria and determined that the acceptance criteria are acceptable because corrective actions will be taken if any indication of DSC aging or degradation are observed in the DSC inspections.

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

As part of this review, the staff considered information from technical references pertinent to age related degradation of materials, including NUREG-1801 reactor renewal guidance, applicable consensus codes and standards, NRC reports, and other peer-reviewed technical references. Based upon that review, the staff concludes that, with the specific acceptance criteria in the DSC AMP, the licensee has demonstrated with reasonable assurance that the DSC subcomponents will maintain their intended function through the renewal period. The staff has determined that the specific acceptance criteria in the DSC AMP are appropriate based upon the technical references pertinent to age related degradation of the materials of construction in similar environments. Therefore, with the inclusion of the specific acceptance criteria in the DSC AMP, the staff concludes that signs of deterioration will be adequately detected and appropriately addressed before degradation reaches a level where the DSC subcomponent would be challenged in performing its intended function.

Because the staff relied upon the specific acceptance criteria in the DSC AMP in reaching its reasonable assurance finding, the staff has added a specific license condition (license condition 23(d)) to prevent changes to the acceptance criteria in the AMP absent a license amendment.

The staff finds that the Acceptance Criteria provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the welded stainless steel DSCs.

7. Corrective Actions

The licensee has stated that corrective actions, including apparent or root cause determinations will be performed in accordance with the 10 CFR Part 50 Appendix B Program and site corrective action procedures. The licensee has stated that in the event that a stress corrosion crack is determined to be present on a DSC, corrective actions necessary to ensure intended function is maintained or restored shall be completed within five years from the time of discovery, provided the DSC heat load at the time of discovery is less than five kW for a 24P DSC or six kW for a 32P DSC. The licensee stated that the basis for this timing was supported by an engineering assessment of the time required for an initiated stress corrosion crack to grow through-wall in a Calvert Cliffs DSC. Based on these calculations, the licensee concluded that the timing would provide a safety factor of 10 relative to the time required for a crack to grow through-wall. The licensee also stated that in the unlikely event that a crack had grown through-wall since the last inspection, this timing also provides substantial margin to the time required for fuel cladding damage to occur on air exposure at this heat load which would not be expected until more than 35 years. The licensee stated that the response times for higher heat load DSCs requiring corrective action shall be determined based on analysis to ensure that fuel damage due to air exposure does not occur.

The licensee stated that corrective actions for confirmed SCC may include further examination of the DSC for the purpose of better characterizing the orientation and/or depth of the cracking if needed. The licensee stated that continued performance of intended function of confinement to the next inspection interval may be demonstrated either through analysis of a thoroughly characterized crack based on accepted industry codes, methods and standards available at the time the crack is identified such as ASME FFS-1 Section 9 (ASME, 2007), or by repair or replacement of the DSC.

The staff reviewed the details provided for the CAP as part of the existing Calvert Cliffs QAP. Per the requirements of 10 CFR 72.172, if aging or degradation of the welded stainless steel canisters is identified in the inspections conducted as part of the DSC external surfaces AMP, the licensee will enter the finding into the CAP and resolve the finding. In addition, the extent of condition will be assessed as part of the corrective actions, and aging effects identified in supplemental inspections of additional DSCs will also be entered into the licensee's corrective action program .

The staff reviewed the timing of the corrective actions and calculations based on the licensee's current understanding of crack growth rates in stainless steel and the oxidation rate of fuel cladding should a crack penetrate through the DSC shell. Per 10 CFR 72.122(h)(5), the package must be designed to confine the high-level radioactive waste for the duration of the license. NRC staff concludes that a through-wall stress corrosion crack does not meet the currently licensed design bases since there is a loss of the DSC's intended safety function which is to maintain the pressure boundary. Therefore, the NRC staff considers a through-wall stress corrosion crack or other through-wall breach to be a condition of non-compliance to 10 CFR 72.122(h)(5) that requires prompt corrective actions to return the DSC back to its approved design bases.

The licensee will follow updates to accepted industry codes and recommendations to perform corrective actions in a timely manner to prevent through wall penetration of the DSC by localized corrosion and SCC and avoid degradation of the fuel cladding. The staff finds that the licensee's Corrective Action Program (CAP) per the quality assurance requirements in 10 CFR Part 50, Appendix B provides reasonable assurance that corrective actions will be adequate for managing the aging mechanisms and effects identified in the AMR of the welded stainless steel DSCs.

8. Confirmation Process

The licensee stated that the activities initiated in accordance with the implementing procedures for the DSC aging management program, such as corrective actions, are subject to QAP controls and the effectiveness is monitored using CAP procedures, review and approval processes, and administrative controls, which are implemented in accordance with the requirements of 10 CFR Part 50, Appendix B. The licensee stated that the use of these procedures, processes, and controls ensures that corrective actions are taken and are effective.

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

9. Administrative Controls

The licensee stated that the DSC External Surfaces AMP is subject to Corrective Action and Quality Assurance procedures, review and approval processes, and administrative controls that are implemented in accordance with site procedures and the requirements of 10 CFR Part 50, Appendix B, and will continue to be adequate for the renewed license (extended storage) period.

The staff reviewed the details provided for the licensee's Administrative Controls, as part of the existing QAP, to ensure that the administrative controls will be adequate to provide a formal review and approval process. The staff concludes that the CCNPP QAP is consistent with the quality assurance requirements in 10 CFR Part 50, Appendix B, and the program provides reasonable assurance that the Administrative Controls are adequate for managing the aging mechanisms and effects identified in the AMR of the welded stainless steel DSCs.

10. Operating Experience

The licensee stated that the Calvert Cliffs ISFSI has been in operation since 1992 and that plant-specific and industry operating experience, as well as a review of ISFSI files, did not indicate any aging related deficiencies with the DSC components. The licensee stated that future examinations and inspections are performed in accordance with plant procedures and repetitive maintenance tasks. The licensee stated that Operating Experience from other sites will be obtained via the INPO OE database, NRC Information Notices, EPRI Reports and/or participation in industry groups such as the TransNuclear Users Group and reviewed in accordance with site Operating Experience review procedures for applicability to the Calvert Cliffs ISFSI.

The staff reviewed the licensee's Operating Experience and found the licensee's evaluation of relevant operating experience demonstrates that the program will effectively manage aging effects of the welded stainless steel DSCs during the period of extended operation. The staff finds that the Operating Experience stated and referenced in the LRA provides reasonable assurance that this AMP will be adequate for managing the aging mechanisms and effects identified in the AMR of the welded stainless steel DSCs.

3.5.2 Horizontal Storage Module (HSM) Aging Management Program

The HSM Aging Management Program, described in Attachment 2, of its 4th RAI response provides the details of the activities to manage the aging mechanisms and effects of the HSMs. The licensee described the HSM AMP as a "learning" AMP, which the licensee stated to mean that the program will be updated, as necessary, to incorporate new information on degradation due to aging effects identified from plant-specific inspection findings, related industry operating experience, and related industry research. The licensee clarified that future plant-specific and industry operating experience is captured through the site's operating experience review process following the regulatory framework for the consideration of operating experience concerning aging management and age-related degradation in LR-ISG-2011-05.

The licensee stated that an ongoing review of both plant-specific and industry operating experience will continue through the period of extended operation to ensure that the program continues to be effective in managing the identified aging effects. The licensee further stated that Calvert Cliffs reviews of operating experience in the future may identify areas where AMPs should be enhanced or new programs developed.

The licensee committed to maintain the effectiveness of this AMP under the QAPs used to meet the criteria of 10 CFR Part 72, Subpart G, and 10 CFR Part 50, Appendix B, respectively.

The staff reviewed the AMP against the criteria provided in Section 3.6.1 of NUREG–1927. The staff's evaluation of each of the program elements is as follows:

1. Scope of Program

The licensee defined the scope of the program to include periodic visual inspections, radiation surveys, groundwater surveys and non destructive examination as determined by personnel qualified to monitor structures and components for applicable aging effects, such as those described in the American Concrete Institute (ACI) Standards 349.3R-02, ACI 201.1R-08, and American National Standards Institute/American Society of Civil Engineers Standard 11-99. The licensee stated that this AMP will also be used to maintain the air inlets and outlets free from obstructions.

The licensee further stated that the scope of the HSM AMP for external and internal surfaces program includes the concrete and steel components including the HSM walls, roof, and floor slab (foundation), HSM access door, DSC support structure and rail assembly, heat shields, air inlet and outlet vents, embedments and anchorages (i.e., structural connections including anchor bolts, cast-in-place bolts, thru-bolts, and mounting hardware).

Table 3.4-1, "Revised Aging Management Review Result Tables," in Attachment 3 of the supplemented LRA identified the HSM Aging Management Program to be applicable to all aging mechanisms and effects for the in-scope HSM subcomponents. The aging effects managed by this program for the concrete pads are listed in Table 3.3-3 of this SER.

The staff reviewed the Scope of Program and determined that the licensee adequately defined the activities to performed, the subcomponents within the scope of the AMP, and the aging mechanisms and effects to be managed by the program. The staff finds the Scope of Program provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the HSM.

2. Preventive Actions

The licensee defined the AMP as a condition monitoring program. With the exception of daily surveillances to ensure HSM inlets and outlets are not obstructed, no preventive actions are performed. Maintaining the inlets and outlets free from obstruction ensures temperatures are not elevated for prolonged periods, the concrete is not subject to related damage, and overheating of the components inside an HSM is prevented.

The staff concludes that the groundwater surveys are mitigation activities to prevent aging effects from exposure to an aggressive chemical environment. The staff finds that the condition monitoring and mitigation activities provide reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the HSM.

3. Parameters Monitored or Inspected

The licensee stated that the parameters to be monitored and inspected depend on the particular HSM component. The licensee further stated that the parameters monitored or inspected are commensurate with industry codes, standards, and guidelines and take into account industry and specific operating experience. ACI 349.3R-02 and ASCE 11-99 provide an acceptable basis for selection of parameters to be monitored or inspected for concrete and steel structural elements. The licensee stated that steel components (both steel components on the external surface of the HSM and the DSC structural support steel components) will be visually inspected for the aging effect of loss of material due to general, pitting and crevice corrosion.

The licensee further stated that the condition of below grade concrete, which is not accessible, will be monitored through groundwater sampling. The groundwater sampling will monitor for chloride concentration, sulfate concentration and pH.

The HSM inlet and outlet vents are monitored by visual inspection to ensure they are not obstructed. In addition, as an overall means of monitoring of the HSM structure's ability to perform its design function, radiation surveys will be conducted. The surveys will consist of measuring gamma and neutron levels in addition to measuring contamination levels in the vicinity of the HSMs.

The staff reviewed the licensee's Parameters Monitored or Inspected for the visual inspections of the HSM subcomponents, groundwater sampling, radiation surveys, and inlet/outlet vent checks. Pursuant to Control of Special Processes in 10 CFR 72.158, the licensee shall establish measures to ensure that special processes, including nondestructive testing (such as visual inspections), is controlled and accomplished by qualified personnel using qualified procedures (with identified parameters to be inspected or monitored) in accordance with applicable codes, standards, specifications, criteria, and other special requirements. The staff finds that the Parameters Monitored or Inspected provides reasonable assurance for managing the aging mechanisms and effects, and ensuring the intended functions of the HSM will be maintained during the period of extended operation.

4. Detection of Aging Effects

The licensee stated that the detection of aging effects of the HSM subcomponents relies on visual inspections. The licensee provided details for the detection of aging effects of the exterior above grade concrete structure, reinforcing steel, and embedments. The visual survey should identify the source of any staining or corrosion-related activity and the degree of damage. The licensee stated that the visual survey is performed in accordance with Calvert Cliffs site procedure MN-1-319, Attachment 4 (concrete structure walkdown checklist). Observance of exposed steel reinforcement, corroded anchorages and embedments, severe staining, or suspected loss of monolithic behavior would be entered into the site's CAP for further evaluation with other testing methods as determined by an authorized structural engineer. Steel on the external surface of the HSMs which is subject to wetting/moisture is visually examined for the aging effect of loss of material (corrosion). The initial stage of corrosion often produces cracking, spalling and staining in the surrounding concrete. The visual survey performed should identify the source of any staining or corrosion-related activity and the degree of damage. Exposed steel reinforcement, corroded anchorages and embedments, severe staining, or loss of monolithic behavior are conditions that would be entered into the CAP and warrant further evaluation with other nondestructive examination (NDE) methods as determined by a qualified structural engineer. For coated HSM carbon steel subcomponents, the licensee did not credit coatings for the prevention of the aging effect in the AMR. However, the licensee stated that the AMP will manage loss of coating integrity due to blistering, cracking, flaking, peeling, or physical damage.

The licensee further stated that visual inspections of the exterior above ground concrete structures and structural components are conducted annually by a qualified individual. This annual inspection will consist of a walk thru around all existing HSMs. As a supplement to this annual inspection, every five years a professional structural engineering firm will conduct a focused inspection of at least five targeted HSMs with areas of degradations that have been identified by the annual inspections.

The licensee comitted to also perform area radiation surveillances as another means for the detection of aging effects for the HSMs. Increased radiation levels could indicate a reduction in the ability of the concrete and steel to provide adequate radiation shielding, or could indicate a breach in the containment function of the DSC or irradiated fuel assemblies. The surveillance will be conducted annually and consists of measuring dose rate on contact and at 30 cm from the door of each HSM. A swipe of each HSM door will also be taken to check for contamination levels. In addition six thermoluminescent detectors (TLDs) are positioned on the ISFSI perimeter fencing. These TLDs are read semiannually and provide a record of radiation exposure at the ISFSI perimeter.

The license stated that exposure of concrete to penetrating water can result in the leaching of salts and chlorides producing a loss of mechanical properties. NRC staff confirms that exposure to water with high levels of chlorides can result in a loss of mechanical properties. The licensee stated that the concrete below ground is susceptible to leaching since it is exposed to moisture. To help monitor the condition of below ground concrete in the ISFSI area, groundwater sampling will be performed at a minimum of three locations every five years in order to trend the potential for corrosive environment existing in the area of the ISFSI. The licensee stated that the frequency for the groundwater sampling over 20 years reflects that the ISFSI has been in operation without any signs of degradation indicative of a groundwater chemistry environment.

The licensee also committed to perform daily surveillances by security personnel to ensure that the inlet and outlet vents are free from obstruction consistent with the ISFSI TS Surveillance Requirement 4.4.1.2.

The licensee provided details for the detection of aging effects of the interior concrete structure and DSC support structure. The licensee stated that visual inspections can be conducted by remote and direct methods using a high-resolution remote pan-tilt-zoom camera that is capable of detecting age-related degradation such as loss of material due to corrosion, and cracking of metallic components. Remote inspection is conducted using a camera and/or fiber-optic technology through openings, such as HSM air inlets and outlets. According to the licensee, inspections using this technology produces VT-3 level results and is appropriate for assessing the aging effects identified in the AMR. The HSM access door can be removed for direct inspection of the DSC bottom end for signs of aging degradation. The licensee stated that this inspection of the interior concrete shall be conducted every five years in concert with the DSC inspection. The inspection will be conducted on the same HSM each time. The first examination of interior concrete was performed on the selected HSM in June 2012. The HSM selected for inspection was one that contained a DSC which had the longest time in service, and/or other parameters that contributed to degradation. This inspection provides baseline information that will be used during subsequent examination of the same HSM(s) for trending purposes.

The licensee provided a summary of the inspections performed as part of this HSM AMP in Attachment 2 of the 4th RAI response, “Revised Aging Management Programs,” of the supplemented LRA .

The staff reviewed the licensee’s Detection of Aging Effects for the visual inspections of the HSM subcomponents, groundwater sampling, radiation surveys, and inlet/outlet vent checks. Pursuant to Control of Special Processes in 10 CFR 72.158, the licensee shall establish measures to ensure that special processes, including nondestructive testing (such as visual inspections), is controlled and accomplished by qualified personnel using qualified procedures in accordance with applicable codes, standards, specifications, criteria, and other special requirements. The licensee is relying upon the use of applicable industry codes and standards for the visual inspection, which is a type of nondestructive testing method. The staff expects that the licensee’s choice and use of applicable codes and standards will provide reasonable assurance that the visual inspections will satisfy the requirements of 10 CFR 72.158.

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

As part of this review, the staff considered information from technical references pertinent to age related degradation of materials, including NUREG-1801 reactor renewal guidance, applicable consensus codes and standards, NRC reports, and other peer-reviewed technical references. Based upon that review, the staff concludes that, with the specific inspection frequencies identified in the HSM AMP, the licensee has demonstrated with reasonable assurance that the HSM subcomponents will maintain their intended function through the renewal period. The staff has determined that the inspection frequencies in the HSM AMP are appropriate based upon the technical references pertinent to age related degradation of concrete and steel in similar environments. Therefore, with the inclusion of these specific inspection frequency intervals in the HSM AMP, the staff concludes that signs of deterioration will be adequately detected and appropriately addressed before degradation reaches a level where the HSM subcomponent would be challenged in performing its intended function.

Because the staff relied upon the inspection frequency identified in the HSM AMP in reaching its reasonable assurance finding, the staff has added a specific license condition (license condition 21) to prevent increasing the inspection intervals or altering the specific inspection methods staff relied upon in making this finding, absent a license amendment.

The staff therefore concludes that the inspection methods and frequencies for the HSM subcomponents provide acceptable means to effectively detect the aging mechanisms and effects in the AMR. The staff finds that the Detection of Aging Effects provides reasonable assurance that the HSM subcomponents will maintain their intended functions for the period of extended operation.

5. Monitoring and Trending

The licensee stated that the inspections and surveillances in this AMP are all performed periodically in order to identify areas of degradation. The licensee clarified that the results of the inspections will be used in two ways. First the results will be evaluated by qualified individuals consistent with industry guidelines, standards and regulations. Areas of degradation not meeting established criteria will be entered into the sites CAP for resolution or more detailed evaluation. Second the results of the inspection will be compared against future inspections in order to monitor and trend the progression of the aging effects over time. The licensee stated that the trending of aging effects over time is a key element that will help provide aging management so that there will be high confidence the HSM structures remain capable of performing their design function during the period of extended operation.

The staff reviewed the licensee’s monitoring and trending for the visual inspections of the HSM subcomponents, groundwater sampling, radiation surveys, and inlet/outlet vent checks. The staff expects all monitoring and trending activities under this AMP will be commensurate with the requirements of 10 CFR Part 50, Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants” or 10 CFR Part 72, Subpart G, “Quality Assurance,” as applicable. The staff determines that the licensee’s description of monitoring and trending methods provide acceptable means to effectively predict the extent of the aging effects and timely corrective actions. The staff determined that the monitoring and trending methods for the HSM subcomponents provide acceptable means to effectively detect the aging mechanisms and effects in the AMR. The staff finds that the monitoring and trending provides reasonable assurance that the HSM subcomponents will maintain their intended functions for the period of extended operation.

6. Acceptance Criteria

The licensee provided details for the acceptance criteria of the exterior above grade concrete structure, reinforcing steel, and embedments. The licensee stated that a set of inspection attributes and acceptance standards for steel and concrete that is commensurate with industry codes, standards, and guidelines has been established. The licensee further stated that the American Concrete Institute Standard 349.3R-02 includes a quantitative three-tier acceptance criteria for visual inspections of concrete surfaces, namely (1) acceptance without further evaluation, (2) acceptance after review, (3) acceptance requiring further evaluation. Acceptable signifies that a component is free of significant deficiencies or degradation that could lead to the loss of structural integrity. Acceptable after review signifies that a component contains deficiencies or degradation but will remain able to perform its design bases function until the next inspection or repair. Acceptance requiring further evaluation signifies that a component contains deficiencies or degradation that could prevent (or could prevent prior to the next inspection) the ability to perform their design bases function. Degradations or conditions meeting the ACI 349.3R-02 Tier 2 and 3 criteria will be entered into the site's CAP for evaluation and resolution.

The licensee stated that loss of material due to age-related corrosion of carbon steel components in the HSM shall be evaluated by a structural engineer in accordance with ACI 349.3R-02. The licensee further stated that radiation surveys taken annually are evaluated against the acceptance criteria established in TS 2.4. In addition as part of the trending aspect of this program, results within TS but above normal expected levels would be further evaluated. The TLD results, read semiannually, are compared against regulatory limits.

The licensee also stated that the acceptance criteria for the groundwater chemistry monitoring are concentrations of chlorides < 500 ppm, sulfates < 1,500 ppm, and pH > 5.5. These values are consistent with guidance provided in NUREG–1801 and would demonstrate that ISFSI concrete pad is exposed to a non aggressive soil and groundwater environment.

The licensee stated that loss of material due to age-related corrosion of the DSC Support Structure shall be evaluated by a Structural Engineer. Acceptance Criteria for the DSC Support Structure for both stainless and carbon steel components shall be based on the design methodologies defined in CCNPP ISFSI USAR Section 4.2.1.1. Calvert Cliffs ISFSI USAR Section 4.2.1.1 references "American Institute of Steel Construction (AISC), "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" 8th Edition.

The licensee further stated that the acceptance criteria for the daily surveillance performed by security personnel is to ensure that the inlet and outlet vents are free from obstruction consistent with ISFSI Technical Specification Surveillance 4.4.1.2. Any blockage would be removed and the issue would be captured in the site's CAP.

The staff reviewed the acceptance criteria in the consensus standard ACI 349.3R-02 and determined that the second-tier criteria was adequate for ensuring timely corrective actions before loss of intended function in the HSM subcomponents."

The staff reviewed the groundwater chemistry monitoring criteria , and found it to be consistent with criteria in ASME B&PV Code Section XI, Subsection IWL. The staff determined that the acceptance criteria for the HSM subcomponents provide acceptable means to effectively detect the aging mechanisms and effects in the AMR.

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

As part of this review, the staff considered information from technical references pertinent to age related degradation of materials, including NUREG-1801 reactor renewal guidance, applicable consensus codes and standards, NRC reports, and other peer-reviewed technical references. Based upon that review, the staff concludes that, with the specific acceptance criteria in the HSM AMP, the licensee has demonstrated with reasonable assurance that the HSM subcomponents will maintain their intended function through the renewal period. The staff has determined that the specific acceptance criteria in the HSM AMP are appropriate based upon the technical references pertinent to age related degradation of concrete and steel in similar environments. Therefore, with the inclusion of the specific acceptance criteria in the HSM AMP, the staff concludes that signs of deterioration will be adequately detected and appropriately addressed before degradation reaches a level where the HSM subcomponent would be challenged in performing its intended function.

Because the staff relied upon the specific acceptance criteria in the HSM AMP in reaching its reasonable assurance finding, the staff has added a specific license condition (license condition 21) to prevent changes to the acceptance criteria in the AMP absent a license amendment.

The staff finds that the Acceptance Criteria provides reasonable assurance that the HSM subcomponents will maintain their intended functions for the period of extended operation.

7. Corrective Actions

The licensee stated that degradations or conditions meeting ACI 349.3R-02 (Tier 2 or Tier 3 acceptance criteria will be entered into the site's CAP. Corrective actions undertaken to resolve the degradation and condition could require (i) a modification to the existing AMP, and/or (ii) official notification to the NRC. Corrective actions are taken in a timely manner commensurate with the significance of the defect. Deficiencies are either promptly corrected or are evaluated to be acceptable through engineering analysis, which provides reasonable assurance that the intended function is maintained consistent with current licensing bass conditions.

The staff expects that all corrective actions under the HSM AMP will be commensurate with the requirements of 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants" or 10 CFR Part 72, Subpart G, "Quality Assurance," as applicable. Per the requirements of 10 CFR 72.172, if an unanalyzed degraded condition is identified by the AMP inspections, the licensee will enter the finding into the CAP and resolve the finding. The staff finds that the licensee's CAP is consistent with the quality assurance requirements in 10 CFR Part 50, Appendix B, and therefore, provides reasonable assurance that corrective actions will be adequate for managing the aging mechanisms and effects identified in the AMR of the HSM subcomponents.

8. Confirmation Process

The licensee stated that activities initiated in accordance with the procedures implemented for the HSM AMP, such as corrective actions, are subject to QAP controls. Thus, the effectiveness is monitored using CAP procedures, review and approval processes, and administrative controls, which are implemented in accordance with the requirements of 10 CFR Part 50, Appendix B. According to the licensee, use of these procedures, processes, and controls ensures that corrective actions are taken and are effective.

The staff reviewed the details provided for the Confirmation Process, as part of the existing QAP, to ensure that appropriate corrective actions are completed and are effective. The staff determined that the licensee's CAP is consistent with the quality assurance requirements in 10 CFR Part 50, Appendix B, and therefore, that there is reasonable assurance that the Confirmation Process is adequate for managing the aging mechanisms and effects identified in the AMR of the HSM subcomponents.

9. Administrative Controls

The licensee stated that the the HSM AMP is subject to the site's Corrective Action and Quality Assurance procedures, review and approval processes, and administrative controls. These are implemented in accordance with the requirements of 10 CFR Part 50, Appendix B, and will continue to be adequate for the renewed license (extended storage) period.

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

10. Operating Experience

The licensee stated that the ISFSI has been in operation since 1992. Since then, the licensee stated that examinations and inspections have been performed in accordance with plant procedures and repetitive maintenance task. Deficiencies, when noted, have been entered into the licensee's CAP for evaluation. While the licensee's operating experience has not indicated any significant degradation to any of the HSM components, several minor degradations on external concrete surfaces have been noted. To provide a current assessment of these external degradations, Calvert Cliffs engaged, in June 2012 (ADAMS Accession No. ML12212A216), a licensed structural engineering firm to perform a cursory visual inspection of all in-use HSMs and an up-close visual survey and hammer sounding of selected HSM units, including those for which earlier minor degradation had been noted. In all cases the crack widths noted during this inspection were less than 0.04 inches and hammer soundings in their vicinity indicated sound concrete in the area. The licensee stated that the structural engineering firm found that the HSM structures were in good condition and did not identify any issues that currently warranted further evaluation. In addition the structural engineering firm also recommended, and through this AMP the licensee has committed to continue monitoring and inspections in accordance with ACI 349.3R-02.

In June 2012, the licensee performed an inspection of the interior HSM structure of two HSMs in conjunction with an inspection of the exterior surface of the DSC. The licensee stated that the visually accessible surfaces of the HSM concrete walls, roof and floor all appeared overall to be in good condition with little to no signs of spalling or cracking. There was evidence of localized water intrusion to the interior of the HSM as indicated by a few concrete stalactites. These stalactites were seen only in the vicinity of the rear outlet vents. This suggested that the source of the water intrusion came from the outlet vent stack. Broken stalactite debris was also observed on the surface of the heat shields. Water was observed to flow inward along concrete surface cracks. The licensee stated that the pure white color observed in the stalactites indicated that water had not penetrated to the rebar. A condition report was initiated to evaluate the possible implications this could have on the HSM capability to perform their function in later years.

The licensee stated that a coating of dust/dirt was present on the floors of each HSM but no debris or standing water was observed. In both HSMs the DSC structural support beams and rails were in good condition, with coating intact in most areas. There were no signs of loose or missing bolts or fasteners. There was some general surface corrosion noted on the carbon steel surface and bolting hardware. The licensee stated that this general surface corrosion was limited and does not represent a current challenge to the capability of the DSC structural supports to perform their function.

The licensee further stated that these inspections have served to provide a baseline status that will be used in future periodic inspections to trend HSM material conditions. This will help ensure that accelerated degradation will be detected before the HSM structures are unable to perform their design function and that appropriate corrective actions can be implemented.

The licensee clarified that industry operating experience for the ISFSI is conducted in accordance with site's Operating Experience Program. The Operating Experience program reviews issues identified from a variety of sources including NRC, Institute of Nuclear Power Operations, Industry Owner groups, etc. Issues are evaluated and can result in the issue being entered into the CAP and evaluated for whether there is a need for modifying the AMP.

The licensee provided details on one significant industry operating experience involving HSMs at the Three Mile Island (TMI) ISFSI. In 2000 cracks were noted in the TMI HSMs and the cracks were considered cosmetic and insignificant. However in 2007 the TMI licensee observed continued cracking, crazing, and spalling as well as increased efflorescence on the HSM surfaces. The TMI licensee performed an evaluation which indicated the HSMs were still capable of performing their design bases function. In 2008, the TMI licensee noted that 28 of 30 HSMs had cracks of which most were emanating from the anchor bolt blockout holes. At this point it was determined the HSMs were prematurely deteriorating and that continued crack growth could affect the HSMs ability to perform their design bases function for the duration of their service life. The TMI licensee concluded that the cracks were the result of water entering the anchor bolt blockout holes on the roof of the HSMs. Subsequent freeze and thaw cycles initiated the crack formation.

The licensee further clarified that, to date, the Calvert Cliffs ISFSI has not experienced any cracking that is due to freeze thaw cycles. Although this has not occurred, the lessons learned from the issue at TMI will be factored into the visual inspections of the HSM structures including that personnel performing the inspections or evaluations will meet the qualification requirements of ACI 349.3R-02 and that the visual inspections will be performed in accordance with the requirements of ACI 349.3R-02 and ACI 201.1R-08.

The licensee further clarified that operating experience to date has not indicated any significant degradation to any of the HSM components. Inspections and surveillances that would identify any deficiencies continue to be conducted. A CAP is in place to track and correct deficiencies in a timely manner. Continued implementation of the ISFSI AMP provides reasonable assurance that the aging effects will be managed, such that the intended functions of the HSM components, particularly the structural concrete and steel of the HSMs, will be maintained under current licensing basis conditions for the renewed license period.

The staff reviewed the licensee's Operating Experience, including NRC Information Notice 2013-07 (NRC, 2013), which described the TMI ISFSI freeze-thaw degradation issues near the HSM anchor bolt blockout holes. The staff did not find operating experience to indicate that the HSM AMP would not be effective in managing the aging effects of the HSM subcomponents during the period of extended operation. Therefore, staff finds that the operating experience stated and referenced in the LRA provides reasonable assurance that the HSM AMP will be adequate for managing the aging mechanisms and effects identified in the AMR of the HSM.

3.5.3 Transfer Cask Aging Management Program

The Licensee proposed the, "Transfer Cask Aging Management Program," in Attachment 2 of its 4th RAI response. The AMP details the activities to be performed to ensure the transfer cask will maintain its intended design safety function per 10 CFR 72.42(a)(2). The following sections provide the details of the staff review of the adequacy of the Transfer Cask AMP to address the identified aging mechanisms and effects for the transfer cask.

The licensee stated that the objective of the program is to manage the aging effects including loss of material due to general pitting and crevice corrosion on surfaces that are exposed to borated water and cracking due to stress/strain from lifting through inspection of external surfaces of the transfer cask and subcomponents. The staff reviewed the AMP against the criteria provided in Section 3.6.1 of NUREG–1927. The staff's evaluation of each of the program elements is as follows:

1. Scope of Program

The Licensee defined the scope of the program to include monitoring inspection of the transfer cask and subcomponents to ensure that they are intact and free from loss of material due to general, crevice, or pitting corrosion for intermittent wetted surfaces and cracking due to stresses/stains from loading operations. The licensee stated that the program includes visual testing of the cask exterior to prevent the corrosion of exposed surfaces and penetrant testing (PT) of the transfer cask trunnions, trunnion welds, and two inches [50 mm] of the transfer cask surface adjacent to the trunnion welds.

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

2. Preventive Actions

The licensee stated that the transfer cask AMP includes guidance and direction for maintaining a suitable environment that precludes the onset or propagation of a loss of material due to crevice or pitting corrosion for continuously wetted surfaces. Following use, all subcomponents of the transfer cask that are immersed in borated water are rinsed with deionized water.

The staff reviewed the licensee's guidance and direction for maintaining a suitable environment for the transfer cask and finds the guidance provides reasonable assurance that aging effects, including onset or propagation of a loss of material due to crevice or pitting corrosion for continuously wetted surfaces will be precluded.

3. Parameters Monitored or Inspected

The licensee stated that the visual aging management inspections of external cask, upper and lower trunnion assembly, and cask lid surfaces are performed to ensure that the intended function of the pertinent cask subcomponents are not compromised. The licensee stated that the inspections look for loss of material for stainless steel subcomponents due to crevice and/or pitting corrosion in wetted locations and general corrosion of carbon steel subcomponents exposed to moist atmospheric environments. The licensee stated that penetrant testing of the transfer cask trunnions, trunnion welds, and two inches [50 mm] of the transfer cask surface adjacent to the trunnion welds are performed to ensure that the intended function of the pertinent cask subcomponents are not compromised as a result of cracking due to stresses/strains from loading operations.

The staff reviewed the licensee's Parameters Monitored or Inspected for the visual inspections of the transfer cask and determined them adequate for detection of the effects of corrosion and cracking due to stresses/strains, using both visual and non-destructive testing. The staff finds that the Parameters Monitored or Inspected provide reasonable assurance for managing the aging mechanisms and effects, and ensuring the intended function of the transfer cask will be maintained during the period of extended operation.

4. Detection of Aging Effects

The licensee stated that visual inspections of external cask and cask lid surfaces are performed every 5 years or prior to moving a DSC (if no other inspection has been performed), to ensure that the intended function of the cask subcomponents are not compromised. The Licensee indicated that visual inspections look for signs of deterioration (corrosion). The licensee stated that the visual inspections will be conducted in accordance with ASME Section XI IWA-2211, the VT-1 visual examination is conducted to detect discontinuities and imperfections on the surface of components, including such conditions as cracks, wear, or corrosion in order to provide confidence the transfer cask remains able to perform its intended function.

The licensee stated that pentrant testing (PT) examination of the trunnions and two inches of the adjacent cask surface are conducted once every five years or prior to each use. The licensee stated that the PT examinations will be conducted in accordance with ASME III Div. 1 NF-5350. PT is performed to detect cracks that may develop as a result of stresses/strains from loading operations.

The licensee stated that qualification of personnel conducting the visual and penetrant testing for the transfer cask AMP will be accomplished in accordance with site procedures and will meet the requirements of ASME Section XI Article IWA-2300. In addition, personnel performing nondestructive examinations (NDE) shall be qualified and certified using a written practice prepared in accordance with ANSI/ASNT CP-189, Standard for Qualification and Certification of Nondestructive Testing Personnel, as amended, of ASME Section XI Article IWA-2300.

The staff reviewed the licensee's Detection of Aging Effects and determined that the visual inspection method and approach described in the transfer cask AMP is appropriate for detecting the effects of aging including general and localized corrosion such as pitting. The staff reviewed the subcomponents inspected as part of the transfer cask AMP and has determined that the subcomponents examined are appropriate for detecting aging of the transfer cask.

The staff reviewed inspection criteria provided by the licensee in the transfer cask AMP and determined that VT-1 examination of the external surfaces of the transfer cask is appropriate for detecting indications of aging including general corrosion, pitting corrosion crevice corrosion and wear. The staff also reviewed the personnel qualifications and has confirmed that these requirements are appropriate for personnel conducting visual and penetrant testing.

Pursuant to Control of Special Processes in 10 CFR 72.158, the licensee shall establish measures to ensure that special processes, including nondestructive testing methods (such as visual and penetrant testing), are controlled and accomplished by qualified personnel using qualified procedures (with identified parameters to be inspected or monitored) in accordance with applicable codes, standards, specifications, criteria, and other special requirements.

The staff finds that the visual inspection and non-destructive method, inspection frequency and inspection requirements described in Detection of Aging Effects are appropriate to detect aging and therefore, provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the transfer cask.

5. Monitoring and Trending

The licensee stated that visual inspections will determine the existence of loss of material on the external surfaces of the transfer cask, and observations regarding the material condition are recorded in accordance with inspection procedures and are corrected or evaluated as satisfactory before use of the transfer cask. The licensee stated that these inspections are either performed periodically or during the preparations for retrieval of a DSC from the corresponding HSM. The licensee stated that evaluation of this information during the preparations for DSC retrieval and transfers provides adequate predictability and allows for corrective action prior to the need for the intended function of the component to be performed.

The staff reviewed the licensee's Monitoring and Trending and determined that the licensee's monitoring and trending methods provide acceptable means to monitor for aging effects on the transfer cask to allow for the timely implementation of corrective actions. Therefore, the staff finds that the Monitoring and Trending provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the transfer cask.

6. Acceptance Criteria

The licensee has stated that if VT identifies corrosion on the transfer cask, the issue would be entered into the CAP and an engineering analysis would be performed to determine the extent and impact of the corrosion on the transfer casks ability to perform its intended function. The licensee has indicated that the acceptance criteria for PT are as defined in ASME Section III Div.1 NF-5350.

The staff reviewed the licensee's acceptance criteria and determined that the acceptance criteria are acceptable. The Acceptance criteria are consistent with the requirements identified in consensus codes and standards and corrective actions will be taken if aging or degradation are observed in the transfer cask inspections. Therefore, the staff finds that the Acceptance Criteria provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the transfer cask.

7. Corrective Actions

The licensee has stated that corrective actions, including root cause determinations and/or additional examinations are performed in accordance with the CAP. The licensee indicates that corrective actions are taken in a timely manner commensurate with the significance of the defect. The licensee also indicated that deficiencies are either promptly corrected or are evaluated to be acceptable through engineering analysis, which provides reasonable assurance that the intended function is maintained consistent with current licensing bases conditions. Each of the implementing procedures associated with the transfer cask AMP is within the scope of the CAP.

The staff reviewed the details provided for the CAP as part of the existing Calvert Cliffs QAP. The staff reviewed the timing of the corrective actions based on the significance of the defect. Per the requirements of 10 CFR 72.172, if aging or degradation of the transfer cask is identified in the inspections conducted as part of the transfer cask AMP, the licensee will enter the finding into the CAP and resolve the finding. The staff finds that the licensee's CAP is consistent with the quality assurance requirements in 10 CFR Part 50, Appendix B, and therefore, provides reasonable assurance that corrective actions will be adequate for managing the aging mechanisms and effects identified in the AMR of the transfer cask.

8. Confirmation Process

The licensee stated that the activities initiated in accordance with the implementing procedures for the transfer cask aging management program, such as corrective actions, are subject to QAP controls and the effectiveness is monitored using CAP procedures, review and approval processes, and administrative controls, which are implemented in accordance with the requirements of 10 CFR Part 50, Appendix B. The licensee stated that the use of these procedures, processes, and controls ensures that corrective actions are taken and are effective.

The staff reviewed the details provided for the licensee's Confirmation Process, as part of the existing QAP, to ensure that appropriate corrective actions are completed and are effective. The staff concludes that the licensee's CAP is consistent with the quality assurance requirements in 10 CFR Part 50, Appendix B, and therefore, provides reasonable assurance that the Confirmation Process is adequate for managing the aging mechanisms and effects identified in the AMR of the transfer cask.

9. Administrative Controls

The licensee stated that the transfer cask AMP is subject to corrective action and quality assurance procedures, review and approval processes, and administrative controls that are implemented in accordance with site procedures and the requirements of 10 CFR Part 50, Appendix B, and will continue to be adequate for the renewed license (extended storage) period.

The staff reviewed the details provided for the licensee's Administrative Controls, as part of the existing QAP, to ensure that the administrative controls will be adequate to provide a formal review and approval process. The staff concludes that the CCNPP QAP is consistent with the quality assurance requirements in 10 CFR Part 50, Appendix B, and therefore, provides reasonable assurance that the Administrative Controls are adequate for managing the aging mechanisms and effects identified in the AMR of the transfer cask.

10. Operating Experience

The licensee stated that the Calvert Cliffs ISFSI has been in operation since 1992 and that the transfer cask has been in use since the initial loading of the ISFSI. The licensee stated that inspections of the transfer cask have been performed prior to each movement to the ISFSI and these examinations and inspections are currently performed in accordance with a combination of procedures. The licensee noted cask degradation has not been identified in these inspections indicating that operating procedures and maintenance of the transfer cask have been effective in maintaining its condition and functionality. The licensee stated that any deficiencies identified are promptly corrected prior to moving fuel and the same process will be followed, as applicable, for moving the DSCs from the HSM back to the Calvert Cliffs spent fuel pool.

The staff reviewed the licensee's Operating Experience and found the licensee's evaluation of relevant operating experience demonstrates that the program will effectively manage aging effects of the transfer cask during the period of extended operation. The staff finds that the Operating Experience stated and referenced in the LRA provides reasonable assurance that this AMP will be adequate for managing the aging mechanisms and effects identified in the AMR of the transfer cask.

3.5.4 Transfer Cask Lifting Yoke Aging Management Program

The Licensee proposed the, "Transfer Cask Aging Management Program," in Attachment 2 of its 4th RAI response. The AMP details the activities to be performed to ensure the transfer cask lifting yoke will maintain its intended design safety function per 10 CFR 72.42(a)(2). The sections here after detail the staff review of the adequacy of the Transfer Cask Lifting Yoke AMP to address the identified aging mechanisms and effects for the transfer cask lifting yoke.

The licensee indicated objective of the program is to manage the aging effects including loss of material due to general, pitting and crevice corrosion as a result of exposure to borated water and cracking of the yoke due to stress/strain during lifting of the cask. The licensee stated that the program consists of visual inspections and magnetic particle testing of the yoke. The staff reviewed the AMP against the criteria provided in Section 3.6.1 of NUREG–1927. The staff's evaluation of each of the program elements is as follows:

1. Scope of Program

The licensee defined the scope of the program to include the transfer cask lifting yoke. The focus of this AMP is on the components that have external surfaces exposed to intermittent wetting and critical lifting components subject to strain. The program performs visual inspections of the exterior surface for corrosion as a result of periodic wetting from normal use that includes exposures to spent fuel pool water and cracking as a result of applied loads during lifting operations.

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

2. Preventive Actions

The licensee stated that the transfer cask lifting yoke AMP includes guidance and direction for maintaining a suitable environment that precludes the onset or propagation of a loss of material due to corrosion for intermittently wetted surfaces. Following use, all subcomponents of the transfer cask lifting yoke that are immersed in borated water are rinsed with deionized water.

The staff reviewed the licensee's guidance and direction for maintaining a suitable environment for the transfer cask lifting yoke and finds the guidance provides reasonable assurance that aging effects, including onset or propagation of a loss of material due to crevice or pitting corrosion for continuously wetted surfaces will be precluded.

3. Parameters Monitored or Inspected

The licensee stated that the parameter inspected by the transfer cask lifting yoke AMP is visual evidence of degradation of external surfaces of the transfer cask lifting yoke. This is done via visual inspection of the subcomponents of the transfer cask lifting yoke and through magnetic particle testing of the lifting hooks and areas around the lifting pin hole.

The staff reviewed the licensee's Parameters Monitored or Inspected for the visual inspections of the transfer cask lifting yoke and concludes that the parameter of visual evidence of degradation is appropriate for detecting aging mechanisms and effects. Therefore, the staff finds that the Parameters Monitored or Inspected provide reasonable assurance for managing the aging mechanisms and effects, and ensuring the intended function of the transfer cask lifting yoke will be maintained during the period of extended operation.

4. Detection of Aging Effects

The licensee stated that the transfer cask lifting yoke AMP relies upon a visual inspection to check for loss of material due to corrosion and determine the physical condition of the exterior surfaces of the transfer cask lifting yoke. The licensee stated that magnetic particle testing examination of the lifting hook plates is conducted to examine for cracks as a result of stresses/stained from lifting operations. The licensee stated that visual inspection and magnetic particle testing are conducted annually or prior to moving a DSC.

The licensee has stated that the qualification of personnel conducting the visual inspections and magnetic particle testing for the transfer cask lifting yoke AMP shall be accomplished in accordance with site procedures and shall meet the requirements of ASME Section XI Article IWA-2300. Personnel performing nondestructive examinations (NDE) shall be qualified and certified using a written practice prepared in accordance with ANSI/ASNT CP-189, Standard for Qualification and Certification of Nondestructive Testing Personnel, as amended by the requirements of ASME Section XI Article IWA-2300.

The staff reviewed the licensee's Detection of Aging Effects and determined that the visual inspection and magnetic particle testing described in the transfer cask lifting yoke AMP is appropriate for detecting the effects of aging including general and localized corrosion such as pitting. The staff reviewed the subcomponents inspected as part of the transfer cask lifting yoke AMP and has determined that the subcomponents examined are appropriate for detecting aging of the transfer cask. The staff also reviewed the personnel qualifications and has confirmed that these requirements are appropriate for personnel conducting visual inspections and magnetic particle testing.

Pursuant to Control of Special Processes in 10 CFR 72.158, the licensee shall establish measures to ensure that special processes, including nondestructive testing (such as visual inspections and magnetic particle testing), is controlled and accomplished by qualified personnel using qualified procedures (with identified parameters to be inspected or monitored) in accordance with applicable codes, standards, specifications, criteria, and other special requirements.

The staff finds that the Detection of Aging Effects provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the transfer cask lifting yoke.

5. Monitoring and Trending

The licensee stated that visual inspections will determine the existence of loss of material on the external surfaces of the transfer cask lifting yoke, and observations regarding the material condition are recorded in accordance with inspection procedures. The licensee indicated these issues are corrected or evaluated as satisfactory before use of the transfer cask lifting yoke. The licensee also indicated these inspections are either performed periodically or during the preparations for movement of the transfer cask and that the evaluation of this information during the preparations for DSC retrieval and transfers provides adequate predictability and allows for corrective action prior to the need for the intended function of the component to be performed.

The staff reviewed the licensee's Monitoring and Trending and determined that the licensee's monitoring and trending methods provide acceptable means to monitor for aging effects on the transfer cask lifting yoke to allow for the timely implementation of corrective actions. The staff finds that the Monitoring and Trending provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the transfer cask lifting yoke.

6. Acceptance Criteria

The licensee has stated that the transfer cask lifting yoke acceptance criteria for the transfer cask lifting yoke AMP for exterior surfaces is no unacceptable loss of material that could result in a loss of component intended function(s). The licensee stated that acceptance criteria for MT of the lifting hook plates are consistent with ASME Section III Division 1 paragraph NF-5340 (ASME, 1986). The licensee stated that unsatisfactory results in accordance with baseline data and code requirements will be entered in the CAP for evaluation and resolution.

The staff reviewed the licensee's acceptance criteria and determined that the acceptance criteria are acceptable because corrective actions will be taken if any indication of DSC aging or degradation are observed in the transfer cask lifting yoke inspections. The staff therefore finds that the Acceptance Criteria provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the transfer cask lifting yoke.

7. Corrective Actions

The licensee has stated that corrective actions, including root cause determinations are performed in accordance with the CAP. The licensee indicates that corrective actions are taken in a timely manner commensurate with the significance of the defect. The licensee also indicated that deficiencies are either promptly corrected or are evaluated to be acceptable through engineering analysis, which provides reasonable assurance that the intended function is maintained consistent with current licensing basis conditions. Each of the implementing procedures associated with the transfer cask AMP is within the scope of the CAP.

The staff reviewed the details provided for the CAP as part of the existing Calvert Cliffs QAP. The staff reviewed the timing of the corrective actions based on the significance of the defect. Per the requirements of 10 CFR 72.172, if aging or degradation of the transfer cask lifting yoke is identified in the inspections conducted as part of the transfer cask lifting yoke AMP, the licensee will enter the finding into the CAP and resolve the finding. The staff finds that the licensee's correction action program is consistent with the quality assurance requirements in 10 CFR Part 50, Appendix B, and therefore, provides reasonable assurance that corrective actions will be adequate for managing the aging mechanisms and effects identified in the AMR of the transfer cask lifting yoke.

8. Confirmation Process

The licensee stated that the activities initiated in accordance with the implementing procedures for the DSC aging management program, such as corrective actions, are subject to QAP controls and the effectiveness is monitored using CAP procedures, review and approval processes, and administrative controls, which are implemented in accordance with the requirements of 10 CFR Part 50, Appendix B. The licensee stated that the use of these procedures, processes, and controls ensures that corrective actions are taken and are effective.

The staff reviewed the details provided for the licensee's Confirmation Process, as part of the existing QAP, to ensure that appropriate corrective actions are completed and are effective. The staff considers that the licensee's CAP is consistent with the quality assurance requirements in 10 CFR Part 50, Appendix B, and therefore, provides reasonable assurance that the Confirmation Process is adequate for managing the aging mechanisms and effects identified in the AMR of the transfer cask lifting yoke.

9. Administrative Controls

The licensee stated that the transfer cask AMP is subject to corrective action and quality assurance procedures, review and approval processes, and administrative controls that are implemented in accordance with site procedures and the requirements of 10 CFR Part 50, Appendix B, and will continue to be adequate for the renewed license (extended storage) period.

The staff reviewed the details provided for the licensee's Administrative Controls, as part of the existing QAP, to ensure that the administrative controls will be adequate to provide a formal review and approval process. The staff concludes that the CCNPP QAP, is consistent with the quality assurance requirements in 10 CFR Part 50, Appendix B, and therefore, provides reasonable assurance that the Administrative Controls are adequate for managing the aging mechanisms and effects identified in the AMR of the transfer cask lifting yoke.

10. Operating Experience

The licensee stated that the Calvert Cliffs ISFSI has been in operation since 1992 and that the transfer cask lifting yoke has been in use since the initial loading of the ISFSI. The licensee stated that inspections of the transfer cask lifting yoke have been performed prior to each movement to the ISFSI and these examinations and inspections are currently performed in accordance with a combination of procedures. The licensee stated that during the latest inspection no issues that would impact the ability of the transfer cask lifting yoke to perform its intended function were identified and noted transfer cask lifting yoke degradation has not been identified in these inspections indicating that operating procedures and maintenance of the transfer cask lifting yoke have been effective in maintaining its condition and functionality.

The staff reviewed the licensee's Operating Experience and found the licensee's evaluation of relevant operating experience demonstrates that the program will effectively manage aging effects of the transfer cask lifting yoke during the period of extended operation. Therefore, the staff finds that the Operating Experience stated and referenced in the LRA provides reasonable assurance that this AMP will be adequate for managing the aging mechanisms and effects identified in the AMR of the transfer cask lifting yoke.

3.5.5 Cask Support Platform Aging Management Program

The Licensee proposed the, "Cask Support Platform Aging Management Program," in Appendix A of the LRA. The AMP detailed the activities to be performed to ensure the cask support platform will maintain its intended design safety function per 10 CFR 72.42(a)(2). The sections here after detail the staff review of the adequacy of the Cask Support Platform AMP to address the identified aging mechanisms and effects for the cask support platform.

The licensee indicates the purpose of the cask support platform AMP is to ensure that no significant degradation occurs while the cask support platform is in the borated water environment of the spent fuel pool. The licensee stated the cask support platform AMP credits the Chemistry Control Program which monitors and controls the chemistry of the spent fuel pool water to control leachable chlorides and fluorides in order to maintain a non-corrosive environment for the stainless liner, fuel racks, and components and cask support platform and other structures stored in the pool. The staff reviewed the AMP against the criteria provided in Section 3.6.1 of NUREG–1927. The staff's evaluation of each of the program elements is as follows:

1. Scope of Program

The Licensee defined the scope of the program to include the cask support platform and the pertinent subcomponents. The licensee indicated that the focus of this AMP is on the stainless steel subcomponents that are continuously exposed to borated water.

The staff reviewed the licensee's Scope of Program and determined that the licensee has appropriately identified the cask support platform and pertinent subcomponents to be within the scope of this program, and has appropriately identified aging mechanisms and effects of the cask support platform to be managed by the program. The staff finds the Scope of Program provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the cask support platform.

2. Preventive Actions

The licensee stated that the cask support platform AMP credits the Chemistry Control Program which monitors and controls the concentrations of aggressive species in the spent fuel pool water chemistry to prevent corrosion of the cask support platform

The staff finds that the Preventive Actions described in the cask support platform AMP provides reasonable assurance that aging effects, including corrosion of the cask support platform, will be precluded because the Chemistry Control Program provides a basis for identifying an aggressive chemical (high chloride) environment to the platform.

3. Parameters Monitored or Inspected

The licensee stated that the cask support platform AMP includes guidance and direction for maintaining a suitable environment that precludes the onset or propagation of a loss of material and cracking due to pitting and/or stress corrosion for stainless steel components in the spent fuel pool. The licensee indicated that the Cask Support Platform AMP relies on the Chemistry Control Program to monitor chloride levels in the spent fuel pool to ensure conditions that would be conducive to the onset or propagation of loss of material and cracking due to pitting and/or stress corrosion in this stainless steel platform do not occur and that samples are taken on a monthly basis.

The staff reviewed the licensee's Parameters Monitored or Inspected for the cask support platform AMP. The staff finds that the Parameters Monitored or Inspected are appropriate for preventing the effects of corrosion and stress corrosion cracking and therefore, provide reasonable assurance for managing the aging mechanisms and effects, and ensuring the intended function of the cask support platform will be maintained during the period of extended operation.

4. Detection of Aging Effects

The licensee stated that the cask support platform AMP relies upon chloride sampling of the spent fuel pool water to ensure favorable conditions for this aging effect do not develop.

The staff reviewed the licensee's Detection of Aging Effects and determined that the preventative actions in the chemistry control program credited in the cask support platform AMP are appropriate for preventing the effects of aging including general and localized corrosion such as pitting and stress corrosion cracking of the cask support platform.

5. Monitoring and Trending

The licensee stated that chloride sampling will determine whether conditions favorable for development of aging effects for the cask support platform have developed. In addition the licensee indicated that in the event that the water chemistry was found to contain a sufficient concentration of aggressive species that could promote aging of the cask support platform, additional inspections would be required to ensure that the water chemistry was corrected before use of the cask support platform.

The staff reviewed the licensee's Monitoring and Trending and determined that the licensee's monitoring and trending methods are reasonable and provide acceptable means to prevent aging effects on the cask support platform. The staff, therefore, finds that the Monitoring and

Trending provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the cask support platform.

6. Acceptance Criteria

The licensee has indicated that the acceptance criterion for the cask support platform AMP is spent fuel pool chlorides within acceptable limits. The licensee has indicated that under the Chemistry Control Program, a chloride sample of the spent fuel pool water is taken monthly and compared to the target threshold value (<100 ppb). The licensee has provided justification for the target value selected by Calvert Cliffs that is more conservative than the target recommendation specified in the Electric Power Research Institute (EPRI) PWR Primary Guidelines of <150 ppb.

The staff reviewed the licensee's acceptance criteria and determined that the acceptance criteria are acceptable because the spent fuel pool water chemistry will be frequently sampled and analyzed and the acceptance criteria are conservative with respect to the EPRI PWR water chemistry standard. The staff finds that the Acceptance Criteria provides reasonable assurance for managing the aging mechanisms and effects identified in the AMR of the cask support platform.

7. Corrective Actions

The licensee has stated that corrective actions, including root cause determinations are performed in accordance with the CAP. The licensee indicates that corrective actions are taken in a timely manner commensurate with the significance of the defect. The licensee also indicated that deficiencies are either promptly corrected or are evaluated to be acceptable through engineering analysis, which provides reasonable assurance that the intended function is maintained consistent with current licensing basis conditions. Each of the implementing procedures associated with the cask support platform AMP is within the scope of the CAP.

The staff reviewed the details provided for the CAP as part of the existing Calvert Cliffs QAP. The staff reviewed the timing of the corrective actions based on the significance of the defect. Per the requirements of 10 CFR 72.172, if the spent fuel pool water chemistry is found to be out of compliance with the stated acceptance criteria, the licensee will enter the finding into the CAP and resolve the finding. The staff finds that the licensee's CAP is consistent with the quality assurance requirements in 10 CFR Part 50, Appendix B, and, therefore, provides reasonable assurance that corrective actions will be adequate for managing the aging mechanisms and effects identified in the AMR of the cask support platform.

8. Confirmation Process

The licensee stated that the activities initiated in accordance with the implementing procedures for the cask support platform aging management program, such as corrective actions, are subject to QAP controls and the effectiveness is monitored using CAP procedures, review and approval processes, and administrative controls, which are implemented in accordance with the requirements of 10 CFR Part 50, Appendix B. The licensee stated that the use of these procedures, processes, and controls ensures that corrective actions are taken and are effective.

The staff reviewed the details provided for the licensee's Confirmation Process, as part of the existing QAP, to ensure that appropriate corrective actions are completed and are effective.

The staff finds the licensee's CAP is consistent with the quality assurance requirements in 10 CFR Part 50, Appendix B, and, therefore, provides reasonable assurance that the Confirmation Process is adequate for managing the aging mechanisms and effects identified in the AMR of the cask support platform.

9. Administrative Controls

The licensee stated that the cask support platform AMP is subject to corrective action and quality assurance procedures, review and approval processes, and administrative controls that are implemented in accordance with site procedures and the requirements of 10 CFR Part 50, Appendix B, and will continue to be adequate for the renewed license (extended storage) period.

The staff reviewed the details provided for the licensee's Administrative Controls, as part of the existing QAP, to ensure that the administrative controls will be adequate to provide a formal review and approval process. The staff concludes that the CCNPP QAP is consistent with the quality assurance requirements in 10 CFR Part 50, Appendix B, and, therefore, provides reasonable assurance that the Administrative Controls are adequate for managing the aging mechanisms and effects identified in the AMR of the cask support platform.

10. Operating Experience

The licensee stated that a review of plant operating experience for the cask support platform was conducted as part of the license renewal application and did not identify any occurrences of unsatisfactory degradation associated with the cask support platform. Specifically the licensee stated that a review of the spent fuel pool chloride sample values taken during the last three years showed no instances where the threshold value of 100 ppb was exceeded. The licensee reported that between January 2010 and June 2011 the spent fuel pool chloride ranged from less than 5.0 ppb to 13.1 ppb where 5.0 ppb corresponds to the limit of detection. The licensee stated that the spent fuel pool chloride average for this period is 5.8 + 1.7 ppb.

The staff reviewed the licensee's Operating Experience and found the licensee's evaluation of relevant operating experience demonstrates that the program will be effective in preventing aging effects of the cask support platform during the period of extended operation. The staff confirmed that the licensees threshold value of chloride concentration of 100 ppb is conservative with respect to established industry guidance provide by EPRI (2007). The staff finds that the Operating Experience stated and referenced in the LRA provides reasonable assurance that this AMP will be adequate for managing the aging mechanisms and effects identified in the AMR of the cask support platform.

3.5.6 High Burnup Fuel Aging Management Program

The licensee specified that the Calvert Cliffs ISFSI provides for long-term dry fuel interim storage for high burnup irradiated fuel assemblies, i.e., fuel assemblies with discharge burnups greater than 45 GWD/MTU, until such time that the irradiated fuel assemblies may be shipped off-site for final disposition. Section 3.2.6 of the LRA specifies that the AMR of the irradiated fuel assemblies (IFAs) in a dry inert environment did not identify any aging effects/mechanisms that could lead to a loss of intended function. However, the licensee recognized that there has been relatively little operating experience, to date, with dry storage of high burnup fuel. Therefore, the licensee submitted an AMP in its 4th RAI response describing the High Burnup

Fuel Aging Management Program which establishes procedures to confirm that the high burnup fuel assemblies' intended function(s) are maintained during the period of extended operation.

The licensee's AMP was submitted in conformance with ISG -24, which identifies an acceptable confirmation method through a surrogate high burnup fuel surveillance program. The AMP is based on the U.S. Department of Energy (DOE) funded high burnup fuel dry storage cask demonstration program, or other high burnup fuel surveillance demonstrations that meet the criteria of ISG-24. ISG-24, "The Use of a Demonstration Program as a Surveillance Tool for Confirmation of Integrity for Continued Storage of High Burnup Fuel Beyond 20 Years" provides the acceptance criteria for the surveillance demonstration. The staff also developed ISG-11, Rev. 3, with models that extrapolate the expected performance of low and high burnup fuel during storage. Based upon this data, the staff has reasonable assurance that HBF performance will continue as expected throughout the term of this renewed licensee. Because the operating experience in this area is limited, the licensee's AMP relies on a surrogate surveillance program to confirm that the high burnup fuel performance continues as expected and supports the conclusions drawn in ISG-11, Rev. 3, before moving into the period of extended operation beyond the initial 20-year period. The NRC staff recognizes that this is a similar approach to that used to provide reasonable assurance for low burnup fuel performance (EPRI, 2002, 2014; Einziger, et al., 2003a & b; Bare, et al., 2001). Because the staff requires this high burnup fuel surveillance AMP to provide this confirmatory information, it has included a license condition (license condition 22) documenting this requirement.

1. Scope of Program

The licensee specified that the spent fuel cladding materials are either Zircaloy-4 or ZirloTM stored in an environment that is predominantly helium with trace amounts of water vapor and air. The licensee specified that this program will also be designed to cover future NUHOMS-32PHB DSC loadings which may also include fuel assemblies using the zirconium-based alloy M5.

The licensee stated that the AMP relies upon the joint Electric Power Research Institute (EPRI) and DOE "High Burnup Dry Storage Cask Research and Development Project" (HDRP), or an alternative program meeting the guidance in ISG-24 as a surrogate program to monitor the condition of high burnup irradiated fuel assemblies in dry storage. The licensee further stated that the HDRP is a program designed to collect data from a spent nuclear fuel storage system containing high burnup fuel in a dry helium environment. More specifically, the program entails loading and storing a TN-32 bolted lid cask (the Research Project Cask) at Dominion Virginia Power's North Anna Power Station with intact high burnup spent nuclear fuel (with nominal burnups ranging between 53 GWd/MTU and 58 GWd/MTU). The fuel assemblies to be used in the HDRP include four different kinds of cladding (Zircaloy-4, low-tin Zircaloy-4, Zirlo^{TM}, and M5^{TM}), which cover the range of fuel cladding materials in use at Calvert Cliffs. The licensee clarified that the HDRP cask is to be licensed to the temperature limits contained in ISG-11, and loaded such that the fuel cladding temperature is as close to the limit as practicable.

The staff reviewed the licensee's Scope of Program, which is defined by the DOE-funded HDRP or alternative program meeting the criteria in ISG-24. The staff finds that the Scope of Program provides reasonable assurance that the licensee will be informed of any aging mechanisms and effects from such surrogate surveillance program because the DOE-funded HDRP or an alterantive program meeting the criteria in ISG-24, will provide characterization results for HBF cladding representative of the Calvert Cliffs ISFSI. The staff further finds that such surrogate surveillance programs will serve as confirmation that fuel performs as expected per ISG-11 Rev. 3, and can be readily retrieved.

2. Preventive Actions

The licensee stated that the AMP is a condition monitoring program to confirm there is no degradation of a high burnup fuel assembly that would result in a loss of intended function(s). The licensee further stated that no preventive or mitigating attributes are associated with these aging management activities, except initial design limits placed during loading operations.

More specifically, the licensee referenced technical specifications that ensure fuel is stored in a dry inert environment thus preventing cladding degradation due to oxidation. Technical Specification 2.2.1, “DSC Vacuum Drying,” according to the licensee, demonstrates that the cask cavity is dry by maintaining a cavity absolute pressure less than or equal to 3 torr for a 30 minute period with the cask isolated from the vacuum pump. The licensee specifies that this indicates, per ISFSI USAR Section 4.3.1 (ADAMS Accession No. ML12275A428), that all liquid water has evaporated in the DSC cavity, and that the resulting inventory of oxidizing gases is less than 0.25% (Vol%). In addition, Technical Specification 2.2.2, “DSC Helium Backfill Pressure,” requires that the cask then be backfilled with helium. According to the licensee, these two Technical Specifications requirements ensure that the high burnup fuel is stored in an inert environment thus preventing cladding degradation due to oxidation mechanisms.

Furthermore, the licensee asserts that the conditions of loading and storage also constitute actions to prevent age-related degradation of high burnup fuel cladding. Specifically, the licensee specifies, in Section A1.8.2 of this AMP, that design bases calculations demonstrate that peak cladding temperatures are maintained below the 400C limit recommended in ISG-11, Rev. 3 to protect high burnup fuel cladding from aging mechanisms such as creep or embrittlement due to redissolution and precipitation of hydrides in a radial orientation.

The staff reviewed the licensee’s Preventive Actions and finds that it provides reasonable assurance that the licensee will be informed of any aging mechanisms and effects by the DOE-funded HDRP or alternative program meeting the criteria in ISG-24 because the DOE-funded HDRP, or the alternative program, will provide characterization results for HBF cladding representative of the Calvert Cliffs ISFSI. The staff further finds that such surrogate surveillance program will serve as confirmation that fuel performs as expected per ISG-11 Rev. 3, and can be readily retrieved because the DOE-funded HDRP will provide characterization results for HBF cladding representative of the Calvert Cliffs ISFSI.

3. Parameters Monitored or Inspected

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

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

4. Detection of Aging Effects

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

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

5. Monitoring and Trending

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

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

The licensee further stated it will perform formal evaluations of the aggregate feedback from the HDRP and other sources of information at specific points in time during the period of extended operation. 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. The licensee stated that these separate evaluations will occur by April 4, 2028, 2038 and 2048, respectively.

The NRC staff finds that the schedule for the Monitoring and Trending provided in the AMP, which takes into account operating experience with fuels gained from other sources, will deliver the requisite reasonable assurance prior to the high burnup fuel entering into the period of extended operation in 2033 because the DOE-funded HDRP, or the alternative program, will provide characterization results for HBF cladding representative of the Calvert Cliffs ISFSI. The staff further finds that the surrogate surveillance program will serve as confirmation that fuel performs as expected and can be readily retrieved because it is consistent with ISG-11 Rev. 3.

6. Acceptance Criteria

The licensee specifies that the HDRP or any other demonstration used to provide fuel performance data should meet the acceptance criteria guidance provided in ISG-24.

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

1. Cladding Creep—total creep strain extrapolated to the total approved storage duration based on the best fit to the data, accounting for initial condition uncertainty shall be less than 1 percent.

2. Hydrogen—maximum hydrogen content of the cover gas over the approved storage period shall be extrapolated from the gas measurements to be less than 5 percent.

3. Drying—The moisture content in the cask, accounting for measurement uncertainty, shall indicate no greater than one liter of residual water after the drying process is complete.

4. Fuel rod breach—fission gas analysis shall not indicate more than 1 percent of the fuel rod cladding breaches.

The licensee specifies that while it is not a fuel performance criteria, the spatial distribution and time history of the cladding temperature must be known to evaluate the relationship between the performance of the rods in the HDRP and the HBF rod behavior expected in the DSCs in use at Calvert Cliffs. If the results of the HDRP or other any other demonstration used to provide data are found to be not representative of the temperature history of high burnup fuel in storage at Calvert Cliffs, a corrective action will be initiated to drive an update to the aging management approach for this subset of the high burnup fuel population.

The staff reviewed the licensee's Acceptance Criteria and finds that it provides reasonable assurance that the licensee will be informed of any aging mechanisms and effects by the DOE funded HDRP or alternative program meeting the criteria in ISG-24 because the DOE-funded HDRP, or alternative program, will provide characterization results for HBF cladding representative of the Calvert Cliffs ISFSI. The staff further finds that such surrogate surveillance programs will serve to confirm whether the fuel performs as expected per ISG-11 Rev. 3, and can be readily retrieved.

7. Corrective Actions

The licensee specified that its CAP commensurate with 10 CFR Part 50, Appendix B will be followed.

The licensee clarified that, at each of the assessments detailed in Section 1.8.5.5 of the AMP, the impact of the aggregate feedback will be assessed and actions taken when warranted. The licensee further clarified that 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);
- Take actions to prevent reoccurrence;
- Perform an evaluation of the DCS system (DCSS) to perform it's safety and retrievability functions;
- Perform an evaluation of the effect of the corrective actions on this component to other safety components.

The staff reviewed the details provided for the CAP, as part of the existing QAP. Per the requirements of 10 CFR 72.172, "Corrective Action," if an unanalyzed degraded condition is identified by the surrogate surveillance program, the licensee will enter the finding into the CAP and resolve the finding. The staff finds that the licensee's correction action program is consistent with the quality assurance requirements in 10 CFR Part 50, Appendix B, and therefore, provides reasonable assurance that corrective actions will be adequate for managing any aging mechanisms and effects identified by the DOE-funded HDRP or alternative program meeting the criteria in ISG-24.

8. Confirmation Process

The licensee stated that the confirmation process is part of the Calvert Cliffs CAP and ensures that the corrective actions taken are adequate and appropriate, have been completed, and are effective. The licensee further stated that the focus of the confirmation process is on the follow-up actions that must be taken to verify effective implementation of corrective actions. More specifically, the measure of effectiveness is in terms of correcting the adverse condition and precluding repetition of significant conditions adverse to quality. The licensee clarified that the 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. The licensee specifies that these procedures provide for tracking, coordinating, monitoring, reviewing, verifying, validating, and approving corrective actions, to ensure that effective corrective actions are taken.

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

9. Administrative Controls

The licensee stated that the Calvert Cliffs QAP, 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 Calvert Cliffs Quality Assurance Topical Report and 10 CFR Part 50, Appendix B. The licensee further specifies that the administrative controls that govern aging management assets at Calvert Cliffs are established in accordance with Exelon Fleet Procedures.

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

10. Operating Experience

The licensee asserts that surrogate surveillance demonstration programs with storage conditions and fuel types similar to those in the dry storage system that satisfies the acceptance criteria recommended in ISG-24 are a viable method to obtain operating experience. The licensee specifies that it intends to rely on the information from the HDRP with similar types of high burn up fuel. The licensee further specifies that additional data/research to assess fuel performance from both domestic and international sources that are relevant to the fuel in the Calvert Cliffs DSCs will also be used.

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

3.5.7 Evaluation Findings

The staff reviewed the AMPs presented in its 4th RAI response against the regulatory requirements of 10 CFR 72.42, "Duration of License; Renewal." The staff verified that the AMPs are adequately identified and appropriate for managing the aging effects identified for the SSCs. The staff also verified that the methods and technical bases of these AMPs are acceptable.

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

As part of this review, the staff considered information from technical references pertinent to age related degradation of materials, including NUREG-1801 "Generic Aging Lessons Learned (GALL) Report," applicable consensus codes and standards, NRC reports, and other peer-reviewed technical references. Based upon this review, the staff concludes that, with the specific SSC and SSC subcomponents and aging effects/mechanisms identified in the AMPs, the licensee has demonstrated with reasonable assurance that the SSC or SSC subcomponents will maintain their intended function through the renewal period. The staff has determined that the SSC and SSC subcomponents are appropriately identified, and the identified aging effects/mechanisms are consistent with the technical references pertinent to age related degradation of materials. Therefore, with the inclusion of the specific SSC and SSC subcomponents and aging effects/mechanisms in the AMPs, the staff concludes that signs of deterioration will be adequately detected and addressed before degradation reaches a level where the SSC or SSC subcomponent would be challenged in performing its intended function.

Because the staff is relying upon these specific SSC and SSC components and aging effects/mechanisms being within the scope of the AMPs in reaching its reasonable assurance finding, the staff has added a specific license condition (license condition 20) to prevent removal of an SSC or SSC subcomponent or an aging effect/mechanism from the scope of the AMP absent a license amendment.

Based on its review of the information provided in the LRA (ADAMS Accession Nos. ML102650247; ML110620134; ML110730720; ML11180A270; ML113640129; ML12212A216; ML131190290; ML14267A065), the staff finds:

F3.1 The licensee has identified maintenance and surveillance programs that will provide reasonable assurance that aging effects would be managed during the period of extended operation, in accordance with 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste."

4 CONCLUSION

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

The NRC staff reviewed the licensee's LRA in accordance with NRC regulations 10 CFR 72.42(a). The staff followed the guidance provided in NUREG–1927, "Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance," as supplemented by ISGs identified in Table 1.6-1. Based on its review of the LRA and the license conditions, the staff determined that the licensee has met the requirements of 10 CFR 72.42(a).

APPENDIX A
AGING MANAGEMENT PROGRAMS

APPENDIX B
REFERENCES

"Application for Renewal of the Site-Specific License," letter from G.H. Gellrich (Calvert Cliffs Nuclear Power Plant, LLC) to NRC, dated September 17, 2010 (ADAMS Accession No. ML102650247).

Response to First Request for Supplemental Information, dated February 10, 2011 (ADAMS Accession No. ML110620134).

Response to Second Request for Supplemental Information, dated March 9, 2011 (ADAMS Accession No. ML110730720).

Response to First Request for Additional Information, dated June 28, 2011 (ADAMS Accession No. ML11180A270).

Response to Second Request for Additional Information, dated December 15, 2011 (ADAMS Accession No. ML113640129).

Response to Third Request for Supplemental Information, dated July 27, 2012 (ADAMS Accession No. ML12212A216).

Partial Response to Third Request for Additional Information, dated June 14, 2013 (ADAMS Accession No. ML131700610).

Supplemental Response to Third Request for Additional Information, dated April 24, 2014 (ADAMS Accession No. ML131190290).

Response to Fourth Request for Additional Information, dated September 18, 2014 (ADAMS Accession No. ML14267A065).

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"Summary Findings Resulting from the Staff Review of the 2010 Decommissioning Funding Status Reports for Operating Power Reactor Licensees," dated October 26, 2011 (ADAMS Accession No. ML112620046).

Safety Evaluation by the Office of Nuclear Reactor Regulation Indirect Transfer of Control of Facility Operating Licenses Due to the Proposed Merger Between Exelon Corp & Constellation Energy Group, Inc., Calvert Cliffs Nuclear Power Plant, Units 1 & 2, dated February 15, 2012 (ADAMS Accession No. 113560438).

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Topical Report for the NUTECH Horizontal Modular Storage System for Irradiated Nuclear Fuel NUHOMS®-24P, Pacific Nuclear Fuel Services, Volume 1, dated April 30, 1991 (ADAMS Accession No. ML110730769).

NUREG–1801, "Generic Aging Lessons Learned (GALL) Report." Rev. 2, dated December 10, 2010 (ADAMS Accession No. ML103270684).

Literature Review of Environmental Conditions and Chloride-Induced Degradation Relevant to Stainless Steel Canisters in Dry Cask Storage Systems. EPRI, Palo Alto, CA: 2014.

NUREG/CR-7170, "Assessment of Stress Corrosion Cracking Susceptibility for Austenitic Stainless Steels Exposed to Atmospheric Chloride and Non-Chloride Salts," dated February 28, 2014 (ADAMS Accession No. ML14051A417).

NUREG/CR–6831, "Examination of Spent PWR Fuel Rods After 15 Years in Dry Storage" dated September 30, 2003 (ADAMS Accession No. ML032731021).

NRC Information Notice 2012-20, "Potential chloride-induced stress corrosion cracking of austenitic stainless steel and maintenance of dry cask storage system containers," NRC, dated November 14, 2012.

NRC Information Notice 2013-07, "Potential chloride-induced stress corrosion cracking of austenitic stainless steel and maintenance of dry cask storage system containers," NRC, dated November 14, 2012.

NRC Information Notice 2013-07, "Premature Degradation of Spent Fuel Storage Cask Structures and Components from Environmental Moisture," NRC, dated April 16, 2013.

NRC Interim Staff Guidance 11, Rev. 3, "Cladding Considerations for the Transportation and Storage of Spent Fuel," NRC, dated November 17, 2003.

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